

## **METACOGNITIVE INTERVENTION EFFECTIVENESS IN IMPROVING MATHEMATICS PERFORMANCE AMONG SECONDARY SCHOOL STUDENTS IN MEERUT DISTRICT**

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### **ABSTRACT**

Today, mathematics serves as the foundation for the advancement of society's technology and modern science. As a result, it gains national attention. Students in secondary schools are unable to develop an interest in mathematics or attain high levels of proficiency with the current teaching techniques. To raise math accomplishment levels, it is necessary to acknowledge the need for fresh approaches and methods. The goal of the study is to determine how well metacognitive interventions affect arithmetic achievement about gender and intellect. It is a natural experiment study. For the study, samples of 60 Xth standards were selected. Two groups, a control group, and an experimental group were created from the sample. Each group consists of 30 students in each group. The experimental group received instruction using math modules built on metacognitive intervention, while the control group received instruction using conventional lesson plans. The study's findings demonstrated that metacognition has a considerable impact on mathematical achievement. The data analysis revealed that there was no connection between metacognitive interventions, and intellect, on mathematical achievement. The learning of mathematics, as well as the teaching of mathematics, can both benefit from metacognitive intervention techniques. Therefore, it can be inferred that employing metacognitive methods and procedures can improve secondary school students' mathematical achievement as well as intellect.

**Keywords:**Metacognition,Mathematics,Achievement, Effectiveness

### **INTRODUCTION**

The most defining aspect of contemporary society is its reliance on science-based technology, which has had a significant influence on not just the nation's political and economic systems but also on the way that education is conceptualized, opening up new fields of study. It is the arousal of curiosity, the fostering of intelligence, the growth of appropriate interest, attitude, and values among pupils, and the development of crucial abilities like independent study. Future technological developments, a deep understanding of mathematics, and the practical application of mathematical concepts are all required. Unfortunately, we are not paying for it since traditional teaching approaches fall short of students' intellectual, psychological, and emotional needs and are insufficient to pique their interest in mathematics. It is necessary to alter the way arithmetic is taught. The shift from a teacher-centered system to a learner-centered system is a slow one, even though modern teaching is seen as being more learner-centered and learner-driven. Improve the teaching-learning process, necessitates modifications to the instructional strategy and supporting materials. The learner should take an active role in their education, and learning should result in positive modifications to habits, ways of living, knowledge, and abilities, among other things. It seeks to maximize educational opportunities. We are on the cusp of a new era for innovation in all aspects of life, including education. Through efficient teaching methods, teachers nowadays must acquaint their students with the ever-expanding world of knowledge. The main responsibility of a teacher is to develop systematic instructional materials and offer learning opportunities, which are fundamental components of dynamic and effective instruction. Through the effective application of metacognitive tactics and approaches in the teaching-learning process, the classroom can transform into a wonder world of delight for children with simple absorption of learning material.

Recently, the idea of metacognition has gained popularity in the field of education. Concerns regarding the types and levels of knowledge that children are learning in classrooms are shared by researchers and educators. Memorization of information and passive transmission of information are not the types of learning that will be necessary for

success in the future. The students will be asked to analyze what they have seen and heard critically, find connections between concepts, make complicated decisions, and keep an eye on their mental processes. Studies demonstrate the critical role that metacognitive interventions play in the efficient learning that results in academic achievement in mathematics.

The applicability of metacognition to academic success is extensive. The ability to design a plan for achieving a goal and assess how successfully one accomplished that objective are the core components of metacognition, which is the awareness of one's cognitive processes. It is well acknowledged that metacognition is essential for learning and problem-solving of the highest caliber. For instance, specialists who have a thorough understanding of their particular subject areas have been proven to have a high level of metacognition.

### **IMPORTANCE AND PLACE OF MATHEMATICS IN OUR LIFE**

Although it would be pointless to put up a distinct argument for adding mathematics to the school curriculum. Some people believe that since middle school mathematics knowledge is sufficient, mathematics should be made an elective subject in high school. They oppose requiring mathematics as a subject up through the high school level. However, there is another side to the story. The opinions of the detractors, according to those who support making mathematics a high school requirement, are irrational. They believe that mathematics instruction should be mandated through the high school years for the following reasons:

1. It has been demonstrated through experimentation that general intelligence (G) rather than specialized intelligence is required for special skills in mathematics (S). The claim that only brilliant kids should be encouraged to learn mathematics is untrue.

2. Furthermore, it is untrue that mathematics is a challenging topic. The professors are to blame for instilling a dislike and loathing for the subject as well as degenerating understanding because they frequently emphasize memory exercises. The flaw resides in the teaching strategy rather than the topic matter. It is not necessary to memorize the equations, regulations, and concepts. If appropriately reached, then it can be quickly remembered when forgotten. The student's ability to reason and think critically will improve as a result of the teacher's efforts to simplify and make the subject simple.

3. Without a shadow of a doubt, mathematics fosters the development of reasoning and thinking skills. It provides the most beneficial mental exercise for enhancing brain functions. The reasoning used is clear, precise, truthful, and beneficial. Young, a mathematician, claims that mathematics is the only topic that fosters and advances logical reasoning. The students can distinguish between necessities and non-necessities thanks to it. They gain the ability to go through the information, come to clear conclusions, and understand what rigid thinking entails.

4. It is also accurate to say that mathematics is helpful in the study of many other topics. The majority of the physical and social sciences, including physics, chemistry, economics, psychology, fine arts, history, and others, require the use of mathematics at the college and university level. Making this topic mandatory up until the high school stage expands the range of learning transfer for many disciplines and the majority of students' career choices.

5. Because education at one stage must strive to prepare the child for education at a higher stage, addressing the needs of higher education at the school stage is not a waste of time. Indeed, the youngster might not currently require the study of specific mathematics topics, but it is also true that his lack of these topics would be a significant barrier to his ability to learn at higher levels. Thus, it is accurate to state that studying mathematics aids in preparing for higher education.

6. not every student of mathematics in the classroom will go on to become an engineer, accountant, math teacher, or statistician, but at this early stage of education, it can be challenging to predict who will become an engineer, a banker, or a statistician. Therefore, it is incorrect to claim that by making mathematics required up to the high school level, we will be taxing children's cognitive abilities. Instead, we are giving them a broad perspective of what they can accomplish in the future.

7. Compared to our country, the standard of mathematics instruction is far greater in those nations where it is only required up to the middle school level. Their middle school pupils study more than our high school students do up to that point. Additionally, a youngster in eighth grade in those nations is roughly the same age as a student in tenth grade in the United States in terms of both mental and chronological development. In other words, students in foreign nations are two years old at the high school level.

### **METACOGNITION AND MATHEMATICS**

Metacognition is described as "knowing about knowing" and "cognition about cognition," and it requires high levels of human cognition. It involves valuing what one already knows and having a thorough understanding of the learning task. Therefore, at least two factors make the capacity for metacognition crucial for the study of mathematics.

Control of one's thought, which is crucial for grasping ideas, concepts, and problems; Awareness of one's thought, which has a big impact on one's ability to solve difficulties.

### **CONCEPT OF INTELLIGENCE**

We frequently say in casual conversation that a specific child or person is brilliant. All educators agree that intellect, also known as *Viveka* by our great rishis and seers of ancient India, is one of the most significant factors that influence education. According to psychological research, intelligence is a trait that is widely seen as acceptable.

### **METACOGNITION AND INTELLIGENCE**

The capacity for self-regulation of one's cognitive process, or metacognition, has been connected to intelligence. These executive functions are referred to as "meta components" in Sternberg's triarchic theory of intelligence. Executive among these components are meta components. Sternberg claims that Meta components are in charge of "determining how to perform a certain task or set of activities, and then ensuring that the job or set of tasks is performed correctly." Planning, assessing, and overseeing activities aimed at fixing problems are all included in these executive processes. According to Sternberg, intelligence is primarily the capacity to allocate cognitive resources effectively, such as choosing the best time and method for completing a task.

### **STATEMENT OF THE PROBLEM**

Modern mathematics serves as the foundation for modern science and technological advancement, making it a topic of national significance. Even though mathematics is a subject that is used in every aspect of life, it is nevertheless taught in schools today as a subject that may be learned in isolation, without interest, or by mechanically using the correct method to solve problems. For students to become more proficient in mathematics, there is no room for self-directed learning or the application of metacognitive techniques.

The last ten years have seen a loud cry from students who struggle with severe math anxiety and are unable to solve straightforward mathematical problems. The way mathematics is taught in schools, with its full separation from students' real-world knowledge, appears to be a major factor in why kids perform less well on math tests.

Most youngsters today are enrolled in school but are compelled to leave because they cannot handle the responsibilities of school and find the word "uninteresting" or "difficult." According to the national curriculum framework from 2005, the vision for school mathematics is:- The way of teaching is designed by their textbooks and teachers alienate them, not allowing them to use their rich experiences as well as their cognitive strategies, and they are soon made to believe they have no brains.

- Children acquire the skills necessary to enjoy arithmetic rather than dread it.
- Children view mathematics as a subject that can be discussed, communicated, and worked on together.
- Children formulate and address important issues.
- Children use abstractions to understand relationships, recognize the structure, make inferences, and debate the veracity or untruth of claims.

### **REVIEW OF LITERATURE**

A study on secondary school students' metacognitive abilities about their locus of control, self-efficacy, and academic accomplishment was carried out by Gupta (2017). This study found a substantial and positive correlation between secondary school student's academic achievement, locus of control, and self-efficacy. However, a negative and significant correlation between the academic achievement of high achievers and low achievers and knowledge of the cognitive process was discovered. The current study discovered no statistically significant differences in academic achievement, self-efficacy, locus of control, or metacognitive capacity between male and female students. A variety of study techniques should be offered, along with monitoring activities, to help students develop their metacognitive skills, internal locus of control, self-efficacy, and academic achievement. This will help to ensure that they are learning effectively and that they achieve their potential. Changes in the student's curriculum may be made to improve learning and metacognitive abilities.

A study on the causal association between mathematical creativity and IQ was done by Tyagi (2017). This study examined the causal connection between mathematical inventiveness and IQ. By using a random cluster technique, 439 eighth graders with ages ranging from 11 to 14 were chosen as the sample. A math test in Hindi was also administered with a 4-month time lag. This study showed that mathematical intelligence and mathematical creativity are interdependent, i.e., intelligence promotes mathematical creativity.

A study on the mathematics proficiency of senior secondary school students, The Contribution of Intelligence and Socio-Economic Status were done by Siddiqui and Anzar (2018). Out of five senior secondary C.B.S.E. schools, a

sample of 123 students was chosen at random, 66 of whom were male and 66 of whom were female. According to the study, intelligence was found to be the most important predictor of teenage math achievement.

In a study published in 2018, Smith et al. investigated the connection between metacognitive collaborative discussion and group mathematics problem-solving. By collaborative metacognitive, what do we mean? According to research, metacognitive discussion, which is linked to better learning outcomes, may be mediated through collaborative talk. Here, primary pupils participated in group arithmetic problem-solving sessions while being videotaped in a genuine classroom environment. Research has traditionally concentrated on either the individual or the group as a whole. We discovered that metacognitive conversation had a higher likelihood of both coming before and coming just after the collaborative talk, making it more likely to meet the requirements for being called collaborative. Our findings imply that a combination of individual and group processes gives birth to collaborative metacognition.

**OBJECTIVES OF THE STUDY**

- To study the metacognition level of secondary school students.
- To find out the effect of meta cognitive intervention on achievement in mathematics among secondary school students.

**METHODOLOGY FOR THE STUDY**

Not all research is haphazard. The most significant contribution to the improvement of any study is methodology. A study must be purposeful and scientifically deliberate to avoid becoming a confusing mess of unrelated pieces of work that are thrown together at random.

**DESIGN OF THE STUDY**

The intended study was an experiment. The equivalent group pre-and post-test designs were used. Because it enables evaluating the combined effect of two or more independent variables, the factorial design was employed. The experimental group and the control group were the two groups. The metacognitive intervention was presented to the experimental group, whereas the traditional method was presented to the control group. Because a genuine experimental design uses a randomization technique to give complete experimental control, the researcher decided to utilize a quasi-experimental design for the intended investigation. It was not always practicable for the investigator to assign individuals to groups at random or have complete control over the scheduling of the experimental conditions. In a quasi-experimental, non-randomized control group, the pretest-posttest approach was therefore employed by the researcher. Any group of people or event that piques the researcher's interest is referred to in research as the "population." The word "population" in the current study exclusively refers to class X children who attend school in the Meerut district of Uttar Pradesh. A sample of 60 pupils from the Meerut district X grade was used to gather the data.

**STATISTICAL ANALYSIS**

The data will be analyzed using the next statistical methods.

- 1) To investigate the nature of the sample's distribution, descriptive statistical measures such as mean, median, mode, and standard deviation will be used.
- 2) To evaluate the hypothesis, inferential statistics such as the t-test, 2x2x2 ANOVA, and product moment co-relational approach will be used.

**ANALYSIS AND INTERPRETATION OF DATA**

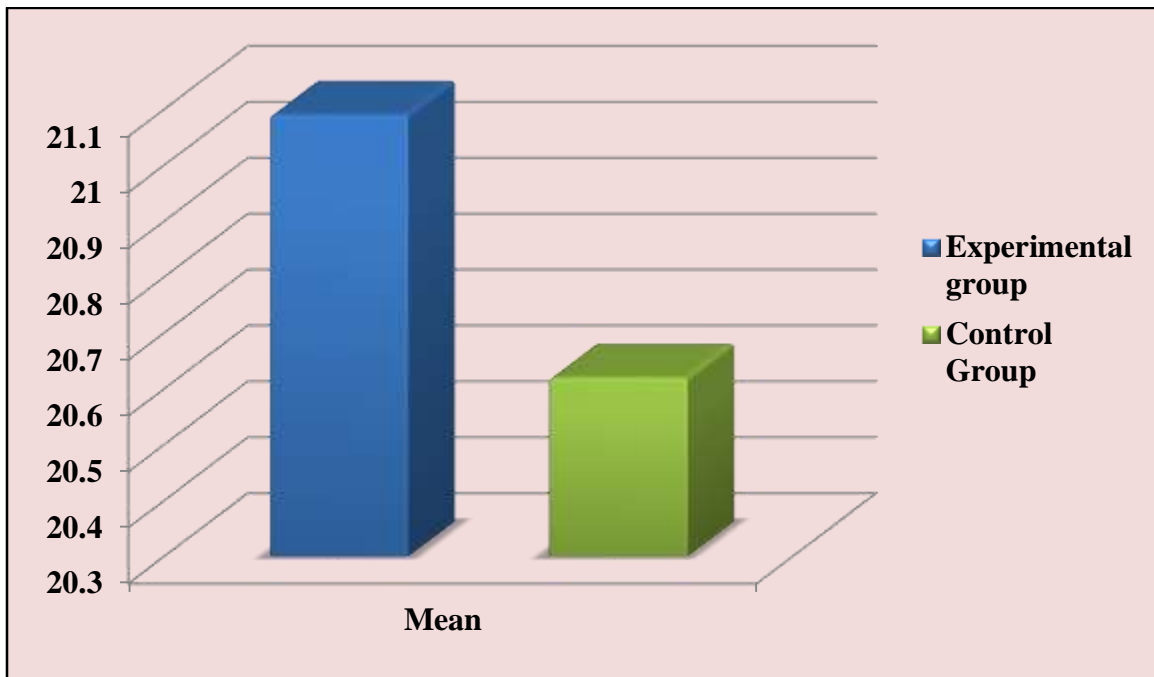
The analysis and interpretation of the data is the process that follows the collection of data in educational research. Because it provides a clear image of the data, this portion is the core of the study.

The control and experimental groups' homogeneity was examined before conducting two group experiments by comparing their pre-test results for achievement in mathematics, IQ, and metacognition levels.

**TABLE-1: MATCHING OF EXPERIMENTAL GROUP AND CONTROL GROUP BASED ON PRE-TEST SCORES IN ACHIEVEMENT IN MATHEMATICS (N=60)**

Groups	N	Mean	S.D.	SE <sub>M</sub>	t-ratio
Experimental group	30	21.09	8.40	1.18	0.28(N.S.)
Control Group	30	20.62	8.30	1.15	

*N.S. means non-significant*



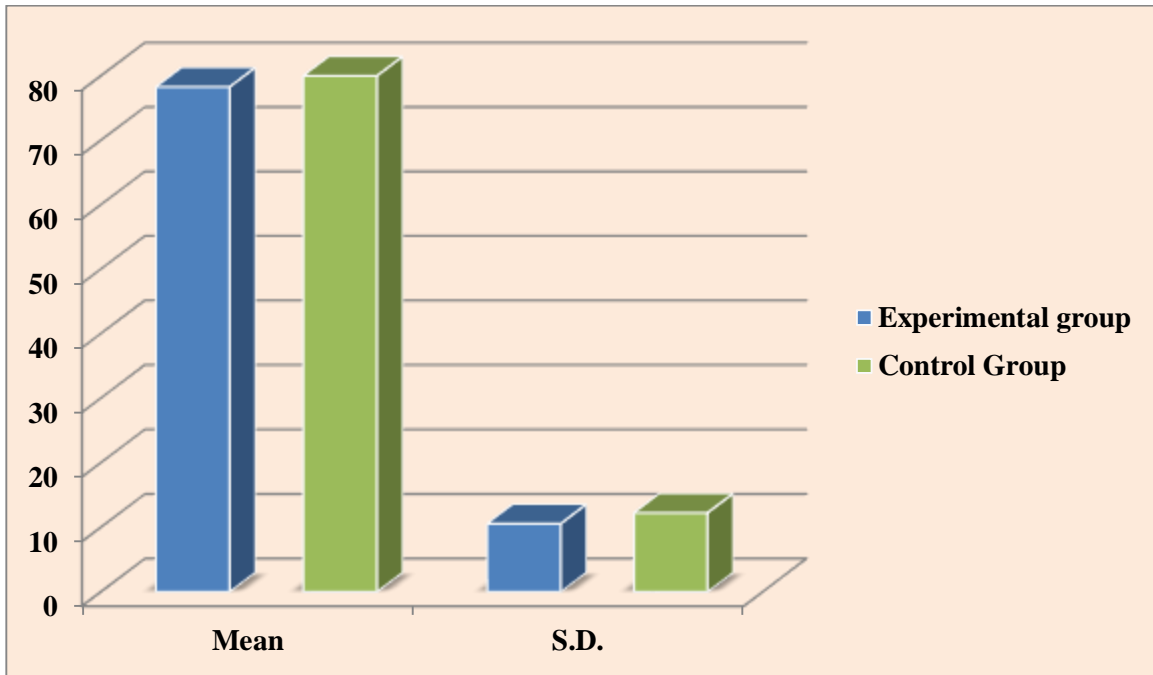
**FIGURE- 1: MATCHING OF EXPERIMENTAL AND CONTROL GROUPS BASED ON PRE-TEST SCORES OF ACHIEVEMENT IN MATHEMATICS (N=60)**

The table shows that the mean pre-test scores of the experimental group on the variable of mathematical achievement were 21.09 and the standard deviation for the same was 8.40, whereas the mean pre-test scores of the control group were 20.60 and the standard deviation for the same was 8.30. The t-ratio was 0.28, which is not statistically significant. It shows that there is no discernible difference between the experimental and control groups' levels of mathematics achievement before the experiment.

**TABLE- 2: MATCHING OF EXPERIMENTAL AND CONTROL GROUPS BASED ON METACOGNITIONLEVEL(N=60)**

Groups	N	Mean	S.D.	SE <sub>M</sub>	t-ratio
Experimentalgroup	30	78.28	10.55	1.47	0.73 (N.S.)
ControlGroup	30	79.99	12.23	1.70	

*N.S.meansnon-significant*



**FIGURE- 2: MATCHING OF EXPERIMENTAL AND CONTROL GROUPS BASED ON METACOGNITION (N=60)**

According to Table, the experimental group's mean pre-test scores on the variable of metacognition were 78.28 and the standard deviation for the same was 10.55, whereas the control group's mean pre-test scores on the same variable were 79.99 and the standard deviation for the same was 12.23. The t-ratio was 0.73, which is not statistically significant. It shows there is no discernible difference between the experimental and control groups on the variable of metacognition before the experiment's conduct.

**HYPOTHESIS TESTING**

'There will be no significant difference in the achievement in mathematics of secondary school students belonging to the experimental and control group after metacognitive intervention'

**TABLE- 3: EFFECT OF METACOGNITIVE INTERVENTION ON ACHIEVEMENT IN MATHEMATICS OF**

**THESECONDRYSCHOOLSTUDENTSOFBOTHGROUPS(EXPERIMENTALANDCONTROL)(N=60)**

Groups	Variable	N	Mean	S.D.	SE <sub>M</sub>	t-ratio	Sig/Not sig.
Experimental group	Achievement in Mathematics	30	11.70	6.23	0.92	6.23	Sig. at .01 level
ControlGroup		30	3.95	5.03	0.75		

The table shows that the experimental group of secondary school students' mean gain scores in mathematics are 11.70 and the standard deviation for the same is 6.23, while the control group's mean gain scores are 3.95 and the standard deviation for the same is 5.03. The t-ratio value, which is 7.20, is significant at the 0.01 level. It shows that there is a substantial difference between the experimental group (those who received metacognitive intervention) and the control group's mathematics achievement (treated without metacognitive intervention).

The claim made by H<sub>0</sub> that "There will be no significant difference in the achievement in mathematics of secondary school students belonging to the experimental and control group after metacognitive intervention" is rejected because a significant difference in mathematics achievement was found between the experimental and control groups of secondary school students.

**TABLE- 4: SUMMARY OF 2X4 ANOVA FOR BOTH GROUPS (EXPERIMENTAL AND CONTROL GROUP) IN MEAN GAIN SCORES OF ACHIEVEMENT IN MATHEMATICS OF SECONDARY SCHOOL STUDENTS ABOUT INTELLIGENCE (N=60)**

Variable	Source of Variance	SS	df	MS	F-Value
Achievement in mathematics	Metacognitive Intervention (A)	712.81	1	712.81	23.22**
	Intelligence (B)	662.03	3	146.57	7.55**
	Metacognitive Intervention X Intelligence (AXB)	55.11	3	11.03	0.63
	Within Group (Error)	2707.31	111	23.00	
	Total	6515.26	117		

According to Table, the F-ratio for the difference in mean math achievement gain scores between the group of secondary school students treated with and treated without metacognitive intervention was 23.22, which is significant at the 0.01 level. This shows a substantial difference in arithmetic achievement between the Experimental group of secondary school students (treated with metacognitive intervention) and the Control group (treated without metacognitive intervention). The secondary school pupils in both groups have considerably different mean gains in mathematics achievement than one another.

#### DISCUSSION

Metacognition intervention has been demonstrated to have a significant impact on secondary school students mathematics achievement.

It is also made clear that intelligence has an impact on how well math is learned. Metacognitive intervention and IQ are found to have no interactional effect on mathematical achievement.

In a nutshell, we can state that while gender has no bearing on arithmetic achievement in secondary school pupils, intellect and metacognitive intervention do. Therefore, by utilizing metacognitive tactics and procedures, we can improve secondary school kids' mathematical achievement as well as their intellect.

#### CONCLUSION

Data analysis has revealed that metacognition interventions have a considerable impact on secondary school pupils' mathematical achievement. According to the study's findings, metacognitive interventions should be used when teaching mathematics and other disciplines. When teaching concepts and conditions, teachers can incorporate metacognitive methods as a composite teaching approach or as one of the component strategies for problem-solving, interpreting data, and applying the principles of metacognition. Therefore, metacognitive intervention in classroom instruction, particularly in the teaching of mathematics, is recommended. When it comes to metacognitive intervention, the teaching curriculum is still largely unaltered. To deliver successful and high-quality instruction in mathematics and other disciplines included in the curriculum, teachers must be instructed and trained in the use of composite metacognitive intervention strategies during preservice and in-service training programs. Students are given the chance to think freely and honestly here. The abilities required for metacognitive intervention, such as reflective questions, modeling, self-questioning, thinking aloud, scaffolding, and self-assessment, must be taught to teachers. These training courses could be offered in collaboration with NCTE, SCERT, CTE, etc. Instructional staff and textbooks Writers can use the advice from metacognitive interventions to present their lessons in a way that will help their audience's cognitive abilities. To raise students' achievement in mathematics and other topics in the curriculum, suggestions relating to the steps/phases of metacognitive intervention may be introduced into the text concepts.

#### SUGGESTIONS FOR FURTHER STUDIES

- 1) Metacognitive teaching strategies and abilities can be used in experiments of teaching through metacognitive intervention. Additionally, comparison examinations of various tactics and metacognition models can be conducted.

- 2) The material choices can be expanded to include science, social studies, English, Hindi, Punjabi, and other educational subjects at various levels of academic study.

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