Projecting Learning Styles and Metacognitive Awareness as Predictors of Problem-Solving Abilities in Mathematics Among Elementary Pre-Service Teachers

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This study examined the influence of learning styles and metacognitive awareness on mathematics problem-solving skills among elementary pre-service teachers. Using total enumeration sampling procedure, this study included 290 respondents. Questionnaires on Problem-solving abilities and metacognitive skills were utilized as research instruments. Anchored on Learning Styles Theoretical Model (Kolb, 1984), Mathematics Problem-Solving Knowledge for Teaching framework (MPSKT) popularized by Chapman (2015), and the General Theory of In-the-Moment Decision Making (Schoenfeld, 2010; 2013), descriptive analysis was used in determining the perceived learning styles and problem-solving abilities through JAMOVI to descriptively define means and standard deviation associated with variables being examined. A multiple linear regression analysis was performed to determine whether learning styles and metacognitive awareness could predict respondents' problem-solving abilities. Findings showed that learning styles and metacognitive awareness are positive predictors of problem-solving abilities in mathematics. Furthermore, the study provides teacher education students with learning insights for developing better learning strategies.

Keywords: mathematical achievement, learning styles, problem-solving skills, metacognitive awareness, mathematics education

INTRODUCTION

Learning styles and problem-solving abilities play critical role in the teaching and learning process. Students use a variety of learning styles to process new information and to manage a specific learning task. Similarly, students vary in how they perceive and recognize information using cognitive factors whose recognition is crucial yet essential in helping students in their academic pursuit. As cited in Can (2009), the concept of learning styles has been introduced five decades ago by Dunn and Dunn in 1960, providing the connotation as a way through in which individual learner starts to focus on, process, absorb, recall and retain new and challenging ideas. With similar trajectory, learning style has been emphasized as individual's preferred strategy as each learner receives and processes information cognitively. The aim of determining students' learning styles has likewise been associated to understanding their weaknesses as

well as their strengths to maximize their learning potential and be able to formulate their transitional technique to higher levels of cognitive functioning. By doing so, this would allow educators to come up with instructional materials in a manner that would best fit the diverse classroom learning situations. One of the predominant reasons for the formulation of such "term" is that learning style in its very essence has been found to have practical application predominantly in the areas of teaching and learning (Baraz, Memarian and Vanaki, 2014).

Subsequently, numerous empirical studies were conducted on the application of the learning styles and various cognitive skills and variables (Arono et al., 2022; Casey & Ganley, 2021; Corcoran & O'Flaherty, 2022; Ocampo et al., 2023). For instance, the results of Arono et al. (2022) exploring the effect of cognitive literacy skill and learning style of students on their meta-cognitive strategies indicated similarities with Verma (1988) that students having extrovert and introvert characters were alike than different in their learning style preferences. Conversely, in gender differences in spatial skills and math attitudes in relation to mathematics success, Casey and Ganley (2021) specified that the main interactional impact on socio-demographics and economic status and intelligence was not found to have established significant connection with the learning styles. Furthermore, Corcoran and O'Flaherty (2020) detailed that no substantial correlation has been found between personalities and learning styles of adolescent female students in their teacher preparation. However, in the previous report of Verma (1998), indicated intellectually gifted students both in the applied sciences including mathematics and engineering as well as social sciences, prefer different learning styles.

On the other hand, there had been definitions of term "problem" in literature (e.g. Ader, 2019; Evans, 2012; Polya, 1985; Schoenfeld, 1992; Van De Walle, Karp, & Bay-Williams, 2010). Some described a problem as an exercise students need to get engage in the process in utilizing new mathematical knowledge and learning strategies, while others labelled the term as complex tasks in whom the students encounter obstacles and try to formulate solutions in overcoming such challenge (Schoenfeld, 1992). Further, Evans (2012) indicated that problem-solving is an integral part of mathematics education and continuously transmit its important reputation in the academe. Therefore, individuals should realize how to deal with a certain challenge or problem to understanding the concepts of mathematics (Van De Walle, Karp, & Bay-Williams, 2010). With that said, the main idea of mathematical comprehension is a process that requires indepth understanding, visualizing, analyzing, associating, generalizing, and rationalizing numerical challenges. In the study of Polya (1985), four phases of problem-solving had been recognized namely understanding problems, making schemes, carrying that schemes, and checking out solutions. These defined phases are likewise in parallel with the concepts of planning, monitoring, control and evaluation skills associated with metacognitive awareness (Ader, 2019; Whitebread et al., 2009).

Problem-solving necessitates not only basic knowledge and cognitive skills but likewise metacognitive awareness and skills and to apply these constructs in various academic tasks. While cognitive abilities assist student understanding of the tasks and distinguish strategies for certain solution, the metacognitive awareness and skills may help to regulate the process of problem-solving approach and decision-making (Ader, 2019). Güner and Erbay (2021) indicated that crucial function of metacognition in mathematics education as imperative to student learning process. In the early stage, for instance, the task of problem-solving like representation of specific problem and formulating strategies to solve such problem necessitates metacognition (Tohir, 2019). After crafting the solution, its precision is doubled checked. To apply put, problem-solving necessitates the use of cognitive abilities to comprehend what and how to perform and proceed with the correct procedure. This kind of practice may be associated to metacognition and metacognitive awareness that may likewise enhance problem-solving performance by equipping students with skills to represent the problem numerically applying various strategies to solving such tasks. Thus, problem-solving assists students in constructing new mathematical knowledge, which is coincide as doing mathematics or "mathematicquing" (Güner & Erbay, 2021; Van De Walle, Karp, & Bay-Williams, 2010). Though, students have difficulty in problem-solving which needs modifying their learning approach and using different strategies. It is in this context that Desoete (2007) has recommended that classroom instructions should provide opportunities to students in realizing the importance of metacognition and awareness to held students enhance their problem-solving skills. Consequently, students must likewise be

cognizant of their cognitive resources and how to utilize that metacognitive awareness to understanding mathematical concepts.

In the context of Metacognition, this defines what individuals know relative to his or her own mindset and how he or she would regulate that thinking process while involving on certain task. The metacognition awareness has been defined by various research (see Biryukov, 2003; Iwai, 2011; Koriat, 2007; Salam et al., 2020; Wells, 2009). Koriat emphasized that metacognitive awareness means defining what individuals know about cognition including cognitive processes and how it is used to adjust their information processes and attitudes, while Wells described metacognitive awareness as a thinking process on individual mindset or thinking on thinking by Iwai. In the general connotation of metacognitive awareness, research has provided a clear characterization as individuals being aware of one's personal cognitive skills and processes or knowledge of any concept. This notion highlights two significant elements by Schraw (1998) which are knowledge on cognition and regulation of cognition. The former involves declarative, procedural and conditional knowledge. Declarative refers to individual's self, strategies and other elements influencing academic performance. Procedural in an awareness of how to perform such task including which strategies to use while conditional may mean knowing when to employ cognitive process that would allow students in adapting their knowledge to specific changing learning situations. Thus, conceptualizing the scope of this research on learning styles, problem-solving abilities and metacognitive awareness required systematic approach to looking at the significant connections of these constructs to mathematical achievement.

Definition of the Research Problem

Educators accentuated the significance of active and constructive process of sense-making, understanding, and problem-solving abilities within the boundaries of metacognition defined by individuals learning styles. Various countries such as the US (National Council of Teachers of Mathematics [NCTM], 2000) and Turkey (Ministry of National Education [MoNE], 2018) have introduced metacognitive skills as an essential component of mathematics education (Ader, 2019). In the Philippines, research on metacognition is believed have been constantly growing this present era maybe due to the fact that problem-solving abilities of students seemed to be quite alarming now a days. In the study of Ader (2019) on the continuous changes in mathematics curricula, teachers should offer learning opportunities for reasoning and problem-solving. Thus metacognitive awareness and skills play a crucial function in monitoring and regulating students cognitive processes that would define their mathematical achievement. This would help students to comprehend when and how they would use their own cognitive skills to solve numerical problems successfully.

In this context, this research accentuated the debatable concern why and how the process of receiving ang and processing of information would make significant difference in students reasoning and problem-solving abilities, and how could metacognitive awareness and skills mediate to understanding the connection of learning styles and problem-solving abilities for better students' outputs in the classroom. On the other hand, it is noticeable in mathematics classroom that students who are not able to notice the errors in the problem-solving tasks, monitor their solutions, apply appropriate teachniques, or even explain solutions they have come up tend to manifest below average performance. In this contention, metacognitive awareness would be one of the critical concerns in problem-solving skills of students. Problem-solving includes not only cognitive approaches but likewise metacognitive skills. Accordingly, this research emphasized that it is more than just implementing strategies to solve certain mathematical problems but the metacognitive preparedness to approach such challenge. Besides, metacognitive skills are deemed related to problem-solving abilities, and this research argues that students possessing these skills may have the capacity to decide whether a given problem is math-sensible, discern consistencies between techniques and solutions, distinguish accuracy of answers, and recognize their errors. However, since analysis and observations of metacognitive awareness and skills are challenging, this concern has not been adequately explored by mathematics educators.

Objectives of the Study

This study examined the significant influence of learning styles and metacognitive awareness in relation to problem-solving abilities in mathematics among pre-service teachers in the College of Education of Central Luzon State University, Nueva Ecija, Philippines. Specifically, the study sought the following research objectives: 1) describe the learning styles of respondents in terms of competitive, collaborative, independent, dependent, avoidant, and participative; 2) determine the respondents' metacognitive awareness of the respondents; 3) describe the problem-solving abilities of the respondents in terms of novice, apprentice, competent, and expert; and, 4) find out whether respondents' learning styles and metacognitive awareness predict their problem-solving abilities. More so, the study likewise hypothesized that there are no established significant predictors between learning styles, and problem solving abilities to problem-solving skills among pre-service teacher respondents of the study. As the primary significance of the research outputs, the findings offered potential strategies to refine the mathematics education as regard to mathematical skills on problem-solving and achievement of learners, fostering the growth of students' numerical creativity. This enhancement is envisioned through articulating mathematics instructional approaches which is informed by the established significant difference model format that represents the relationship between learners' learning styles and problem-solving skills with their creative outlook at mathematics in general thereby optimizing the meaningful learning experience.

Theoretical and Conceptual Framework

This proposed study is anchored the following theoretical frameworks: Learning Styles Theoretical Model (Kolb, 1984); Mathematics Problem-Solving Knowledge for Teaching framework (MPSKT) popularized by Chapman (2015); and the General Theory of In-the-Moment Decision Making (Schoenfeld, 2015). In Kolb's (1984) Learning Style Model, learning style enables learning to be oriented according to one's preferred methodology. In this theoretical model, everyone responds to and needs the stimulus of all types of learning styles, by using emphasis that best fits with the given learning situation and individual learning style preference. Included in the constructs of this theoretical model are diverging, assimilating, converging and accommodating.

In diverging, learners tend to look at things from different perspectives. Being sensitive, they prefer to watch rather than do, tending to gather information and use imagination in solving problems. Viewing concrete situations from various perspectives would be their best characteristic. Kolb (1984) coined it as diverging since people perform better in situation that requires ideas-generation such as brainstorming. Further, they tend to have broad cultural interests and tend to be imaginative, emotional and strong in the arts, and prefer to work in groups, listen with an open -mind and receive personal feedbacks positively. In assimilating, this pertains to watching and thinking, which involves a concise, logical approach. Ideas and concepts are more significant than individuals. They require clear explanations rather than practice al opportunity. They excel at understanding wide-range of information, organizing it clearly with logical format. This learning style are more focused to ideas and abstract concepts, and more attracted to logically sound theories. People with this style prefer readings, lectures, exploring analytical models and having to think things through. Furthermore, Kolb highlighted "doing and thinking" as features of converging learning style associated with problem solving skills and using learning to find solutions to practical issues. They prefer technical tasks and best at finding practical uses for ideas and theories. They can solve problems and make decisions by finding solutions to questions and problems. People with converging learning style tend to focus on technical tasks, enable specialist and practical abilities, and prefer to experiment with new ideas, and work with practical applications. Finally, Kolb's learning style on accommodating defines learning style as "hands-on" and relies on intuition rather than logical contexts. They tend to use other people's analysis and prefer to take a practical, experiential approach. Accommodating is attracted to new challenges and experiences in carrying out plans. Commonly acting on "guts", they tend to rely on others for information than carry out their own analysis as this learning style is prevalent within the general population.

In Mathematics Problem-Solving Knowledge for Teaching framework (MPSKT) popularized by Chapman (2015), the MPSKT framework is a useful tool to addressing pressing issues on what pre-service

teachers need to know and how to teach the various logical operations in mathematics which require problem-solving skill. In the preparation stage of pre-service teachers, studies have shown that the framework explored different strategies to develop deeper understanding of the academic factors needed to teach the various logical operations in mathematics with emphasis on problem-solving. Based on the theories mentioned above regarding learners' cognitive and social learning development, these theoretical frameworks served as the guide of this study.

Conversely, Schoenfeld (2015) lays out the structures of a General Theory of In-the-Moment Decision Making which is straightforward in its sense: what one needs for a theoretical account of someone's decisions while that person is engaged in a familiar goal-oriented activity such as problem solving, teaching, or other related practices, would be a thorough descriptions of the following: a) the goals an individual tries to achieve that is comprehension of the problem; b) the individual's knowledge and more broadly, the resources at everyone's disposal or a form of plan; c) the individual's belief and orientations on everyone's working domain as action plan; and, d) the individual's decision making mechanism and assessment of tasks.

As regard to depicting goals, it is necessary since the theory describes a much broader spectrum of learning behavior than problem solving. Depending on the context, one's highest priority goal may be for instance, to solve a numerical problem, to make sure that once students understand a particular body of mathematics. Thus, the role of knowledge is central, meaning what one can achieve depends on the fundamental ways on what one knows. In Kolb's (1984) theoretical view, he always views problem solving strategies as form of knowledge but in the problem solving work, Kolb tries to validate their importance and utility. Further, beliefs still play the same central role in shaping what the individual perceives and prioritizes. Kolb had chosen to use the word orientation including preference, values, tastes and others as a more encompassing term than beliefs since, for instance, choices of what to purchase and how to cook it, are not necessarily the matter of beliefs. Lastly, the decision-making mechanism in the theory is implemented in two ways: if circumstances are familiar, that is, one is collecting homework or doing over familiar content in class, people would use a variety of mechanisms that would essentially offers what move to do next. If the circumstance vary from the predictable such as student makes a comment indicating a serious misconception, an explanation obviously does not work, then it would be possible to model the individual's decision making using a form of subjective expected utility.

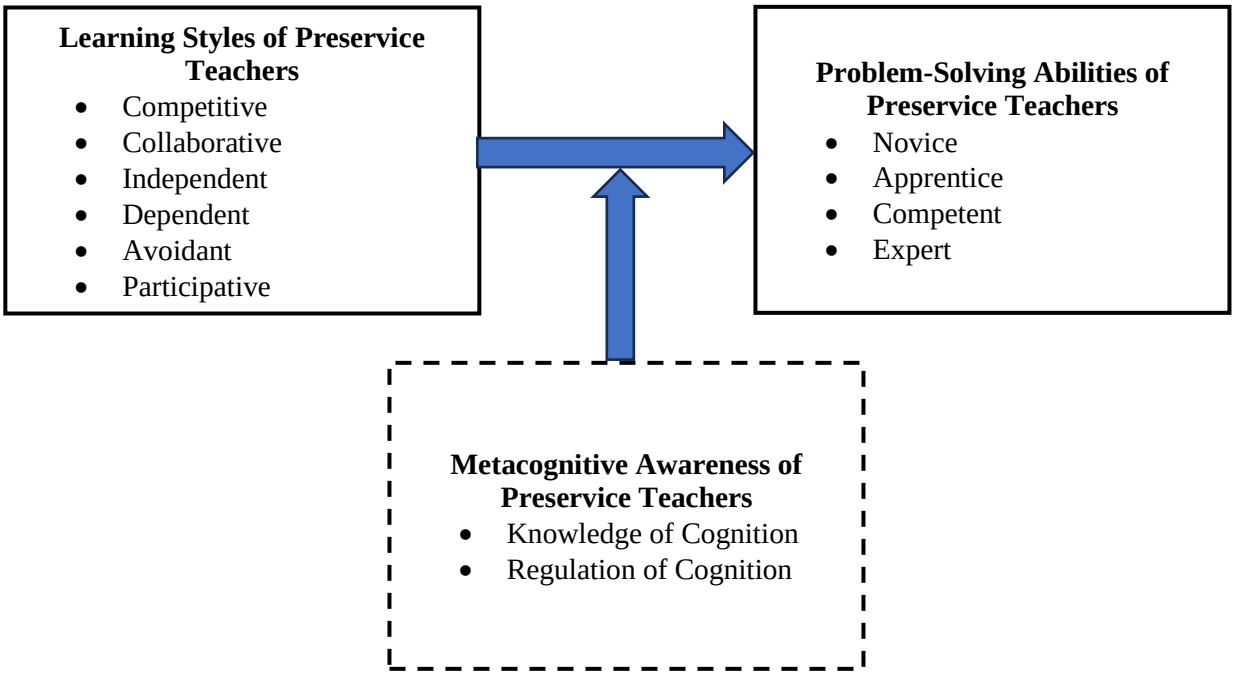
The concepts discussed above were the procedures utilized to find out how metacognitive awareness as mediating variable could influence respondents' learning style and the problem-solving abilities, as well as factors related to problem solving abilities of selected preservice elementary teachers. The three theoretical models mentioned above were the principles that the pre-service teachers could use as lens in problem solving skills to determine their levels of problem-solving ability. The three foundational theoretical constructs believes that the problem-solving strategy is independent of the nature of the question/problem and dependent on individual ability to work on numerical problems. In other words, these principles can be applied in various contexts of higher order thinking skills. In determining the learning style, one must likewise understand his/her own way of how to learn effective, then devise a plan on how these styles can contribute to learning process and apply these styles to be an effective and active learner that later can also contribute to the teaching styles of math teachers.

Figure 1 below illustrated the research paradigm showing the relationships of the independent and dependent variables. The role metacognitive awareness as intervening variable highlighted its influencing power to determining its contribution to learning style and skills in problem-solving. The independent variables comprised age, sex, type of elementary school graduated from, average number of days present per week, time allocation in studying math per week highest educational attainment of parents, occupation of parents and monthly gross income of the family. The learning styles encompassed competitive, collaborative, independent, dependent, independent, avoidant and participative. The metacognitive awareness as mediating variable covered knowledge and regulation cognition. Problem-solving abilities served as dependent variable categorized as novice, apprentice, competent and expert. These were examined in terms of testing the difference in perceptions between learning styles and socio-demographic characteristics, as well as in their problem-solving abilities. Correlational design had likewise been applied

to determining the significant relationships of learning styles and problem-solving abilities. In examining the relationships, predictors were identified. Lastly, the influence of metacognitive awareness as mediating variable to learning styles and problem-solving abilities had also been evaluated.

As presented in Figure 1, there was a recurring interplay between respondents' socio-demographic profile and learning styles. As such, these two variables intertwined with the dependent variable problem-solving abilities of pre-service teachers. Thus, the center of the conceptual frame highlighted the significant role of metacognitive awareness playing its pivotal part as mediating variable to learning styles and problem-solving abilities. The significant difference and correlations being established may offer new knowledge to the body of literature in this chosen topic for research.

FIGURE 1
THE CONCEPTUAL PARADIGM SHOWING THE RELATIONSHIP BETWEEN INDEPENDENT AND DEPENDENT VARIABLES



METHODOLOGY

Research Design

The research used a descriptive research design. It is descriptive research in way that it describes and focus on quantitative assessment of the respondents' learning styles, problem solving abilities, and metacognitive awareness of the respondents. According to Bernard (2013), descriptive research provides information about conditions, situations and events, among others. It can only describe the who, what, when, where and how of a situation, not what caused it. It does not seek to measure the effect of variables; it seeks only to describe. The greatest strength of this method is that it can be used when experimental research is not possible because the predictor variables cannot be manipulated. Because the focus of this study was to describe the socio-demographic characteristics, learning styles and problem-solving skills, descriptions were likewise be utilized in examining the difference of the variables. Since the study focused on significant difference, correlational research was used to explore the links between variables. It does not describe the nature of the relationship as in descriptive research and it cannot be used to determine causation as experimental research. Rather, it measures the extent to which two variables are related. The purpose of the research it to determine which variables are interacting and what type of interaction is occurring.

Sampling and Sampling Procedures

Respondents of the study were 290 elementary pre-service teachers (Bachelor of Elementary Education) currently enrolled at the College of Education, Central Luzon State University during second semester of S.Y. 2023-2024. The entirety of the population was considered since the population is not large. Since cognitive skill achievements are the ways that one's brain remembers, reasons, holds attention, solve problems, thinks, reads, and learns, it would be very important that elementary pre-service teachers develop these skills before having their in-service teaching in order to assist them to develop more effective teaching method. This study utilized total enumeration sampling design, a type of purposive sampling technique where researchers choose to examine the entire/total population that have a particular set of characteristics (Bernard, 2013). Total enumeration of pre-service teachers during the conduct of the study were considered respondents.

Instrumentation

Survey questionnaire was used which included three (3) parts: Part I measured their learning styles; Part II measured their problem-solving abilities. Part III covered their perceived metacognitive awareness in mathematics. The research utilized a standardized instrument to measure the learning styles and problem-solving abilities. Furthermore, the study employed a set of problem-solving activity sheets that was develop by researcher, and survey questionnaire for each student. The types of problems in the problem set included Number and Number Sense which is crucial and vital competencies in the elementary level. Specifically, Part I pertained to respondents' learning styles (competitive, collaborative, independent, dependent, avoidant, participative) using opinionnaire choices. There were five indicators or statements per category answerable by numerical choices like 5 (strongly agree), 4 (moderately agree), 3 (undecided), 2 (moderately disagree) and 1 (strongly disagree). Part II was a researcher-made instrument to measure the problem-solving skills of respondents. The questionnaire comprised problem-solving activities to measure student abilities in forming specific formula on the several logical operations in mathematics. Students' scores were categorized accordingly such as novice, apprentice, competent, or expert. More so, Part III measured their perceived metacognitive awareness specifically their knowledge and regulation cognition. There were fifty indicators answerable by Likert Scale such as 5 (strongly agree), 4 (moderately agree), 3 (undecided), 2 (moderately disagree) and 1 (strongly disagree).

Data Gathering and Analysis

Prior to data gathering, the researcher sought for the approval of the ethics review committee. To protect the privacy of the respondents, there were precautionary measures that had been properly observed during the conduct of this study. In the data collection, respondents' real names were not revealed and all gathered data were kept with utmost confidentiality. All data were used solely for the interpretation of the results of the study. In case the data be introduced to public, it would only be used for academic purposes such as presenting to conference and other related scholarly endeavors. All data that were collected from the survey questionnaire had been analyzed by descriptive analysis using inferential statistical tools. Descriptive statistics such as mean and standard deviation were employed learning styles (competitive, collaborative, independent, dependent, avoidant, participative). Furthermore, similar analysis was done on pre-service teachers' problem-solving abilities (novice, apprentice, competent, expert). To address the objectives on examining the significant influence of learning styles and metacognitive awareness to problem-solving abilities, multiple linear regression was used to determine if such variables could impact individual's skills in mathematics.

RESULTS AND DISCUSSION

Respondents' Perceived Learning Syles

The perceived learning styles of the pre-service teacher respondents includes their knowledge on the concept of competitive, collaborative, independent, dependent, avoidant, and participative. Respondents' perceived learning styles are depicted in the table below.

TABLE 1
RESPONDENTS' PERCEIVED LEARNING STYLES

LEARNING STYLES	MEAN	SD	DESCRIPTION
Competitive	**3.68**	**1.20**	**Moderately Agree**
1. To stand out in my classes, I complete my assignments better than the other students	*4.13*	*0.98*	*Moderately Agree*
2. To do well it is necessary to compete with other students for my teacher's attention	*2.45*	*1.38*	*Moderately Disagree*
3. Students have to be aggressive to do well in class	*4.13*	*1.24*	*Moderately Agree*
4. I know how well other students are doing exams	*3.63*	*1.20*	*Moderately Agree*
5. Being one of the best students in my class is very important to me	*4.07*	*1.19*	*Moderately Agree*
Collaborative	**3.94**	**1.25**	**Moderately Agree**
1. I enjoy hearing what other students think about issues raised in class	*3.59*	*1.40*	*Moderately Agree*
2. I am willing to help other students when they do not know or understand something in class	*4.08*	*1.14*	*Moderately Agree*
3. I like to study for the test with other students	*3.93*	*1.32*	*Moderately Agree*
4. I enjoy participating in group activities during class	*4.11*	*1.14*	*Moderately Agree*
5. Working with other students in class activities is something I enjoy doing in class	*3.98*	*1.26*	*Moderately Agree*
Independent	**3.78**	**1.19**	**Moderately Agree**
1. I learn a lot on my own	*3.37*	*1.16*	*Undecided*
2. I prefer to work by myself on assignments	*3.53*	*1.25*	*Moderately Agree*
3. It is my responsibility to get as much as I can out of the course	*4.20*	*1.20*	*Strongly Agree*
4. When I don't understand something, I first try to find it out for myself	*3.84*	*1.24*	*Moderately Agree*
5. I complete required assignments as well as those that are optional	*3.98*	*1.11*	*Moderately Agree*
Dependent	**3.92**	**1.17**	**Moderately Agree**
1. I want my teacher to state exactly what he expects from the student	*3.72*	*1.19*	*Moderately Agree*
2. I rely on my teacher to tell me what is important for me to learn	*4.02*	*1.18*	*Moderately Agree*
3. I want clear and detailed instructions on how to analyze and compute problems	*4.14*	*1.16*	*Moderately Agree*
4. I want my teacher to have an outline or notes on the board	*3.72*	*1.16*	*Moderately Agree*
5. Students should be told exactly what topics are to be covered in exams	*3.97*	*1.15*	*Moderately Agree*

LEARNING STYLES	MEAN	SD	DESCRIPTION
Avoidant	**2.42**	**1.33**	**Moderately Disagree**
1. I don't want to attend most of my classes	*1.78*	*1.05*	*Strongly Disagree*
2. I typically cram for exams	*2.45*	*1.25*	*Moderately Disagree*
3. Paying attention during class sessions is difficult for me to do	*2.39*	*1.29*	*Moderately Disagree*
4. I study just hard enough to get by	*2.68*	*1.48*	*Undecided*
5. I very seldom am excited about materials covered in the course	*2.80*	*1.42*	*Undecided*
Participative	**3.86**	**1.22**	**Moderately Agree**
1. I do all assignments well whether or not I think they are interesting	*4.03*	*1.19*	*Moderately Disagree*
2. I often sit toward the front of the room	*3.07*	*1.31*	*Undecided*
3. I do whatever is asked of me to learn the content in my class	*3.89*	*1.29*	*Moderately Agree*
4. Classroom activities are interesting	*3.99*	*1.16*	*Moderately Agree*
5. Classroom sessions typically are worth attending	*4.35*	*1.14*	*Strongly Agree*

Legend:

1.00 – 1.80	Strongly Disagree
1.81 – 2.60	Moderately Disagree
2.61 – 3.40	Undecided
3.41 – 4.20	Moderately Agree
4.21 – 5.00	Strongly Agree

Competitive Learning Style

Competitive learning style was examined based on pre-service teachers' perception. Responses to five statements had a pooled mean of 3.68 and a standard deviation of 1.20 indicated Moderate Agreement. The mean scores for statements 1 and 3 which state "To stand out in my classes, I complete my assignments better than the other students " and "Students have well to be aggressive to do well in class" gained the highest means of both 4.13, with standard deviations of 0.98 and 1.24 respectively, indicating Moderate Agreement with the statements. Similarly, statement 5 which says "Being one of the best students in my class is very important to me," gained the mean score of 4.07, with a standard deviation of 1.19, also indicating Moderate Agreement. Conversely, statement 2 which states "To do well it is necessary to complete with other students for my teacher's attention", obtained the lowest mean score of 2.45, with a standard deviation of 1.38, which indicates Moderate Disagreement. The consistent moderate agreement on the indicators of competitive learning style indicated their goals of being stand out in class and being aggressive to gain above satisfactory performance. The findings likewise suggested the notion of individualistic learning in this sense within the context of traditional classroom. Individual style of studying and completing assignments while learning specific concept are deemed crucial to student learning. More so, scores defined individual's measures on their learning progress. In this style, students may become competitive among themselves for the best achievement and recognition. Ocampo et al. (2023) and Bhat (2019) accentuated in their studies that students' learning style was a dispositional or trait concept that defines how an individual commonly approaches learning and how each learns. Consequently, findings of previous studies found that students might be left behind in more competitive classroom environment brought about by classroom instruction pressures.

Collaborative Learning Style

Collaborative learning style had been measured through five indicators arriving at a pooled mean of 3.94 and standard deviation of 1.24 interpreted as Moderately Agree. As illustrated in the table, statement 5 "I enjoy participating in group activities during class" received the highest mean of 4.11 (SD=1.14) indicating Moderate Agreement. This was followed by statement 2 which states "I am willing to help other students when they do not know or understand something in class" having a mean of 4.08 (SD=1.14) suggesting Moderate Agreement as well. On the other hand, statement 1 which says "I enjoy hearing what other students think about issues raised in class" obtained the lowest mean of 3.59 (SD=1.40) but still interpreted as Moderate Agreement. These perceptions may indicate the crucial role of collaborative efforts in the learning process. As such, the collaborate classroom commonly provides individuals in groupings encouraging learning atmosphere together to maximize their own learning, including others in the group. This would include activities which everyone works together and discusses strategies to solve such problem within the group. Working together on a large scale may provide great learning opportunities and offer positive learning environment to students. Empirical studies have established the significant connection between collaborative learning and academic achievement of students (Bhat, 2019) students learn important cooperative social skills which are imperative to future working career and can actually learn better when helping each other. Bicer, (2014) emphasized the influence of collaborative learning that occurs when dyads or small group of students have been engaged to sharing responsibility, authority, and learning outcomes resulting in positive exchange of learning ideas.

Independent Learning Style

Independent learning style included five indicators to measure pre-service teachers' perceptions on this context yielded a pooled mean of 3.78 (SD=1.19) indicating the overall Moderate Agreement. Out of five indicators, statement 3 which states "It is my responsibility to get as much as I can out of the course" gained the highest mean of 4.20 (SD=1.20) showing a Strong Agreement by the respondents. This was followed by statement 5 which says "I complete required assignments as well as those that are optional" having a mean of 3.94 (SD = 1.11) indicating a Moderate Agreement. Meanwhile, statement 1 saying "I learn a lot on my own" obtained the lowest mean of 3.37 (1.16) descriptively interpreted as Undecided. This findings may be attributed to individual's independent capacity to learn the skills and realize their responsibility to enhance their learning capacity. This also indicates that an independent learner possesses all the tools necessary to effect their learning into their own hands, with the capability to investigate and explore new knowledge and skills with lesser assistance from others. Thus, students having this learning style may independently perform the task asking questions frequently rather than relying solely on materials or modules that teachers hands them. Similarly, students may take ownership of their educational trajectory by setting their clear goals and monitoring their progress. In congruence with the findings of Ocampo et al. (2023) on mathematics performance and learning styles of students, independent student learning style was found to be connected with student-centered learning that shifts between teacher and student interaction. It allowed students as prime actors in the classroom to become active and take charge of their learning rather than sitting passively during discussion which defines their role taking the lead of their own learning.

Dependent Learning Style

Dependent learning style had been examined by the pre-service teachers along with five indicators indicating a pooled mean of 3.92 (SD = 1.17) suggesting a descriptive interpretation that they Moderately Agree to somehow dependent of their learning styles. With the five indicators being assessed, statement 3 which states "I want clear and detailed instructions on how to analyze and compute problems" gained the highest mean of 4.14 (SD = 1.16) indicating a Moderate Agreement in the context of the statement. This was followed by statement 2, "I rely on my teacher to tell me what is important for me to learn", obtaining a mean of 4.02 (SD = 1.18) likewise suggesting a Moderate Agreement in the statement. On the other hand, statements 1 and 4 "I want my teacher to state exactly what he expects from the student" and "I want my teacher to have an outline or notes on the board" yielded both means of 3.72 (SD=1.19; SD=1.16) also indicating Moderate Agreement respectively. As manifested in their perception on dependent learning style,

the outcome may suggest externally driven motivation to pursue their learning goals. As such, dependent learning style may also dependent on the teacher to carrying most of the cognitive load of tasks, and maybe unsure of how to proceed with new tasks. Further, their being dependent learning style can complete tasks with the necessary scaffolding intervention since information and concepts do not usually retain well as they tend to stay passively and wait teachers' interventions to properly absorb the concepts being learned. In the analysis of Bhat (2019) and Bicer (2014) on student learning styles, studies found that dependent learners frequently seek for a kind of reassurance and seeking constant approval of their outputs with some sort of doubts. They prefer detailed instructions or need for step-by-step instruction, feeling overwhelmed with open-ended activities which necessitates them to creating their own path. Thus, they commonly manifest difficulty in making independent decision-making, as they struggle to even small detailed choices about their learning and there is a feeling of uncertainty, and seemed reluctant to take initiative to participate in discussions.

Avoidant Learning Style

The table above also presented the perceived assessment of pre-service teachers on the learning style as to avoidant using the five indicators wherein a pooled mean of 2.42 (Sd=1.33) indicating Moderate Disagreement was recorded. With these five statements, number 5, "I very seldom am excited about materials covered in the course" gained the highest mean of 2.80 (SD=1.42) indicates their being Undecided. This was followed by statement 4, "I study just hard enough to get by" attaining a mean of 2.68 (SD=1.48) indicating neutrality of their perception of being Undecided. Contrarywise, statement 1 which says "I don't want to attend most of my classes" received the lowest mean of 1.78 (SD=1.05) suggesting a descriptive interpretation of Strongly Disagree. As specified in the perceptions of pre-service teachers, the learning style of avoidant seemed to be perceived its neutrality in the assessment. This may simply mean that impartiality of avoidant as learning style has not been vividly defined by the respondents since absenteeism was not among their common practice. Similar to Ocampo et al. (2023), avoidant syle of learning was least chronicled in the context of learning style-based in differentiated instruction activities which allows students to actively get engaged in the learning process that is facilitated with proper classroom management. However, avoidant and independent learning styles were found to be significant predictors of students' academic performance.

Participative Learning Style

In the last context of learning style being evaluated, pre-service teachers perceived participative as one of their dominant learning styles with a pooled mean of 3.86 (SD=1.22) indicating their Moderate Agreement on the statements provided. Along with the five indicators, statement 5, "Classroom sessions typically are worth attending" obtained the highest mean of 4.35 (SD = 1.14) descriptively described as Strongly Agree, while statement 1 which states "I do all assignments well whether or not I think they are interesting" attained the mean of 4.03 (SD=1.19) also indicating their Moderate Agreement. Nonetheless, statement 2 which says "I often sit toward the front of the room" gained the lowest mean of 3.07 (SD=1.31) suggesting a descriptive interpretation of Undecided or neutral. Highlighted in the data that classroom setting is worth attending by the students, this indicates the significant role of classroom as an avenue and platform for collaborative learning engagement wherein students are provided with opportunity for participative discussion and involvement in the process. In participatory learning, lessons are provided to individual learners with active involvement in the discussion as possible. This is commonly provided with intentional sequence of tasks or learning events that assist students achieve the specified and desired objectives in classroom instruction. These findings concurred with Bhat (2019), Bicer (2014) and Ocampo et. al (2023), their studies suggest participatory learning or active learning was found of having the elements of engaging everyone in the classroom who deserves an education that supports their respective potentials. Participatory learning has been formulated for student success and empowerment wherein all students in the classroom are provided with opportunities to participate, getting involved in the process which reinforces a self-reflective method by engaging them in metacognition, a process that tasks students with critical examination of the teaching and learning modes.

Respondents' Perceived Metacognitive Awareness

Table 2 below depicts the elementary pre=service teachers' metacognitive awareness along with the fifty indicators that define their perception on area being examined. Overall, pre-service teacher respondents rated their perceived metacognitive awareness in mathematics with an overall mean and standard deviation ($\bar{x}$=4.46; SD=0.54) indicating they Strongly Agree with the indicators in general. This most likely suggests that elementary pre-service teachers most likely to concur with the indicators that define their metacognitive awareness reflected in the individual's inherent qualities of mind and character.

TABLE 2
RESPONDENTS' PERCEIVED METACOGNITIVE AWARENESS

METACOGNITIVE AWARENESS	MEAN	SD	DESCRIPTION
3. When I solve a Mathematics problem, I try to use methods of solving a problem that have worked in the past.	4.77	0.47	Strongly Agree(HMA)
21. I periodically do revision to help me understand important relationships in Mathematics.	4.82	0.43	Strongly Agree(HMA)
25. I ask other learners for help when I do not understand something in Mathematics.	4.75	0.47	Strongly Agree(HMA)
27. I am aware of what learning strategies I use when I study Mathematics.	4.81	0.38	Strongly Agree(HMA)
34. When I solve a Mathematics problem, or when I study for a Mathematics test or examination. I find myself pausing regularly to check my comprehension.	4.12	0.69	Agree(LMA)
38. After I have solved a Mathematics problem, I ask myself whether I have considered different ways to solve the problem.	4.16	0.71	Agree(LMA)
48. I ask myself questions about how well I am doing while I am solving a Mathematics problem.	4.89	0.31	Strongly Agree(HMA)
50. When I read a Mathematics question, I stop and reread any section of the question that is not clear.	4.15	0.70	Agree(LMA)
Over-all Mean	**4.46**	**0.54**	**Strongly Agree(HMA)**

Legend:		**Level**	
1.00 – 1.80	Strongly Disagree	< Mean	Low Metacognitive Awareness (LMA)
1.81 – 2.60	Disagree	$\geq$ Mean	High Metacognitive Awareness (HMA)
2.61 – 3.40	Neutral		
3.41 – 4.20	Agree		
4.21 – 5.00	Strongly Agree		

Among the fifty items being assessed, five indicators were recorded to be of highest means such as statements 48, 21, 27, 25, and 3. Statement 48 which states "*I ask myself questions about how well I am doing while I am solving a Mathematics problem*." got the highest mean of 4.89 (SD = 0.31) followed by statement 21 which says "*I periodically do revision to help me understand important relationships in Mathematics*" having a mean of 4.82 (SD=0.43) indicating *Strong Agreement* on High Metacognitive Awareness with the indicators. Furthermore, statement 27 which states "*I am aware of what learning strategies I use when I study Mathematics*" obtained a mean of 4.81 (SD=0.38) while statement 25 that says "*I ask other learners for help when I do not understand something in Mathematics*" and statement 3 which states "When I solve a Mathematics problem, I try to use methods of solving a problem that have worked in the past" got both means of 4.77 (SD=0.47) similarly indicate *Strong Agreement* on High Metacognitive Awareness. On the other hand, out of fifty indicators, there were three significant statement that received

the lowest means. These include statement 38 which states "*After I have solved a Mathematics problem, I ask myself whether I have considered different ways to solve the problem*" having a mean of 4.16 (SD=0.71), statement 50 that says "*When I read a Mathematics question, I stop and reread any section of the question that is not clear"* with a mean of 4.15 (SD=0.70) and statement 34 which states "*When I solve a Mathematics problem, or when I study for a Mathematics test or examination. I find myself pausing regularly to check my comprehension*" obtaining the lowest mean of 4.12 (SD=0.69) indicating *Agreement* under Low Metacognitive Awareness.

In reference with the findings on respondents' perceived metacognitive awareness in mathematics, the most prominent element in the process of inclination to problem-solving abilities is defined by their mindset of how well they perform in mathematics by way of setting their goals. Coupled with understanding the fundamental concepts, the habit of constant study is deemed significant. Spousing the notion of active framework, students may certainly be able to formulate their learning scheme. In addition, students may be persuaded to concentrating and sustaining their motivation within the span of their learning process. Students may likewise twist their learning preparations and approaches. By setting their goals through focused mindset, this may provide students a vibrant learning path to develop their focus, and sustain their being optimistic and stay motivated in every numerical task given to them. Furthermore, understanding the basic fundamentals as individual practiced habit delineates their inquisitiveness, boldness, and enthusiasm to learn new things. Students may likewise be able to explain the idea of learning a specific concept and mastering the skills required in mathematics instructions. Comparable to reviewing mathematical elements, this process may be recognized as the systematic method or strategy students use to maximize time management associated with learning.

Numerous studies conformed these findings (e.g. Brown & Linn, 2023; Niño-Rojas et al., 2024; Sides & Cuevas, 2020). These findings on respondents perceived metacognitive awareness in mathematics found similarities in the studies of Brown and Linn about setting goals on examination, Niño-Rojas et al. on learning the essentials, and Sides and Cuevas on frequent review of the concepts. Definitely, Brown and Linn studied the process of setting goals among students as regard to their performance in mathematics. As a result, setting goals play pivotal role on what individuals would like to achieve like mind-setting of doing well in the examination and breaking it down into specific achievable objectives. Measuring this progress is crucial to being motivated, and setting goals could be quantifiable like aiming to complete a certain number of practice tasks daily as well as increasing study time gradually. Similarly, Brown and Linn studied the three key essentials of mathematics achievements and found out that for students to be more motivated, an individual goal must be relevant to their over-all examination preparation strategy as their constant mindset. This is through identifying the areas that need further improvement coupled with set goals on those specific areas. Concurred with Niño-Rojas et al., their findings highlighted the critical role of understanding the key components of successful review concepts through evaluating the viability, feasibility as well as desirability of specific constructs that could assist individuals to be successful in their goals.

Respondents' Problem-Solving Abilities

Problem-solving abilities were examined along with the parameters of expert, competent, apprentice and novice among 290 pre-service teachers. Results are presented in Table 3 below that descriptively defined using the JAMOVI statistical tool that demarcated frequency count, percentage, mean and standard deviation.

TABLE 3
RESPONDENTS' PROBLEM-SOLVING ABILITIES

PARAMETERS Mean = 42.13 SD = 4.43	FREQUENCY n = 290	PERCENTAGE	DESCRIPTION
76 - 100	12	4.14	Expert
51 – 75	78	26.90	Competent
26 – 50	148	51.03	Apprentice
0 - 25	52	17.93	Novice

Statistical Tool: JAMOVI (Descriptive Statistics – frequency count, percentage, mean, and standard deviation)

As illustrated on the table, four descriptive categories were used to assessing respondents' problem solving abilities as to expert, competent, apprentice and novice. Based on the assessment parameters, majority of the respondents were classified as apprentice (148 or 51.03%) and novice (52 or 17.93%). By combining these two categories, the data might suggest that 200 pre-service teachers (68.96%) have been found to have problem-solving abilities categorized as Apprentice or lower. Fewer than half or 78 (26.90%) were found to be in Competent category and very few or 12 (4.14%) attained the category of an Expert. In the data presented above, the results might be alarming since teacher education institutions are mandated to sustain quality teachers possessing the qualifications to maintain quality education and instruction in both private and public educational system. While problem-solving skill is one of the provisions in mathematics education for reinforcement, the quality of teachers in mathematics is deemed critical for classroom instructions.

More so, the results may have undesirable implication to mathematics education since apprentice and novice operate by using context-free features and rules. As highlighted in Ocampo et al. (2023), they may seem to have insufficient understanding of problem-solving rules that are contextually based and seldom assume the responsibility for the consequences and feel little accountability of their acts. As a consequence, apprentice and novice may tend to feel little responsibility while an unfortunate outcome, based on problem-solving task, may be viewed as a product of inadequately specified elements or rules. With that said, the quality of teachers in mathematics coming from the pre-service teachers will have to be properly monitored and provide measures to enhance this skills as problem-solving indicates competence.

Respondents' Learning Styles and Metacognitive Awareness as Predictors of Problem-Solving Abilities

Presented in Table 4 are respondents' learning styles and metacognitive awareness as predictors of problem-solving abilities in multivariate context. As illustrated in the table model, learning styles include competitive, collaborative, independent, dependent, avoidant, and participative along with the metacognitive awareness using fifty indicators presented in the previous table.

TABLE 4
MULTIPLE REGRESSION ANALYSIS PREDICTING THE PROBLEM-SOLVING ABILITIES OF THE RESPONDENTS

MODEL	UNSTANDARDIZED COEFFICIENTS		STANDARD COEFFICIENTS	t	p-value
	B	SE	Beta		
Constant	63.651	10.138		7.964	0.014
Learning Styles					
Competitive	0.221	0.974	0.126	5.109	*0.021*
Collaborative	1.865	0.877	0.565	4.007	*0.038*
Independent	0.875	0.271	0.651	1.298	*0.041*
Dependent	-0.142	0.308	-0.095	-4.231	0.245
Avoidant	-0.329	0.189	-0.211	-0.876	0.112
Participative	1.298	0.456	0.784	3.449	0.052
Metacognitive Awareness	4.275	0.470	3.112	5.389	*0.001*

DV: Problem-solving Abilities
$R = 0.517$, $R^2 = 0.411$, $F = 17.025$, $p < 0.001$

A multiple linear regression analysis was performed to determine whether learning styles and metacognitive awareness predict respondents' problem-solving abilities. Results show that the model is significant, $F = 17.025$, $p < 0.01$. The coefficient of determination R2 is equal to .411 which means that about 41.10 % of the variance in respondents problem-solving abilities is explained or accounted for by the independent variables combined and the remaining percentage could be attributed to the variables not covered by this study.

Learning styles particularly, competitive ($B = 0.221$, $p < 0.05$), collaborative ($B = 1.865$, $p < 0.05$), and independent ($B = 0.875$, $p < 0.05$) and metacognitive awareness ($B = 4.275$, $p < 0.01$) are positive predictors of problem-solving abilities of the respondents. These findings more likely implicate metacognitive awareness skills were significantly associated to problem-solving abilities in which they can influence students' problem-solving skills and outcomes positively. Thus, students who are inclined to demonstrate certain degree of metacognitive awareness or cognitive skills more likely to provide correct solutions and answers to certain mathematical problems. Further, they are able to distinguish problem requirements and formulate strategies as well as checking the consistency of their solutions to the problem. On the other hand, students having insufficient understanding and application of the metacognitive awareness skills seemed to be unsuccessful in problem-solving tasks and manifest difficulty in comprehending the problem, determining correct solution, recognizing errors, and applying proper strategic approach to arrive at correct solutions. Güner Erbay (2021) found similar results in their study on metacognitive awareness and problem-solving skills of students. Metacognitive awareness was found to be the moderating element to mathematics achievement. Students possessing inadequate metacognitive skills tend to manifest not being good at solving non-routine problems. They tend to respond and show lack of awareness on what problem-solving tasks require. Although they believed that they controlled and corrected their mistakes while solving the problem, it was found that they did not tend to check, detect, or correct mistakes in their solutions.

More so, the variables influencing problem-solving abilities can be measured by way of cognitive and affective skills (Ozturk et al., 2020). Briefly, Ozturk et al. emphasized cognitive skills (metacognition, reading comprehension skill, intelligent, need for cognition) and affective skills (mathematics self-efficacy, mathematics attitude, mathematics anxiety, beliefs, mathematics interest) affect problem-solving skills together. In addition, there are various studies on the criticality of metacognition in the success of problem-solving (Ader, 2019; Arsuk & Memnun, 2020; Garcia, et al., 2015). For instance, Güner Erbay (2021) emphasized the influence of the development of metacognition in early years on higher-order thinking processes since it provided better cognitive skills. Students better performed the tasks in learning

mathematics and solving problems (Kaplan, et al., 2016). Salam et al. (2020) stated that successful students are those who are aware of the times when they act strategically or not as learning becomes effective when it is accomplished consciously. Metacognition helps students to carry out the steps of problem-solving and manage this process (Sevgi & Cagliköse, 2019).

CONCLUSION

The consistent moderate agreement on the indicators of competitive learning style indicates their goals of being stand out in class and being aggressive to gain above satisfactory performance. The notion of individualistic learning in this sense within the context of traditional classroom. Individual style of studying and completing assignments while learning specific concept are deemed crucial to student learning. More so, scores define individual's measures on their learning progress. In this style, students may become competitive among themselves for the best achievement and recognition. The collaborate classroom commonly provides individuals in groupings encouraging learning atmosphere together to maximize their own learning, including others in the group. This would include activities which everyone works together and discusses strategies to solve such problem within the group. Independent learning may be attributed to individual's independent capacity to learn the skills and realize their responsibility to enhance their learning capacity. This also indicates that an independent learner possesses all the tools necessary to effect their learning into their own hands, with the capability to investigate and explore new knowledge and skills with lesser assistance from others. Thus, students having this learning style may independently perform the task asking questions frequently rather than relying solely on materials or modules that teachers hands them. Similarly, students may take ownership of their educational trajectory by setting their clear goals and monitoring their progress.

In reference with respondents' perceived metacognitive awareness in mathematics, the most prominent element in the process of inclination to problem-solving abilities is defined by their mindset of how well they perform in mathematics by way of setting their goals. Coupled with understanding the fundamental concepts, the habit of constant study is deemed significant. Spousing the notion of active framework, students may certainly be able to formulate their learning scheme. In addition, students may be persuaded to concentrating and sustaining their motivation within the span of their learning process. Students may likewise twist their learning preparations and approaches. By setting their goals through focused mindset, this may provide students a vibrant learning path to develop their focus, and sustain their being optimistic and stay motivated in every numerical task given to them.

Learning styles particularly competitive, collaborative, and independent and metacognitive awareness are positive predictors of problem-solving abilities of the respondents. These more likely implicate metacognitive awareness skills were significantly associated to problem-solving abilities in which they can influence students' problem-solving skills and outcomes positively. Thus, students who are inclined to demonstrate certain degree of metacognitive awareness or cognitive skills more likely to provide correct solutions and answers to certain mathematical problems. Further, they are able to distinguish problem requirements and formulate strategies as well as checking the consistency of their solutions to the problem. On the other hand, students having insufficient understanding and application of the metacognitive awareness skills seemed to be unsuccessful in problem-solving tasks and manifest difficulty in comprehending the problem, determining correct solution, recognizing errors, and applying proper strategic approach to arrive at correct solutions.

RECOMMENDATIONS

This research needs to verify that there is still basic conceptual flaw with learning style theory as the data suggest that, although there is an ongoing controversy about learning styles and metacognitive awareness, their actual application and use may be low, and further attempts to educate colleagues in mathematics education about this limitation which might best centers on the fundamental learning style

framework. While continue using the learning styles to gauge student understanding, further research may still be better to focus on the promotion of techniques that are deemed demonstrably efficient and effective.

LIMITATIONS

This research article can have some limitations on sampling procedures that could be representative of the population being measured, as well as on the scope on metacognitive awareness and the standardized tool to measure such phenomenon which is beyond the perceived concept of the topic.

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