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Research Article

A Path Analytic Model of Socio-Psychological Attributes on the Performance of College Students in Mathematics

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Abstract: This paper used path analysis in determining the best causal model of the mathematics performance of the students. The participants of the study were non-math major college students of Bukidnon State University. The results revealed that paths of students' engagement, self-efficacy, math anxiety, and math attitude to their mathematics performance are significant. Furthermore, all attributes have indirect path to the mathematics performance except for the students' engagement. Based on the results, students' engagement, self-efficacy, and mathematics attitude have a positive effect on the students' mathematics performance. However, mathematics anxiety can negatively affect the students' performance in mathematics.

Keywords: Causal Model, Mathematics Performance, Path Analytic Model, Socio-Psychological Attributes

1. Introduction

The concept of academic performance has become a source of concern to researchers, especially as the academic performance of college students is declining. The quality of students' performance remains a top priority for educators. It is meant for making a difference locally, regionally, nationally, and globally. Educators, trainers, and researchers have long been interested in exploring variables contributing effectively to the quality of performance of learners since the weak math skills of students entering college present a problem nationwide.

According to **Ashcraft and Kirk (2001)**, using correlation analysis significant negative relationship exists between mathematics anxiety and academic performance. Moreover, **Clute (1984)** and **Hembree (1990)**; have found that students who have a high level of mathematics anxiety have lower levels of mathematics achievement. They have also noted that math anxiety seriously constrains performance in mathematical tasks, and reduction in anxiety is consistently associated with improvement in achievement. **Finn (1989)**, in the Participation-Identification Model, it was claimed that participation in school and class activities increases students' performance and their achievement and that students' performance has an influence on their feeling of identifying themselves with the school. The study of **Nicolaidou and Philippou (1997)** using multiple regression analysis self-efficacy contribute significantly to the prediction of problem-solving achievement. **Cerna and Pavliushchenko (2015)** revealed that study habits is an important determinant of academic performance.

The aim of this paper is to determine best-fit models of socio-psychological attributes: math anxiety, math engagement, self-efficacy beliefs, and academic attitude on the performance of college students in mathematics. Path analysis will determine the direct and indirect relationships and degree of influence of the independent variables to the dependent variable. This paper will give light to the math teachers and students on which attributes give the strongest influence on the academic performance and will help them give importance to which attributes to improve.

2. Theoretical Framework

This study is anchored in the following theories:

Carey E. et al. (2016) also showed that math anxiety has negative effects on the mathematics performance of the students. That is, they found that increase math anxiety of the students might result in a decrease in mathematics performance.

Akin, H. &Kurbanoglu, I. (2011) found that mathematics anxiety is negatively correlated to students' mathematics attitudes and self-efficacy. Further, according to their path analysis results, positive attitudes were predicted positively, and negative attitudes were predicted negatively by self-efficacy.

A Positive attitude, encompassing strong interests and beliefs in one's ability, is thought to have a significant influence on a child's academic learning and success **(Pinxten et al., 2014)**.

The positive attitude of the students towards mathematics manifested a significant influence on mathematics performance. Hence, performance in mathematics can be improved by developing a positive attitude towards the subject **(Tudy, R. et al., 2014).**

Within the context of mathematics, self-efficacy is a better predictor of performance than measures of math anxiety or prior experience with math **(Pajares& Miller, 1994; Pajares& Miller, 1995)**.

Gunuc, S. (2014) showed that a relationship exists between students' academic performance and engagement, especially in cognitive engagement, behavioral engagement, and sense of belonging. In addition, he stressed that students with a high level of student engagement had higher levels of academic achievement and that those with a low level of student engagement had lower levels of academic achievement.

Lindsey, H. (2017) cited that research indicates a positive relationship between self-efficacy and students' behavioral engagements. Students with positive attitudes about their capabilities to do a task are much more likely to put forth effort, persist, and seek help adaptively. Students who have negative attitudes are much less likely to put forth effort and more likely to give up easily when faced with adversity and difficulties completing a task.

Students who believe they are capable of completing a task are more likely to be cognitively engaged than those with lower self-efficacy beliefs. High self-efficacy beliefs support students' efforts to understand the content and think deeply about it, thus increasing metacognitive processes. Research indicates a positive relationship between self-efficacy and student cognitive and metacognitive strategies **(Linnenbrink&Pintrich, 2003)**.

3.Objectives of the Study

This study aims to:

- describe the level of socio-psychological attributes of college students in mathematics in terms of (i) attitude towards mathematics; (ii) engagement in mathematics; (iii) self-efficacy beliefs in mathematics; and (iv) anxiety in mathematics;
- determine the relationships among the socio-psychological attributes of the students taking general education math;
- estimate both indirect and direct effects of the socio-psychological attributes of the students to their mathematics performance; and
- develop best-fit models on the mathematics performance of students.

4. Methodology

In this study, the researchers used a correlational design in determining the best fit models of math performance of college students who are non-math majors in Bukidnon State University taking general education math in the first semester of the school year 2016-2017. Stratified random sampling was used in selecting the participants of the study. A survey questionnaire served as an instrument in measuring the socio-psychological attributes and academic attitudes of the students. The performance of the college students in Mathematics was measured using their Mathematics grade in the first semester of the school year 2016-2017. Descriptive statistics, correlation analysis, and path analysis were used to answer the objectives of the study.

5. Results and Discussions

Table 1. Students' attitude towards mathematics subject

Mathematics Attitude	*M*	*SD*	Description
1. I try to learn mathematics because it helps develop my mind and helps me think more clearly in general.	4.19	0.75	Agree
2. The skills I learn in this class will help me in other classes for my major subjects.	4.04	0.82	Agree
3. Mathematics is important for my chosen profession.	4.01	0.96	Agree
4. In mathematics you can be creative and discover things by yourself.	3.97	0.77	Agree
5. Mathematics is enjoyable and stimulating to me.	3.84	0.79	Agree
6. Mathematics is important in everyday life.	3.83	0.23	Agree
7. Ordinary students can understand mathematics, they can apply it in real-world problems.	3.82	0.36	Agree
8. Mathematics is creative; it's more than just formulas and equations.	3.80	0.19	Agree
9. Mathematics is more important to me compared to other subjects.	3.78	0.24	Agree
10. I have liked mathematics, and it is my most favorite subject.	3.35	0.34	Agree
Over All Mean	3.86	0.55	Agree

Legend:

1.00 – 1.80 Strongly Disagree	2.61 – 3.40 Undecided	4.21 – 5.00 Strongly Agree
1.81 – 2.60 Disagree	3.41 – 4.20 Agree	

The student's attitude towards math is positive, having a mean of 3.86. Table 1 shows that most of the students agree with the statements. As shown, students agree that learning mathematics helps develop their minds and helps them think more clearly in general (4.19). The skills the students learn in mathematics help them to do well in their major subjects (4.04), important for their chosen profession (4.01), and helps them be creative (3.97). According to **Laney Kennedy (2019)** relationship between attitude and achievement is bidirectional. This means a relationship can develop in two different directions. The first one is that student with a positive attitude towards math tends to be more confident when learning math. As a result, the student enjoys mathematics, then becomes motivated to exert more effort learning, actively engages during lessons, gets more practice, leading to higher achievement in math. The second direction is that student with higher achievement in mathematics has more confidence in their abilities. Eventually, the students see the value of mathematics, leading to a positive attitude towards mathematics subject.

Table 2. Students' Engagement in Mathematics Subject

Student Engagement in Mathematics	*M*	*SD*	Description
1. I did a lot of thinking in math class.	4.70	0.75	Strongly Agree
2. Students in my math class helped each other learn.	4.65	0.7	Strongly Agree
3. I tried to learn as much as I could in math class.	4.33	0.7	Strongly Agree
4. It was important to me that I understood the math really well.	4.25	0.68	Strongly Agree
5. In math class I solved problems as much as I could.	4.17	0.72	Agree
6. I talked about math to others in class.	3.75	0.54	Agree
7. I felt enthusiastic in math class.	3.72	0.41	Agree

8.	I helped others with math when they didn't know what to do.	3.70	0.52	Agree
9.	I liked the feeling of solving problems in math.	3.65	0.38	Agree
10.	I enjoyed thinking about math.	3.60	0.43	Agree
	Over All Mean	4.05	0.58	Agree

Legend:
1.00 – 1.80 Strongly Disagree 2.61 – 3.40 Undecided 4.21 – 5.00 Strongly Agree
1.81 – 2.60 Disagree 3.41 – 4.20 Agree

The students' engagement in math has a mean of 4.05, which shows that the students, on average, agree on the statements. The result shows that the students strongly agree that they did a lot of thinking in math class (4.70), helped each other learn mathematics (4.65), tried to learn as much as they could (4.33), and important to them to understand math well (4.25). Further, it also shows that the students agree that they solve problems as much as they could (4.17), talked about math (3.75), enthusiastic in the class (3.72), helped others (3.70), like solving math problems (3.65), and enjoyed thinking about mathematics (3.60). According to **Fung et al. (2018)**, the three levels of mathematics engagement (affective, behavioral, and cognitive) were individually related to their mathematics achievement. Though the authors suggested that it might be more important for the students to be more cognitively engage than affectively or behaviorally in their mathematics learning, they emphasized that the combination of these three are positively contributory to mathematics achievement in many instances. The study recommended that a whole-school approach that enhanced the students' engagement in different aspects might raise their mathematics achievement. Mathematics teachers, therefore, needed to intellectually challenge their students in class, extra-curricular teachers needed to encourage students to participate in exciting mathematics activities, and guidance teachers needed to foster in students a sense of belonging to their schools. These actions would be a great help for the students to be more engaged, which will lead to higher achievement in mathematics.

Table 3. Students' Self-Efficacy in Mathematics Subject

	Mathematics Self-Efficacy	*M*	*SD*	Description
1.	I feel confident enough to ask questions in my mathematics class.	4.26	0.65	Strongly Agree
2.	I believe I will be able to use mathematics in my future career when needed.	4.23	0.57	Agree
3.	I believe I can learn well in a mathematics course.	4.18	0.47	Agree
4.	I believe I am the type of person who can do mathematics.	4.10	0.68	Agree
5.	I believe I can understand the content in a mathematics course	3.47	0.72	Agree
6.	I believe I can do well on a mathematics test.	3.45	0.84	Agree
7.	I believe I can get a high grade in a mathematics course.	3.36	0.81	Undecided
8.	I believe I can complete all of the assignments in a mathematics course.	2.67	0.92	Undecided
9.	I believe I am the kind of person who is good at mathematics.	2.63	0.98	Undecided
10.	I believe I can think like a mathematician.	2.47	0.88	Disagree
	Over All Mean	3.40	2.48	Agree

Legend:
1.00 – 1.80 Strongly Disagree 2.61 – 3.40 Undecided 4.21 – 5.00 Strongly Agree
1.81 – 2.60 Disagree 3.41 – 4.20 Agree

The students' self-efficacy in math has a mean of 3.40, which shows that they believe that they can do well in math. Having a high mathematics self-efficacy is important because, according to **Ayotola and Adedeji (2009),** it has a strong positive relationship to achievement in mathematics. Their findings were supported by

Bendura's (1986, 1997) claim that self-efficacy beliefs predict academic outcomes. The paper recommended that teachers should find ways of enhancing mathematics self-efficacy in students and should place emphasis on students' confidence to succeed in Mathematics achievement. Researchers and school counselors should be looking to student's beliefs about their mathematics capability, for they are important components of motivation and academic achievement **(Bandura, 1997; Pajares, 1997; Schunk, 1991; Zelding and Pajares, n.d.)**.

Table 4. Students' Anxiety in Mathematics

Mathematics Anxiety	*M*	*SD*	Description
1. I get nervous when taking a mathematics test.	4.28	0.96	Strongly Agree
2. I worry that I will not be able to get a good grade in my mathematics course.	4.26	0.83	Strongly Agree
3. I get tense when I prepare for a mathematics test.	4.12	0.91	Agree
4. I worry that I will not be able to pass in my mathematics course.	4.11	0.99	Agree
5. I worry that I will not be able to do well on mathematics tests.	4.07	0.87	Agree
6. I am afraid to give an incorrect answer during my mathematics class.	4.05	0.94	Agree
7. I worry I will not be able to understand the lessons in mathematics.	3.47	0.97	Agree
8. I worry that I do not know enough mathematics to do well in future mathematics courses.	2.77	1.75	Undecided
9. I feel stressed when listening to mathematics instructors in class.	2.71	1.07	Undecided
10. I get nervous when asking questions in mathematics class.	2.42	1.08	Disagree
Over All Mean	3.63	1.04	Agree

Legend:
1.00 – 1.80 Strongly Disagree
1.81 – 2.60 Disagree
2.61 – 3.40 Undecided
3.41 – 4.20 Agree
4.21 – 5.00 Strongly Agree

The mean of 3.63 on students' anxiety in math shows that they are anxious about math. On average, the students strongly agree that they are nervous when taking mathematics tests (4.28) and worry that they will not be able to get a good grade in mathematics (4.26). The students also responded, on average, that they agree that they get tensed, worry, and afraid in dealing with mathematics activities. Students should deal with these correctly since it was found that mathematics anxiety has a negative impact on mathematics achievement. **Geist (2010)** stated that math anxiety is a serious obstacle for children in all levels of schooling. This negative attitude toward mathematics is creating a disparity between levels of mathematics achievement.

Since mathematics anxiety was found to have a negative effect on academic achievement, it is important to know its root cause to properly address it. **Sarah et al. (2014)** found out that the causes of math anxiety include social, cognitive, and academic elements. For social factors, researchers suggested parent education and workshops increase student support of academic endeavors at school and home **(Geist, 2010; Gillen-O'Neel et al., 2011; Renya, 2000; Tobias, 1978)**. Other researchers explored changes in giving assessments to identify early mathematics learning problems and specialized instruction to address the cognitive aspects that contribute to math anxiety **(Ashcraft, 2002; Mattarella-Micke et al., 2011; Mundia, 2012; Ramirez et al., in press)**. Lastly, on the academic factor, as interventions to replace the anxiety-inducing traditional math curriculum, curriculum changes such as group work, open discussion, real-life applications, and group or peer assessments were offered **(Geist, 2010; Sparks, 2011; Willis, 2010)**. Researchers also encouraged teachers to examine their math anxiety and take steps to create stress-free and positive classroom environments **(Beilock et al., 2010; Bekdemir, 2010; Swars et al., 2010)**.

Table 5. *Correlation Between Socio-Psychological Attributes and Mathematics Performance ofthe Students*

Independent Variables	Dependent Variable: Mathematics Performance			
	Correlation Coefficient	p-value	Degree	Interpretation
Students' Attitude	.67	.034	High	Significant
Students' Engagement	.75	.028	High	Significant
Self-Efficacy	.54	.041	Moderate	Significant
Math Anxiety	-.50	.045	Moderate	Significant

Table 5 showed that the socio-psychological attributes of the students are all significantly correlated to the mathematics performance of the students. It revealed that students' engagement ($r=0.75$, $p<.05$) has the highest effect on the mathematics performance, then closely followed by students' attitude ($r=0.67$, $p<.05$) and self-efficacy ($r=0.54$, $p<.05$). The effects of these attributes are positive, which means that higher values will result in higher performance of the students in mathematics. Furthermore, students' math anxiety ($r=-0.50$, $p<.05$) is negatively correlated to their mathematics performance. This means that the more the students anxious about mathematics subjects, the more they will have poorer mathematics performance.

This finding is similar to the study of **Ayatollah Karimi and S. Venkatesan (2009)**that there is a significant negative correlation between mathematics anxiety and mathematics performance. Math-anxious students had negative attitudes toward math and possessed negative outlooks on their mathematical aptitude. **Ashcraft (2002)** expressed that there was no surprise that people with math anxiety avoided career paths depending on math skills.

Figure 1. Best Fit Model on Mathematics Performance

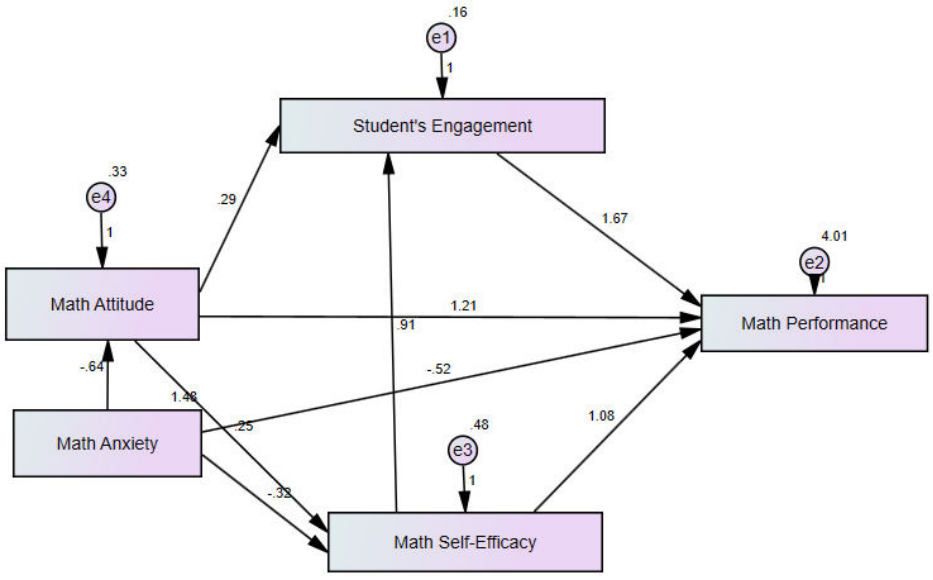

Figure 1 showed the obtained best fit model on the mathematics performance of the students with a chi-square value of 1.986 and a p-value of 0.091. The non-significant result means that this model does not significantly different from the saturated model (perfect model). In other words, the model fits the data well. The obtained model is parsimonious, which means it has the least number of parameters, and all paths are significant.

Table 6. Effects of the Socio-Psychological Attributes of the Students to their Mathematics Performance.

Socio-Psychological Attributes	Direct	Indirect	Total
Math Attitude	1.21	.754	.913
Math Engagement	1.67	--	1.670
Math Self-Efficacy	1.08	1.520	2.600
Math Anxiety	-.52	-.832	-1.352

Table 6 revealed the effects of the socio-psychological attributes of the students on their mathematics performance. In figure 1, math attitude ($\beta_1 = 1.21$), math engagement ($\beta_2 = 1.67$), math self-efficacy ($\beta_3 = 1.08$), and math anxiety ($\beta_4 = -0.52$) have a direct effects on mathematics performance. It also showed that all socio-psychological attributes have indirect effects on mathematics performance except for mathematics engagement. These values are shown in the table above. Moreover, the total effect of each attribute is reflected in the table, which is computed as the sum of direct and indirect effects on mathematics performance. These values are the change in the mathematics performance of the students in every 1 level increase each of the psychological attributes of the students.

Table 7. Parameter Estimates of the Paths of Causal Model

Paths	Estimate	SE	CR	P-value
Attitude <-- Anxiety	-.639	.035	-18.418	***
Self-Efficacy <-- Anxiety	-.325	.070	-4.668	***
Self-Efficacy <-- Attitude	.250	.087	2.858	.004
Math Engagement <-- Self-Efficacy	.909	.040	22.745	***
Engagement <-- Attitude	2.94	.038	7.760	***
Math Perf <-- Math Engagement	1.674	.368	4.554	***
Math Perf <-- Self-Efficacy	1.083	.396	2.737	.006
Math Perf <-- Attitude	1.205	.281	4.288	***
Math Perf <-- Anxiety	-.521	.213	-2.440	.015

Table 7 also shows that the mathematics attitude and self-efficacy of the students mediate the effect of math anxiety on mathematics performance. This means that the mathematics attitude and self-efficacy of the students reduce the negative effect of anxiety on their mathematics performance. Mathematics engagement and self-efficacy are found to mediate the effect of mathematics attitude on mathematics performance. Lastly, mathematics engagement is also a significant mediator to the effect of self-efficacy on mathematics performance.

Table 8. Fit Indices of the Causal Model

Fit Indices	Standard Values	Model Values	Remark
Cmin/Df	0 < CMIN/df < 2	1.986	Good fit
p-value	>0.05	0.091	Good fit
CFI	>0.95	0.998	Good fit
NFI	>0.95	0.997	Good fit
TLI	>0.95	0.981	Good fit
GFI	>0.95	0.994	Good fit
RMSEA	<0.05	0.10	Good fit
RMR	<0.05	0.023	Good fit

The table above shows the fit indices of the model. As shown all indices of the models satisfy the standard values. This means that the obtained path analytic model is a good fit on the mathematics performance of the students.

6.Conclusion

Based on the results, the socio-psychological attributes of the students can significantly affect their performance in mathematics. It was found that students who participated and engaged in the class, have a positive attitude towards mathematics, and high self-efficacy would tend to have good performance in mathematics. However, students who have fear, anxiety, and worry too much about mathematics would likely have poor performance. Additionally, students' engagement was found to mediate the effect of math self-efficacy and math attitude on math performance. At the same time, self-efficacy mediates the effect of math anxiety on math performance.

Theory Generated:

There is a positive effect of student engagement, math attitude, and math self-efficacy on math performance of students; negative effect of math anxiety on the math performance of the students.

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