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Differential calculus aptitude: A correlation to self-efficacy and self-regulation of pre-service mathematics teachers

Von Xernan M. Garcia[1]*, Florante P. Ibarra[2], John Rafael M. Antalan[3], Eduard C. Taganap[4]
[1,2]Department of Science in Education, College of Education, Central Luzon State University Science City of Muñoz, Nueva Ecija, Philippines; garcia.vonxernan@clsu2.edu.ph (V.X.M.G) florante.ibarra@clsu2.edu.ph (F.P.I.).
[3,4]Department of Mathematics and Physics, College of Science, Central Luzon State University Science City of Muñoz, Nueva Ecija, Philippines; johnrafael.antalan@clsu2.edu.ph (J.R.M.A.) eduard.taganap@clsu2.edu.ph (E.C.T.).

Abstract: This study explores the relationship between the two independent variables, self-efficacy (SE) and self-regulation (SR), and the dependent variable, mathematics aptitude in differential calculus, of pre-service mathematics teachers from Central Luzon State University (CLSU). The study also investigates which parameters of SE and SR are the best predictors of mathematics aptitude in differential calculus. The study utilizes a descriptive correlational research design with stratified random sampling, and the respondents are 71 pre-service mathematics teachers. The data collection methods used include a 24-item self-efficacy scale, a 31-item self-regulation scale, and a 30-item researcher-made questionnaire on differential calculus. Results revealed that the relationship between self-efficacy and mathematics aptitude has a significant positive correlation, as does the relationship between self-regulation and mathematics aptitude in differential calculus. Stepwise regression analysis discovered that vicarious experiences (SE), social persuasion (SE), and external regulation (SR) are the best predictors of mathematics aptitude in differential calculus. This study highlights the significance of enhancing mathematics performance by improving the self-efficacy and self-regulation of the students. Understanding these variables will greatly assist in designing effective teaching strategies to improve students' mathematical abilities and performance.

Keywords: *Mathematics aptitude, Performance in differential calculus, Pre-service mathematics teachers, Self-efficacy, Self-regulation.*

1. Introduction

Self-efficacy is the individual's ability to make significant results. Others who know their abilities to make a difference feel pleased, and hence, they take the initiative, others who believe they can't do it are miserable and lack the motivation to act [1]. Study consistently shows that learners with higher levels of self-efficacy in mathematics perform better than learners with lower levels of self-efficacy. This is because learners with higher self-efficacy are more likely to believe in their abilities, and as a result, they are more likely to put the effort needed to achieve success in mathematics. On the other hand, students who have low self-efficacy are more likely to be discouraged or give up when faced with difficult problems or challenges [2]. According to Usher and Pajares [3] when students overcome challenges or difficult tasks, the impact of mastery experiences is evident and clear. However, to determine one's ability, the amount of effort exerted in accomplishing a task is used as an indicator. The students' self-efficacy may be weakened if they face failure despite the significant effort they have made. Additionally, compared to independent success, it is a weaker indication of personal ability if the success is achieved with the assistance of their peers or others. Beyond the interpretation of their actions, students shape their beliefs in self-efficacy by observing others or through vicarious experiences. In academic endeavors

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* Correspondence: garcia.vonxernan@clsu2.edu.ph

lacking absolute proficiency measures, students assess their capabilities with the performance of their peers or others. Social persuasion influences the development of student's self-efficacy, particularly when students possess uncertainty about their abilities or possess limited experience with a given task, comparisons to their classmates, peers, and adults help students to form judgments about their academic capabilities. Lastly, physiological and emotional states influence the students' self-efficacy, including anxiety, stress, fatigue, mood, and the like. Physiological stimulation is interpreted by the students as a measure of their capability by evaluating their performances under various conditions. Expected success or failure is indicated by strong emotional reactions to academic tasks. Thus, completing the four sources of self-efficacy: mastery experiences, vicarious experiences, social persuasion, and physiological and emotional states.

Self-regulation in education is a well-known and essential issue among all educators, including professors, administrators, teachers, researchers, journalists, and academics. Because educational standards demand students to decide what and how they study, self-regulation abilities are critical for student achievement [4]. Research demonstrated a positive relationship between self-regulation and academic performance, which means that students with strong self-regulation skills in calculus tend to achieve higher grades. Developing a deeper understanding of the concepts and demonstrating higher engagement with the subject matter [5]. Determination is more likely to be shown by self-regulated learners through challenges, seeking help when needed, and exhibiting higher academic achievement. According to Inzlicht, et al. [6] external regulation refers to the regulation of behavior through external means, such as rewards and constraints. An individual engaging in an activity due to external pressures, like the influence of a significant other, exemplifies extrinsic motivation. In this case, the individual's behavior is not self-determined because they feel obligated, pressured, or directed by an outside source. The first internalization of motivation is introjected regulation, although internally motivated, it is not entirely accepted as one's own. Introjected regulation happens when external motivation is internalized and reinforced by internal pressures like worry or self-esteem-related emotions. It involves individuals monitoring and sanctioning themselves, but the process lacks complete internalization, resulting in pressure and tension. Identified regulation is a more autonomous and self-determined type of motivation. The activity is appreciated and viewed as a personal choice, even though the incentive is extrinsic and serves as a means to a goal (e.g., achieving personal goals). Individuals experience a sense of direction and purpose, free from obligation and pressure, marking successful internalization. Intrinsically motivated behaviors are performed for their inherent enjoyment, pleasure, and satisfaction. These are voluntary actions without external contingencies that are driven by the individual's needs for competence, autonomy, and relatedness. Intrinsic motivation is in contrast to external and introjected regulation, as activities are undertaken for the satisfaction they bring without external influences. These complete the four forms of self-regulation: external regulation, introjected regulation, identified regulation, and intrinsic motivation.

Although some students do not like math, an increase in the level of students' self-efficacy causes better student performance. According to Bandura [7] self-efficacy is the belief that one can perform the behaviors needed to produce a desired performance. Feedback from instructors, peers, and parents increases the level of self-efficacy. For students who may lack self-efficacy during math performance, educators can increase their level of self-efficacy. In case there is an increase in performance, students will remain active at all times.

As previously indicated in many research papers, the relationship between self-efficacy and self-regulation appeared to be interconnected; students with higher levels of self-efficacy were more motivated to engage in self-regulated learning practices. Their confidence in their abilities gives them a greater sense of control over their learning, which improves their self-regulation skills. In contrast, self-regulation shapes and influences self-efficacy; as students engage in self-regulated learning strategies, set goals, and track their progress, they gain a better understanding of their abilities and develop a sense of efficacy in their ability to tackle difficult calculus tasks.

The interaction dynamics of self-efficacy and self-regulation significantly impact the extent to which the individual master's differential calculus. Therefore, personal belief in the capability to succeed in a given domain and the proficiency of particular learning strategies are among the key determining factors that allow people to achieve success in mastering the challenging mathematical field in question. Moreover, the fact that mastering differential calculus presumes several layers and steps of self-regulation is another aspect worth noting. The latter occurs as the learner starts working on the task, as well as during the problem-solving process.

Many studies show the relationship between self-efficacy and self-regulation toward the academic performance of students, but few studies in the context of differential calculus. In fact, differential calculus is a difficult subject student face in their chosen path or career, which is in need to be address.

Furthermore, identifying at-risk students early on allows for timely interventions and assistance to minimize academic setbacks. This is made possible by investigating the relationship between self-efficacy, self-regulation, and mathematical performance. Overall, this study supports long-term academic performance in mathematics and related subjects, improves teaching strategies, and influences the development of a supportive learning environment.

The study aims to know if the self-efficacy and self-regulation of CLSU pre-service secondary teachers have a relationship with their mathematics aptitude in differential calculus. Specifically, the study aims to:

[1] Determine the levels of self-efficacy of the respondents in terms of their:
a. Mastery Experiences;
b. Vicarious Experiences;
c. Social Persuasion; and
d. Physiological and Emotional States
[2] Determine the levels of self-regulation of the respondents in terms of their:
a. External Regulation;
b. Introjected Regulation;
c. Identified Regulation; and
d. Intrinsic Motivation
[3] Determine the levels of mathematics aptitude in differential calculus of the respondents.
[4] Determine if there is a significant relationship between the self-efficacy of the respondents and their mathematics aptitude in differential calculus.
[5] Determine if there is a significant relationship between the self-regulation of the respondents and their mathematics aptitude in differential calculus.
[6] Determine which parameters of self-efficacy and self-regulation best predict the mathematics aptitude of students in differential calculus.

2. Literature Review

2.1. Self-Efficacy in Mathematics

Self-efficacy in mathematics refers to an individual's belief in their capability to finish a mathematical activity successfully. Self-efficacy has regularly been found to be a major predictor of a wide range of outcomes, including academic achievement, work performance, and health behaviors. According to research by Bandura, et al. [2] junior middle school children with high levels of self-efficacy in arithmetic outperform their counterparts with lower levels of self-efficacy.

In the path analysis conducted by Appiah, et al. [8] the study found that senior high school students' confidence in their math abilities and their positive perception of mathematics significantly contributed to their math achievement. In general, students perform better in math if they are confident with their mathematical abilities and have a positive attitude towards the topic. Students who were confident understood complex mathematical concepts, worked hard, and mastered math skills received higher performance ratings. These findings highlight the significance of enhancing students' self-efficacy and perceptions of mathematics in order to improve math performance.

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Further research and studies have demonstrated that self-efficacy, or an individual's belief in their ability to effectively accomplish a task or achieve a goal, is critical to academic achievement. In calculus, self-efficacy has been demonstrated to be a strong predictor of students' performance and attitudes about the subject. Liem, et al. [9] discovered that self-efficacy was positively associated with 9th-grade students' motivation and attitudes toward calculus. The authors hypothesized that treatments focused on increasing students' self-efficacy could lead to improved performance and attitudes toward the subject.

2.2. Self-Regulation on Mathematics

Self-regulation in mathematics entails metacognitive, cognitive, and behavioral processes that promote effective learning to the students. It also involves setting goals, developing study strategies, tracking progress, and adapting approaches. Self-regulated learners are proactive, seeking assistance as needed and reflecting on their understanding. Research has demonstrated that self-regulation and academic success are positively related. Strong self-regulation abilities in calculus are linked to higher grades, deeper conceptual understanding, and improved engagement.

Furthermore, Boekaerts [10] defines motivational self-regulation as an individual's ability to control their motivation, goal-setting, and efforts to achieve their desired results. It consists of several components: (a) values, which reflect the importance students assign to specific domains; (b) efficiency and effectiveness beliefs, concerning opinions about the efficiency of learning methods; (c) self-efficacy beliefs, indicating students' confidence in their abilities; (d) outcome expectations, reflecting beliefs about potential success or failure; (e) goal orientation, encompassing how students approach learning tasks; and (f) effort beliefs, These factors influence motivation and drive people to succeed in a variety of areas.

2.3. Self-Efficacy and Self-Regulation in Mathematics

According to research, self-efficacy and self-regulation are connected and have a good impact on students' academic and mathematical performance. Self-efficacy and self-regulation are both predictors of mathematical performance, hence they are connected.

In addition, in the study by Peteros, et al. [11] 10th-grade students' self-regulation and self-efficacy in modular distance learning significantly impact math performance. Despite the absence of in-person classes, students demonstrate high levels of self-regulation and self-efficacy, which have a positive impact on math achievement. This highlights the importance of mindset and self-perception in learning, especially self-directed modular distance learning. The study emphasizes the importance of self-assessment and the significant impact of self-efficacy on math performance. Maintaining good self-regulation and self-efficacy is crucial to the improvement of mathematics performance, emphasizing the need to develop these skills for success in mathematics and other courses during distant studying.

In conclusion, math can be difficult for students due to a lack of understanding of fundamental concepts and a variety of other factors, such as inadequate instruction or a lack of exposure to mathematical ideas at an early age. Students may sometimes struggle in mathematics because they lack drive or confidence in their abilities. This can make it difficult for pupils to interact with mathematical content, perhaps leading to failures and problems in this subject area. Self-efficacy and self-regulation, or an individual's belief in their ability to successfully complete a task or achieve a goal, have been shown to be a significant predictor of math achievement, motivation, and attitudes toward the subject. Furthermore, researchers have shown that students' performance and attitude toward calculus are dependent on self-efficacy. Also, research has consistently demonstrated that self-efficacy is critical to academic accomplishment in this subject area. Thus, interventions focused on increasing students' self-efficacy may be good for boosting academic success in mathematics.

Previous researches show the relationship between self-efficacy academic achievement and self-regulation in academic achievement, which is in a broad and wide area. Narrowing it down to one subject matter will make it more focused on how to deal with academics effectively and efficiently. Pairing the variables SE and SR to correlate with mathematics aptitude in differential calculus provides various insights on how aptitude can be increased with the help of both variables.

3. Methods

A descriptive research framework seeks to explore, summarize, and describe one or multiple variables [12]. This design is used to determine the different levels of the respondents according to their self-efficacy, self-regulation, and mathematics aptitude in differential calculus. The correlational research design examines the connections between variables, with no intentional manipulation or control by the researcher. In correlational research, according to Cohen, et al. [13] the correlations between the variables of interest are ascertained by gathering information or looking up records of a certain population. Neither random assignment nor experimental variable manipulation are used in this type of study.

Correlational research, in which information is systematically integrated as hypotheses start to take shape and variables and parameters are connected to one another. This design is used to determine if a relationship between two or more variables exists and to what degree that relationship exists. The goal of this research design is to identify the degree to which the self-efficacy and self-regulation of students are related to their differential calculus aptitude. And also, to determine which of the parameters of self-efficacy and self-regulation best predicts the mathematics aptitude in differential calculus.

3.1. Population and Sample

A stratified random sampling procedure was used in selecting participants. Stratified random sampling, according to Cochran [14] is the division of the population into a subpopulation called strata. The target respondents are all students who have or are currently taking Calculus subject. Specifically, the students with a bachelor of secondary education, major in mathematics at Central Luzon State University from the second year up to the fourth year. The respondents are 21 sophomores, 21 juniors, and 29 seniors, for a total of 71 respondents.

3.2. Data Collection

The data was collected from 71 students through a 4-part questionnaire that will gather data from the respondents regarding their levels of self-efficacy, self-regulation, and mathematics aptitude. The instrument will be utilized through an online survey questionnaire with the help of Google Forms and face-to-face with printed questions for the mathematics aptitude in differential calculus.

3.3. Instruments

The first part of the questionnaire will focus on the socio-demographic profile of the students, which will cover their sex, year level, academic status, and their GPA or grades on the subject Differential Calculus.

The second part of the questionnaire will tackle their self-efficacy (mastery experiences, vicarious experiences, social persuasion, physiological and emotional states). The contexts on this part are answerable by rating the items in terms of how each statement will suffice their initiative, social attention, success/failure, social attraction, and self-confidence towards the learning of subject differential calculus. The researcher adopts the structure of a questionnaire from Kandemir and Akbaş-Perkmen [15]. The questionnaire was determined by using a Likert scale to gather data and information; responses will range from 1 (strongly disagree) to 5 (strongly agree). The Likert scale, according to Cohen, et al. [13] offers a range of answers to a certain question or statement. Participants select the option that most accurately reflects their views about the provided statement or topic, giving a more nuanced evaluation of their agreement levels. However, Likert scales are prone to response bias since respondents may uniformly agree or disagree due to exhaustion, social desirability, or a proclivity to deliver extreme responses.

The third part of the questionnaire is about the self-regulation of the students. The survey was adopted from the survey questionnaire of Ryan and Connell [16]. The questions are classified into four groups: external regulation, introjected regulation, identified regulation, and intrinsic motivation. The questionnaire was also determined by using a Likert scale to gather data and information, responses will range from 1 (strongly disagree) to 4 (strongly agree).

The last part of the questionnaire, which is all about the mathematics aptitude in differential calculus, will present some questions related to the subject, containing terminologies, formulas, and processes, and some problems that will be used to gather information on how well they perform in the said subject. The questions in part 3 are a researcher-made questionnaire.

3.4. Expert Validation

Cronbach's alpha assesses the reliability of an instrument by comparing the shared variance among its items to the overall variance. High covariance relative to variance indicates instrument reliability. It is computed as the average of all possible split-half reliabilities. Common statistical software can calculate Cronbach's alpha. Analyzing changes in alpha after deleting an item helps identify if it is suitable for the measure; a substantial increase suggests the item may not belong in the instrument [17]. To test the reliability of the questionnaire, a Cronbach alpha of 0.793 is obtained. 0.793>0.70, which indicates that the test questions are reliable and ensures that the test scores reflect more than just random error.

4. Results

4.1. Self-efficacy of the respondents

The self-efficacy of the pre-service mathematics teachers is presented in Table 1. The researcher adopted the Kandemir and Akbaş-Perkmen [15] survey questionnaire that examines the four parameters of self-efficacy: mastery experiences, vicarious experiences, social persuasion, and physiological and emotional states. Mean and standard deviation are computed to interpret the data gathered by the researcher.

Table 1.
Self-efficacy of the respondents.

Self-Efficacy	Mean	Standard Deviation	Descriptive Interpretation
Mastery Experiences	3.40	0.695	Average Self-Efficacy
Vicarious Experiences	3.24	0.716	Average Self-Efficacy
Social Persuasion	2.44	0.683	Below Average Se lf-Efficacy
Physiological and Emotional States	3.11	0.583	Average Self-Efficacy
Overall Self-Efficacy	3.05	0.471	Average Self-Efficacy

Note: Legend: Low Self-Efficacy (1.00-1.80), Below Average Self-Efficacy (1.81-2.60), Average Self-Efficacy (2.61-3.40), Above Average Self-Efficacy (3.41-4.20), and High Self-Efficacy (4.21-5.00).

Overall, the self-efficacy of the pre-service mathematics teachers is categorized as average self-efficacy with a grand mean of 3.05 and a standard deviation of 0.471.

4.2. Self-regulation of the Respondents

The self-regulation of the pre-service mathematics teachers is presented in Table 2. The researcher adopted a Ryan and Connell [16] survey questionnaire that examines the four parameters of self-regulation: external regulation, introjected regulation, identified regulation, and intrinsic motivation. Mean and standard deviation are computed to interpret the data gathered by the researcher.

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Table 2.
Self-regulation of the respondents.

Self-Regulation	Mean	Standard Deviation	Descriptive Interpretation
External Regulation	3.41	0.545	Above Average Self-Regulation
Introjected Regulation	3.30	0.535	Average Self- Regulation
Identified Regulation	3.38	0.562	Average Self- Regulation
Intrinsic Motivation	3.10	0.508	Average Self- Regulation
Overall Self-Regulation	3.30	0.488	Average Self-Regulation

Note: Legend: Low Self-Regulation (1.00-1.80), Below Average Self- Regulation (1.81-2.60), Average Self- Regulation (2.61-3.40), Above Average Self- Regulation (3.41-4.20), and High Self- Regulation (4.21-5.00).

Overall, the self-regulation of the pre-service mathematics teachers is categorized as above average self-regulation, with a grand mean of 3.30 and a standard deviation of 0.488.

4.3. Mathematics Aptitude in Differential Calculus of The Respondents

The mathematics aptitude in differential calculus of the pre-service mathematics teachers is presented in Table 3. The aptitude in differential calculus is measured using a researcher-made questionnaire. Empirical rule (68%) is used to analyze the scores of the respondents. The empirical rule, according to Menon [18] also called the three-sigma rule or the 68-95-99.7 rule, asserts that in a normal distribution, nearly all data points will lie within three standard deviations (σ) of the mean (μ). The empirical rule states that 68% of data falls within one standard deviation, 95% within two standard deviations, and 99.7% within three standard deviations of the mean. The mean and standard deviation are especially useful when data is expected to follow a normal distribution because they allow the calculation of probabilities and percentages for various outcomes using the empirical method.

Table 3.
Mathematics aptitude in differential calculus of the respondents.

Descriptive Interpretation	Score Range Mean= 18.94, SD= 3.45	Frequency n= 71	Percentage %
Low Level	Below 15.49	4	5.63
Moderate Level	15.49– 22.39	56	78.87
High Level	Above 22.39	11	15.49

Note: Legend: Low Level (below 15.49), Moderate Level (15.49 – 22.39), High Level (above 22.39).

4.4. Self-efficacy and Mathematics Aptitude in Differential Calculus

Pearson product-moment correlation was used to determine the relationship between self-efficacy and mathematics aptitude in differential calculus of the pre-service mathematics teachers is presented in Table 4. The Pearson correlation coefficient (r) is a widely used method for quantifying linear correlations. Ranging from -1 to 1, it indicates both the strength and direction of the relationship between two variables [19].

Table 4.
Correlation of self-efficacy and mathematics aptitude in differential calculus.

		Mathematics Aptitude in Differential Calculus
Self-Efficacy	Pearson Correlation	0.541**
	Sig. (2-tailed)	0.000

Note: ** Correlation is significant at the 0.01 level (2-tailed).

Results show that self-efficacy and mathematics aptitude in differential calculus are positively related (r= 0.619, p< 0.01), and a moderately strong correlation indicates that students with high self-efficacy have high aptitude in differential calculus.

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4.5. Self-regulation and Mathematics Aptitude in Differential Calculus

Pearson product-moment correlation was used to determine the relationship between self-regulation and mathematics aptitude in differential calculus of the pre-service mathematics teachers, which is presented in Table 5.

Table 5.
Correlation of self-regulation and mathematics aptitude in differential calculus.

		Mathematics Aptitude in Differential Calculus
Self-Regulation	Pearson Correlation	0.409**
	Sig. (2-tailed)	0.000

Note: ** Correlation is significant at the 0.01 level (2-tailed).

Results show that self-regulation and mathematics aptitude in differential calculus are positively related ($r= 0.409$, $p< 0.01$). Its weak correlation indicates that students with high self-regulation have high aptitude in differential calculus.

4.6. Regression analysis to define which parameters of self-efficacy and Self-Regulation Predict Mathematics Aptitude in Differential Calculus

Table 6 shows which parameters of self-efficacy: mastery experiences, vicarious experiences, social persuasion, physiological and emotional states, and self-regulation: external regulation, introjected regulation, identified regulation, and intrinsic motivation predicts mathematics aptitude in differential calculus, a forward stepwise regression analysis was performed. According to Lewis [20] Stepwise approaches are occasionally utilized in instructional and psychological analysis to determine the significance of the many variables and to choose practical subsets of them. As a variation on the forward selection method, stepwise regression entails creating a series of linear models where predictor variables are entered one at a time. However, true stepwise entry is different from forward entry in that each step of a stepwise analysis takes the removal of each entered predictor into account; entered predictors are removed in subsequent steps if they no longer provide a significant amount of unique predictive power to the regression when taken into account in combination with newly entered predictors. Assumptions are met, and so stepwise regression can be performed.

This iterative method evaluates the statistical significance of each independent variable in a linear regression model. Forward selection, a specific approach within stepwise regression, begins with no variables and incrementally adds each new variable, testing for statistical significance along the way.

Table 6.
Best predictors of mathematics aptitude in differential calculus from the parameters of SE and SR.

No.	Model	B	t	Sig.
1	(Constant)	12.446	7.106	0.000
	Vicarious Experiences	2.003	3.798	0.000
2	(Constant)	6.411	2.517	0.014
	Vicarious Experiences	1.676	3.299	0.002
	External Regulation	2.079	3.111	0.003
3	(Constant)	3.196	1.204	0.233
	Vicarious Experiences	1.067	2.032	0.046
	External Regulation	2.464	3.805	0.000
	Social Persuasion	1.587	2.925	0.005

Results show that the model is significant, $R2=0.358$, Adjusted $R2= 0.329$, $F(3,67)= 99.486$, $p< 0.001$. Vicarious experience positively predicts mathematics aptitude in differential calculus, $\beta= 1.067$, Std. error= .525, $t= 2.032$, $p< 0.05$. It means that the higher the vicarious experience of respondents, the higher their aptitude in differential calculus. External regulation positively predicts mathematics

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aptitude in differential calculus, β= 2.464, Std. error= 0.647, t= 3.805, $p < 0.01$. It means that the higher the external regulation of respondents, the higher their aptitude in differential calculus. Social Persuasion positively predicts mathematics aptitude in differential calculus, β= 1.587, Std. error= 0.543, t= 2.925, $p < 0.05$. It means that the higher the vicarious experience of respondents, the higher their aptitude in differential calculus. The mathematics performance of the respondent can be predicted using the regression formula y= 3.196 + 1.067x1 + 2.464x2 + 1.587x3, where x1, x2, and x3 are the predictors: vicarious experiences, external regulation, and social persuasion respectively.

5. Discussion

5.1. Research Objective 1 (RO1) - Levels of Self-Efficacy of the Respondents

Mastery experiences of pre-service mathematics teachers are regarded as average self-efficacy, with a mean of 3.40 and a standard deviation of 0.695. Vicarious experiences are regarded as average self-efficacy, with a mean of 3.24 and a standard deviation of 0.716. Social persuasion is categorized as below-average self-efficacy, with a mean of 2.44 and a standard deviation of 0.683. Lastly, physiological and emotional states are regarded as average self-efficacy, with a mean of 3.11 and a standard deviation of 0.583.

High math self-efficacy improves students' enthusiasm for learning mathematics, but poor math self-efficacy individuals may avoid mathematics tasks, according to findings by Arifin and Herman [21] and Skaalvik, et al. [22]. Preservice teachers' self-concepts in maths are generally moderate (Mean = 2.46, SD = 0.69). The findings, though not entirely, reveal preservice teachers' subjective assessments of their aptitude for completing mathematical tasks and activities. Even now, preservice teachers maintain that mathematics is one of the hardest and most demanding disciplines. They wonder if they are math people and get frustrated when they can't figure out a mathematical challenge [23].

5.2. Research Objective 2 (RO2) - levels of self-regulation of the respondents

External regulation of pre-service mathematics teachers is regarded as above-average self-regulation, with a mean of 3.41 and a standard deviation of 0.545. Introjected regulation is regarded as average self-regulation with a mean of 3.30 and a standard deviation of 0.535. Identified regulation is also categorized as average self-regulation with a mean of 3.38 and a standard deviation of 0.562. Lastly, intrinsic motivation is regarded as average self-regulation with a mean of 3.10 and a standard deviation of 0.508.

According to Musso, et al. [24] the primary factors influencing performance among the student groups with the highest 30% of mathematics performance seem to be self-regulation and background variables (namely, the degree of student interest in the task and social indicators like parents' occupation). Because this group's cognitive processing levels were likely higher, cognitive processing variables in this group had significantly lower predictive weights. As a result, these variables are less discriminating when the model (Artificial Neutral Networks) tries to categorize the students based on their performance level.

5.3. Research Objective 3 (RO3) - Levels of Mathematics Aptitude in Differential Calculus of the Respondents

The mathematics aptitude of the respondents was divided into three categories: low, moderate, and high level. With a frequency of 56 (78.87%), majority of the respondents demonstrated a moderate level of mathematics aptitude, with scores ranging from 15.49 – 22.39.

The article by Radmehr and Drake [25] employed interviews with nine university students and eight year 13 students to investigate students' mathematical performance, metacognitive experiences, and metacognitive skills in relation to Fundamental Theorem of Calculus (FTC) problems. Their findings show that a lot of students had difficulties when attempting to answer FTC-related questions, and that students' metacognitive experiences and abilities may improve.

5.4. Research Objective 4 (RO4) - Significant Relationship between the Self-Efficacy of the Respondents and their Mathematics Aptitude in Differential Calculus

Base on the results, the self-efficacy and the mathematics aptitude in differential calculus of the respondents is positively correlated to each other. This means that if one variable increases, the other will also increase.

According to Pajares and Miller [26] students' confidence in their ability to solve problems that were later presented to them as a predicted success more than their confidence in performing math-related activities or excelling in math-related subjects. Similarly, confidence in performing math-related courses had a greater influence on the decision to pursue a math-related degree than confidence in problem-solving or completing tasks.

The findings are further supported by the study of Yuniati, et al. [27] which found that self-efficacy and differential calculus courses are in the intermediate category and have a linear relationship, with self-efficacy having a 57.3% positive effect on student learning results.

5.5. Research Objective 5 (RO5) - Significant Relationship between the Self-Regulation of the Respondents and their Mathematics Aptitude in Differential Calculus

Based on the results, the self-regulation and the mathematics aptitude in differential calculus of the respondents is positively correlated to each other. This means that if one variable increases, the other will also increase.

This finding is supported by the research study of Lawrence and Saileela [28] which indicates that through bivariate correlation, the self-regulation and achievement in mathematics of higher secondary students have a positive relationship. This means that they have a linear relationship, that if the level of self-regulation increases, mathematics performance also increases.

Contrary to the study findings of Nemati, et al. [29] self-regulation did not have a significant predictive effect on multiplication performance among both German and Iranian students overall. However, when examining specific fields of study, self-regulation was found to predict multiplication performance among German and Iranian students studying Human Sciences within their respective countries.

5.6. Predictors of Mathematics Aptitude in Differential Calculus

The mathematics performance of the respondent can be predicted by the parameters: vicarious experiences, external regulation, and social persuasion respectively.

Özcan and Kültür [30] supported the stepwise regression results. Mastery experience significantly predicted mathematical course achievement, accounting for 56% of the variance. Similarly, mastery experience, social persuasions, and physiological state all predict mathematics test performance, accounting for 27% of the variance. To summarize, different sources of mathematics self-efficacy influence both mathematics tests and course achievement.

The study of Sartawi, et al. [31] also supports the regression results. The study aimed to predict students' math achievement by assessing their motivation and math self-efficacy. The six predictors, which included task-specific, external, and intrinsic regulation, combined to explain 32% of the variance in math achievement. Gender differences were evident, with predictors accounting for 30% of male and 21% of female math achievement variance, resulting in different rankings. Furthermore, the model accurately predicted math performance for low and high-ability students (within 20% variance), but it was not appropriate for medium-ability students.

Another study shows support for the result. Fomina and Morosanova [32] investigated the relationships between self-regulation, math self-efficacy, math interest, and various types of mathematics achievement among 14–16-year-old 9th-grade students in Russia. There were significant correlations between these factors and various aspects of math performance. Self-regulation was identified as a significant predictor of overall year math grades and successful problem-solving. Math self-efficacy was linked to completing specific mathematical tasks, whereas math interest was associated

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with overall year math grades. In addition, self-regulation mediated the relationship between math interest and year-end math grades.

6. Conclusion

The study has investigated the relationship between self-efficacy, self-regulation, and mathematics aptitude in calculus of the pre-service mathematics teacher from the second year up to the fourth year of Central Luzon State University. The study also examined which of the parameters of self-efficacy and self-regulation best predicts the mathematics aptitude in calculus of the respondents.

The self-efficacy of the respondents is described as above average level, which means that they have confidence in doing mathematics problems involving topics in differential calculus. The self-regulation of the respondents is described as high level, which means that they can manage their thoughts and actions in order to achieve high aptitude in their calculus subject. Their mathematics aptitude in differential calculus is categorized as high level, which means that the respondents perform well on the test questionnaire given to them. They have satisfactorily answered the questionnaires and got high scores.

The relationship between self-efficacy and mathematics aptitude in the calculus of the respondents is positive and significant. This means that the higher the self-efficacy of the student, the higher they will perform in calculus. The same is true with the relationship between self-regulation and mathematics aptitude in calculus, with a positive relationship and is significant.

The study found that among the parameters of self-efficacy and self-regulation, the best predictors of mathematics aptitude in calculus are vicarious experiences and social persuasion for self-efficacy and external regulation for self-regulation.

7. Future Research Suggestions

To improve the teaching and learning experience through self-efficacy and self-regulation, the following recommendations are proposed:

Policy Advocacy:

The Department of Education, Republic of the Philippines, should prioritize policies that enhance teaching strategies that will improve the self-efficacy and self-regulation of the students. These policies are essential for students to hone and expand their knowledge regarding the subject matter.

Classroom Integration:

School heads and educators should improve and empower the teaching strategy to enhance the learning of the students by providing training and programs to future teachers on how to delve into the students' confidence and motivation. The best strategy to use is to have a fun and collaborative teaching and learning process. Where every student will have the opportunity to share and interact with each other. Making them feel that learning, even with complex ideas, is fun and exciting.

Focus on Evaluation:

Future studies could do a more comprehensive analysis of the variables. Such as, analysis on gender differences and year level differences, as the knowledge of students differ according to their status. Gender roles have different approach in studying, and the year level differs on how they acquire the knowledge from their educators. Also, year level differs because some levels they obtain the knowledge recently.

8. Limitations

Although the study received positive outcomes and feedback from the respondents, several limitations must be acknowledged. First, the sample size is smaller than expected. This is due to the number of enrolled students on the campus. Second, the course program of the respondents. The study only involved a bachelor of secondary education major in mathematics, which only focuses on the status of a one-course program. Lastly, the analysis of variables is narrow, which makes the topic open for other variables to partake in the analysis.

Future research should address these limitations through involving larger sample size with varying program that includes differential calculus to their course. Also, future studies should also involve other analysis such as gender differences and year level differences, as students have different approach in studying and obtaining knowledge.

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Transparency:
The authors confirm that the manuscript is an honest, accurate and transparent account of the study that no vital features of the study have been omitted and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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The authors declare that they have no competing interests.

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