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STEM Students' Perception, Grit, and Motivation in Learning Precalculus in a Cyclical Learning Modality

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Abstract

Precalculus is essential for reinforcing the mathematical abilities of STEM students in Senior High School. However, limited studies have explored the correlation between students' perception, grit, and motivation in learning Precalculus within a cyclical learning modality. This study aimed to measure the levels of students' perception, grit, and motivation among 80 STEM Grade 11 students from a Laboratory High School of a state university and to analyze the relationships between these factors. A descriptive correlational research design was employed, utilizing three research questionnaires to gather data, which were analyzed using descriptive statistics and Pearson Correlation. Findings revealed high levels of students' perception, grit, and motivation. Furthermore, while students' perception and grit showed no significant correlation, perception and motivation, as well as grit and motivation, were significantly correlated. Therefore, institutions should continue enhancing the quality of education in Precalculus to sustain students' high levels of perception, grit, and motivation.

Keywords: mathematics education, precalculus, perception, grit, motivation, cyclical learning modality

Introduction

Background of the Study

Mathematics is an undeniably significant subject of science with numerous applications in many aspects of life and in the world. It is extremely significant in all fields, including engineering, sciences, commerce, and industries (Reyes & Castillo, 2015). Despite its significance, mathematics is really one of the most challenging subjects for Filipino learners.

In fact, the National Achievement Test shows a poor performance in mathematics in the Philippines, with an average rating of 70.33% in secondary, below the national passing percentage (Department of Education, 2016). Furthermore, the results released by the Program for International Students Assessment (PISA) survey (2018), revealed that the Philippines was positioned as the second-lowest performer in Mathematics assessments, demonstrating a low performance, particularly in advanced subjects like Calculus (Padernal & Diego, 2020).

It can be noted that one of the specialized subjects in the Science, Technology, Engineering, and Mathematics (STEM) strand of Senior High School (SHS), specifically in Grade 11, is the Precalculus subject. Giangan and Gurat (2022) emphasized that Calculus is part of the process of strengthening students' mathematical skills and abilities to improve STEM education in SHS. Even though many enrollees of STEM are familiar with mathematical concepts; they still fail to retain the knowledge gained from their earlier experiences.
Meanwhile, with the emergence of the Coronavirus Disease 2019 (COVID-19), Philippines adapted a new learning environment to continue the quality education: Blended Learning Modality. It is an integration of face-to-face and

online learning methods that maximizes the benefits of both (Osguthorpe & Graham, 2003) and it has become a standard practice across all educational levels. In a particular state university, a sub-type of blended learning called the cyclical learning modality was implemented, especially since limited face-to-face classes were allowed by the Department of Education. Cyclical learning modality is a cyclic timetable in which some students are permitted to be on campus for face-to-face instruction while others have flexible off-campus study options (Balsomo et al., 2022).

With this new learning environment, SHS students build their perception, grit, and motivation in studying precalculus. Initially, students' perception on Precalculus contributes to their performance (Liang, 2009) and mathematics achievement (Lee & Kung, 2018). Students in varied situations and statuses perceive the foundation of the prerequisite information in learning calculus differently. However, this prompted a further investigation into how students or learners communicate their perceptions when learning Calculus (Giangan & Gurat, 2022).

Subsequently, Duckworth (2007) defined grit as "perseverance and passion for long-term goals". He suggested that grit may impact achievement more than intrinsic talent or intelligence. Cognitive elements like perception, confidence, and expectations were major determinants of grit in STEM (Burtner, 2005).

Ultimately, motivation, according to Pintrich and Schunk (2002), is "the process by which targeted activity is instigated and sustained." They discovered that motivation is a fundamental factor for explaining student academic achievement. Students with high levels of motivation engage in more difficult tasks, exert greater effort, and persevere in the face of adversity, resulting in higher skill and a significant improvement in their academic achievement (Almendra, 2019).

For a long time, educators in learning institutions have been concerned about the high failure rate in Calculus subjects. They have conducted numerous studies to improve students' performance in this area. For instance, Giangan and Gurat (2022) investigated the Perception and Academic Performance of STEM Students in Learning Calculus. It aimed to determine the relationship between academic performance and students' perceptions in learning Calculus during distance learning modality. Based on the result, the level of students' perceptions was positive, while the level of academic performance was very satisfactory. Moreover, no significant correlation exists between students' perceptions and academic performance in learning calculus on distance learning. On the other hand, one weakness of their study is that their data collection procedure was not done in a face-to-face setting. Therefore, further assessments are needed to enhance the study.

Meanwhile, Carter (2022) measured the Precalculus Self-Efficacy, Grit, And Achievement in University Precalculus Courses Taught with an Online Flipped Model. The results showed that no significant evidence was found to suggest that grit moderated precalculus contributes to self-efficacy and achievement.
Further, Almendra (2019) conducted a study on Competency-Based Learning for Motivation and Academic Performance in a Precalculus Course. The study analyzed students at the University of Guadalajara's University Center of the South Coast in Engineering. The results showed that students who participated in CBL achieved higher academic performance and higher levels of intrinsic motivation.

In total, after reviewing literature and studies related to the research, the researcher discovered that limited studies have focused on the perception, grit, and motivation of STEM students in learning Precalculus on a cyclical learning modality. Moreover, a minimal amount of research has correlated these three variables and concluded with empirical data.

Therefore, this study examined the relationship between the three previously mentioned variables within the cyclical learning environment. This research would provide base-line data for school administrators and the Department of Education in reviewing the curriculum, specifically for the calculus subjects, in Senior High School. Moreover, educators can use the findings of this study to improve their teaching strategies about Precalculus.

Objectives of the Study

The study aimed to explore the relationship between the perception, grit, and motivation of Grade 11 STEM students at a Laboratory High School in learning precalculus within a cyclical learning modality. Specifically, it sought to identify the demographic profile of the respondents in terms of sex and age, assess their levels of perception, grit, and motivation in precalculus learning under this modality, and analyze the interrelationships among these three variables within the context of a cyclical learning environment.

Theoretical Framework

The research is principally based on Piaget et al.'s Constructivism Learning Theory (CLT), which suggests that knowledge is best acquired through reflection and active construction (Mascolo & Fischer, 2005). It suggests that students construct their own learning by integrating new information with their prior experiences, shaping a unique reality for everyone. CLT emphasizes the active and personalized nature of learning experiences.

Moreover, the CLT is crucial in providing information regarding students' perception, motivation, and engagement in learning precalculus in a cyclical learning environment. Piaget's constructivism emphasizes active engagement in understanding through interaction with surroundings. Students' perceptions of precalculus are influenced by their cognitive development and assimilation of new mathematical concepts, as their cognitive structures evolve as they engage with content.

Meanwhile, Piaget's constructivism is supplemented by Vygotsky's concept of the Zone of Proximal Development (ZPD). Grit, defined as tenacity and desire for long-term goals, corresponds to a student's ZPD problems. Students with high grit are more likely to persevere through difficult precalculus ideas (Duckworth et al., 2007).

Constructivism emphasizes learning as an active process where students construct knowledge through hands-on experiences. This aligns with the tenets of self-determination theory (Deci & Ryan, 1985), suggesting that students' intrinsic motivation in precalculus is enhanced when they have autonomy in their learning process. The said theory is significant to the study since it revolved around the construction of students' perception, grit, and motivation in learning precalculus. Thus, the Constructivism Learning Theory is regarded as a suitable framework for research.

Conceptual Framework

Based on Piaget et al.'s Constructivist Learning Theory, the demographic profile of STEM 11 students, such sex and age, influences their levels of perception, grit, and motivation, as well as the correlation among these variables. Ultimately, these factors shape their precalculus learning within a cyclical learning environment. The interconnectedness of these variables is illustrated in the conceptual framework of the research.

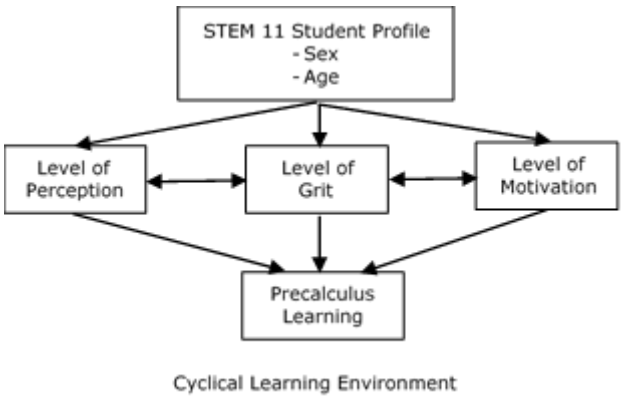

Figure 1. Hypothesized Relationship Between Students' Level of Perception, Grit, and Motivation in Learning Precalculus on a Cyclical Learning Modality.

Methodology

Research Design

This research utilized a descriptive-correlational research design. Descriptive correlational studies are effective in explaining how one phenomenon relates to another when the researcher has no control over the independent variables, which are thought to cause or impact the dependent or outcome variable (Lappe, 2000).

The descriptive approach determined the level of students' perception, grit, and motivation in learning precalculus in terms of their sex and age. On the other hand, the correlational approach analyzed the relationships among their perception, grit, and motivation.

In relation to the study, there are various researches that utilized the descriptive-correlational method. These include Padernal and Diego's (2020) Academic Performance of Senior High School Students in Pre-Calculus and Estonanto's (2017) Math Anxiety and Academic Performance in Precalculus of Selected Senior High School in Sorsogon State College.

Research Respondents and Sampling

The research was conducted among all the 80 students in Grade 11 STEM of a Laboratory High School. The researcher utilized total enumeration sampling to include all the students of the population. Bullen (2022) stated that a sample size lower than 100 requires all the members to be surveyed. Demographic profiles such as their sex and age are collected from the respondents, including their responses to the questionnaires, provided that they will be coded accordingly.

Research Instrument

The study used three survey questionnaires to measure the level of students' perception, grit, and motivation in learning precalculus respectively.

The first instrument is the Perception on Calculus Courses and Me Questionnaire (PCCMQ) that was adapted from Tang et al. (2013). It utilized a 4-point Likert Scale: 4= Strongly Agree, 3= Agree, 2= Disagree, 1= Strongly Disagree. It measured the level of students' perception in learning precalculus.

The second survey questionnaire is the 12-Item Grit Scale based on the study by Duckworth et al. (2007) "Grit: Perseverance and passion for long-term goals." It also used a 4-point Likert Scale: 4= Very much like me, 3= Mostly like me, 2= Not much like me, 1= Not like me at all. It assessed the grit of students in precalculus learning.

Lastly, the study used the Motivated Strategies for Learning Questionnaire (MSLQ) adapted from Nugent (2009) research titled "The Influence of Teacher-Student Interaction on Student Motivation and Achievement,". It assessed the student motivation using a 4-point Likert scale, where 1 corresponds to not being true at all, to 4 corresponds to true at all. Nugent (2009) introduced the Motivated Strategies for Learning Questionnaire (MSLQ) to measure students' evaluations of their motivation levels and their utilization of learning strategies.

Meanwhile, the instrument was validated by three (3) experts: a psychometrician, a social science professor, and a mathematics professor. The validity of the instrument yielded a mean of 4.35 which indicates that the statements in the questionnaire are valid for the conduct of the survey.

After validation, the researcher conducted a pilot test to STEM students to test for the reliability of the instrument. The reliability score for the PPCMQ yielded a Cronbach's alpha of .66, indicating a moderate reliability, the Grit Scale Questionnaire got a cronbach's alpha of .70 (good reliability), while the MSLQ has a cronbach's alpha of .71 (good reliability). Overall, the reliability of the research instrument yielded a cronbach's alpha of .69 (moderate reliability).

Data Fathering Procedure

Before the data gathering process began, the study sought the approval from the university administration. Subsequently, permissions were obtained, including a letter addressed to the dean and chairperson, parent's consent, and letter of assent for students, ensuring their voluntary participation in the survey and granting permission to conduct the survey in the classroom. The above-mentioned procedures took place in the third week of February 2024.

After taking the consent, the researcher then conducted the data gathering to the respondents by the first week of March 2024. The recorded data was then immediately tabulated in preparation for the analysis.

Data Scoring

The three research questionnaires utilized a 4-point Likert Scale. The data interpretation for the level of perception, grit, and motivation will be based on the following data scoring.

Table 1
Data Scoring

Range	Description
3.50 - 4.00	Very High
2.50 - 3.49	High
1.50 - 2.49	Low
1.00 - 1.49	Very Low

Statistical Treatment of Data

Descriptive statistical methods, including calculation of frequency, percentage, means, and determination of standard deviation, were employed to examine the characteristics of the respondents, as well as their levels of perception, grit, and motivation in the context of learning precalculus through a cyclical learning modality. Further, to test if there is a normal distribution of data, SPSS software was used in evaluating the skewness and kurtosis of the data in terms of sex. Females' data recorded a skewness of .169 and a kurtosis of .125. On the other hand, Males' data noted a skewness of -.174 and a kurtosis of -.631. Since the range for the skewness and kurtosis falls under the acceptable value for normality, the parametric Pearson Correlation was utilized to investigate the relationships among these variables. All statistical analyses were conducted with a significance level of 5%.

Ethical Consideration

In the process of gathering data, informed consent was obtained from both respondents and their parents through the signing of a consent form. This document includes essential details about the study, outlining its advantages and potential risks, emphasizing the respondent's entitlement to privacy and anonymity in accordance with the Data Privacy Act of the Philippines. The form will include a statement indicating the respondent's voluntary agreement to participate in the study.

Results and Discussions

Profile of Respondents

This study collected the demographic profile of STEM 11 students of BiPSU-LHS with regards to their sex and age which is shown in Table 1. The majority of the surveyed students were male (55%), while female students comprised 45% of the sample.

Table 2
Demographic Profile

Variable		f	%
Sex			
Female		36	45
Male		44	55
	Total	80	100
Age			
Mean = 16.56			

Note: f – frequency, % - percentage

Furthermore, the respondents' mean age is 16.56, ranging from 16 to 18 years old. Most of them are 16 years old (48.75%), followed by 17-year-olds (46.25%), and 18 year-olds with just 5% of the sample. These statistics are expected since total enumeration was used as the sampling technique. Thus, there are more male respondents than females, and the respondents are 16-18 years old. By using the total enumeration, the totality of the population is included in the study.

Levels of Students' Perception, Grit, and Motivation in Learning Precalculus

Table 3 presents the summarized levels of students' perception, grit, and motivation in learning precalculus in a cyclical learning environment. All three of the variables have generally yielded to high levels.

Table 3
Levels of Students' Perception, Grit, and Motivation in Learning Precalculus in a Cyclical Learning Environment

Variables	Mean	SD	Interpretation
Perception	2.72	0.890	High
Grit	2.96	0.709	High
Motivation	3.20	0.716	High

As shown in Table 3, the students' perception indicated a high level amongst STEM 11 students (M=2.72, SD=0.890). Moreover, their grit also measured a high level with a mean of 2.96 and a standard deviation of 0.709.

Finally, their motivation yielded a mean of 3.20 and a standard deviation of 0.716 which stipulates that they have a high level of motivation in learning precalculus.

Meanwhile, the succeeding tables shall present a detailed discussion of the three variables (perception, grit, and motivation). The data in the tables are presented per statement according to the research instrument in order for each variable to be explained comprehensively and include specific statements that the respondents generally perceive positively or negatively.

In Table 4, the students' perception in learning precalculus was specifically presented. As mentioned earlier, the findings revealed that the STEM 11 students generally have a high level of perception in precalculus learning (M=2.72, SD=0.890). This result might be because of the teaching strategy and intrinsic motivation of the students (Mariamah et al., 2021).

Moreover, this result compliments Giangan and Gurat's (2022) study on the perception and academic performance of STEM students in learning calculus which concluded that the students generally have a positive perception towards the subject. This indicates that even though Filipino students have difficulties in learning mathematics (Canduhay, 2010), they still perceive it positively.

Table 4
Students' Perception in Precalculus Learning

Statement	Mean	SD	Interpretation
1. I would like to continue my Calculus learning in an advanced course.	2.80	0.947	High
2. I feel that Calculus will be useful to me in my future profession.	2.78	0.968	High
3. The thought of being enrolled in a Calculus course makes me nervous.	3.41	0.774	High
4. Calculus seems very mysterious to me.	2.88	0.862	High
5. Most people would benefit from taking a Calculus course.	2.45	0.926	Low
6. I have difficulty seeing how Calculus is related to my field of study.	2.93	1.053	High
7. I see being enrolled in a Calculus course as a very pleasant experience.	2.45	0.926	Low
8. Calculus is not useful because it tells me what I already know anyway	1.74	0.926	Low
9. I wish that I could avoid taking my Calculus course.	2.65	0.969	High
10. Calculus is too Calculus-oriented to be of much use to me in the future.	2.63	0.734	High
11. I get upset at the thought of enrolling in another Calculus course.	2.73	0.871	High
12. I feel frightened when I have to deal with mathematical formulas.	2.99	0.999	High
13. I am excited at the prospect of actually using Calculus in my future job.	2.26	0.868	Low
14. Studying Calculus is a waste of time.	1.84	0.848	Low
15. Calculus thinking can play a useful role in everyday life.	2.70	0.863	High
16. Dealing with numbers makes me uneasy.	2.85	1.008	High
17. Calculus is too complicated for me to use effectively.	3.04	0.961	High
18. Calculus thinking will one day be as necessary for efficient citizenship as the ability to read and write.	2.83	0.823	High
19. Calculus will be useful to me in comparing the relative merits of different objects, methods, programs, etc.	2.93	0.792	High
20. Calculus training is relevant to my performance in my field of study.	2.91	0.917	High
As a whole	**2.72**	**0.890**	**High**

As indicated in Table 4, the majority (67%) of the positive items were evaluated between 2.50 and 3.49. The overall weighted mean is 2.72, indicating that the STEM 11 students of BiPSU-LHS have a high level of perception toward learning precalculus in a cyclical learning modality.

Moreover, the students contradicted that most of the people will benefit from learning precalculus and use their knowledge about the subject to their future profession. However, they disagreed that Calculus is useless and that studying it is a waste of time. This result is supported by the study of Giangan and Gurat (2022) which yielded the same conclusion.

Meanwhile, Table 5 shows the students' grit in learning precalculus. The result yielded a mean of 2.96 and a standard deviation of 0.709, which indicates that STEM 11 students have a high level of grit in studying precalculus. This coincides with previous studies which concluded that students have moderate to high grit level in mathematics, specifically precalculus (Al-Mutawah & Fateel, 2018).

A possible reason for their high grit level is their ability to persist and persevere in learning mathematics (White, 2023). Since precalculus is a subject that builds on its content, a high grit level is needed in order for the students to succeed.

Table 5
Students' Grit in Precalculus Learning

	Statement	Mean	SD	Interpretation
1.	I have overcome setbacks to conquer an important challenge.	2.96	0.605	High
2.	New ideas and projects sometimes distract me from previous ones.	3.09	0.749	High
3.	My interests change from year to year.	2.99	0.907	High
4.	Setbacks don't discourage me.	2.71	0.799	High
5.	I have been obsessed with a certain idea or project for a short time but later lost interest.	3.06	0.847	High
6.	I am a hard worker.	2.98	0.779	High
7.	I often set a goal but later choose to pursue a different one.	2.92	0.823	High
8.	I have difficulty maintaining my focus on projects that take more than a few months to complete.	3.03	0.899	High
9.	I finish whatever I begin.	3.09	0.829	High
10.	I have achieved a goal that took years of work.	2.85	0.955	High
11.	I become interested in new pursuits every few months.	2.90	0.851	High
12.	I am diligent.	2.93	0.591	High
	As a whole	**2.96**	**0.709**	**High**

In Table 5, all of the positive items were rated between 2.50 to 3.49. The overall mean of students' grit was recorded at 2.96 with a standard deviation of 0.709. Thus, STEM 11 students have a high level of grit in learning precalculus.

To elaborate, the students relate to the statement that 'setbacks don't discourage them, they have overcome it, and persevered to achieve their goals in the subject'. The remaining statements such as but not limited to the 'distractions they encounter and their difficulty in maintaining a focus', also got a high rating from the respondents.

Furthermore, Table 6 presents the descriptive statistics of students' motivation in learning precalculus in a cyclical learning environment. The survey resulted in a high level of motivation among STEM 11 students in precalculus learning (M=3.20, SD=0.716). This supports the result of Matthews et al. (2013) study on Academic Motivation in Calculus, which stated that students have a moderately high academic motivation in learning calculus. The high motivation of the students is due to their mindset that mathematics is useful in their daily lives (Fuqoha et al., 2018). Moreover, it is also influenced by fear of failure, self-efficacy beliefs, and achievement goals (Pantziara & Philippou, 2014).

Table 6
Students' Motivation in Precalculus Learning

	Statement	Mean	SD	Interpretation
1.	During class time, I often miss important points because I'm thinking of other things.	2.86	1.064	High
2.	When reading for a course, I make up questions to help focus my reading.	3.09	0.783	High
3.	When I become confused about something I'm reading, I go back and try to figure it out.	3.65	0.618	Very High
4.	If course materials are difficult to understand, I change the way I read the material.	3.31	0.628	High
5.	Before I study new material thoroughly, I often skim it to see how it is organized.	3.09	0.874	High
6.	I ask myself questions to make sure I understand the material I have been studying.	3.36	0.783	High
7.	I try to change the way I study in order to fit the course requirements and the instructor's teaching style.	3.06	0.876	High
8.	I often find that I have been reading for a class but don't know what it was all about.	2.78	0.993	High
9.	I try to think through a topic and decide what I am supposed to learn from it rather than just reading it over when studying.	3.20	0.719	High
10.	When studying, I try to determine which concepts I do not understand well.	3.43	0.708	High
11.	When I study, I set goals for myself in order to direct my activities in each study period.	3.40	0.722	High
12.	If I get confused about taking notes, I make sure I sort it out afterwards.	3.21	0.896	High
	As a whole	**3.20**	**0.716**	**High**

As stipulated in Table 6, all of the positive items got a high to very high levels of motivation from the respondents with a mean of 3.20 and a standard deviation of 0.716. The statement that got a very high response from the respondents is 'When I become confused about something I'm reading, I go back and try to figure it out,' which defines their motivation in precalculus comprehensively. Therefore, the STEM 11 students of BiPSU-LHS have a high level of motivation in learning precalculus despite being in a cyclical learning modality.

Relationship of Students' Perception, Grit, and Motivation in Learning Precalculus in a Cyclical Learning Environment

The correlation between students' perception, grit, and motivation in learning precalculus in a cyclical learning environment were analyzed using the Pearson Correlation. Table 7 depicts the relationship of perception, grit, and motivation of the students in learning precalculus.

Table 7
Correlation of Students' Perception, Grit, and Motivation in Learning Precalculus in a Cyclical Learning Modality

Variables	Perception	Grit	Motivation
Perception	-	.175	.255*
Grit	-	-	.435**
Motivation	-	-	-

*Note: *p < .05, **p < .01, ***p < .001*

In Table 7, considering that significant correlation is labeled with an asterisk, the correlation between perception and grit showed that there is no significant relationship of the said variables (r=.175). The said result implies that the students' perception does not necessarily affect their grit in learning the subject.

This result may be associated with the students having the capability to build their own grit in the subject despite their initial perception. Moreover, it contradicts Liang (2009), who said that perceptions of learning calculus would affect students' performance, specifically grit, in learning calculus.

Meanwhile, perception and motivation were significantly correlated (r=.255*), which means that the perception of students may affect their motivation in learning precalculus. This might be due to students' perception on the usefulness of topics, autonomy, and teacher support which were found to relate to their motivation and enjoyment of education (Radovan & Makovec, 2015). Hence, the result agrees with the study of Valdez and Maderal (2021) which explained that students' perception has a significant correlation with their motivation towards Math learning.

Finally, when motivation and grit were correlated, the result showed a highly significant correlation between the two variables (r=.435**). The result indicates that grit can influence students' motivation in learning precalculus and vice versa. A possible reason for this is that students develop a grit for the subject due to their motivation in learning Precalculus. Furthermore, it coincides with the study by Eskreis-Winkler et al. (2014) that concluded a strong positive correlation between the overall grit of students and school motivation.

Conclusion

STEM 11 students demonstrate a positive perception, grit, and motivation in learning Precalculus within a cyclical learning environment. Furthermore, students' perception and grit in learning precalculus were not significantly correlated. However, students' perception affects their motivation in precalculus learning. The same case applies to their grit and motivation. Thus, the study suggests that students' motivation to learn Precalculus can be enhanced by an optimistic introduction and improved grit, as perception does not directly impact grit.

Recommendation

Based from the findings and conclusions, the following are the recommendations by the researcher: (1) School administrators must continue developing teaching strategies in maintaining students' positivity in precalculus learning despite having high levels of perception, grit, and motivation; (2) Teachers must be oriented in applying an optimistic approach to the introduction of precalculus to STEM 11 learners; (3) For further advancement of this research, a parallel study in both Precalculus and Basic Calculus subjects in STEM 11 under the same variables yet of greater number of respondents is highly recommended.

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