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FACTORS INFLUENCING MATHEMATICS LEARNING TO IMPROVE PROBLEM-SOLVING ABILITY USING COGNITIVE AND METACOGNITIVE LEARNING PROCESS AT HIGHER SECONDARY LEVEL STUDENTS

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Abstract: The essence and heart of studying mathematics are problem-solving and critical thinking. However, due to a variety of emotional factors, many students find it difficult to solve problems, especially analytical ones. In this instance, students' emotional health has an impact on their analytical problem-solving abilities. Therefore, the research presents an attempt to study problem-solving ability based on thinking skills, lack of knowledge, self-confidence, practice, curiosity, math in daily life, teaching others and creativity among higher secondary students. The focus of the research is on utilizing cognitive and metacognitive learning processes to enhance students' mathematical skills. This study is a quasi-experimental research, the population in this study consists of higher secondary level students. The research is also expected to enhance high school student's ability in problem-solving and mathematical connections. Through the lenses of cognitive capabilities, metacognitive techniques, motivation, instructional methods, and environmental circumstances, the factors impacting mathematics learning are examined. The results show that cognitive skills like logical reasoning and spatial visualisation abilities have an impact on students' problem-solving abilities. Additionally, students' problem-solving abilities are positively impacted by the efficient use of metacognitive methods including self-monitoring, planning, and reflection. To engage students and provide a supportive learning environment, motivation is essential. The study also identified instructional strategies, such as inquiry-based learning, collaborative learning, and the use of technology, as important elements in fostering problem-solving skills. The results of this study can help instructors, curriculum designers, and educational policymakers when developing instructional interventions and conducive learning settings to improve students' mathematical problem-solving skills at the higher secondary level. The study also emphasises the value of encouraging learning settings, such as interactions between teachers and students and the availability of learning tools, in promoting successful mathematics learning and improving students’ problem-solving skills, respectively.

Keywords: Mathematics Learning, Problem-Solving Ability, Cognitive and Metacognitive Learning, Higher Secondary Level Students, Quasi-Experimental Design, and Students’ Capability

1. INTRODUCTION

Mathematics is a language using carefully, clearly, and accurately described notations. The thinking and logic processes are the basic form of mathematics, it helps to grow and developed mathematics [1]. Mathematics is a basic science that is widely used in various fields of life because mathematics has a very important subject. Learning achievement can be impacted by a variety of factors, one of which is the difficulty pupils have with the learning process [2]. Students experience certain obstacles to participating in the learning process and achieving optimal learning outcomes are conditions of learning difficulties [3]. Students encounter some challenges in engaging in the learning process and getting the best possible learning outcomes

[4]. Problem-solving skills, intelligence, learning motivation, subject-specific mindsets, and personality are examples of internal components [5]. Sensory impairments and severe behavioural, psychological, or emotional problems are the various reasons are do not perform well academically students who experienced this learning difficulty [6]. Low interest and involvement in campus education may result from laziness. Given that learning issues can be related to a lack of drive [7]. The academic performance of students has become increasingly prevalent in the cognitive and metacognitive processes associated with both general and special education [8]. The processes involved in higher-order academic skills including reading comprehension, composition, and, to a lesser extent, mathematics problem-solving have drawn the attention of researchers [9].
Education professionals are increasingly more aware of and concerned about the large number of students who have trouble solving mathematical issues with that focus [10]. The recent research focused on the information processing theory provides the theoretical framework and the mathematical problem solving, mainly because it deals with the intricate interaction of many cognitive and metacognitive processes and techniques people use while solving difficulties [11]. Many conceptual models have been created to show not just the mental processes involved in problem-solving but also how these processes interact with external factors like the learning context and experience [12]. The creation of diagnostic/prescriptive materials for evaluating students' capacity for solving mathematical problems also highlighted the requirement for developing procedures for evaluating students' problem-solving processes and their capacity to organise and integrate knowledge and concept [13]. Drawing a diagram, guessing a solution, and choosing an acceptable algorithm are examples of specific heuristics that fall under the category of cognitive strategies for mathematical problem-solving. More general procedural methods are used to solve problems [14]. Visualisation and mental imagery are specific cognitive techniques linked to efficient mathematics problem-solving [15]. To enhance students' problem-solving skills, this study examined the elements impacting mathematics learning using cognitive and metacognitive learning processes. The rest of the work is organized as follows, section 2 reveals the literature survey of the study, section 3 portrays the problem definition and motivation of the work, and section 4 reveals the proposed research methodology. Section 5 exhibits the experimentation and results discussion, and section 6 demonstrated the conclusion of the research.

2. LITERATURE SURVEY

Qomariyah et al [16] developed a math learning evaluation instrument to gauge the mathematical problem-solving skills of high school students. The social essay test is a tool used to assess high school pupils' capacity for solving mathematics problems. Based on the findings of this study, they can conclude what is well-developed and useful. Herman et al [17] determined the relationship between mathematical resilience and students' problem-solving skills, and (2) the differences in mathematical problem-solving skills between students taught using a blended learning paradigm and those with problem-based learning. The covariance test revealed that the value of F (1.231) was 12.260 at 0.001 0.005, indicating a 79.8% relationship between students' problem-solving skills and mathematical resilience. Lin et al [18] indicated Groups of kids with high and poor performance levels ought to be created. The findings of this study showed that a well-balanced environment is essential for fostering creativity in addition to showing that creativity does not depend on a single aspect.

Firmansyah et al [19] explained the learning styles that best fit the mathematics problem- solving skills of the students. A qualitative descriptive method is used in this study. The study's findings provide the following learning style-based description of students' mathematical problem-solving skills: (1) Visual learners are better able to grasp the issue at hand, come up with a suitable solution strategy, implement the strategy properly, and double-check their conclusions. (2) Auditory learners are capable of grasping the issue thoroughly, coming up with sensible solutions, and carrying those solutions out correctly. Malau et al [20] enhanced This study looked at how well grade VIII–6 students at SMP N 4 Medan used the Missouri Mathematics Project paradigm to solve problems using a linear two-variable system. This model can help students become more adept at solving mathematical problems, particularly those involving linear systems with two variables.

Yustinah, et al [21] examined how junior high school pupils' mental habits affect their ability to solve problems. This study's methodology combines a quantitative approach with a correlational approach. Determined that there were 15.79% of people with high habits of mind had high problem-solving skills, 13.16 % of people with moderate habits of mind had moderate skills, and 21.0 % of people with moderate habits of mind had low skills. Additionally, there is a 20.40% positive correlation between junior high school pupils' mental habits and their aptitude for solving mathematical problems. Qomariyah et al [22] developed a tool for measuring math learning that assesses the problem-solving skills of high school students. The high school pupils' capacity for solving mathematical puzzles is assessed by the social essay test. 1 item is deleted (invalid) and 9 items are dependable and valid.

Sa'dijah et al [23] determined the ability of students to complete math activities with a quantitative approach and a descriptive way. The inability of junior high school students to solve problems involving mathematics. To help students develop their numeracy skills, teachers should use task-oriented learning experiences in maths, such as constructivist teaching techniques. Bal et al [24] investigated the convenience sampling technique, 378 students in the sixth, seventh, and eighth grades between the ages of 11 and 14 were examined: 212 females and 166 boys. According to the findings, students' effectiveness in addressing common and uncommon problems was significantly predicted by the variables of trust, self-control, and avoidance of problem-solving perceptions. Novitasari et al [25] delineated to emphasise the management of communicative, kid-friendly math instruction for problem-solving collaboration skills, which involves three components: problem interpretation, and problem- solving conversation.

3. RESEARCH PROBLEM DEFINITION AND MOTIVATION

Nowadays, low to medium-level cognitive components are typically the focus of measurements of students' learning outcomes. Otherwise, the new curriculum requires that students possess high levels of critical, creative, and problem-solving thinking. Mathematical studies place a premium on problem-solving. The ability to solve a wide range of challenging mathematical problems is one of the main objectives of mathematics education. A "mathematical disposition" is a trait of good problem solvers; they meticulously analyse things in mathematical terms and inevitably suggest questions based on what they observe. Additionally, pupils are not supported by the mathematics textbooks that are utilized and are not accustomed to thinking axiomatic deductive when learning in class. The majority of SMA's arithmetic instruction involves memorization, conventional problem-solving techniques, and inductive analysis based on previously established instances. Ironically, teachers instruct children by reproducing tedious procedures from maths textbooks without taking the pupils' levels of cognitive development into account. The capacity for problem-solving is a crucial component of higher-order thinking abilities. Students' capacity to solve mathematical issues needs to be strengthened. They need additional training to comprehend a variety of difficulties, create and interpret a mathematical model of a problem, and solve it appropriately.

One of the main issues in mathematics education research has been how students may use their knowledge of mathematics in different contexts. However, little is known about the assessment techniques that significantly aid in the growth of students in higher secondary schools' capacity to solve mathematical problems. The majority of mathematical ideas can be introduced to pupils through challenges based on real-world or mathematical situations. As students experiment with various approaches to problem-solving, the teacher can assist them in bringing their ideas together to find the answer, thus giving a meaningful introduction to a challenging issue. Students must learn a variety of problem-solving techniques, such as drawing diagrams, searching for patterns, or attempting particular situations or values. Therefore, it is important to comprehend the kind of mathematical abilities required in the modern world.

4. PROPOSED METHODOLOGY

Education serves as an ongoing mechanism for addressing the challenges individuals encounter. Proficiency in mathematics is instrumental in accurately resolving mathematical problems. Actively engaged students are more inclined to self-reliance when confronting obstacles, fostering not only problem-solving skills but also enhancing their capacity for critical thinking, recognizing existing connections, and representing complex scenarios. Assessment activities constitute a pivotal component of the educational system, offering a means to evaluate the effectiveness and performance of the learning journey. Embracing the value of evaluation as a benchmark can elevate instructional standards. The primary objective of this study is to develop a mathematical learning assessment tool designed to gauge the problem- solving aptitude of high school students in mathematics.

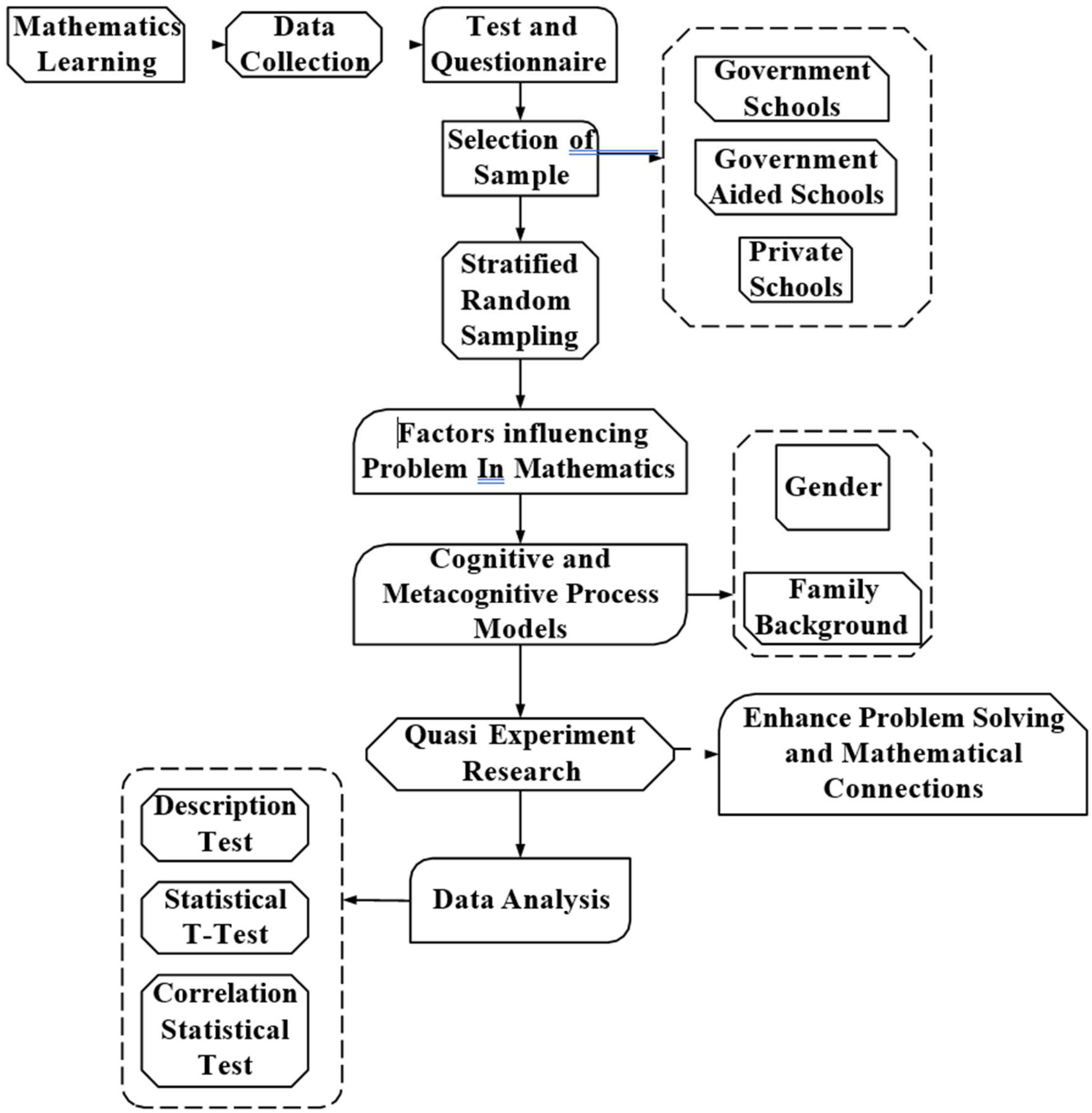


Figure 1: Block Diagram of the proposed work

Figure 1 depicts the block diagram of the proposed work. Students in higher secondary schools' mathematics learning are studied using test and questionnaire data, and a sample of students from public, private, and government-aided schools is chosen. Stratified random sampling is used to identify the variables that affect maths learning. Gender and family history affect models of the cognitive and metacognitive processes. The quasi-experiment research approach is used in this study to strengthen the links between the problem and the mathematics. Description tests, statistical testing, and correlation statistical tests are all used to obtain the data.

4.1 Quasi-Experimental Design

To determine whether there was a cause-and-effect link between the factors, data, and how the data were compared, quasi-experimental research using a post-test-only control group design was used. Comparing the ultimate grades of kids who received various therapies involved using a quantitative approach. 438 people made up the purposive sampling technique's research sample, which was collected. Classes for the experimental and control groups were created. Because they have begun the formal operations' developing stage as a means of problem- solving, high school pupils were chosen as samples. Based on the pupils who had the same knowledge base, the class might be matched. To perform a parametric test intended to demonstrate that the classes were distributed normally, both classes' normality was required. Tests were utilized to collect students' problem-solving abilities, and surveys were used to gauge their opinions on learning through drills with the help of Quizizz interactive media. Although Quizizz media was utilized in the multiple-choice test, the students came up with a logical solution to the issue.

A test on the problem's quality was done when solving mathematical problems. It was carried out to determine each item's reliability and validity. The Pearson product-moment correlation was used to evaluate the test's validity. A tool is considered legitimate if it accurately or very validly reveals the variables under investigation. Software called SPSS was used to calculate the validity test. The results of the validity test revealed that all of the test items had medium and high levels of validity. Therefore, the current research can have employed various questions as queries. The students were given a self-learning pre-test that was integrated into the Quizizz media in the form of multiple-choice questions to ascertain their prior understanding of problem-solving techniques. The pupils then took part in a written post-testing session. A questionnaire was given out after the lesson to gauge their opinion of the Quizizz media.

4.1.1 Post-Test Data

Inferential statistics were applied to the post-test data processing. Because the sample size was 400, the Shapiro-Wilk test was employed for normality testing, while the Levene test was utilized for homogeneity tests. If the data is regularly distributed, the t-test is performed to determine the average difference. If not, the Mann-Whitney test is employed. The gains in students' ability to solve mathematical problems, both before and after learning, were measured using the gain test. The difference between the experimental class's pre-test and post-test scores served as the source of the processed gain data.

4.2 Mathematics Learning Achievement Test (MLAT)

There were 40 multiple-choice questions with four possible answers. The participants have one hour to respond to all the questions. The instrument's dependability coefficient was calculated

using the Kuder-Richardson formula 20 (KR20). To calculate the instrument's internal consistency and overall coefficient, the Kuder-Richardson formula 20 (KR20) was utilized. The test's difficulty index and discriminating power were both calculated using item analysis. This was done in the mathematics class between the higher and lesser scorers. For additional instrument validation, the difficulty and discriminating indices of each test item were computed. However, face and content validation came after the writing of the test items. After submitting the test for review by three (3) secondary school maths teachers, the face and content validation lowered the number of items from sixty-one (61) to forty-five (45), and item analysis further decreased the number of items from forty-five (45) to thirty-one (31). Thirty pupils were given the remaining supplies. The scores were subjected to the Kuder-Richardson algorithm (KR) to assess internal consistency. $Simplify$ $(-8)x(-3)$ is an example of a test item. Determine the value of x if $x2 - 5x = 6$; and determine the value of x if 4x + 7 = 5x +
6. Within three weeks, the test-retest procedure utilized on the students yielded an internal consistency coefficient of 0.79. However, a table of specifications (or test blueprint) was created to build MLG. However, a table of specifications (or test blueprint) for various test items was created to generate MLG.

4.2.1 Mathematics Anxiety Scale

The fourteen (14) items on this scale range from highly agreed (SA) to strongly disagreed (SD) and are each given a rating on a four-point scale. The instrument was adapted from the Mahmood and Khatoon Mathematics Anxiety Scale. With a Cronbach's Alpha of.87, the instrument has a reliability coefficient of 0.761.

4.2.2 Data Collection Test

The steps of implementation for this research is classroom action research, which includes preparation, action, observation, and assessment repeatedly. In the fourth semester of the academic year 2021–2022, this study will be carried out on 438 students. To determine whether student learning outcomes in mathematics improve after receiving action in the form of quizzes with feedback during the learning process, student factors will be examined in this study. The two cycles of this research were carried out by the desired alterations. The first cycle lasts for three weeks, while the second lasts for two. Planning, taking action, observing and evaluating the results, and reflecting are the four processes that make up each cycle. The steps used during this action research can be detailed in more detail as follows. Planning includes: Reviewing STKIP Muhammadiyah Enrekang's competency-based curriculum for fourth-semester mathematics, which calls for creating lesson plans and allocating time by balancing study time with the program's allotted time. Generate an educational agenda for each meeting. Making the initial test questions that will be administered to the students. Make an observation format to track the learning environments in the classroom as the implementation occurs.

Table 1: Demographic Details of Respondents

Demographic	Characteristics	No. of Respondents	Percentage
Gender	Male	151	34.4%
	Female	287	65.6%
Age	17-18	124	28.3%
	16-17	143	32.6%
	15-16	78	17.8%
	14-15	93	21.3%
Standard	11	215	49%
	12	223	51%
Type	Government	193	44%
	Private	245	56%
Location	Semi-rural	239	54.5%
	Urban	199	44.5%

Schools were approached for the data collection either by phoning the head teacher or dean of studies or by going in person. The information gathered from high school students in semi- rural and urban locations is displayed in Table 1. These made the researcher and the department head of mathematics connect. The student survey and the Mathematics test were given out at the start of the academic year. With the assistance of one or more math teachers, the researcher and/or his assistants gave the tests and questionnaires to the students during math class. First, for this poll, two different geographical and education categories are chosen. They chose 231 pupils from urban areas and 158 students from semi-rural areas for this survey. In the merging of government and private school students, they gathered 151 male and 287 female students between the ages of 17-18, 16-17, 15-16, and 14-15. The confidentiality of the study's data collection and its exclusive usage for research purposes were guaranteed to the students.

For the cycle's final assessment, research tools in the form of learning motivation scales and learning outcomes exam questions will be used. The general actions taken during this step of the process are listed below. Students take a 10-minute test at the start of every class to gauge how well they remember past lectures and how prepared they are to take on new content. The student response sheet is gathered, checked, and returned. The teacher explains the connection between the content and its solution once again if it turns out that a significant number of students are still unable to complete the task correctly before moving on to the next topic. Discuss the topic matter in light of the created learning situation. After providing some sample questions, students are free to ask inquiries. Instructions instruct students to complete the maths vocational module questions and compile their answers. Teachers ask students to post their work on the board.

4.2.3 Data Analysis Technique

Both quantitative and qualitative analyses of the data collected will be performed. Descriptive statistics were first used to qualitatively analyze observational data and then categorization methods. Data on learning outcomes were statistically and descriptively analyzed. The standards used to categorize learning outcomes are based on report card writing standards and grade raising, and they are as follows: 0% - 34% are classified as Very Low, 35% - 54% are classified as Low, 55% - 64% are classified as Medium, 65% - 84% are classified as High, and 85% - 100% are classified as Very High.

4.3 Statistical t-Test

The study is a descriptive research of the survey type and focused exclusively on the comparison of student performance based on the credentials of the teacher, whether professional or not. It is a type of survey used to gather information about and systematically describe the traits, traits, or facts about a certain community. The participants in this study include students of both sexes. The study included 438 students in the 10th grade (males = 151 and females = 287) from five private and five public schools that were conveniently chosen. The Fennema-Sherman Mathematics Attitude Scale, translated into Urdu, was used to measure attitudes. There were 47 statements in it. This survey was developed to measure male and female students felt attitudes toward mathematics. The confidence scale, usefulness scale, teacher perception scale, and male domain scale were its four subscales. These subscales each contained 12 items. They measured attitudes in two different ways: positively and negatively. This measurement tool used a Likert scale with five possible values. The total score for that attitude was calculated by averaging the results of each subscale. Each subscale had a maximum possible score of 60 points.

For calculating the distance, two sets of information were prepared. The first batch of data was restricted to 11th graders. Here, the authors' constructed an accomplishment test for the 11th grade, and the secondary level's final results were taken into account for analysis. The 12th-grade students were taken into consideration for the second batch of data. The authors' achievement test scores for the 12th grade as well as the secondary-level final results and 11th- grade final results were taken into consideration for analysis. Since those were the original prerequisites for the Mahalanobis Distance, descriptive statistics like mean, standard deviation, etc. were computed. The following equation was used to determine the Mahalanobis Distance:

$$\Delta^2 = (X - Y)^T \Sigma^{-1} (X - Y) \quad (1)$$

Where Σ is the pooled covariance matrix of the two groups of data and X and Y are column vectors representing the respective means. Mahalanobis Dist is presented as follows.

$$Mahalanobis\ Distance = [(X - Y)^T \Sigma^{-1} (X - Y)]^{\frac{1}{2}} \quad (2)$$

Pooled covariance matrix equation is given as follows.

$$\Sigma = [(n_1 - 1)\Sigma_1 + (n_2 - 1)\Sigma_2]/N \quad (3)$$

Where $1n$ and $2n$ are the sample sizes for the first and second groups, the covariance matrices are represented as Σ_1 and Σ_2.

$$N = n_1 + n_2 - 2 \quad (4)$$

There are two sets of information created for every college student. The first group of them consists of the authors' accomplishment test results and secondary-level achievement scores for the academic year 2021–2022. The secondary level achievement score for 2020, the final score for the 11th grade (2020), and the results of the authors' accomplishment tests from the 2018–2019 school year are used to create the second set. Calculated descriptive statistics include mean, median, quartile deviation, standard deviation, etc.

5. RESULT AND DISCUSSION

Students' capacity for metacognition also contributes to their ability to conceive of mathematical concepts when solving problems. The process by which a person thinks about creating solutions to problems is known as metacognition. Metacognition can be summed up as the awareness of thinking about one's thought process. The four levels of metacognition capacity that a person possesses are strategic usage, aware use, tacit use, and reflective use. The stages of problem-solving are connected to these four levels. The stages of problem- solving are connected to these four levels. However, the level of students' metacognition capacity is only at the level of use techniques, aware use, and tacit use, according to the examination of their level of ability to solve problems in the social arithmetic theme. The ultimate level of mental awareness is reflective usage, but no subject can get there. This is because students still hesitate to ask their teachers questions during the learning process, they are unable to recognize their thought processes in full, and they are unable to fix their faults in the steps taken to solve the problem. A more direct exchange of information between students and teachers will improve learning.

Table 2: Simulation System Configuration

SPSS Statistical Tool	Version 23.0
Operation System	Windows 10 Home
Memory Capacity	6GB DDR3
Processor	Intel Core i5 @ 3.5GHz

For descriptive analysis, reliability, and correlation analysis, a structured SPSS-based data collection was used. In the statistical model, the link between the dependent and independent

variables is estimated. As a result, the accompanying Table 2 provides information on the simulation tools used for the suggested system. The variable analyzed in this work is students' thinking skills (STS), lack of knowledge (LK), self-confidence (SC), mathematical practices (MP), students' curiosity (SC), the capability of math learning (CML), mathematical connections skills (MCS), and mathematics problem-solving ability (MPSA).

5.1 T-Test Analysis

A statistical hypothesis test known as the sample t-test, also known as a single sample t-test, is used to ascertain whether the mean estimated from sample data obtained from a single group differs from a predetermined value set by the researcher.

Table 3: One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
STS	438	19.02	6.118	.292
LK	438	19.20	5.898	.282
SC	438	19.14	5.862	.280
MP	438	19.19	5.955	.285
SC	438	18.48	5.911	.282
CML	438	19.39	5.969	.285
MCS	438	19.24	5.802	.277
MPSA	438	18.95	5.925	.283

The findings of the one-sample statistics are shown in Table 3 and provide descriptive statistics for the sample, including a comparison of the sample mean to the test value. The outcomes of the t-test are displayed in the "One-Sample Test" section. The null hypothesis in this instance is that the sample means for the variables STS, LK, SC, MP, SC, CML, MCS, and MPSA are 19.02, 19.20, 19.14, 19.19, 18.48, 19.39, 19.24, and 18.95, respectively, with a smaller standard error of 0.277 for MCS.

Table 4: One-Sample T-Test

	Test Value = 45					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
STS	-88.886	437	.000	-25.984	-26.56	-25.41
LK	-91.549	437	.000	-25.799	-26.35	-25.25
SC	-92.318	437	.000	-25.858	-26.41	-25.31
MP	-90.708	437	.000	-25.811	-26.37	-25.25
SC	-93.880	437	.000	-26.516	-27.07	-25.96
CML	-89.794	437	.000	-25.612	-26.17	-25.05
MCS	-92.917	437	.000	-25.760	-26.31	-25.22
MPSA	-92.039	437	.000	-26.055	-26.61	-25.50

The one-sample t-test is displayed in Table 4 with the significance (alpha) level set to 0.05. The test's p-value is displayed in the Sig. column. The findings demonstrate that all variables' p-values (.000) are less than 0.05. This implies that the null hypothesis can be disproved and that the sample's variables differ considerably from 18.5 in terms of significance.

5.2 Descriptive Statistics

A set of techniques known as descriptive statistics is used to enumerate and explain a dataset's key characteristics, such as its central tendency, variability, and distribution. These techniques give a summary of the information and aid in finding trends and connections.

Table 5: Descriptive Statistics Analysis

	N	Minimum	Maximum	Mean	Std. Deviation	Variance
STS	438	4	30	19.02	6.118	37.430
LK	438	7	30	19.20	5.898	34.783
SC	438	7	35	19.14	5.862	34.364
MP	438	7	30	19.19	5.955	35.463
SC	438	7	31	18.48	5.911	34.941
CML	438	7	30	19.39	5.969	35.634
MCS	438	9	30	19.24	5.802	33.666
MPSA	438	7	32	18.95	5.925	35.100
Valid N (listwise)	438					

Table 5 presents descriptive statistics regarding students' problem-solving abilities, thinking abilities, knowledge gaps, sense of self-worth, and mathematical connections abilities. Except for passive learning activities facilitated by technology, where the observed greatest mean and standard deviation are 19.39 and 6.118, the means of the learning activities varied around the theoretical scale average. It seems that all forms of learning activities were encouraged for students in higher education courses overall. The average means for all learning outcomes showed that students believed they had gained cross-domain skills in addition to domain- specific knowledge during their higher education courses. The medium to high variances indicates that students' perceptions varied widely among themselves.

5.3 Correlation Analysis

The Pearson correlation coefficient (r), which measures a linear relationship, is the most widely used approach. A number between -1 and 1 is used to describe the strength and direction of the relationship between two variables. Pearson correlation coefficient (r) is a type of correlation.

Table 6: Pearson Correlation Analysis

Correlations									
		STS	LK	SC	MP	SC	CML	MCS	MPSA
STS	Pearson Correlation	1	.102*	-.014	-.078	.046	.019	-.042	-.040
	Sig. (2-tailed)		.033	.770	.105	.335	.699	.375	.405
	N	438	438	438	438	438	438	438	438
LK	Pearson Correlation	.102*	1	.193**	-.049	-.010	.005	-.018	-.004
	Sig. (2-tailed)	.033		.000	.302	.839	.923	.704	.926
	N	438	438	438	438	438	438	438	438
	Pearson Correlation	-.014	.193**	1	.119*	-.035	-.045	-.032	.034
	Sig. (2-tailed)	.770	.000		.013	.462	.349	.503	.484

	N	438	438	438	438	438	438	438	438
	Pearson Correlation	-.078	-.049	.119*	1	.180**	-.013	.000	.016
	Sig. (2-tailed)	.105	.302	.013		.000	.790	.995	.737
	N	438	438	438	438	438	438	438	438
	Pearson Correlation	.046	-.010	-.035	.180**	1	.235**	.053	-.008
	Sig. (2-tailed)	.335	.839	.462	.000		.000	.265	.865
	N	438	438	438	438	438	438	438	438
	Pearson Correlation	.019	.005	-.045	-.013	.235**	1	.158**	-.034
	Sig. (2-tailed)	.699	.923	.349	.790	.000		.001	.472
	N	438	438	438	438	438	438	438	438
	Pearson Correlation	-.042	-.018	-.032	.000	.053	.158**	1	.222**
	Sig. (2-tailed)	.375	.704	.503	.995	.265	.001		.000
	N	438	438	438	438	438	438	438	438
	Pearson Correlation	-.040	-.004	.034	.016	-.008	-.034	.222**	1
	Sig. (2-tailed)	.405	.926	.484	.737	.865	.472	.000	
	N	438	438	438	438	438	438	438	438
*. Correlation is significant at the 0.05 level (2-tailed).									
**. Correlation is significant at the 0.01 level (2-tailed).									

The Pearson correlation analysis for STS, LK, SC, MP, SC, CML, MCS, and MPSA is shown in Table 6. The averages, ranges, and correlations of the variables were assessed for each type of instruction. The notion that simulation is more effective based on students' perspective than the other two techniques in establishing self-confidence and enhancing mathematical connections abilities is supported by the fact that the means for simulation are higher than those for the case study and lecture methods for two components. A higher correlation of 0.222** is found between students' problem-solving skills and their mathematical connections.

Table 7: Pearson Correlation for Boys and Girls' Cognitive and Metacognitive Skill

Correlations					
		BCM	GCM	BMM	GMM
BCM	Pearson Correlation	1	.099*	-.096*	.033
	Sig. (2-tailed)		.037	.045	.490
	N	438	438	438	438
GCM	Pearson Correlation	.099*	1	.080	.026
	Sig. (2-tailed)	.037		.096	.590
	N	438	438	438	438
BMM	Pearson Correlation	-.096*	.080	1	.147**
	Sig. (2-tailed)	.045	.096		.002

	N	438	438	438	438
GMM	Pearson Correlation	.033	.026	.147**	1
	Sig. (2-tailed)	.490	.590	.002	
	N	438	438	438	438
*. Correlation is significant at the 0.05 level (2-tailed).					
**. Correlation is significant at the 0.01 level (2-tailed).					

The Pearson correlation coefficient for boys and girls in mathematics for developing problem-solving abilities is shown in Table 7. It shows that there is a lower connection (0.099*) between a boy's cognitive math scores and a girl's math scores and that there is a higher correlation (0.147**) between a boy's math metacognitive scores and a girl's math metacognitive scores.

5.4 ANOCOVA Analysis

Regression analysis and analysis of variance (ANOVA) are combined in the analysis of covariance. Occasionally, observations are made on one or more independent variables in addition to the study variable from each experimental unit. The independent variables are referred to as ancillary or concomitant variables. In these cases, ANOCOVA is used to assess whether the variation in the study's (dependent) variable across classes may be attributed to class effects or the variables depend on it. The ANOCOVA controls experimental error by taking into account reliance.

Table 8: Tests of Between-Subjects Effects

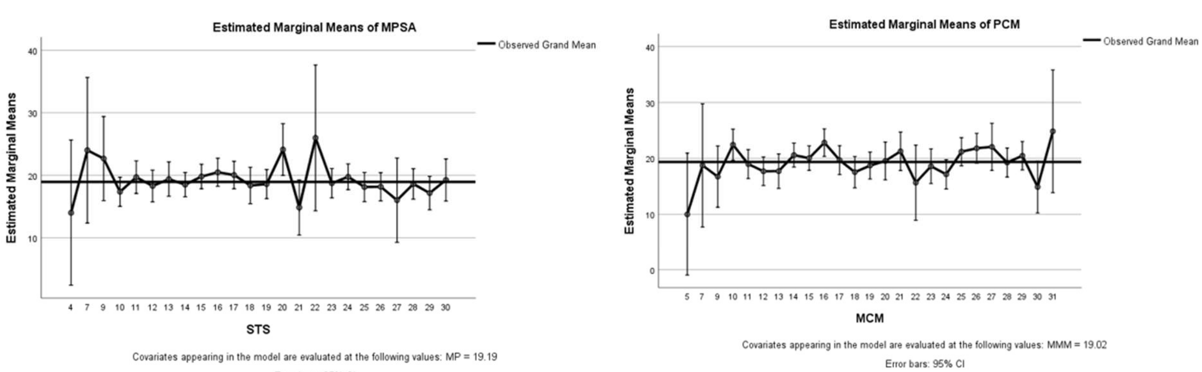
Dependent Variable: MPSA					
Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Corrected Model	844.671[a]	24	35.195	1.003	.461
Intercept	10771.386	1	10771.386	306.925	.000
MP	.306	1	.306	.009	.926
STS	840.685	23	36.552	1.042	.411
Error	14494.014	413	35.094		
Total	172546.000	438			
Corrected Total	15338.685	437			
a. R Squared = .055 (Adjusted R Squared = .000)					

The tests for between-subject effects in Table 8 show that there were no interaction effects in the ANCOVA data. The data were subjected to additional analyses using ANCOVA to test the null hypothesis that there are no interaction effects between problem-solving abilities and cognitive capacity. Table 9 presents the outcomes. As a result of the p-value of 0.35 being higher than the 0.05 alpha threshold, the analyses' results demonstrate that the F-value was not significant ($F(1,23) = 1.003$, $p>0.05$). This finding allays research worries because it demonstrates that there was no discernible interaction between therapy and gender or scoring levels when students were taught using tasks that tested their problem-solving abilities. As a consequence, the hypothesis was confirmed, proving that the moderating factors of gender and level of the score had no impact on the student's capacity to solve problems.

Table 9: Tests of Between-Subjects Effects on Family Background

Tests of Between-Subjects Effects					
Dependent Variable: PCM					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	9676.544[a]	233	41.530	1.348	.014
Intercept	5859.049	1	5859.049	190.191	.000
MMM	6.404	1	6.404	.208	.649
MCM	1152.334	24	48.014	1.559	.053
PMM	1569.349	26	60.360	1.959	.005
MCM * PMM	6971.958	182	38.307	1.243	.065
Error	6284.460	204	30.806		
Total	180140.000	438			
Corrected Total	15961.005	437			
a. R Squared = .606 (Adjusted R Squared = .157)					

Table 9 represents the variance analysis tests of between-subject effects. The model's capacity to take into account variation in the dependent variable is evaluated for each term and the model as a whole. It examined the cognitive and metacognitive analysis of middle-class and low-income households. It showed that the R square value is 0.606.



(a) Problem-Solving Ability (b) Family Background

Figure 2: Estimated Marginal Mean Graph

Figure 2 displays the mathematical achievement Estimated Marginal Mean Graph. The profile plot of one element, which represents the estimated marginal means, shows whether they are rising or declining across levels. One factor's values should be checked since parallel lines for two or more factors indicate that there is no interaction between the factors. The profile plot of one element, which represents the estimated marginal means, shows whether they are rising or declining across levels.

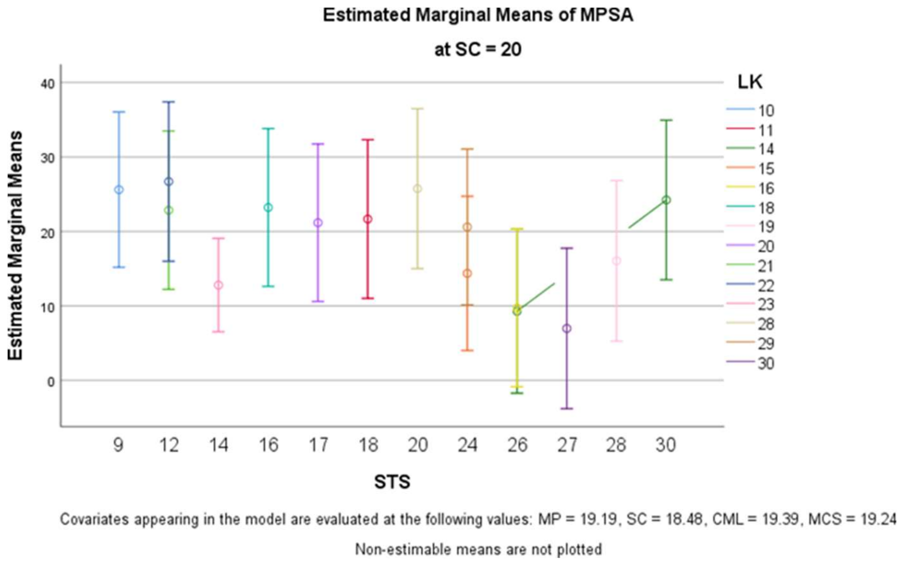


Figure 3: Estimated Marginal Mean

The computed marginal means and standard errors are shown in Figure 3. Examining the potential interaction impact between these two elements using this figure is helpful. Investigate the values of the individual components in this situation since the parallel lines demonstrate that there is no interaction between variables for two or more components. Lines that are not parallel denote a relationship.

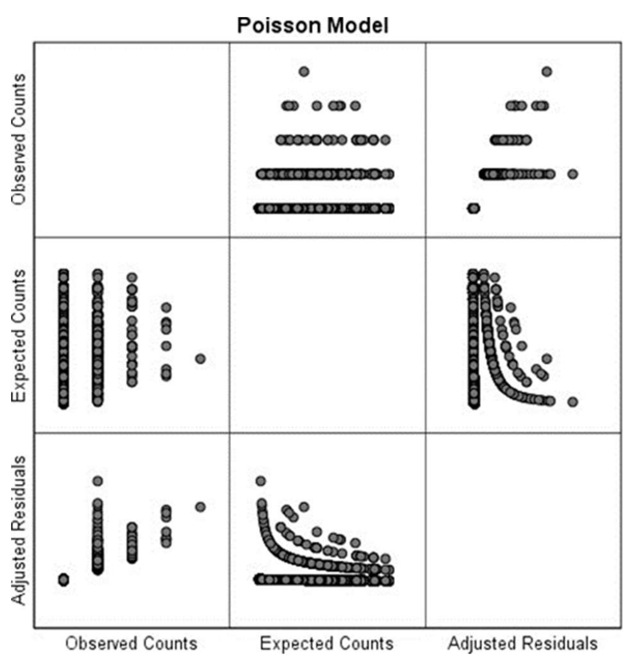


Figure 4: Poisson Model Result Plot

In Figure 4, the Poisson regression method is shown as being used to forecast a dependent variable made up of "count data" given one or more independent factors. The variable that you're trying to forecast is known as the dependent variable, also known as the response, outcome, goal, or criteria variable. The independent variables (also known as predictor, explanatory, or regressor variables) are the variables are utilizing to make predictions about the value of the dependent variable. Several situations in which Poisson regression may be employed.

5.5 Reliability Testing of the Questionnaire

Internal consistency was employed as a dependable tool that produced consistent results to assess the validity of the questionnaire by taking into account all respondents. Four items from STS, LK, SC, MP, SC, CML, MCS, and MPSA were eliminated from a further study following analysis and consultation with these experts since the reliability was found to be less than 0.761 for both groups.

Table 10: Cronbach's Alpha Test

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.761	.159	6

The Cronbach's alpha of the three variables supports the high reliability of these components; for instance, the suggested study's Cronbach's alpha coefficient is 0.761, which is shown in Table 10. Therefore, it can be said that the information gathered from the pilot study was accurate and had a respectable level of internal consistency.

Table 11: Item Statistics for Reliability Test

	Mean	**Std. Deviation**	**N**
EM	19.03	5.852	409
SIM	18.90	5.733	409
SE	18.83	5.900	409
LSE	19.27	5.868	409
RL	19.10	6.017	409
MA	18.48	5.997	409

Table 11 displays the summary item data from the reliability test. It shows that summary statistics, a subset of descriptive statistics, give a general overview of the sample data. Statisticians typically try to describe and characterize the observations by determining their minimum, maximum, range, and variance. The lowest mean and standard deviation for this set of six items are 18.48 and 5.852, respectively.

Table 12: Item-Total Statistics Test Analysis

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
EM	94.58	195.989	.065	.012	.138
SIM	94.71	209.735	-.010	.009	.203
SE	94.78	190.988	.093	.026	.113
LSE	94.34	201.202	.032	.012	.168
RL	94.51	181.236	.145	.026	.061
MA	95.13	193.106	.071	.016	.133

The reliability statistics from the item total statistics are shown in Table 12. This column displays the Cronbach's alpha value that would result from the removal of that specific item from the scale. A lower Cronbach's alpha would follow from the removal of any question. For question 10, the "Corrected Item-Total Correlation" value was low (0.033), while the lower Cronbach's alpha for RL is 0.061. It only offers a total dependability coefficient for a collection of variables (like questions). This could prompt you to consider whether to remove this item.

6. RESEARCH CONCLUSION

Learning mathematics is necessary for fostering problem-solving skills, which are crucial for success in both academic and practical contexts. Educators and policymakers need to comprehend the variables that affect mathematics learning and how they affect one's capacity for problem-solving to develop efficient teaching strategies and interventions. The different aspects that affect maths learning and how they affect students in higher secondary school's ability to solve problems are clarified by this research study. Students' mathematical abilities can be strengthened through the use of cognitive and metacognitive learning processes, which will improve their ability to solve problems. The results of this study emphasize the importance of cognitive talents in learning mathematics. Students who are proficient at spatial visualization and logical reasoning solve problems more effectively. Additionally, the effective use of metacognitive techniques like self-monitoring, planning, and reflection helps pupils improve their problem-solving abilities. Teachers can assist students in becoming more self-aware, strategic, and reflective learners by encouraging them to engage in metacognitive processes. The ability to learn mathematics and solve problems is strongly influenced by motivation. Students are more likely to succeed at problem-solving tasks if they show intrinsic drive, curiosity, and a growth mentality. The focus should be placed on creating a supportive and interesting learning environment that fosters students' motivation and excitement for mathematics among educators and policymakers. The way that students are taught is very important in developing their problem-solving skills.

Effective teaching methods include inquiry-based learning, collaborative learning, and incorporating technology. These strategies promote engaged learning, critical thinking, and the use of mathematical ideas in practical contexts. To improve students' problem-solving abilities, educators must include these techniques in their lesson plans. The study also highlights the value of a safe learning environment. An ideal learning environment for mathematics includes supportive teacher-student interactions, access to sufficient learning tools, and a setting in the classroom that promotes experimentation and taking risks. By creating such a setting, educators can make sure that students feel empowered and encouraged as they develop their problem- solving skills. Overall, this study emphasizes the complexity of the variables that affect students at higher secondary levels as they learn mathematics and develop their problem- solving skills. Teachers and policymakers can develop specialized interventions, curricula, and instructional practices that successfully improve students' mathematical skills and problem- solving abilities, by recognizing and addressing these factors, which ultimately prepare them for success in their academic and future endeavors.

REFERENCES

[1] Acharya, B.R., 2017. Factors affecting difficulties in learning mathematics by mathematics learners. International Journal of Elementary Education, 6(2), pp.8-15.

[2] Elastika, R.W. and Dewanto, S.P., 2021. Analysis of Factors Affecting Students' Mathematics Learning Difficulties Using SEM as Information for Teaching Improvement. International Journal of Instruction, 14(4), pp.281-300.

[3] Hamukwaya, S.T. and Haser, Ç., 2021. "It does not mean that they cannot do Mathematics": Beliefs about Mathematics Learning Difficulties. International Electronic Journal of Mathematics Education, 16(1), p.em0622.

[4] Ozturk, M., 2021. Cognitive and Metacognitive Skills Performed by Math Teachers in the Proving Process of Number Theory. Athens Journal of Education, 8(1), pp.53-71

[5] DaDeppo, L.M., 2009. Integration factors related to the academic success and intent to persist of college students with learning disabilities. Learning Disabilities Research & Practice, 24(3), pp.122-131.

[6] Leiss, D., Plath, J. and Schwippert, K., 2019. Language and mathematics-key factors influencing the comprehension process in reality-based tasks. Mathematical Thinking and Learning, 21(2), pp.131-153.

[7] Brand, B.R., Glasson, G.E. and Green, A.M., 2006. Sociocultural factors influencing students' learning in science and mathematics: An analysis of the perspectives of African American students. School Science and Mathematics, 106(5), pp.228-236.

[8] Caviola, S., Toffalini, E., Giofrè, D., Ruiz, J.M., Szűcs, D. and Mammarella, I.C., 2022. Math performance and academic anxiety forms, from sociodemographic to cognitive aspects: A meta-analysis on 906,311 participants. Educational Psychology Review.

[9] Aguiar, M., Anam, V., Blyuss, K.B., Estadilla, C.D.S., Guerrero, B.V., Knopoff, D., Kooi, B.W., Srivastav, A.K., Steindorf, V. and Stollenwerk, N., 2022. Mathematical models for dengue fever epidemiology: A 10-year systematic review. Physics of Life Reviews.

[10] Rokhataliyeva, A.N., 2022. The teaching of mathematics is based on advanced international experiences. Web of Scientist: International Scientific Research Journal, 3(7), pp.50-55.

[11] Zhang, J., Cenci, J., Becue, V. and Koutra, S., 2022. Analysis of spatial structure and influencing factors of the distribution of national industrial heritage sites in China based on mathematical calculations. Environmental Science and Pollution Research, pp.1-16.

[12] Samura, A.O., 2023. Improving Mathematics Critical Thinking Skills of Junior High School Students Using Blended Learning Model (BLM) in GeoGebra Assisted Mathematics Learning. International Journal of Interactive Mobile Technologies, 17(2).

[13] Almaiah, M.A., Hajjej, F., Lutfi, A., Al-Khasawneh, A., Shehab, R., Al-Otaibi, S. and Alrawad, M., 2022. Explaining the factors affecting students' attitudes to using online learning (Madrasati Platform) during COVID-19. Electronics, 11(7), p.973.

[14] Ryan, J. and Bowman, J., 2022. Teach Cognitive and Metacognitive Strategies to Support Learning and Independence. In High Leverage Practices and Students with Extensive Support Needs (pp. 170-184). Routledge.

[15] Malela, N.M., Kusnandi and Albania, I.N., 2022, December. Cognitive and metacognitive instruction in the process of solving math word problem: A literature study. In AIP Conference Proceedings (Vol. 2468, No. 1, p. 070041). AIP Publishing LLC.

[16] Qomariyah, S., Darmayanti, R., Rosyidah, U. and Ayuwanti, I., 2023. Indicators and Essay Problem Grids on Three-Dimensional Material: Development of Instruments for Measuring High School Students' Mathematical Problem-Solving Ability. JEMS: Jurnal Edukasi Matematika dan Sains, 11(1), pp.261-274.

[17] Herman, T. and Fatimah, S., 2023. Considering the Mathematical Resilience in Analyzing Students' Problem-Solving Ability through Learning Model Experimentation. International Journal of Instruction, 16(1).

[18] Lin, C.Y., 2023. Creative problem-solving ability does not occur by chance: Examining the dynamic system model of creative problem-solving ability. Gifted Education International, p.02614294221149478.

[19] Firmansyah, M.A. and Syarifah, L.L., 2023. Mathematical Problem Solving Ability In View Of Learning Styles. Prima: Jurnal Pendidikan Matematika, 7(1), pp.58-66.

[20] Malau, K.A.W. and Mukhtar, M., 2023. Improving Students' Mathematical Problem-Solving Ability By Using The Missouri Mathematics Project At Smp Negeri 4 Medan. Jurnal Riset Rumpun Matematika dan Ilmu Pengetahuan Alam (JURRIMIPA), 2(1), pp.239-253.

[21] Yustinah, N., Rohaeti, E.E. and Yuliani, A., 2023. The Effect of Habits of Mind on Mathematical Problem-Solving Ability of Junior High School Students. (JIML) Journal Of Innovative Mathematics Learning, 6(1), pp.12-19.

[22] Qomariyah, S., Darmayanti, R., Rosyidah, U. and Ayuwanti, I., 2023. Indicators and Essay Problem Grids on Three-Dimensional Material: Development of Instruments for Measuring High School Students' Mathematical Problem-Solving Ability. JEMS: Jurnal Edukasi Matematika dan Sains, 11(1), pp.261-274.

[23] Sa'dijah, C., Purnomo, H., Abdullah, A.H., Permadi, H., Anwar, L., Cahyowati, E.T.D. and Sa'diyah, M., 2023, January. Students' numeracy skills in solving numeracy tasks: Analysis of students of junior high schools. In AIP Conference Proceedings (Vol. 2569, No. 1, p. 040011). AIP Publishing LLC.

[24] Bal, A.P. and Or, M.B., 2023. Investigation of the relationship between problem-solving achievement and perceptions of students. Pedagogical Research, 8(1).

[25] Novitasari, M., Suharini, E., Arbarini, M. and Sumardjoko, B., 2023. Communicative Child-Friendly Mathematics Learning Management: Collaborative Skills In Problem- Solving. Mojem: Malaysian Online Journal of Educational Management, 11(1), pp.23-35.