Asian Journal of Education and Social Studies

Volume 36, Issue 3, Page 43-55, 2022; Article no.AJESS.94612
ISSN: 2581-6268

Non-Cognitive Factors Affecting Mathematics Performance Using Structural Equation Modeling: Basis for a Mathematics Learning Intervention Framework

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJESS/2022/v36i3781

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/94612

Original Research Article

Received: 06/10/2022
Accepted: 11/12/2022
Published: 13/12/2022

ABSTRACT

The study was conducted to determine the non-cognitive factors affecting the mathematics performance of Bachelor of Secondary Education students using Structural Equation Modeling as a basis for the formulation of a proposed Mathematics Learning Intervention Framework. This study employed a descriptive-correlational method.
A total of 266 pre-service teachers participated and answered the survey questionnaires through complete enumeration sampling. The results revealed that self-efficacy, study strategies, teacher support, and involvement directly affect the mathematics performance of the BSED major in

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mathematics students. In addition to this, the Mathematics Learning Intervention Framework was crafted highlighting self-efficacy, study strategies for math class, teacher support, and involvement factors to improve students' mathematics performance.

Keywords: Non-cognitive factors; psycho-sociological characteristics; study habits; classroom learning climate; mathematics performance; mathematics learning intervention framework.

1. INTRODUCTION

Students' academic performance has been the area of interest for higher education institutions. Investigation of factors associated with the academic performance of college students has gained increasing attention in the higher education community. Numerous studies were carried out to explore factors that affect college students' academic performance [1-3]. Cognitive ability was one of the most extensively studied topics as a predictor of student academic performance [4-6]. Research has consistently shown a positive relationship between cognitive abilities and academic achievement measured by various psychometric tests.

Although the focus of this study is on non-cognitive factors, an acknowledgment of the role of cognitive factors in students' academic performance is warranted. However, there is overall recognition that cognitive factors are not isolated and are not the sole contributors to academic performance [7]. Therefore, other factors like non-cognitive skills that contribute to academic performance require attention.

Non-cognitive abilities, which are often skills that are not directly affected by intellectual capacity, are another equally important aspect that most educational experts have mostly disregarded. Character strength [8,9], soft skills [10], personal skills [11], and emotional intelligence [12] are all examples of non-cognitive skills. According to Avila (2021), Biddle stated that poor academic performance could be due to personality rather than low Intelligence Quotient (IQ), poor teaching, an uncooperative environment, or other factors. He emphasized that the student with a great need for achievement avoids failure, expects success, takes risks and persists.

Nevertheless, the division of cognitive versus non-cognitive is basically flawed. As others have pointed out, there is no human activity that does not involve cognitive processes [13]. However, because the term non-cognitive has been widely accepted, this study utilized the term to represent abilities or skills that are not typically measured by an IQ test.

These perspectives have prompted educational researchers across the country and around the world to continue looking for factors that can account for Math achievement. Psychologists and educational experts have studied factors associated with academic achievement and discovered several reasons for students' success. However, non-cognitive skills as a predictor of academic performance in Mathematics have not yet been thoroughly explored as a special field. Hence, this study was conducted.

With the foregoing claims, the researcher assessed how the non-cognitive factors affect college students' mathematics performance. Further, it aimed to answer the following: determine the level of students' performance in mathematics, determine the level of psycho-sociological characteristics, determine the quality of study habits, determine the extent to which the practices that affect the classroom learning climate are observed, determine the relationship of the students' Psycho-sociological Characteristics, Study Habits and Classroom Learning Climate Practices to the Students Mathematics Performance, and determine the factors that best predict mathematics performance of the BSED students.

Moreover, the results of this study served as a basis for the researcher to craft a Mathematics Learning Intervention Framework to enhance the mathematics performance of the BSED students.

2. MATERIALS AND METHODS

2.1 Respondents

The study's respondents were the 266 students enrolled in the State Universities and Colleges (SUCs) in Davao Region, Philippines. Specifically, the fourth-year BSED major in Mathematics students. They were chosen because of their availability to the researcher and suitability for the study. The study employed a complete enumeration method since only a few students specialized in mathematics, and the study demanded a large number of respondents.

2.2 Instrument

The researcher utilized a validated survey questionnaire drawn from various online sources. There were two sections of the tool. Part I was the 30-item researcher-made test used to determine the mathematics performance of the respondents. The questionnaire contained questions covering all the major subjects of the BSED major in Mathematics curriculum. The researcher also prepared a Table of Specifications (TOS) to distribute the questions equally based on Bloom's Taxonomy of cognitive domains. Further, it was validated by experts in the field of Mathematics.

In the second section of the questionnaire, students' psycho-sociological characteristics, study habits, and classroom learning climate practices were assessed. The researcher adapted questionnaires developed by renowned education scholars. Modifications were made, such as modifying the phrase to suit the study's context. These questionnaires were validated by experts with the requisite knowledge and research experience in the topic. Furthermore, the questionnaires underwent a full board review by the University of Immaculate Conception (UIC) Research and Ethics Committee.

The following are the adapted questionnaires used in the study:

The Self-esteem Scale: Is a 10-item scale that measures overall self-worth by measuring positive and negative feelings about oneself. This questionnaire was developed by Rosenberg in 1965.

The General Self-efficacy Scale: Consists of a 10 item self-report measure of self-efficacy. This questionnaire was adapted from Schwarzer and Jerusalem in 1995.

The Grit Scale: Was developed by Angela Duckworth and her team in 2007 to evaluate focused effort and interest over time.

Math Study Skills Inventory: This questionnaire helped the students gauge their current ability level when studying math. This inventory questionnaire is composed of 19 questions adapted from Dr. Carolyn H. Hopper.

What Is Happening in This Class? (WIHIC) Questionnaire: This is a self-structured questionnaire developed by Fraser, Fisher, and McRobbie in 1996 and designed to measure the psychosocial aspects of the classroom learning environment in various contexts. The study focuses solely on student perceptions of a variety of classroom aspects, including student cohesiveness, teacher support, involvement, and equity.

The charts below include list of scales used as well as a description and interpretation of the data collected for all variables under study.

2.3 Research Design and Methods

This study utilized the descriptive-correlational design to determine the relationship among the non-cognitive factors affecting the mathematics performance of fourth-year college students. Descriptive-correlation research design describes and interprets what is and reveals conditions and relationships that exist and do not exist. It is a fact-finding study that allows the researcher to examine the study participants' characteristics, behaviors, and experiences [14,15].

Chart 1. Qualitative interpretations of the respondents' level of mathematics performance

Range of Scores	Description	Interpretation
25 - 30	Outstanding	Students exceed the core requirements in terms of knowledge and skills.
19 - 24	Very Satisfactory	Students developed fundamental knowledge and skills.
13 - 18	Satisfactory	Students developed fundamental knowledge and skills but need minimal guidance from their instructors or peers.
7 - 12	Fairly Satisfactory	Students possess the minimum knowledge and skills but need help and guidance from their instructors or peers.
1 - 6	Poor	Students did not possess the minimum knowledge, skills, and core requirements

Chart 2. Qualitative interpretations of the respondents' level of psycho-sociological characteristics

Range of Means	Description	Interpretation
3.26 – 4.00	Very High	This means that the respondents' psycho-sociological characteristics are always observed.
2.51 – 3.25	High	This means that the respondents' psycho-sociological characteristics are oftentimes observed.
1.76 – 2.50	Moderately High	This means that the respondents' psycho-sociological characteristics are sometimes observed.
1.00 – 1.75	Low	This means that the respondents' psycho-sociological characteristics are never observed.

Chart 3. Qualitative interpretations of the respondents' study habits

Range of Means	Description	Interpretation
3.26 – 4.00	Very Good	This means that the respondents' study habit is very effective
2.51 – 3.25	Good	This means that the respondents' study habit is effective
1.76 – 2.50	Fair	This means that the respondents' study habit is slightly effective
1.00 – 1.75	Poor	This means that the respondents' study habit is not at all effective

Chart 4. Qualitative interpretations of the respondents' extent of practices of the classroom learning climate

Range of Means	Description	Interpretation
3.26 – 4.00	Very High	This means that the classroom learning climate practices are always observed.
2.51 – 3.25	High	This means that the classroom learning climate practices are often observed.
1.76 – 2.50	Moderately High	This means that the classroom learning climate practices are seldom observed.
1.00 – 1.75	Low	This means that the classroom learning climate practices are never observed.

Chart 5. Structural equation modeling standard fit indices and their respective critical values

Index	Critical Values
CMIN/DF (The minimum Discrepancy divided by its Degrees of Freedom)	< 2
P – value	> 0.05
GFI (The Goodness of Fit Index)	> 0.95
CFI (The Comparative Fit Index)	> 0.95
TLI (Tucker Lewis Index)	> 0.95
NFI (The Normed Fit Index)	> 0.95
RMSEA (The Root Mean Square Error of Approximation)	< 0.05

3. RESULTS AND DISCUSSION

3.1 Level of Students' Performance in Mathematics

Table 1 displays students' performance in mathematics based on the achievement test. Most respondents (57.1%) have scores ranging from 19 to 24. It has a mean score of 19.55 and is described as very satisfactory. This result implies that most students perform very satisfactorily in college mathematics. Moreover, the students at this level have developed fundamental knowledge and skills. This can be attributed to the strict adherence to college institutions' retention policies. Students who fail to maintain the required undergraduate average must exit the teacher training program.

3.2 The Level of Psycho-sociological Characteristics of the Respondents

The psycho-sociological characteristics of the respondents are classified into three domains, namely: self-efficacy, self-esteem, and grit. Table 2 shows the respondents' level of psychosocial characteristics.

The students' self-efficacy has a category mean of 3.05, meaning that the indicator stated is oftentimes observed. This further implies that most students are willing to exert effort to manage and solve complex problems. Students with high levels of self-efficacy envision themselves succeeding and have trust in their abilities [16]. A high sense of self-efficacy enhances human accomplishment and personal well-being in many ways. It is considered an accurate predictor of performance [17]; further, self-efficacy is an important non-cognitive skill ensuring success.

Self-esteem got a category mean of 3.19, meaning that the indicator stated is often observed. This further means that the respondents generally have a good personal outlook on their self-worth. High self-esteem among students is important in their academic undertakings. Individuals with high self-esteem set higher expectations for themselves and only consider themselves "good enough" when those goals are satisfied, resulting in positive self-evaluation and increased academic engagement [18]. Moreover, individuals with high levels of self-esteem can effectively alleviate the negative academic emotions caused by high expectations [19].

On the other hand, Rosenberg [20] observed that persons with low self-esteem continuously criticize themselves and cannot establish positive connections with colleagues and teachers. Further, Kariuki et al., [21] recommend the need to build self-esteem among students. She added that this would guarantee good academic performance in schools.

Grit is one of the characteristics utilized in this study. It can be gleaned from Table 2 that grit has a category mean of 3.09 and described as high. This means that the indicators stated are oftentimes observed. This indicates further that most respondents are more persistent, diligent, focused, and not discouraged by setbacks or failure. Hogan and Wong [22] claim that grittier persons work harder and longer and are more likely to engage in purposeful practice to improve performance or success. In addition, [23] found out that grittier individuals are more diligent and persistent, and are not discouraged by setbacks or failure due to their focus on the goal.

In general, the students' psycho-sociological characteristics have a grand mean of 3.11, which means that students can solve most problems, are satisfied and have a positive attitude towards themselves, are hard workers, and are most likely to finish what has been started.

Table 1. Level of students' performance in mathematics

Scores	Frequency	Percentage	Description
25 – 30	9	3.4	Outstanding
19 – 24	152	57.1	Very Satisfactory
13 – 18	103	38.7	Satisfactory
7 – 12	2	0.8	Fairly Satisfactory
1 - 6	0	0	Poor
Mean: 19.55	**Very Satisfactory**		

Table 2. Level of psycho-sociological characteristics of the respondents

Psycho-sociological Characteristics	Mean	Description
Self-efficacy	3.05	High
Self-esteem	3.19	High
Grit	3.09	High
Grand Mean	**3.11**	**High**

3.3 Quality of Study Habits of the Respondents

Presented in Table 3 is the quality of the study habits of the respondents. The study habits instrument comprises three domains - time and place for studying math, math test strategies and study strategies for math class. Among the three categories, the time and place for studying math got the highest category mean score of 3.31, followed by math tests, 3.27, and the last is the study strategies for math class with a mean score of 2.86.

Two of the three indicators of study habits have a very good description, time and place for studying math (3.31) and math test strategies (3.27). This means that the respondents' study habit is very effective. Kesici, Baloglu, and Deniz [24] emphasized that students who manage their time and study environment more effectively experience less worry and have more favorable attitudes about mathematics subjects. Also, when taking exams, respondents use various strategies with which they are comfortable. Results corroborate the findings of Odiri [25] and Katelyn as cited by Ebele and Olofu [26], which indicate that students' study habits vary by student and by place. Some habits are deemed more desirable than others in terms of academic progress. Moreover, it is essential for learning because student progress in school depends on their study habits.

In addition, the respondents' study strategies got the lowest mean of 2.86, described as good, meaning that the respondents' study habit is effective. Good learning is developed using productive study strategies [27]. Each student has their own distinct study habits. What may be a beneficial study practice for one student may be detrimental to another. Good study habits occur as a result of practice and knowing what methods are most effective for the student.

3.4 Extent of Classroom Learning Climate Practices

This study considers four domains of classroom climate practices. These are equity, teacher support, cohesiveness, and involvement. Table 4 presents the extent of the classroom learning climate practices of the respondents.

As indicated in Table 4, equity has a category mean of 3.51 and described as very high. It indicates that teachers have demonstrated fairness and equality toward students by giving them equal opportunities to participate in class discussions and activities, ask questions, receive encouragement and support, have an equal say in class, and access to instructional materials.

Table 3. Quality of students' study habits

Study Habits	Mean	Description
Time and Place for Studying Math	3.31	Very Good
Math Test Strategies	3.27	Very Good
Study Strategies for Math Class	2.86	Good
Grand Mean	**3.15**	**Good**

Table 4. Extent of classroom learning climate practices

Classroom Learning Climate Practices	Mean	Description
Equity	3.51	Very High
Teacher Support	3.51	Very High
Cohesiveness	3.56	Very High
Involvement	3.37	Very High
Grand Mean	**3.49**	**Very High**

The second indicator of classroom climate practices is Teacher Support. It has a category mean of 3.51 and described as very high. This finding indicates that mathematics teachers demonstrate a very high level of support for their students. This further means that students are well supported by the teachers personally, emotionally, and academically. Teachers know that students are more intrinsically motivated to learn when they see and feel supported by others, especially when they are looked up to as second parents by the students in the classroom. This finding confirms Rosenshine's point of view, which cited that the most important aspect of classroom climate is the relationship between the teacher and the students [28]. There must be an element of caring, trust, and respect in the interpersonal relationships between the teacher and the students.

As shown in Table 4, cohesiveness has a category mean of 3.56, described as very high. This means that teacher education students manifested a very high level of cohesiveness. This is because major subjects in mathematics are taught in the higher years when students have known each other for a long time, have developed friendships, and have become more comfortable with one another. According to Boehnke, as cited by Moldes et al. [29], when students are encouraged and motivated by peers, they will perform admirably in class and earn high grades in mathematics. By getting the support needed from the peer group, students tend to excel, exceed their capability, concentrate more on their studies, and do good in academic tasks [30]. With the necessary encouragement from peers, students tend to flourish and exceed their capabilities, concentrating more on their studies and performing well on academic assignments at school [31].

As gleaned in the same table, it can be noted that involvement in the class gained a category mean of 3.37, described as very high. Students believe that leading the group during collaborative activities and sharing ideas during the class discussion is necessary because students develop teamwork skills. Additionally, students who engage in collaborative learning obtain higher marks, are more satisfied with their education and are more likely to complete their college careers [32].

The finding further shows that students are aware of the importance of active involvement in class activities to enhance performance in their subjects. As would-be teachers, they are knowledgeable about effective and proven practices in the teaching-learning process as these were taught in their professional education subjects. The Grand mean of classroom learning climate practices is 3.49 and is described as very high. Students feel safe, nurtured, and intellectually stimulated in a positive classroom climate. Teachers continually look to create a positive classroom climate that maximizes student learning [33]. This positive classroom climate allows students to meet their basic physical and mental health needs.

3.5 Relationship of the students' Psycho-sociological Characteristics, Study Habits and Classroom Learning Climate Practices to the Students Mathematics Performance

As shown in Table 5, correlation results indicated that the psycho-sociological characteristics r=0.237, p-value=0.000 and its indicator self-efficacy r=0.305, p-value=0.000 showed statistical significance to students' mathematics performance. This is to say that an increase in psycho-sociological characteristics in terms of self-efficacy precedes an increase in students' mathematics performance, which also means that the higher the students' self-efficacy, the more they can improve their performance in mathematics.

Correlation results further suggested that study habits r=0.199, p-value=0.001 and its domains, namely: study strategies r=0.274, p-value 0.000 and math test strategies r=0.144, p-value=0.019) displayed statistical significance relative to students' mathematics performance. This indicates that their mathematics performance will eventually improve when the students develop these study strategies and math test strategies as part of their study habits.

Further, correlation results indicated that the classroom learning climate r=0.185, p-value= 0.003 and its domains cohesiveness r= 0.164, p-value=0.007 and involvement r= 0.213, p-value=0.000 have a significant relationship to the students' mathematics performance. Results show that the students' mathematics performance will also increase with an increase in the classroom learning climate in terms of cohesiveness and involvement. When students feel supported by their classmates and peers,

they become motivated to participate in class activities, inspiring them to study well to get high grades and become more responsible.

3.6 Regression Analysis of Students' Psycho-sociological Characteristics, Study Habits, Classroom Learning Climate Practices and Students' Mathematics Performance

Table 6 shows a linear regression model of the students' mathematics performance, best described with the three factors: self-efficacy, study strategies, and involvement which obtained unstandardized coefficients of 1.623, 1.111, and 0.703, respectively, and a constant value of 9.053. Using stepwise regression, it was found that other factors do not contribute to students' mathematics performance.

This model obtained an R square value of 0.138, which means that the generated regression model can explain only 13.8% of the total data being considered, while 86.2% of the data can be credited to other factor variables apart from the regression model.

3.7 Structural Model of the Students' Mathematics Performance

Fig. 1 shows the final hypothesized model. In the hypothesized model, 18% of the students' mathematics performance could be estimated by psycho-sociological characteristics with self-efficacy as the measured variable, study habits with measured variable study strategies for math class, and classroom climate practices with teacher support and involvement as the measured variables.

The model represents the best fit for students' mathematics performance, as shown in Table 7. The CMIN/DF test, which is 1.063, is statistically significant with a p-value of 0.363. Thus, it represents an acceptable good fit with the data. Other measures of goodness of fit likewise identically assumed true model being fitted to the data as indicated: NFI (0.976), TLI 0.995, CFI (0.998), and GFI (0.995).

Table 5. Correlation Analysis of the Psycho-sociological Characteristics, Study Habits and Classroom Learning Climate Practices to the Students' Mathematics Performance

Factors	r-value	p-value	Interpretation
Psycho-sociological Characteristics	**.237***	**.000**	**Significant**
Self-esteem	.110	**.**073	Not Significant
Self-efficacy	.305*	.000	Significant
Grit	.108	.079	Not Significant
Study Habits	**.199***	**.001**	**Significant**
Time and place for studying Math	.051	.409	Not Significant
Study strategies	.274*	.000	Significant
Math test strategies	.144*	.019	Significant
Classroom Learning Climate Practices	**.185***	.**003**	**Significant**
Equity			
Teacher Support	.088	.154	Not Significant
Cohesiveness	.108	.079	Not Significant
Involvement	.164*	.007	Significant
	.213*	.000	Significant

Significant at 0.05 level (2-tailed)

Table 6. Summary of Stepwise Multiple Regression Analysis Result

Predictors	R Square	Unstandardized Coefficients	Regression Model
Self-Efficacy		1.623	$y = 9.053 + 1.623_{x1} + 1.111_{x2} + .703_{x3}$
Study Strategies	0.138	1.111	
Involvement		0.703	where,
Constant		9.053	y= Mathematics Performance
			x_1 = Self-efficacy
			x_2= Study Strategies
			x_3= Involvement

Table 7. Fit indices of the Hypothesized Model

Index	Critical Values	Results	Remarks
CMIN/DF	< 2	1. 063	Satisfied
P - value	> 0.05	0. 363	Satisfied
GFI	> 0.95	0.995	Satisfied
CFI	> 0.95	0.998	Satisfied
TLI	> 0.95	0.995	Satisfied
NFI	> 0.95	0.976	Satisfied
RMSEA	< 0.05	0. 015	Satisfied

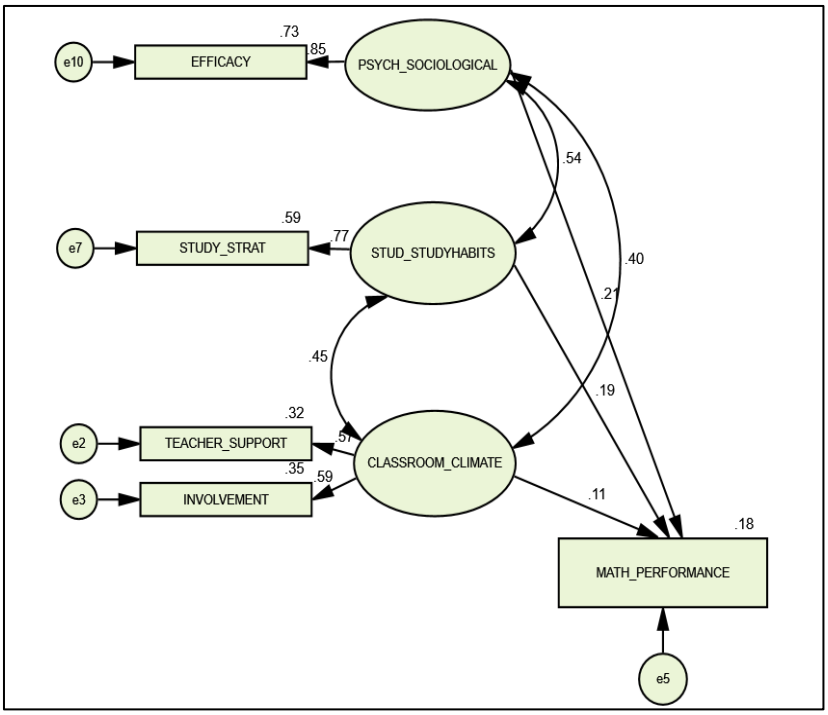

Fig. 1. Model of best fit

Further, the RMSEA, which is regarded as one of the most informative fit indices due to its sensitivity to the number of estimated parameters in the model (0.015), indicated a good model fit. Thus, the direct relationship of psycho-sociological characteristics, study habits, and classroom climate practices to the students' mathematics performance was kept as the measurement model where all specified values for goodness-of-fit measures were completely satisfied.

3.8 The Mathematics Learning Intervention Framework

The Mathematics Learning Intervention Framework aims to determine the factors that will help improve students' performance in mathematics. It will also serve as a guide for the teachers on what activities and strategies they will adopt to maximize the cooperation and participation of the students in the class.

Based on the best fit model, study habits with the measured variable study strategies for math class, classroom climate practices with teacher support and involvement as the measured variables, and psycho-social characteristics with self-efficacy as the measured variable could be used to estimate students' mathematics performance.

As shown in Fig. 1, 21% of the students' mathematics performance is affected by their psycho-sociological characteristics, especially self-efficacy. The result shows that psycho-sociological characteristics, particularly self-efficacy, are significant to the dependent variable. In addition, when students' psycho-sociological characteristics are enhanced, their mathematics performance will also improve.

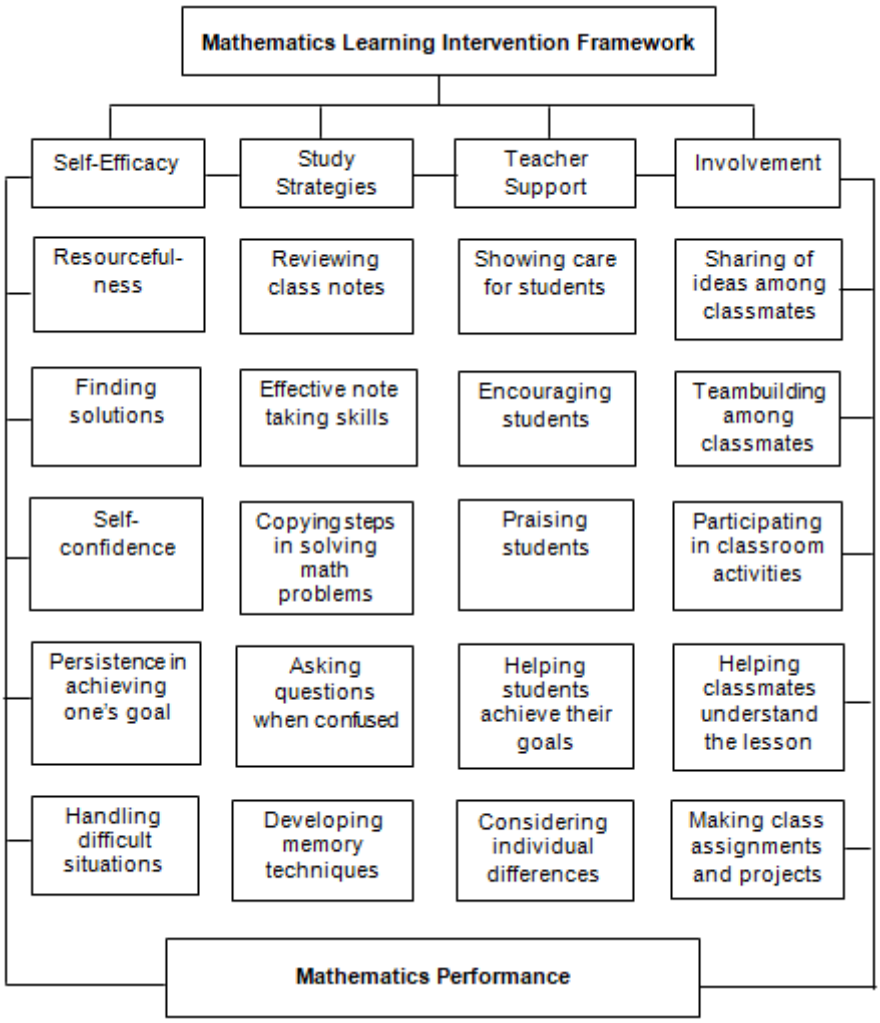

Fig. 2. Mathematics learning intervention framework

Further, the students' study habit is also a factor in their mathematics performance. As revealed, 19% of the students' mathematics performance is affected by their study habits. Study habits, specifically the study strategies of the students, directly contributed to the dependent variable of the study.

Another variable understudy that is significant to the dependent variable is classroom climate practices, including teacher support and student involvement. Results revealed that 11% of the students' classroom learning climate practices affect their mathematics performance. Teachers who establish positive relationships with their students develop a positive classroom climate. It will undoubtedly improve student performance when instructors engage in interpersonal interactions that demonstrate that students are respected and cared for. Although instructor-student rapport plays a critical role in the classroom environment, student-student rapport may also contribute.

4. CONCLUSION

Using Structural Equation Modeling (SEM), the non-cognitive factors and classroom learning climate practices that affect the mathematics performance of students are the following: self-efficacy, study strategies for math class, teacher support, and involvement. Hence, the Mathematics Learning Intervention Framework, which contains the variables that directly affect the students' performance in mathematics, such as self-efficacy, study strategies for math class, teacher support, and involvement, was formulated.

5. STUDY LIMITATIONS AND RECOMMENDATION FOR FUTURE STUDY

The study was limited to investigating the non-cognitive factors that affect the students' mathematics performance. Another limitation of this study is related to the sample and its generalizability. The samples were drawn from the 5 State Universities and Colleges in Davao region; hence, Private Higher Education Institutions were not included in the study. Moreover, this study only considered BSED major in Mathematics students.

Future research is encouraged to include other non-cognitive factors as predictors of students' mathematics performance. Consider broader scope to include higher education institutions in the region to provide more inclusive results. Encourage future researchers to apply the mathematics learning intervention framework to strengthen and maximize students' learning.

CONSENT AND ETHICAL APPROVAL

The study followed the elements of ethics clearly stated in the National Ethical Guidelines for Health and Health-Related Research (2017). To ensure that respondents were protected in this study, the manuscript was submitted to the University of Immaculate Conception Research Ethics Committee (UIC-REC) for full board review on the ethical aspects of the investigation. Strict adherence to the principles of respect for persons, beneficence, and justice was considered. Specifically, this study abodes the 10 dimensions of research ethics: social value, informed consent, vulnerability issues, risk-benefit ratio, privacy and confidentiality of information, justice, transparency, qualification of the researchers, adequacy of facilities, and community involvement. The certification was issued dated June 6, 2019, by the UIC Research, Publication, and Innovation Center with RPIC_FO_ 0059 Control Number 0417.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
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