EXPLORING STUDENTS' MATHEMATICS GROWTH MINDSET: A GROUNDED THEORY APPROACH

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ABSTRACT: *This study adopted a grounded theory approach to qualitatively explore students' basic patterns of experiences in learning secondary mathematics and collect explicit descriptions of their experiences to understand their unique perception of mindset in mathematics. For this study, high school students from grades 7 to 11 with mathematics subjects currently enrolled in the school year 2022-2023 at Casisang National High School served as the participants. Since the objective of this study is to elicit the student's story of the phenomenon understudy, a semi-structured interview was the preferred method for the data collection, and constant comparative analysis was employed for the data analysis. Results revealed two distinct factors of students' mathematics mindset, fixed and growth. This study concludes that a fixed mindset in mathematics comprises three constructs: inferiority behavior, dependent-seeking tendencies, and personal attribution. A growth mindset has three dimensions: grit, adaptive coping strategies, and appreciation. This study opens the scope for scholars in the field to quantitatively investigate high school students mathematics mindset using the factors in the emergent theory of this study through developing appropriate measurement tools.*

Keywords: Education, Mathematics Mindset, Growth and Fixed Mindset, Grounded Theory, Philippines

I. INTRODUCTION

A growth mindset is a desirable attribute for students because it can help them overcome obstacles while learning something new. Students having a growth mindset understand the importance of persistence and determination. Students who possess a growth mindset maintain the belief that intelligence is not a fixed trait, but rather a malleable one that can be improved through hard work and support. It directs them to deal with thought-provoking tasks bravely, persist through challenges by trying different strategies, and eventually achieve greater academic success [1; 2].

An increasing amount of evidence indicates that a growth mindset is a crucial factor in students' math academic achievement since it is a belief that one's abilities in mathematics can be developed [3]. Studies that are pertinent to the subject have suggested that cultivating a growth mindset towards mathematics is crucial for students to perceive their math abilities as malleable, with effort as an essential element to perform well and become better at it [4, 5]. Perhaps, this non-cognitive construct is vital to strengthening students' persistence in mathematics through hard work rather than giving up in the face of adversity while learning mathematics [6].

In the Philippines, an issue faced by students in the present is the lack of mastery of skills and lingering stigma in high school mathematics. As a consequence of this present-day issue, students have exhibited subpar performance in their comprehension of mathematical concepts, lack of proficiency in computational, visualization, and problem-solving abilities, as well as other essential skills and processes required to acquire a strong foundation in mathematics [7]. A large proportion of the students undeniably have the greatest difficulty in this subject [8] and believe that high school mathematics subjects are for intelligent individuals only.

Understanding Filipino students' mindset in mathematics would give educators and stakeholders an idea to help better improve students' mathematics performance and an opportunity to contextualize strategies and approaches in delivering mathematics lessons. This study aims to qualitatively explore students' basic patterns of experiences in learning secondary mathematics and collect explicit descriptions of their experiences to understand their unique perception of mindset in mathematics. This study adopted a grounded theory approach because of its appreciation and attention to the data while purposively exploring the mathematics mindsets of high school students.

II. METHODS

Research Design

This study utilized a grounded theory method because its intensely inductive approach to the data guarantees that students' perceptions and experiences in learning mathematics were highly valued. Symbolic interactionism underlies the development of grounded theory, as it posits that individuals negotiate and comprehend meaning through their interactions with others within social processes [9; 10].

Grounded theory is an interpretive method suitable for generating research-based data about the behavioral pattern through people's interactions within groups which shape social processes. It is founded on the notion that shared patterns arise as individuals within a group construct meaning and define situations that involve themselves and others [11; 12].

In this approach, the researchers are not involved in defining the problems in a particular context that has yet to be discovered. However, only those people interacting in a setting define their problems [13]. Thus, rather than describing what should happen, it explains the actual setting in practical life at a particular time.

Research Participants and Sampling

The grounded theory approach utilizes theoretical sampling, and as such, this investigation employed purposive sampling to select participants with varying experiences of the phenomenon being examined.

Specifically, maximal variation sampling was used to find diverse high school students with different perspectives that can be a valuable source of the necessary information to understand and explore the multiple dimensions of the central phenomenon [14].

In order to generate rich data sets, large samples are not necessarily needed since a person can generate hundreds of concepts or experiences understudy. For this study, fifteen high school students from grades 7 to 11 with mathematics subjects currently enrolled in the school year 2022-2023 at Casisang National High School served as the participants.

Table 1. **Demographic Information of the Study Participants**

Participant	Age	Sex	Grade Level
P1	16	Female	11 (STEM Track)
P2	17	Male	11 (STEM Track)
P3	16	Female	11 (STEM Track)
P4	15	Male	10
P5	15	Female	10
P6	15	Female	7
P7	15	Male	9
P8	14	Female	8
P9	15	Female	9
P10	17	Female	11(GAS Track)
P11	15	Female	11(GAS Track)
P12	15	Female	11(GAS Track)
P13	13	Female	8
P14	15	Male	11 (STEM Track)
P15	15	Male	10

Data Collection

It is often in qualitative research to use interviews as a strategy for data collection, especially in grounded theory, while other techniques such as observing or closely analyzing existing texts can yield valuable data. It can, however, pose potential intrusiveness and logistical difficulty [15;16]. Since the aim of this study is to extract the personal narrative of the phenomenon being investigated from the student's perspective, a semi-structured interview was chosen as the preferred approach for gathering data. In this method, both the researcher's and the student's words were understood as spoken and intended. The researcher posed questions and assumed the role of a listener as the students provided descriptions of their encounters with the central phenomenon.

The researcher asked probing questions to encourage the students to elaborate on their detailed lived experiences to achieve clarity on the variable of interest [16]. The semi-structured interview was best suited for this study because it enables the researcher to ask probing, open-ended questions, and an in-depth reconnaissance to explore students' independent thoughts and experiences while learning mathematics [17].

Data Analysis

The constant comparative analysis, a controlled methodology, was employed for the data analysis in this study. The aforementioned distinct process engages the researcher to collect and analyze data simultaneously [18]. The process of data analysis commences at the start of data collection, involving the examination of the data into small details or indicators. In the initial interview, the researcher initiates the analysis by taking notes and consistently scrutinizing the gathered data in detail.

This method is comparative in nature, as it methodically compares the indicators to one another, as well as to the data acquired during subsequent interviews. The main objective of this analysis is to identify similarities and differences that facilitate the process of inductive coding and the development of concepts, categories, hypotheses, and theories. Thus, at each stage of this study, the researcher continually revisits the starting point of the analysis and proceeds with the process of analyzing, identifying similarities and differences, writing memos, and coding. Simultaneously, they are involved in analyzing, comparing, and extracting information from the data [19].

In this study, the researcher transcribed each interview within two to three days and proceeded directly to the coding stage. After each interview, the researcher transcribed and coded the gathered information and added the newly collected data to the existing data. In each interview, new categories were expected to emerge and be added, and then the existing categories were combined or redefined to accommodate the collected data. The process continued until data saturation was reached, and all the newly collected data were incorporated into the existing categories without adding, combining, or redefining the categories.

III. RESULTS AND DISCUSSION

Main Categories

The student's accounts were investigated by conducting a comprehensive analysis of one category at a time, linking each category and evaluating if it has any potential relationship at the conceptual level. This was then followed by identifying the association between each category and the central category under consistent comparative analysis. The six (6) main categories or themes deduced from the participant's descriptions were: (1) Grit; (2) Inferiority; (3) Adaptive Coping; (4) Personal Attribution; (5) Appreciation; and (6) Dependent Help-Seeking Tendencies.

Theme 1: Grit

This theme refers to student's capacity to overcome challenges, thrive despite difficulties and failures, challenge seeking, having passion and perseverance to accomplish complex tasks, have a strong sense of determination to achieve goals, be diligent and willing to do extra work and take the initiative to further learning and understanding while refuting the common assumptions that natural talent or intelligence such as IQ is the definitive measurement of mathematics achievement. The students' mathematical grit for this study is composed of three essential components, which are tenacity, resilience, and initiative. The capacity to maintain focus on their mathematical goals is referred to as tenacity among students. Resilience is the student's ability to bounce back despite mathematics adversities, failures, and obstacles. The initiative is the student's efforts to use available technological tools to supplement mathematics understanding and learning. Together, the three essential components make up the student's mathematics grit.

The non-cognitive factor of grit has been defined by different researchers in various ways. For instance, Duckworth et al. characterize it as a combination of persistence and devotion toward achieving long-term objectives [20]. It involves

exerting significant effort in the face of challenges and maintaining one's commitment and enthusiasm toward achieving learning objectives despite setbacks and hardships. They claimed that grit is the most influential factor in achieving an individual's potential rather than talent. They refuse to believe that natural talent or intelligence, such as IQ, is the ultimate determinative factor in students' achievement [21].

Alternatively, Thaler and Koval described grit as a consequence of persevering through difficult circumstances, taking calculated risks, possessing unwavering determination, and tirelessly working towards a goal [22]. The ability to tackle challenges, persist in the face of difficulties, and accomplish complex tasks during crucial moments constitutes grit. This concept encompasses four vital components: guts, resilience, initiative, and tenacity. Guts refer to the courage to take calculated risks, while resilience involves remaining focused and motivated despite obstacles. The initiative represents being a self-starter, making a person dynamic and able to set things in motion. Tenacity is the unwavering ability to stay focused on a goal. Overall, grit is a quality that can be developed by working harder, smarter, and with passion for a longer period of time to achieve a goal, even if the person lacks exceptional intelligence or talent.

"When I face that difficulty, you must not only have stock knowledge, you must be persistent in studying, you must not rely on others, you must have your own confidence in yourself. So, I tried volunteering to answer on the board. I was trying to see whether what I was studying was correct or not." [P1; P3; P4; P5; P6; P7; P8; P9; P10; P11; P12; P13; P14]

Theme 2: Inferiority

This theme refers to students' inferiority behavior which stems from their perceived inadequacies against other learners and themselves while learning mathematics. The students' descriptions of their experiences substantiated some studies that inferiority is a common prevailing phenomenon among high school students, especially in an institution emphasizing test scores as the parameter of successful learning. Furthermore, the data indicated that psychological disorders such as low self-confidence, study difficulties, and challenges in handling setbacks contribute to students' sense of inferiority, and there was no notable difference in this regard between junior and senior high school students [23; 24; 25].

Accordingly, it is challenging for students to circumvent themselves from comparing their academic performance to other students in schools. Upon realizing that others possess what they desire but lack, individuals may experience a range of complex emotions, including inferiority, hostility, and resentment. If students choose to escape and not actively make up for their inadequacies, they will develop an inferiority complex which could result in psychological abnormalities [26]. In relation to the participants in this study, some admitted that comparing their mathematics performance to other students was unavoidable. They felt inferior to other students who have what it takes to do mathematics and the talent to pursue it.

Additionally, the emotions of inferiority are amplified when an individual faces discouragement or failure, and eventually inferiority complex occurs. Individuals who have low self-esteem or self-worth, come from a low socio-economic background, or have a history of depressive symptoms are more susceptible to developing an inferiority complex. [27]. Once fully established, the inferiority complex can affect a person's self-esteem and performance [28]. As noted by Kalaivani (2017) and Manoranjan and Srivastava (2017), a student's academic success or failure can engender feelings of superiority and inferiority [29; 30]. Students with an inferiority complex may exhibit unfavorable qualities such as passive dependence, inadequate social skills, pessimistic attitudes, and overall incompetence, which can hinder their motivation to learn or even lead to giving up [31; 32]. Regarding the study participants, in terms of mathematics, students experiencing failure and low esteem are at risk of developing an inferiority complex.

"I'm upset that I'm not like other people who are so talented. It's like he's better because he can answer this, it's so easy for him. I pity myself because I feel so stupid. So, I'm afraid to answer math now because I can't ask for help, I can't ask anybody's help in math." [P1; P2; P5; P7; P8; P9; P12; P13; P14; P15]

Theme 3: Adaptive Coping

This theme refers to students' positive help-seeking and problem-focused coping while in the process of learning mathematical concepts or solving problems. The students' positive help-seeking behavior pertains to seeking someone's help to forward learning which was rooted in their intrinsic motivation to learn and desire to progress in mathematics. Regarding the student's learning setting, help-seeking behavior is defined as the methods utilized by the students and using external resources while learning or trying to solve problems [33]. In the context of a mathematics classroom, after students determine that help is needed, the most fitting people to seek help would be the teacher and informed, well-rounded peers. Students' help-seeking behavior would benefit not only in improving the cognitive and social abilities of the seekers but also those of the helpers [34; 35].

Likewise, the student's problem-focused coping is about their strategies to handle or manage their mathematics stressors, such as accepting, cheering, comforting themselves, taking a break or rest, smiling to soothe frustrations, staying positive, and believing they can do it. Problem-focused coping refers to a style of coping that is oriented towards tasks, which involves taking active steps to solve the problem or minimize its negative effects [36]. Hence, when students encounter challenges in mathematics, coping strategies focused on problem-solving involve directing their attention towards the difficulty caused by the problem., working hard to resolve the difficulty, focusing on the positive side, and seeking relaxing diversions and physical recreation [37].

An individual's management of specific external or internal stressors that lead to cognitive and behavioral changes is called a coping style [38; 39]. One of the two main categories of coping strategies is positive or adaptive [40]. Adaptive coping

strategies such as self-regulation, planning, help-seeking, and self-evaluation increase students learning and improves students' chance to do better at the task in succeeding attempts [42]. Adaptive coping features both help-seeking behavior and problem-focused while dealing with mathematics difficulties since both are positive strategies the students use. Hence, the students help-seeking behavior and problem-focused coping in handling or managing their difficulties in mathematics can be encased into adaptive coping strategies.

"What I did in problem-solving was that I sought guidance, like from my sister, I asked her questions that could possibly help me find answers in solving the problem." [P1; P2; P4; P6; P7; P8; P9; P10; P11; P12; P14]

Theme 4: Personal Attribution

This theme refers to students' lack of mastery and their personal preferences in mathematics. In the academic field, students' successes and failures are often attributed to their ability, effort, task difficulty, and luck [45].

The lack of mastery pertains to student's failed expectations, bad trip moments, blaming one's capacity or ability, disappointments, being scared or backing off, fear of failure, becoming anxious, self-doubt, confusion, and accepting being dumb at math, overthinking, exhaustion, dismayed, hopelessness, and upsets were results because of their lack of mathematical skills that are low in comprehension, inept experience in math, not confident or too confident, lack of mastery, poor in recalling, and limited reasoning and analytical skills.

The student's description above conforms to the study of Tambychik and Meerah (2010), who found that the lack of many mathematics skills can cause difficulties in solving problems [43]. The incomplete mastery of number facts, computational weakness, and difficulty in making connections, comprehending, and visualizing mathematical concepts are factors that contribute to the lack of mathematics skills. This deficiency in mathematical skills could result in errors and confusion while solving problems. Also, students who lack imagination and experience, struggle to comprehend critical information, and have a disinterest in the problem's length and complexity, find it challenging to solve the problem, leading to demotivation [44]. Consequently, students may eventually lose interest and refuse to learn further with continuously low performance in mathematics [45].

Meanwhile, personal preferences are about students' attitudes toward math. Attitudes refer to finding math boring, getting tired of it, being lazy about doing and understanding it, and for them, it is just for the sake of grades, not because they want to learn it. Furthermore, they already believed that mathematics is not their thing; it is stressful and perplexing, and they have no care for it and would rather avoid the subject. Hence, attitude comes in different forms but is interconnected with belief, value, interest, and opinion [46]. Thus, it influences students' preference for whether or not to engage with mathematics [47].

"Equation, parallelogram, quadratic, when I look at math, I get tired of it, I feel so lazy doing it, it's very difficult. It's just stress, I also get tired when it's difficult. I don't like it, but I just accept it. Yes, but most of all the reason is being lazy." [P1; P2; P3; P5; P6; P7; P8; P9; P10; P11; P12; P13; P14]

Theme 5: Appreciation

This theme refers to students' being inspired by others or peer influence and their recognition of the importance of mathematics. Others inspired students to pursue mathematics amidst their shortcomings instead of feeling less than them. Being inspired that they could do the same because others have done something that was for them seems impossible. It includes exploring what others have learned or achieved in mathematics. They also enjoyed seeing other students solving math and being influenced to do the same. Undeniably, in the classroom context, students' social setting where they find themselves does not promote learning in isolation; instead, they interact with each other to develop and create new knowledge, which endorses effective teaching and learning experiences [48].

Peer influence refers to the act of one person motivating or persuading another person to engage or refrain from action, regardless of the latter's desires or intentions [49; 50]. Hence, students' experiences of being inspired by their peers in this study support some research results, which reported that in an academic setting, students perceived their peers as potential helpers and were significant contributors to their academic performance [51]. Also, students' beliefs, such as hoping that through their peers they can also do mathematics problems, can be supported by the findings of Liu (2018), who found out that students who received more social support showed better performance and growth in mathematics, highlighting the significant influence of social support on mathematics achievement [52].

From students' accounts, they recognized that mathematics can be fun, amusing, and enjoyable. Also, it includes appreciating the beauty and importance of mathematics in their day-to-day activities, the benefits of its application, and how they can have fun talking with their friends about it. Hence, the students' descriptions are aligned with the study of Ward et al. (2010), who found out greater appreciation of students for the creativity involved in doing mathematics [53]. Accordingly, the definitive goal of exposing students to mathematics problems is to be able to conduct mathematical investigations by themselves, apply them in real-world situations, and assist them in their daily lives [54], which was what students experienced in this study.

Accordingly, students who appreciate mathematics do not make excuses by blaming others when in fail but tend to accept the social environment and are responsible for their actions. Hence, the study of Leonard (2017) supports the participants' account after finding out that one of the factors that directly and indirectly influence mathematics learning achievement is the student's level of appreciation [55]. For this study, students are not threatened by others' mathematics capabilities but

instead inspired by them while recognizing the joy, fun, and importance of learning mathematics.

"For me, since grade 6, I wasn't interested, but when I came to high school, I saw that there were many bright students, then they were good at math, then I enjoyed seeing them like they enjoyed solving and I feel like being influenced doing the same. It's how they feel when solving in math, so I was inspired that I could do the same." [P1; P3; P4; P6; P8; P9; P14; P15]

Theme 6: Dependent Help-Seeking Tendencies

This theme refers to students' reliance on learning and taking advantage while learning mathematics. Reliance on learning means they rely on others to improve mathematics performance, but without them, they will not move forward or even try. They tend to rely on the knowledge of others and are teacher dependent for understanding. It also includes blaming the teacher's way of teaching and their lack of explanation without even asking questions or clarifying what was not clear to them.

In addition, they are okay with taking advantage of their relationships or bonds with their classmates to achieve mathematics goals. They used their connections or any available means to attain their mathematics objectives even if it would harm their relation or bonds to others.

According to Newman (2000), dependent help-seeking behavior is the a student's inclination to seek assistance immediately when faced with challenges [56]. The students accounted in this study that the minute they encountered mathematics difficulty, they would immediately look for help because they were worrying about getting low marks in mathematics which is aligned with the investigation of Butler (1998) that individuals who excessively seek help are prone to experiencing anxiety regarding their academic performance. [57].

Similarly, the students narrated experiences include that instead of looking inward for an answer, they would look for others for support and assistance, which is similar to the finding of Ryan et al. (2005), who discovered that overly dependent students on seeking help in mathematics reported higher levels of anxiety on their performance [58]. Also, they felt they could have been more efficacious about their capabilities. Rather than persisting independently, they would seek help from their teacher when they experienced challenges in learning mathematics.

"It's like I'm discouraged. I don't like solving math anymore. I will just ask for their answer, I will not solve, I will beg for the answer, it was like that." [P1; P3; P4; P6; P8; P9; P14; P15]

Core Categories

The core categories were mined through spindle coding and by systematically examining the relationship between them and the main categories. During the continuous comparative analysis, it was observed that the core categories were consistently more dominant than other categories, and they effectively explained the relationship between most categories within the theoretical framework. These core categories provide comprehensive coverage of most categories. The two (2) core categories or themes deduced from the participants' descriptions are shown below:

Core Theme 1: Growth Mindset in Mathematics

A growth mindset in mathematics is the student's belief about the malleability of their mathematics intelligence through exhibiting grittier behavior, employing adaptive coping strategies, and fostering appreciation towards the subject when responding to adversities and setbacks while learning mathematics.

Core Theme 2: Fixed Mindset in Mathematics

The fixed mindset in mathematics is the student's belief that mathematics intelligence is a fixed trait that cannot be changed through demonstrating inferiority and dependent help-seeking behavior when responding to adversities while learning mathematics, and attributing their experienced failures due to their mathematic- intelligence, lack of mastery, and selective position over the subject.

Hypothesis Derived from the Results

From the presented core categories, the following hypothesis, and propositions were created.

Hypothesis 1:

Students with a higher growth mindset in mathematics respond to adversities and setbacks while learning mathematics with grittier behavior, often employ adaptive coping strategies, and continuously foster appreciation towards the subject.

Proposition 1:

Students with a growth mindset in mathematics are expected to exhibit grit behavior, adaptive coping strategies, and appreciate the subject when faced with adversities and setbacks.

Hypothesis 2:

Students with a higher fixed mindset trait in mathematics respond to adversities while learning mathematics with inferiority and dependent help-seeking behavior frequently. They often attribute their experienced failures due to their mathematics intelligence, lack of mastery, and selective position over the subject.

Proposition 2:

Students with a fixed mindset in mathematics trait are expected to demonstrate inferiority and dependent help-seeking behavior when faced with mathematics adversities. They would attribute failures due to their mathematics intelligence, lack of mastery, and selective position over the subject.

Generated Theory

With the entire proposition presented, the generated theory on student's mathematics mindset is summarized below:

jPasco Student's Mathematics Mindset Theory

"Students, when faced with adversities and setbacks while learning mathematics, hold differing mindset beliefs. When faced with difficulties, students with a fixed mindset in mathematics will demonstrate inferiority and dependent help-seeking behavior and attribute failure due to mathematics intelligence, lack of mastery, and selective position over the

subject. In contrast, students holding a growth mindset belief when faced with adversities and setbacks will exhibit grit behavior, employ adaptive coping strategies, and foster appreciation towards mathematics."

Mathematics' Mindset Theory Model

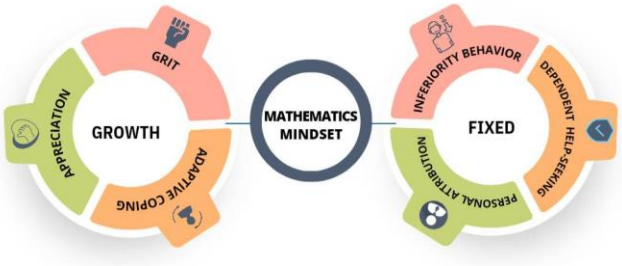

Figure 1. jPasco Model on Student's Mindset in Mathematics

Figure 1 shows the pattern of relationships between students' mindset theory in mathematics (MTM). In the middle is the overarching variable of MTM, the mathematics mindset. The variables on the right and left sides are the core categories: the growth and fixed mindset in mathematics.

Grit, adaptive coping strategies, and appreciation are the three interrelated sub-categories but separate variables of a student with a growth mindset belief when faced with adversities and setbacks in mathematics. The constructs are separate since they describe students' diverse behaviors while learning mathematics. The three constructs are interrelated since the repercussions of the three mentioned concepts lead students to increase their mathematics intelligence, make them want to learn more, do not concern being about looking smart, and will unreservedly grind on strenuous tasks to achieve their mathematics goals. Collectively, the mentioned constructs are the features of students holding a growth mindset in mathematics.

While inferiority behavior, dependent seeking tendencies, and personal attribution are the three interrelated sub-categories but separate variables of a student with a fixed mindset belief when faced with adversities and setbacks in mathematics. The constructs are separate since they explain students' different behaviors while learning mathematics. The constructs are interrelated since the three have features that can describe student's beliefs, such as not believing that their mathematics intelligence cannot be changed, there is nothing they can do with their current state in terms of mathematics, and fearing that the encountered difficulties will reveal their mathematics inadequacies. Together, the three constructs are the framework of students having a fixed mindset trait in mathematics.

IV. CONCLUSION & RECOMMENDATIONS

The mathematics mindset theory is a belief in the malleability of a student's mathematics intelligence and abilities when faced with adversities and setbacks. Hence, mathematics mindset theory concerns students' responses to mathematics adversities and setbacks while learning the subject.

This study presented a new mathematics mindset theory based on students' accounts and experiences while learning mathematics. The jPasco mindset theory has two distinct factors, fixed and growth mindset, specifically in mathematics. The fixed mindset is the student's belief that mathematics intelligence and abilities are not changeable traits. In contrast, a growth mindset is a belief that mathematics intelligence and abilities are malleable traits that can be changed.

This study concludes that a fixed mindset in mathematics comprises three constructs: inferiority behavior, dependent-seeking tendencies, and personal attribution. A growth mindset has three dimensions: grit, adaptive coping strategies, and appreciation.

This study opens the scope for scholars in the field to quantitatively investigate high school students mathematics mindset using the factors in the emergent theory of this study through developing appropriate measurement tools.

This study is grounded within particular public high school students in one location. Thus, future researchers could expand the emergent theory by replicating the methods in this study involving students from another set with different sociodemographic profiles, like in private schools.

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