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# Theory and Analysis of Learning Paradigms: The Capabilities for Critical Thinking of Prospective Instructors of Mathematics

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***Abstract*—*This study aims to analyze the learning paradigm and mathematical critical thinking abilities of prospective mathematics teachers. The analysis of prior literature and pertinent research reflects the key ideas examined in the present paper. The literature review conducted for this study will provide educational leaders, educators, scholars, and anyone else interested in this topic with useful insights. For the future, which depends on these students' talents, these insights provide an organized and shared perspective on how these concepts effect student development. The literature is organized as follows: Learning paradigms and its important aspect, interpretive paradigm in mathematics, critical paradigm and its important aspect, post-modern paradigm, multi-paradigmatic research and how it relates to mathematics, followed by mathematical and critical thinking abilities of the students. These connected research projects and works of literature provide data that genuinely support and broaden our viewpoints on mathematics. Critical thinking is a crucial part of solving problems, which is the skill required for success in the discipline of mathematics. By examining students' mathematical critical thinking skills, teachers can spot areas where they may be having trouble and create plans to help them improve. By looking at students' mathematical critical thinking abilities, it has been shown that developing these abilities improves academic success*.

## I. INTRODUCTION

Mathematics is a significant subject in education because we cannot avoid mathematics in our daily lives. The learning paradigm used to teach mathematics has an impact on how the subject is emphasized and how the learning process is changed (Dekker, 2020). Mathematics is also capable of fostering a sense of fundamental principles. According to some of these, they are a fundamental task in the contemporary system of higher learning in the twenty-first century, that is why critical thinking abilities must be taught to students (Erikson & Erikson, 2019). DepEd Memorandum No. 110, s. 2022 announced the formation of the National Mathematics Program's Technical Working Group (TWG) and Steering Committee (SC). According to the agency, it involves more than just being proficient in fundamental math; it involves having a critical awareness of connections between math and the real world. Additionally, to become a tool for fostering students' critical thinking abilities, critical thinking education programs must be adapted for classroom intervention (Bezanilla et al., 2019). One way to encourage students to think critically is through upgrading the educational and instructional practices of learning paradigm that result in the development of critical thinking (Dekker, 2020).

Studying mathematics teaches us to become thorough and exact, as well as how to think critically and logically, reason, and be positive, creative, responsible, and able to collaborate with others (Guzman Gurat, 2018; Wijaya, 2021; Haryani, 2019). According to Suhirman et al. (2021), learning mathematics has three purposes: developing cognitive patterns, acquiring tools, and acquiring knowledge. Additionally, thinking is defined by Vincent (Dahlan, 2017) as any mental activity that contributes to the formulation or resolution of a problem, the formulation of a decision, or the satisfaction of an understanding want. Several students contend that studying and understanding mathematics is difficult since the subject matter is abstract and that they can only learn from teachers. Due to memory limitations, students memorize mathematical concepts that they believe to be significant. Such occurrences might affect mathematics, which is still seen as a difficult topic by students as well as the public at large (Muijs & Reynolds, 2015). As everyone has a different capacity for thought, studying mathematics requires that each person practice and improve their skills. Students' current method of learning needs to be changed, specifically through developing their thinking abilities, including critical thinking.

Everyday living requires critical thinking, and mathematical reasoning is crucial to comprehending the world around us. Yet, while memorizing and trying to recall what has memorably been the largest mental activity for students who do not improve their thinking abilities, they will not be able to employ the knowledge in their vocabulary (Maulyda, 2020). The majority of students disregard mathematical reasoning because they believe it to be unimportant to their personal growth. The inability of students to recall information



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from earlier sessions, the quick loss of the information, and the complexity of mathematical concepts all contribute to the difficulty of learning mathematics for students. As a result, it is crucial for a person to develop the skills connected with mathematical thinking, understand how solving problems offers numerous chances for the growth of mathematical thinking, and learn how to design lessons to do so.

In this study, we establish a critical analysis on initiatives to enhance students' learning, allowing us to show that the current arguments can be seen as the outcome of a basic conflict of learning paradigms. The attempts at reform stemmed from a widespread viewpoint or learning paradigm in which mathematics was seen as a disembodied collection of impersonal truths that needed to be explained to students, the majority of whom would subsequently find it difficult to internalize them. This study will address different initiatives to enhance mathematics education and offer some insight into why they haven't been successful in addressing the unequal outcomes in math learning. Providing opportunity for students to advance and develop these talents should be the responsibility of educators in this situation. To properly prepare children for complicated life events and academic tests, it is imperative to incorporate critical thinking abilities into daily teaching. In order to increase their students' dispositions for mathematical thinking, problem-solving, reasoning, and critical thinking, teachers must design and carry out their instructional activities or the appropriate learning paradigms in this manner (Stobaugh, 2018).

## II. Literature Discussion

### *Interpretive Paradigm in Mathematics*

To understand the subjective dimension of human experience is the major objective of the interpretivist worldview. By attempting to "get inside the heads of the subjects being studied," in a sense, this method aims to understand and analyze what the subjects are thinking or the interpretations they are making of the setting. Every attempt is made to fully understand the subject of the observation from their perspective as opposed to the observer's perspective. Emphasis is placed on comprehending the individual and how they understand their surroundings (Guba & Lincoln, 2019).

The main conclusions of the study are that examining the many ways in which females perceive themselves as mathematicians provides an insightful window into how these women construct their identities. It was challenging for many girls to articulate the significance of mathematics in their ideas of what it meant to be a mathematician. They saw that many different types of genuine mathematics were being done at home, but that these were being supplanted by numbers, calculations, speed, and processes, and that mathematics was desk-bound and isolated. They learned about their mathematical identity through their interactions, descriptions of mathematics, and comparisons to others (Bermejo, 2018).

The study's participants believed they could get better with consistently more effort, and they assumed a significant amount of responsibility for their own growth. However, this created the need for a safe haven where tutors, loved ones, and friends could help the person continue to develop while shielding them from mathematical harm. This study makes several recommendations, including creating environments that are safe for time, space, and collaborative mathematical exploration, connecting mathematical study to interest and application, redefinition of mathematics as a social activity, and giving girls ownership over their own mathematical growth. The latter point makes a case for the need of practitioners keeping a careful eye on girls' developing mathematical identities (Foley, 2016).

### *Critical Paradigm and Its Impact in Mathematics*

Critical paradigm is an approach in research that aims to challenge dominant power structures and social inequalities. It entails challenging the status quo, examining power relationships, and promoting equitable society. The critical paradigm has been utilized in mathematics education to investigate problems with equality, diversity, and inclusion. One related study that employs the critical paradigm in mathematics education is about how the dominant Eurocentric view of mathematics education marginalizes and alienates students from non-dominant cultures. She argues for a re-humanization of mathematics that acknowledges and values diverse ways of knowing and learning. This work is a powerful example of the impact of the critical paradigm in mathematics education, as it challenges the dominant discourse and advocates for social justice (Gutiérrez, 2018). In order for students to answer word problems, math teachers must help them understand them completely. It will be difficult to motivate children to develop their problem-solving abilities given their low reading proficiency (Valencia, A. et al., 2023).

Another related study is discussing mathematics education for social justice in a Latino urban school. It examines how the critical paradigm can be applied in the classroom to promote social justice. It describes a mathematics lesson that engages students in analyzing the disparities in wealth and resources between their community and a wealthier, predominantly white community. Gutstein's work demonstrates how the critical paradigm can be used to create meaningful and relevant mathematics instruction that empowers students to critically examine social issues and advocate for change Gutstein, 2016).

In terms of its contribution to the mobilization and production of capitalism, classroom mathematics is increasingly being critically evaluated in studies on mathematical teaching (Pais, 2014), which perpetuates educational inequalities based on social socioeconomic status, ethnic background, and gender (Jorgensen & Niesche, 2018; Black, 2014. This work contends that school mathematics (and related credentials) serve as a "gatekeeper" by enabling society as a whole and its dominant organizations (such as colleges and universities, employers, etc.) to select individuals based on their "mathematical ability," which is regarded as a valuable source of human resources. This argument is particularly relevant to the current condition of mathematics education in England, where a new, more challenging curriculum has been in place since 2014 and only serves to further accentuate mathematics' exclusive standing in



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educational institutions. The concept of "gap gazing" was coined by Gutiérrez (2018) to describe the widespread concern among policymakers and researchers achievement discrepancies in the realm of math instruction (between the most and least privileged students or those from disadvantaged backgrounds), which have been linked to increased social inequality (Solomon, 2018).

To challenge dominant ideologies (including those relevant to education in general), criticisms of mathematics and mathematical education are essential and important. However, an ideologically grounded alternative must also be presented. This essay makes the argument for an alternate course of action by first examining the potential connections between social criticism and critical pedagogy. The relationship between reform—that is, progress while maintaining the same basic framework—and greater radical change is then examined in terms of society at large, education, and mathematics instruction (Noyes, 2019).

The requirement for action that addresses the issues that a critical perspective raises comes from our investigation. In particular, it implies collaboration among persons with a variety of viewpoints on the kinds and extent of necessary changes. We then take a quick look at the UK's Stand Up for Education campaign, which unites academics, teachers, parents, and trade unionists, to demonstrate that the viewpoint we are outlining here is not solely ideal or abstract. We wrap off by explaining why it's important for critical researchers that spaces exist for the crucial interaction of critical theory and study with practice (Williams & Choudry, 2016).

We start by examining the connection between critical mathematics pedagogy and criticisms of society or education. Here, envisioning and working for a world beyond capitalism—a shift that entails a total transformation of society—is arguably the most radical approach (Counts 2014; Freire 2015). There are some restrictions on how discussions about education in such a society might go. For example, if we presume, as we should, that moving beyond capitalism entails democratically elected collectively authority over society from the vast majority, afterwards those of us who have been so shaped by and operate within capitalist society aren't in the best position to decide or predict what might happen (Bowles & Gintis, 2016).

However, by assuming the opposite of the features of capitalist instruction that are currently believed to have negative effects, such as the individual-competitive test system that produces "losers" who internalize their failure as objective characteristics of themselves (Swanson, 2016), we can speculatively imagine how an alternative future education might operate. Then, we can combine these with the aspects of education that other people have struggled for (Lavalette & Cunningham, 2016) as well as sometimes implemented (such as the abolition of test taking and homework in revolutionary Russia [Karp, 2014]).

We can draw parallels between critical mathematics education (in the wide sense of the term critical) and many of the more fundamental demands of radical educationalists. For instance, we see pedagogies that encourage teaching for comprehension as opposed to grades and place an emphasis on social learning and conversation (Lerman, 2016), as well as a more significant math curriculum that's associated with the world around us, student experiences, and problems (Gainsburg, 2018). Though not all of the worst effects of capitalist schooling are mitigated, this aids pedagogy in some cases. Here we argue that it is valuable to undermine environments like the classroom as much as possible in these areas, perhaps in opposition to some ideas in critical MER. There is much to be gained from many approaches to critical mathematics education that aim to give low status, underprivileged, or "poor" learners and communities curriculum and pedagogies that have "use value" (Skovsmose & Greer, 2014).

*Post-Modern Paradigm*

The traditional view of mathematics as a science that is stable and objective is challenged by the post-modern paradigm in mathematics, which instead stresses the subjective and cultural components of mathematical knowledge. By referencing post-modernist concepts from philosophy and social theory, this viewpoint has had an impact on a variety of fields, such as mathematics education, mathematics history, and mathematics philosophy. These studies emphasize the crucial part that post-modern theories can play in influencing how we perceive mathematics as a subject that is intricately entwined with social and cultural settings. Post-modern viewpoints can contribute to the development of a more inclusive and varied discipline that is more adapted to meeting the needs of all learners by challenging conventional conceptions of mathematics and highlighting the subjective and cultural components of mathematical knowledge (Sfard, 2018).

Postmodernism, one of the biggest philosophical as well as cultural revolutions of the 20th century, but also one of the most misunderstood, in part because it rejects being limited by a predetermined set of characteristics. Since postmodern epistemology evaluates information based on its usefulness and functionality, it is important to promote the use of computers in mathematical idea discovery and verification. In spite of the fact that computational proofs merely imply a probability rather than a certainty of a mathematical conclusion, they are equally legitimate as the conventional axiom-definition-conjecture-proof procedure under the aforementioned criterion. Math teachers should also promote the use of intuitive explanations and different methods to problems. In order to show how dynamic mathematics is, non-Euclidean structures should be a common occurrence in mathematical discourse (Izmirli, 2017).

A philosophical philosophy called postmodern mathematics was created as a complement to postmodernism. According to the notion, there is no concept of "absolutism" or ultimate truth in mathematics. This idea originated from the relativity of truth postmodernist theory. According to the postmodernist perspective, mathematics is learned more for utility than for knowledge. They also make claims about how students may contribute to curriculum development and the teaching of mathematics. Postmodern mathematics, which emphasizes the diminishing of the notion of objective and



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absolute power in mathematics, claims that a "notion of 2 + 2 = 1" may be true given particular subjective circumstances. However, this does not imply that the concept may be utilized in any "personal situation"; rather, it depends on the numerical context and circumstances in which it is used. In mod arithmetic, for instance, 2 + 2 = 1 holds true even if it would never do so in any other context (Frederick & Sriraman, 2017).

Additionally, postmodern education promotes the use of computers and technology in the search for novel mathematical concepts. Although postmodernism indicates that these ideas are questionable, they can yet have at par or a higher "degree of truth" as those that have been established and discovered via conventional means. The rejection of uncertainty also asserts mathematicians and other scholars to work toward a greater level of truth for human understanding, which promotes additional investigation and study. This further greatly increases human knowledge. Teachers, students, and researchers in mathematics are encouraged by postmodern education to place more emphasis on criticism than evaluation of the accepted mathematical truths. It states that rather than concentrating on what "mathematics" is, mathematicians should consider what it may and might be. It encourages constant critique of the mathematical notions and makes an effort to disprove them in order to raise the degree of truth within mathematics education (Ernest, 2015).

*Multi-Paradigmatic Research*

Multi-paradigmatic research in mathematics is a relatively new approach to studying mathematical phenomena that seeks to integrate multiple perspectives and paradigms within the same study. This approach recognizes that mathematical phenomena are complex and multifaceted, and that different perspectives and paradigms can shed light on different aspects of these phenomena (Li, 2015).

Multi-paradigmatic research in mathematics has been employed to investigate a variety of themes, including mathematical problem-solving, mathematical learning, mathematical reasoning, and the use of technology in mathematics education, according to a survey of related works in the field. An examination of the problem-solving techniques employed by a group of students working on a mathematical exercise using a combination of theoretical frameworks, including activity theory, situated cognition, and social constructivism. In their work, Borba and Villarreal (2015) emphasized the significance of taking into account various viewpoints and paradigms when researching mathematical problem-solving.

Another example that used a multi-paradigmatic approach to study mathematical reasoning in the context of geometry is that they drew on multiple theoretical frameworks, including sociocultural theory and radical constructivism, to analyze how students constructed geometric knowledge and reasoning in a classroom setting. Their study demonstrated the potential benefits of using a multi-paradigmatic approach to study complex mathematical phenomena (Herbst & Chazan, 2015).

An example of a study that employed a multi-paradigmatic approach to examine the usage of technology in arithmetic education is the work of Hitt and Santos (2018). They examined the ways in which technology was utilized to promote mathematical learning in a middle school classroom using a variety of theoretical frameworks, including activity theory and critical theory. Their research emphasized the significance of taking into account various viewpoints and paradigms when examining the utilization of technological devices in the teaching of mathematics.

*Mathematical Abilities of Students*

Materials of math are offered not just to teach memorization skills but also to train mathematical understanding skills. The students' confidence in their abilities to solve the presented problems has an impact on their mathematical understanding (Lambertus, 2016). The results showed that the three measures of students' mathematical comprehension ability—translation, interpretation, and investigation—were successfully mastered by students in the high self-efficacy category. They cannot, however, complete the exploration indicator. Translation and interpretation skills can be attained by students who fall into the moderate self-efficacy category. Students with low self-efficacy can only study translation; they cannot meet the criteria for interpretation and investigation. Accordingly, the students who have high, moderate, or low self-efficacy are able to master the indicator of mathematical knowledge, depending on each student's level of comprehending abilities (Marion et al., 2015).

Understanding mathematics is essential for comprehending both common problems and mathematical puzzles. A meaningful understanding of learning mathematics should be centered on the creation of mathematical connections between distinct ideas and a grasp of how mathematical concepts relate to one another. This will make it possible to fully comprehend and use mathematics in situations outside of those related to mathematics. The majority of students' difficulties in demonstrating were brought on by their ignorance of basic mathematical definitions and concepts, which prevented them from building mathematical proofs, accurately using mathematical notation, or using mathematical language. Students' mathematical proving skills are undoubtedly related to their mathematical understanding skills (Aimee & Richard, 2014).

There are three different types of understanding: translation, interpretation, and investigation. Understanding an idea expressed in a different way than how it was originally stated is known as translation. For instance, students can translate a narrative through a numerical sentence; interpreting is the ability to comprehend and connect information or ideas learned in the past; this is followed by a thorough explanation of the problem; and exploration is the ability to comprehend that one can draw conclusions and provide perspectives on a problem. Understanding a pupil's mathematical aptitude is essential because it allows a teacher to be aware of the challenges that a particular student may be facing. Based on that information, the teacher can create the appropriate lessons to ensure that the material is given effectively and that student achievement rises. It is essential to understand the challenges



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that students experience, and focusing on particular mathematical skills may result in a more meaningful teaching and learning process (Tambychik, 2016).

With the needs of the 21st century motivating students to carry out the original of human resource performance, education should now be targeted toward achieving those demands. The goal of this study is to ascertain whether there is a relationship between students' math achievement and that relationship's contribution to that relationship. The study's conclusions show that students' capacity to make connections between concepts had a substantial impact on how well they learned mathematics. According to research on the impact of mathematics connection ability to students' math learning accomplishment, students' math learning achievement is highly influenced by their level of mathematics connection ability (Ndiung & Nendi, 2018).

Six mathematical skills, including problem-solving, argumentation and evidence, interactions, connections, and representation, are employed in the teaching of mathematics, according to the NCTM (2014). The ability to connect mathematical concepts is another important aspect of conceptual comprehension, according to the National Council of Teachers of Mathematics (NCTM). For grades pre-kindergarten through twelve, this standard has two separate parts. To begin with, it makes connections between and within mathematical topics easier. Students learn to link different mathematical concepts in order to construct a web of ideas that are interconnected. Second, the norm mentions connections between various fields of study and the external world. Thus, kids may understand how crucial mathematics is to social studies, art, and science. In essence, it recommends that mathematics be integrated with other academic disciplines and that practical implications be looked into. Making the connection enables the mathematical ideas previously taught to act as a strong foundation for grasping a new subject (NCTM, 2014).

The ability of students to improve their mathematical link capability and its N-Gainas was influenced, in accordance with pertinent studies, by their earlier levels of arithmetic proficiency. Therefore, before teaching the more complex elements, the instructor needs to pay closer attention to understanding the required mathematics materials. Students' levels of confidence were still average. The process of boosting students' self-confidence is ongoing, therefore developing this quality takes time. Then, Boyaci & Atalay (2016) did their research. The examination of the literature on studies regarding 21st century skills revealed that there did not exist universal agreement on the skills that students should have and that there were differences in some areas. According to Hendriana et al. (2014), among the subdimensions of 21st Century education and creative abilities include inventiveness and originality, critical thinking and solving challenges, cognitive skills or skills related to the individual, working together and interacting, and inter-personal skills.

Researchers observed the mistakes and spoke to the teachers about them. It was discovered as a result that teachers have been putting their learning—which continues to center on the teaching and application of mathematical formulas—into practice. The cornerstones of problem-solving in the real world—understanding mathematical concepts and helping students develop their mathematical thinking skills—are not adequately emphasized in teachers' training. In the classroom, professors frequently give students simple tasks that only require applying formulas with a few different variations. Due to this, they are less able to fully engage with the information and frequently fail to analyze the difficulties they have learned (Lubis et al., 2017).

The student's aptitude for using "What If"-Ethnomathematics Instruments to solve actual ethnomathematics problems is still insufficient, and this includes faults in comprehension, representation, reasoning, and "What-If" Question responding. In the guided reinvention stage, where they are required to rediscover characteristics, theorems, definitions, or methods through activities, students also have trouble. Additionally, they have difficulty with didactic phenomenology and self-developed models, which makes it challenging for them to link their understanding of concrete to abstract circumstances or from informal to formal mathematics and establish their own way of thinking. According to the interview's findings, teachers frequently give instruction that emphasizes the delivery and application of formulas while ignoring students' conceptual knowledge and developing thinking abilities. Therefore, in order to improve the ability of learners to solve mathematical problems and RME success, teachers must design curriculum that routinely delivers more accurate and projected issues so that students can more effectively relate mathematical concepts with the actual world (Allen et al., 2020).

*Critical Thinking Abilities of Students*

The ability to think critically is crucial for success in contemporary complex and evolving world. It calls for analytical, evaluative, and synthesizing skills as well as the capacity for independent, creative thought (Tinapay et al., 2021). Critical thinking is crucial in education because it enables pupils to learn and solve problems more effectively. Critical thinking is an important indicator of academic and job achievement as well as of personal satisfaction and wellbeing, according to research. Thus, it is crucial for educators to encourage the growth of their students' critical thinking abilities (Facione, 2015).

The word "critical thinking" is widely used to refer to self-regulation that involves employing facts, concepts, methodologies, criteria, or contextual factors as the foundation for understanding, analyzing, assessing, inference, and exposure (Facione, 2016). According to Choy and Cheah (2019), critical thinking is the ability to process high-level cognitive information and reflect on what is thought or done. Basic classification abilities, decision-making abilities, drawing conclusions, offering additional justifications, estimating, integration, and other abilities are all examples of critical thinking capabilities. Making fair, logical, and thoughtful decisions requires the use of critical thinking (Tirol, 2021). Additionally, critical thinking refers to the process of responding to a notion or theory that has been presented to us. The ability to objectively assess and make clear, defensible



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decisions about what to do or what to believe is required for the reaction. In the context of this study, the capacity to make decisions based on mathematical information, mathematical ideas, mathematical procedures, or mathematical standards is known as the the ability to think critically (Sutrimo et al., 2019).

Critical thinking constitutes one of the skills that are stressed in mathematics learning, along with problem-solving and creative thinking (Widodo et al., 2019). To solve mathematical problems and overcome challenges in social circumstances, students need to be able to think critically (Fakhriyah, 2014). Teachers frequently push students to give precise answers, but they hardly ever give instruction on how to build critical thinking skills. Math teachers will lose their cool if students can't come up with the correct solutions. Even fresh solutions proposed by students are constantly questioned by the teacher as to their validity (Dagar & Yadav, 2016). pupils' critical thinking skills are also inadequate as a result of teachers' methods of encouraging pupils to retell, define, describe, and register rather than analyze, draw decisions, link up, combine ideas, condemn, establish, evaluate think about, and rethink. Students' ability to think critically in connection to solving mathematical problems deteriorates as a result of a lack of critical thinking instruction during the learning process. The 2015 Trends in International Mathematics and Science Study (TIMSS) results, which rank mathematics scores at 45 out of 50 countries, highlight students' lack of critical thinking skills. This capacity is still only very slightly developed, according to the reasoning domain (Mullis et al., 2016).

The development of students' critical thinking skills depends on several factors, including the formation of an interactive learning environment, the understanding that students are thinkers rather than learners, and the role of the teacher in the role of mediator, facilitator, and motivator (Tirol, 2022). A teacher can use technology to create an engaging learning environment while also encouraging students to listen to authentic materials, incorporate them in group projects, modify the classroom's setting, and get them thinking (Tinapay et al., 2023). One style of education that teachers can use to assist students in developing their critical thinking skills is advocacy learning. This student-centered learning technique typically includes the conversation process (Fox & Wiens, 2019).

Teachers of mathematics can utilize advocacy learning as an alternate method of instruction to engage their pupils more fully in the study of mathematics. Students participate in advocacy learning by debating solutions to math problems provided by the teacher and sharing their ideas and arguments. Students are encouraged to get involved actively during class activities using a teaching technique called advocacy learning. The use of an advocate learning technique is designed to enhance the results of student learning and enable students to actively participate in conversations, ensuring that students' mathematical critical thinking skills are suitably developed (Haryanto & Suhartono, 2019).

A lot of advocacy learning has been applied to social science, civic education, or subjects with similar characteristics to those two subjects. The hallmarks of the advocacy include disagreements between students on particular themes, concerns that are seen as crucial for students, and topics that are focused on their needs and interests (Sumarwoto, 2019). Mathematics and other precision sciences can benefit from the advocacy learning. Mathematical difficulties are presented to students as part of the aforementioned adaptation. Students should be able to evaluate information, formulate questions, ask questions, gather information, assess pertinent material, be receptive to and explain useful mathematical outcomes in order to strengthen their critical thinking skills. This finding is consistent with earlier study, which found that assigning math problems to children can enhance their ability to solve arithmetic issues and foster the development of their critical thinking abilities (Chen & Hu, 2018).

The link between mathematical ability and advocacy learning has been the subject of several studies in the field of mathematics education. For instance, research links mathematical connection skills with advocacy to solve mathematical issues (Nurhasanah & Julyanti, 2019). On the other hand, there is little research on advocacy learning that fosters critical thinking skills in mathematical education. This study does not make use of students' prior knowledge, which is one of the research's main foci. The results of the study could be influenced by the students' prior knowledge. The ability of pupils to investigate and evaluate information, ask questions, obtain information, formulate questions, and assess information is enhanced by the presentation of mathematical problems in advocacy learning, as was already mentioned. Combining advocacy learning with problem-solving in mathematics is essential for enhancing mathematical critical thinking. This study establishes connections between students' prior knowledge, critical thinking skills, and learning about advocacy. The study's problems are formulated in light of these challenges, and one of them is figuring out whether students who use advocacy training using open-ended issues show an improvement in their critical thinking skills at each level of their baseline competency (Asmara et al., 2016).

Students are expected to be able to identify and solve problems in order to come to a decision according to indicators of logical thinking (Tirol, 2023). This indicator evaluates how well students can explain and comprehend diverse components in order to develop a new formula. At this point, student activities are examined as they pertain to how students arrive at mathematical formulas by applying the appropriate concepts, principles, laws, and principles based on the identification outcomes that have been carried out in accordance with their fundamental conceptual skills and how to derive equations in order to produce equations in novel forms (Nuryanti et al., 2018).

Students use convergent thinking, also known as critical thinking (CT), when studying mathematics. Based on the students' degree of mathematical competency, this study aims to develop a complete picture of their mathematical Critical Thinking (CT) abilities. The more diverse a student's thought processes are when solving problems involving algebraic functions, the better their level of mathematical proficiency.



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These results are anticipated to assist educators in enhancing students' counseling abilities (Lisnawati, 2020).

## III. Conclusion

As an overall view, students who are taught mathematics using open-ended questions have a better capacity for critical thought than those who get traditional instruction. Due to the development of their mathematical critical thinking skills, learners who had a high degree of prior knowledge outperformed those with low and moderate levels. Advocates encourage math teachers to use advocacy leaning as a substitute teaching strategy so that students can improve their critical thinking skills. The study results were restricted to the issue of set and only focused on the use of critical thinking and prior knowledge in order to encourage other researchers to carry out similar research by taking into account the variety of materials for instruction and students' abilities (Tinapay & Tirol, 2021). Students should possess the ability to think critically. As a result, schools should be in charge of fostering and evaluating critical thinking skills throughout the process of learning and instruction (Tinapay & Tirol, 2021).

In today's complicated and dynamic environment, thinking critically is a highly regarded skill. One of the main areas of school where critical thinking is encouraged is mathematics. Numerous studies have looked into the connection between critical thinking abilities and mathematics education, concentrating on how teaching mathematics might help students develop their critical thinking abilities. Many researchers have emphasized the need for valid and reliable assessments that measure students' ability to reason logically, solve problems, and communicate their thinking clearly and effectively. Units, assessments, and the scope and sequencing all follow the standards. At least three to four times per year, assessments with the right level of difficulty and alignment to state standards are given to pupils to see if they have understood the material. The scope and chronology of the lesson include time for corrective instruction. Instructional materials with key ideas, essential questions, and recommended materials, including content-rich texts, are used across classrooms (Tinapay,2021)

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