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Predictors of Mathematics Performance: An Inductive Approach Towards Theory Generation

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Abstract: Predictors of Mathematics Performance: An Inductive Approach Towards Theory Generation. Objectives: This study aimed to examine the predictive factors that affect the mathematics performance of the students towards developing a theory. **Methods:** Quantitative non-experimental method employing correlational approach was used in the study and inductive approach as basis for the theory development. Random sample students from the English and Communication Department participated in the study. Mathematics and Technology Attitudes Scale and Revised Mathematics Anxiety Rating Scale were used in this study. **Findings:** The findings exposed that of the fifteen domains, effective communication has the highest mean while self-efficacy has the lowest. This study also discovered that there was a significant difference between the sex and students' level of anxiety in terms of numerical test anxiety and mathematics course anxiety. The multiple regression also further revealed that of the fifteen domains, only instructional planning strategies and effective communication were the best predictors of mathematics performance. **Conclusion:** This study concluded that the level of mathematics performance of the students is multi-factorial in nature which depends on teachers' delivery, pedagogies, and coping with assessment anxiety.

Keywords: mathematics performance, predictive factors, students' attitude, teachers' effectiveness, theory generation.

Abstrak: Prediktor Prestasi Matematika: Suatu Pendekatan Induktif Menuju Generasi Teori. ***Tujuan:*** *Penelitian ini bertujuan untuk menguji faktor-faktor prediktif yang mempengaruhi prestasi matematika siswa dalam mengembangkan teori.* ***Metode:*** *Metode kuantitatif non-eksperimental dengan pendekatan korelasional digunakan dalam penelitian ini dan pendekatan induktif sebagai dasar pengembangan teori. Sampel siswa dipilih secara acak dari Departemen Bahasa Inggris dan Komunikasi berpartisipasi dalam penelitian ini. Skala Sikap Matematika dan Teknologi dan Skala Tingkat Kecemasan Matematika Revisi digunakan dalam penelitian ini.* ***Temuan:*** *Temuan mengungkapkan bahwa dari lima belas domain, komunikasi yang efektif memiliki nilai rata-rata tertinggi sedangkan self-efficacy memiliki nilai rata-rata terendah. Penelitian ini juga menemukan bahwa ada perbedaan yang signifikan antara jenis kelamin dan tingkat kecemasan siswa dalam hal kecemasan ujian numerik dan kecemasan mata pelajaran matematika. Regresi berganda lebih lanjut mengungkapkan bahwa dari lima belas domain, hanya strategi perencanaan pembelajaran dan komunikasi yang efektif adalah prediktor terbaik kinerja matematika.* ***Kesimpulan:*** *Studi ini menyimpulkan bahwa tingkat kinerja matematika siswa bersifat multi-faktorial yang bergantung pada kemampuan mengajar, pedagogi, dan keterampilan guru dalam mengatasi kecemasan penilaian.*

Kata kunci: *prestasi matematika, faktor-faktor prediktif, sikap siswa, efektivitas guru, generasi teori.*

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INTRODUCTION

The Covid-19 pandemic has enforced the implementation of online classes that caused varied predicaments from stakeholders and has been challenged by various conditions and circumstances. Due to safety measures resulting from COVID-19, online learning has become a valuable and practical tool for curriculum delivery worldwide (Elshami et al., 2021).

The factors that determine the quality of learning are determined by external factors and internal factors that affect it. The result of this pandemic is the emergence of new challenges to the quality of education that are being threatened by external factors (Manapa, 2021). At the university level, pandemic online learning presents unique problems for lecturers and students (Irfan et al., 2020). The result of these learnings may lead students to become anxious about the quality of their works and their performance.

Mathematics has been recognized as a significant factor in development that contributes to many fields and emphasizes the national agenda (Angco, 2021). According to Estonanto (2018), people know the significance of Mathematics that is considered as one of the pillars that built the human civilization. Math is a crucial subject; taken by all students, especially in the sciences at various levels of study. Learning mathematics is not just about calculations, memorizing formulas, or theories; even mathematical learning involves research, testing, and problem-solving (Patena & Dinglasan, 2013). During the COVID-19 pandemic, the transition from face-to-face teaching to online teaching made a huge impact on almost all aspects of education (Jaca, 2022). This poses a challenge on the teaching and learning of mathematics particularly the mathematics performance of university students.

In the Philippines, educational institutions are producing mathematically uneqipped graduates yearly. Both results in the Trends for International Mathematics & Science Studies (TIMSS) in 1999 and 2003 were unsatisfactory, which placed the country underachievers in the said examinations (Estonanto, 2017). Moreover, in the Philippines, mathematics is a general education subject in primary and higher education where learners are expected to gain understanding and appreciation of its principles as an applied-using appropriate technology in problem-solving, critical thinking, communicating, reasoning, making connections, representations, and decisions in real life-K to 12 Basic Education Curriculum (Guinocor et.al 2020). Since mathematical knowledge offers a wide scope application to communication and languages, this only requires the students to have a minimum number of mathematics course. Unfortunately, according to Brezavšèek et.al (2020), mathematics in university courses have often been identified as a significant obstacle for students and as one of the main reasons for dropping out of university. With this, there is a need to investigate and identify the possible factors that have contributed the poor performance in mathematics of the students in higher education institutions specifically to the English and Communication major students. Students' performance in mathematics based from their grades is affected by various factors. Among the various factors, in this study, students' affective characteristics were dealt with focusing on study habits and study attitudes (Biswas, 2015).

In Brazil, students' dismal math performance has been demonstrated in significant examinations, including the Programme for International Student Assessment, the Basic Education Assessment System, and the National Exam for Secondary Education (ENEM) (PISA) (Gomes et.al, 2021). Similarly, Thien and Ong (2015) examined PISA data for Singapore and Malaysia revealed that student socioeconomic

status, mathematical self-efficacy, and math anxiety level predict performance in both nations, while socioeconomic status of the school affects performance.

The scarcity of literature elaborating on the difficulties encountered among the English and Communication major students prompted the researcher to look into the factors that affect the language advantaged students in experiencing challenges in their mathematics related courses. Thus, this study aims to identify the factors that predict the mathematics performance of the students in the field of communication and languages. Further, identifying such predictors is not a trivial or irrelevant scientific task, because knowledge about them allows the construction of well-founded information about which factors are associated with worse or better performance (Gomes et.al, 2021). Also, the goal of this paper is to develop and generate a theory based from the results of the study.

METHODS

Research Design and Procedures

This study is a quantitative non-experimental method employing correlational approach. Non-experimental research method is used to describe variables and its relationship wherein the researcher cannot control or alter the predictor variable or subjects, but instead, relies on interpretation, observation or interactions to conclude (Kowalzyk, 2015). To determine the relationship of the two variables, a survey was conducted in a form of questionnaires. Correlational research examines how two or more variables are associated or related (Creswell, 2005). It is considered nonexperimental because it involves neither (a) random assignment of participants to group nor (b) the active introduction or manipulation of an intervention by a researcher, the central tenets of group experimental research (Cook et al.,2008). Inductive approach, also known in inductive reasoning, starts with the observations and theories are proposed towards the end of the research process as a result of observations (Goddard & Melville, 2004). Inductive research "involves the search for pattern from observation and the development of explanations – theories – for those patterns through series of hypotheses. No theories or hypotheses would apply in inductive studies at the beginning of the research and the researcher is free in terms of altering the direction for the study after the research process had commenced (Bernard, 2011). To determine the relationship between the factors that predict mathematics performance, an online survey was conducted through Google Forms. The environment of this study was conducted at Cebu Technological University (CTU) Main Campus under the Department of English Language Studies.

The research procedure of this study included the following: input, process, and output. First, the input consisted of the respondents' profile, and their performance in mathematics. Second, the process consisted of the collection, organization, analysis, and interpretation of the data. Third, the conclusions and recommendations.

Respondent

A purposive sampling method was used to identify the number of research respondents. Students from the Languages, Communication, and English Major students will be the respondents of this study. A total of 70 respondents participated in the study. This study was limited to the students from the Department of Languages and Communication, specifically

those who have undergone any mathematics course in their field.

Instrument

The researcher utilized the three (3) standardized questionnaires for the possible factors that influenced the mathematics performance of the students. To measure students' math confidence, behavioral engagement, confidence with technology, and perceived used of technology in learning mathematics, the researcher adopted the questionnaire from Mathematics and Technology Attitudes Scale (MTAS) used in the study of Pierce et.al (2007). For the math test anxiety, numerical task anxiety, and math course anxiety, the questionnaire was adopted from the Revised Mathematics Anxiety Rating Scale (RMARS) used in the study of Alexander and Martray (1989).

Table 1. Score range and interpretation for the math anxiety test, numerical task anxiety, and math course anxiety

Score Range	Verbal Description	Interpretation
1.00-1.79	Not At All	Low Anxiety
1.80-2.59	A Little	Some Anxiety
2.60-3.39	A Fair Amount	Moderate Anxiety
3.40-4.19	Much	Quite a Bit of Anxiety
4.20-5.00	Very Much	High Anxiety

Table 2. Score range and description for students' math confidence, behavioral engagement, confidence with technology, and perceived used of technology in learning mathematics

Score Range	Verbal Description
1.00-1.79	Strongly Disagree
1.80-2.59	Disagree
2.60-3.39	Neutral
3.40-4.19	Agree
4.20-5.00	Strongly Agree

Table 3. Score range and description for the students' level of motivation in mathematics. The finalized version of Mathematics Motivation Questionnaire (MMQ) by Fiorella et. al (2021) was used.

Score Range	Verbal Description
1.00-1.79	Never
1.80-2.59	Rarely
2.60-3.39	Sometimes
3.40-4.19	Usually
4.20-5.00	Always

Table 4. Score range and description for students' assessment to the teachers' effectiveness. An adopted School Teacher Effectiveness Questionnaire from Akram (2018) was used.

Score Range	Verbal Description
1.00-1.79	Never
1.80-2.59	Rarely
2.60-3.39	Sometimes
3.40-4.19	Often
4.20-5.00	Always

Table 5. Grade range and description for Students' Performance taken from CTU Student Manual 5th Edition

Grade Range	Verbal Description
1.00-1.50	Superior
1.60-2.00	Very Good
2.10-2.50	Good
2.60-3.00	Fair

Data Gathering Procedure

First, the research proposal was transmitted and forwarded to the Office of the University Ethics Committee for their approval. Second, a written permission was sent to the Dean of the College of Arts and Sciences, Dean through the chairpersons of the said programs mentioned. Third, informed consent from the identified respondents to conduct an online survey was secured. Fourth, the answered survey forms from the respondents were retrieved, tabulated, and analyzed. During the analyses of the data, Social Science Statistical Package (SPSS 24.0) was used.

Ethical Considerations

Before the data collection, the researcher sought approval from the student-respondents through a consent form that solicited their voluntary participation in this study. The respondents' identities were assigned a code to maintain anonymity and confidentiality. Likewise, the data collected from the Google form were bound to privacy to ensure that it is solely used for academic purposes only.

■ RESULTS AND DISCUSSION

Factors Affecting the Mathematics Performance of the Respondents

Descriptive statistics for items related to students' attitude towards mathematics and math anxiety are presented in Table 6. For students' attitude towards mathematics, Mathematics Confidence has a mean of 2.81 which corresponds to Neutral. While Behavioral Engagement, has a mean of 3.55 with a verbal description of Agree.

On the neutrality of the respondents in terms of mathematics confidence, it can be implied that the respondents were reluctant to voice out socially their opinions. However, it is also evident in the result that students from communication and language students are not confident in mathematics because of the nature of their field of specialization which is English.

Generally, a mean of 3.13 for mathematics anxiety (mathematics test anxiety, numerical test anxiety, mathematics course anxiety) was computed which corresponds to a verbal description of "A Fair Amount". One of the implications is that students got anxious when they see their teacher solves a math

problem or equation on the board. According to Khun-Inkeeree (2017), if the student's self-confidence towards mathematics is low, it makes it difficult to the student, they will find it boring and not interesting that may affect their mathematic performance.

Table 7 on students' attitude towards involving technology in learning mathematics showed the general mean was 3.05. It implies that the students were just neutral whether the aid or use of the technology could affect their attitude in learning mathematics.

Table 6. Students' attitude towards mathematics and math anxiety

Variables	Mean	Std Dev	Verbal Description
Mathematics Confidence	2.81	0.88	Neutral
Behavioral Engagement	3.55	0.74	Agree
Mathematics Test Anxiety	3.02	1.09	A Fair Amount
Numerical Test Anxiety	3.46	1.07	Much
Mathematics Course Anxiety	2.92	1.18	A Fair Amount

Table 7. Students' attitude towards involving technology in learning mathematics

Variables	Mean	Std Dev	Verbal Description
Confidence with Technology	3.10	0.83	Neutral
Perceived Usefulness of Technology in Learning Mathematics	3.00	0.95	Neutral
General Mean:	3.05	0.89	Neutral

Table 8. Students' motivation in learning mathematics

Variables	Mean	Std Dev	Verbal Description
Intrinsic Value	3.13	1.09	Sometimes
Self-Efficacy	2.55	1.11	Rarely
Utility Value	3.38	0.96	Sometimes
General Mean:	3.02	1.05	Sometimes

As can be gleaned in table 8, the highest mean was 3.38 which pertains utility value with a verbal description of sometimes. While the lowest mean was 2.55 on self-efficacy with a verbal description of rarely. It can be implied based from the highest mean that learning mathematics could be useful to the learners and how important mathematics is in everyday life. It can also be implied that students do not have the strong sense of efficacy because they believe they cannot accomplish in the difficult tasks.

As can also be observed, the students were still not confident in mathematics as they believed that they cannot get an "A" in mathematics under Self-Efficacy. Hence, it also implies that the students lack the motivation in mathematics as this affect their self-efficacy towards mathematics. Students' belief on their ability to overcome the challenges in mathematics is something a problem. This contradicts to the study of Macmull & Ashkenazi (2019) that people who

are motivated and have a greater perseverance in challenging mathematics tasks, attain a more positive self-efficacy in mathematics. However, a study conducted by Gafoor and Kurukkan (2015) that feeling mathematics as difficult for students affects not only their liking of mathematics but also their perseverance, interest, boredom and self-efficacy beliefs related to mathematics.

Table 9 reveals that of all the variables, effective communication has the highest mean of 4.05 which pertains to "responds to students' questions in appropriate language". The lowest mean of 3.70 pertains to "teaches the students according to personal differences".

Based from the results, it can be implied that the students gave more emphasis on the effective communication of the teachers as they "always" felt during their class. It can also be implied that the math teachers always used appropriate languages in response to the students' questions regarding the subject matter. However, the students did not feel the teacher addressed the issue on individual differences and how to overcome such concern.

This is supported in the study of Obilor (2020) that communication skills involve listening and speaking as well as reading and writing. For effective teaching a teacher needs to be highly skilled in all these areas. Teachers with good communication skills always make learning easier and more understandable for students. Effective communication skills are really important for a teacher in the transmitting of education, classroom management and interaction with students in the class. The results also imply that in the process of learning-teaching, it is necessary for the teacher to plan learning by taking these individual differences into consideration. When planning teaching, it is more likely that a plan based on the learning style and speed of the students, rather than the collective instruction, will lead to a more efficient environment (Kubat, 2018).

Table 9. Students' assessment to the teachers' effectiveness

Variables	Mean	Standard Deviation	Verbal Description
Subject Matter Knowledge	3.96	0.72	Often
Instructional Planning Strategies	3.93	0.76	Often
Assessment	3.92	0.74	Often
Learning Environment	4.03	0.76	Often
Effective Communication	4.05	0.74	Often
General Mean:	3.98	0.74	Often

Table 10. Mathematics performance of the respondents

Grade Range	General Weighted Average	%	Verbal Description
	f		
1.00-1.50	7	10	Superior
1.60-2.00	50	71	Very Good
2.10-2.50	9	13	Good
2.60-3.00	4	6	Fair
Total	**70**	**100**	

Table 10 reflects the respondents' mathematics performance. Based on the University's Student Manual 2015 Edition, most of the students belong to a category of Very Good, whose grade range is from 1.60-2.00. It implies that the students manifested a very good performance in mathematics.

It can be seen in Table 11 that among all factors that possible predictors of mathematics performance of the students, only Numerical Test Anxiety (t=-2.418, p=.018), and Mathematics Course Anxiety (t=-2.175, p=.033) concerning their sex based on .05 level of significance using a two-tailed test. The results imply that these two (2) factors are not of the same level when sex is considered.

The differences that exist between the means of the factors above except for numerical test anxiety and mathematics course anxiety were not statistically significant. This implies that these factors that predict mathematics performance of the students are of the same level when sex is considered.

McGinley (2000) supported the results of this study when investigated the gender differences in mathematics anxiety and achievement, which revealed that there was no gender difference in math anxiety. However, this finding is contrary to the findings Devine et. al (2012) that though there were no gender differences emerged for mathematics performance but the levels of mathematics anxiety and test anxiety were higher for girls than boys, which means, there was a difference in terms of gender.

Table 12 reveals the results on the regression analysis of the factors predicting the mathematics performance of the students. Regression analysis in table 7 reveals that among the variables, only the effective communication can predict Mathematics performance of the students. This variable produced an unstandardized B coefficient of .358 with associated p-value of .001 which is less than the significance level set at 0.05. This forms the regression equation which is Y= 1.563 + 0.358X. The other variable, Instructional Planning Strategies has associated probability less than the significance level set at 0.05 but with unstandardized B coefficient equal to - .556. This forms the regression equation which is Y= 1.563 – 0.556X. Hence, not a good predictor of Math performance because the negative coefficient of this variable brings a decrease in the Math performance. This is supported in the study of Adunola (2011) that regular poor academic performance by the majority students is fundamentally linked to application of ineffective teaching methods by teachers to impact knowledge to learners. Substantial research on the effectiveness of teaching methods indicates that the quality of teaching is often reflected by the achievements.

Table 11. Significant difference on the factors of mathematics performance based on sex

Significant Difference on the Factors based on Sex						
Factors	**Source of Difference**	**Mean**	**Std Dev**	**Computed t-value**	**p-value**	**Decision**
Numerical Test Anxiety	Male	2.96	0.652	-2.418	.018*	Significant
	Female	3.59	0.920			
Mathematics Course Anxiety	Male	2.47	0.858	-2.175	.033*	Significant
	Female	3.04	0.871			
	Female	4.01	0.587			

*significant at .05 level of significance

Table 12. Multiple regression analysis of the factors predicting the mathematics performance of the students

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	1.563	.692		2.260	.028
	Instructional Planning Strategies	-.556	.152	-.828	-3.663	.001
	Effective Communication	.358	.105	.547	3.421	.001
	r= 0.7230					
	r^2 = 0.5230					
	f – value =3.949					

*significant at .05 level of significance

Teachers use a variety of instructional strategies when they teach various mathematical topics and concepts. Some of these strategies have been found to positively affect the performance of learners while others do not (Mosimege & Winnaar 2021). Additionally, according to Ayeni (2011), teaching is a process that involves bringing about desirable changes in learners so as to achieve specific outcomes. In order for the method used for teaching to be effective, Adunola (2011) maintains that teachers need to be conversant with numerous teaching strategies that take recognition of the magnitude of complexity of the concepts to be covered.

The standardized Beta coefficient indicates that for every unit increase in the Effective Communication could generate 0.547 increase in the Mathematics performance of the students. The multiple correlation coefficient (r) of 0.7230 indicates a high level of prediction. Moreover, the value of coefficient of determination (r^2) equal to 0.5230 means that the abovementioned predictor variables explain 52.3% of the variability of Mathematics performance. In teaching and learning interactions, communication plays a significant role, because teaching and learning can take place well if there is mutual communication between teachers and students, and between students and students (Nuraina & Mursalin, 2018).

Good communication skills of teacher are the basic need of academic success of students, and professional success of life. Teacher communicates more instructions orally in classroom to students. Teacher with poor communication skills may cause failure of students to learn and promote their academics (Khan et.al, 2017). As cited by Rahman and Lee (2014), teachers agreed that the process of communication in teaching and learning mathematics occurs when both teacher and pupils are communicating and listening to each other. This type of communication, whereby in teaching, the teacher explained mathematically where else from the learning aspect, pupils communicated effectively through questioning and making arguments. They also added that, majority of teachers have agreed that communication in the teaching and learning process is important to enhance students' understanding. Through effective communication, students had a better understanding on the topics taught and could attempt high-level questions correctly.

According to Gyasi (2013), the importance of getting students involved in the teaching process cannot be overemphasized that an important aspect of learning is for students to be able to communicate what they know, or think they know. Teachers should encourage communication from all students

through lively and stimulating classroom discussion or small group works. Similarly, vocabulary instruction is essential to effective math instruction. Not only does it include teaching math-specific terms such as "percent" or "decimal," but it also includes understanding the difference between the mathematical definition of a word and other definitions of that word (Robertson, 2009). The challenge for teachers is to focus on math concepts and the academic language that is specific to mathematics. Teachers must be cognizant of the linguistic demands of their lessons and how they will address those demands explicitly during instruction (Bresser, 2018).

Mathematics can be thought of as a language that must be meaningful if students are to communicate mathematically and apply mathematics productively. Communication plays an important role in making mathematics meaningful; it enables students to construct links between their informal, intuitive notions and the abstract language and symbolism of mathematics. Teaching mathematics to English language learners presents practical instructional strategies for engaging learners that can be incorporated as a regular part of instruction (Kersaint et. al, 2014).

■ CONCLUSIONS

In light of the findings of this, among all the factors identified, effective communication obtained the highest mean, while the lowest was the self-efficacy. The results imply that students perceived the importance of effective teachers' communication during the class discussion. It can also be suggested that effective communication will help the students clarify and solidify their thoughts and understanding of learning mathematics. On the other hand, students lack self-efficacy, which means they do not have the confidence in learning mathematics that they will succeed.

Also, it can be concluded that among all possible factors or predictors of mathematics performance, only instructional planning strategies and effective communication occur or contribute to the students' mathematics performance. However, it can be noted that instructional planning strategies may have a smaller p-value. Still, it has a negative value on the unstandardized beta, which implies that if a teacher has poor instructional methodologies or strategies, it will negatively affect the students' mathematics performance. Contrary to that, effective communication was found to be the best predictor of the students' mathematics performance. This highlights the importance of effective communication between the teacher and the students during the teaching-learning process. It is can also be concluded that the perception towards numerical test anxiety and mathematics course anxiety differs when grouped by sex.

Theory Generated:

The level of mathematics performance of the students is multi-factorial in nature which depends on teachers' delivery, pedagogies, and coping with assessment anxiety

The knowledge and skills of teachers in classroom management as a pedagogical competence could help teachers effectively use instructional time to meaningfully engage students during the teaching and learning process. This could in turn, improve student's academic achievement (Kporyi and Arko, 2021). Khalid et.al (2021) also supported this theory based on their findings that pedagogical skills of teachers have significant impact on academic performance of students. Hence, teachers' pedagogical skills enhance the

students' academic performance. Teacher knowledge affects to the student performance and achievement even becoming one of the most influential factors in student learning. Thus, teachers are expected to be able to teach effectively. The teacher does not only to be a master on the material but also be able to explain using various methods (Kutub & Wijayanti, 2019). A teacher plays a vital role within a few hours in the classroom by delivering the daily specific planned content, part of the curriculum for a particular grade. It depends on the teacher to plan it out and use effective strategies for its instructional deliverance. Teachers must have a passion for learning and teach and understand the needs and interests of the students (Jalbani, 2014). Ramirez et.al (2018) argues that math anxious teachers and their use of particular teaching strategies have the potential to shape students' math achievement and their perceptions of what their teacher believes about math.

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