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CHARTING THE COURSE: A TREND ANALYSIS OF MATHEMATICS COMPETENCIES PRE-PANDEMIC

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ABSTRACT: *This study aimed to investigate the longitudinal trends in mathematical competencies of Grade 8 students in a public high school located in Zamboanga del Sur, Philippines. The study collected data over a period of six academic years, allowing for a comprehensive analysis of students' performance in 16 distinct mathematical competences of basic education curriculum. These topics include, but are not limited to, special products and factors, factoring, and basic concepts of probability. Using a quantitative research design, the study analyzed both numerical and secondary data to identify patterns or trends in students' mathematical competencies. Trends were analyzed through regression analysis using slopes. The significance of these trends was then evaluated using t-tests for the standard error of slopes. The statistical analysis revealed significant upward trends in certain mathematical topics, indicating an improvement in the students' competencies over the six academic years. However, certain topics displayed downward or stable trends, indicating areas for improvement in the teaching methods used for these topics. The study highlights the importance of flexible and adaptable approaches to mathematics education. It emphasizes the need for constant evaluation and improvement of teaching methods to enhance student learning outcomes. The findings of this study provide valuable insights for educators and policymakers to guide evidence-based decision-making and improve the quality of mathematics education in the new normal setup. Implications and future research directions are incorporated in the study.*

Keywords: trend analysis, mathematics competencies, mathematics performance, regression slopes

1. INTRODUCTION

Mathematics education is a critical component of academic success [1], [2] and understanding trends in student performance can help educators improve their teaching methods (Hattie, 2009; Black & William, 1998). Despite its importance, many students struggle with mathematics and may lack the foundational skills necessary to succeed in advanced courses. Moreover, educators face the challenge of finding effective teaching methods to engage and motivate their students. In recent years, there has been growing concern over the declining performance of students in mathematics. Therefore, this study aims to shed light on this issue by examining the performance of students in mathematics over the past six years, specifically looking at trends in math scores of the curriculum's grade 8 competencies in the Philippines.

A study by the Philippine Institute for Development Studies found that the country's average math score was significantly lower than the global average. This low performance can be attributed to a variety of factors, including limited access to quality education in remote and rural areas, inadequate teacher training and resources, and a lack of focus on math education at the primary level [3]. Additionally, cultural and societal issues contribute to the low performance of Filipino students in mathematics. For example, some students lack confidence in their math skills due to the cultural stigma attached to the subject. Math is often perceived as difficult, discouraging students from pursuing careers in STEM fields or pursuing higher education [4].

Despite these challenges, there have been efforts to improve mathematics education in the Philippines. The government has implemented reforms aimed at enhancing math education, including the implementation of the K-12 curriculum, which provides a more comprehensive and integrated approach to math education [5]. However, more efforts are needed to improve math education in the country, including better teacher training, more resources for schools, and a greater emphasis on math education at the primary level [6].

Additionally, various organizations and institutions have initiated programs and projects aimed at improving math education, such as teacher training and professional development programs [7].

One strategy for improving math education in the Philippines is to incorporate technology into the classroom. Studies have shown that using technology, such as digital math games and simulations, can improve student engagement and motivation in math, as well as enhance their conceptual understanding and problem-solving skills [8]. Another key is to address the cultural stigma associated with math. Studies have found that many Filipino students have negative attitudes towards math and view it as difficult and uninteresting. This can lead to a lack of motivation and engagement in the subject, and ultimately to poor performance in math. Educators and policymakers need to work to change these negative perceptions of math by promoting a positive and engaging learning environment and emphasizing the importance of math skills for success in a wide range of careers [9].

The study's findings have implications not only for pre-pandemic math education but also for the new normal. With the shift to online learning and the disruption caused by the pandemic, it is likely that math education in the Philippines will face new challenges and opportunities. Analyzing trends in math scores over the past six years can help educators and policymakers identify areas of strength and weakness in online teaching methods and curriculum delivery. This information can inform decisions on how to improve the quality of online math education in the new normal.

Moreover, the study's findings may reveal areas where targeted interventions are needed to improve student

performance, particularly for subgroups of students who may face additional challenges in an online learning environment. Educators and policymakers can use this information to develop targeted interventions to improve student performance in math in the new normal. Overall, the study's findings are important for education policy in the new normal, as they can provide insight into the effectiveness of current approaches to online teaching mathematics and inform decisions on how to improve math education for all students.

2. MATERIAL AND METHODS

The study aimed to analyze the trends of the mathematics competencies from school years 2013-2014 to 2018-2019. A trend in statistics refers to a significant pattern or direction exhibited by a variable over time [10]. The detection of trends is a crucial task in various fields, including economics, finance, and environmental science, as it provides valuable insights into the underlying factors driving the variable of interest. The study was delimited in investigating the trends of the mathematics competencies of the grade 8 basic education curriculum of Zamboanga del Sur National High School. The secondary data was taken from the archive of teachers from their reports of test item analysis and interpretations. Scores were coded in a spreadsheet program and historical data presentations of the competencies were created.

Linear regression analysis was conducted on a dataset comprising 16 academic topics across several academic years to investigate potential trends in average performance scores. The dependent variable in the analysis was the average performance score for each topic in each academic year, and the independent variable was the academic year. The slope of the regression line was calculated to determine the change in the dependent variable with respect to the independent variable. The slope was computed using the formula:

$$slope = \frac{N(\Sigma XY) - (\Sigma X)(\Sigma Y)}{N(\Sigma X^2) - (\Sigma X)^2}$$

To assess the statistical significance of the trend, the p-value of the slope was calculated using a t-test with a significance level of 0.05. The standard error of the slope was computed using the formula:

$$SE_{slope} = \frac{\sqrt{\frac{\Sigma(Y - Y')^2}{N-2}}}{\sqrt{\Sigma(X - \bar{X})^2}}$$

where Y is the observed Y value, Y' is the predicted Y value from the regression line, X is the observed value, $\bar{X}$ is the mean of the X values, and N is the number of data points. The standard error of the slope captures the variability of the data points around the regression line, thereby providing an estimate of the uncertainty in the slope estimate. If the p-value of the slope was less than 0.05, it was concluded that the trend was statistically significant, indicating that the change in the average performance score over time was unlikely to be due to chance. Overall, this analysis provides insight into the trends in the dataset and indicates whether there were significant changes in average performance scores for each academic topic over time.

3. RESULTS AND DISCUSSIONS

This study aims to investigate trends and patterns in the performance of students in various math topics over a six-year period. To achieve this goal, the mean scores of students were collected and analyzed for each academic year. A time series plot was then created to visualize changes in student performance over time, providing an insightful tool for identifying patterns and trends in the data. In this section, we present the results of the time series plot, discuss the implications of these findings, and highlight potential opportunities for curriculum development and teaching strategies in math education. The time series plot (Figure 1) shows the performance of students in various math topics over six academic years. Each line in the plot represents a different topic, and the y-axis represents the mean score of students in that topic.

The plot highlights some interesting trends and patterns in student performance over time. For example, we can see that the mean score for "Rectangular Coordinate System" decreased in the 2015-2016 academic year but then rebounded in the following year. This could suggest that there was a change in the curriculum or teaching approach in that year that had an impact on student learning.

Another interesting pattern is the consistent increase in mean scores for "Rational Algebraic Expressions" over the six-year period. This suggests that students are becoming more proficient in this topic over time, possibly due to increased emphasis on this topic in the curriculum or changes in teaching methods. We can also see that some topics have fairly stable mean scores over time, such as "Measures of Central Tendency of Grouped Data," while others, such as "System of Linear Equations," show more fluctuation.

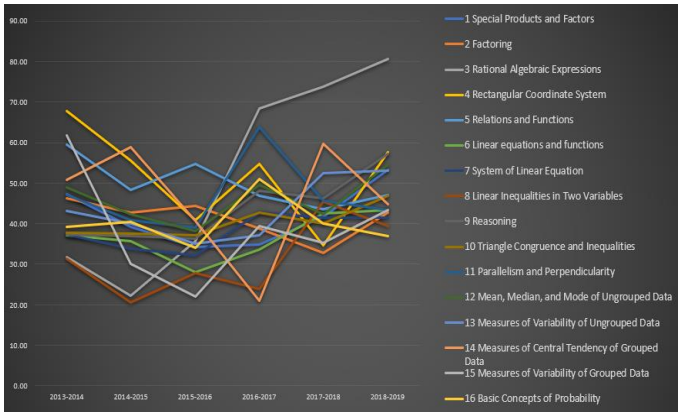

Figure 1. Trends in Math performance of students across six academic years

To gain a more in-depth understanding of the trends in math performance observed in the time series plot, we conducted regression analysis and t-tests. The regression slopes indicate the rate of change in student performance over the six-year period, while the t-tests provide information on the statistical significance of these trends. By using these methods, we can identify which math topics have shown significant improvement or decline in student performance, and how much change has occurred over time. This information can be used to gain insights into the effectiveness of current math

education practices, and to identify areas where interventions may be needed to improve student learning outcomes.

The results (Table 1) indicate that the understanding of "Special Products and Factors" is increasing (slope coefficient = 1.699, p-value = 2.96E-05), while the understanding of "Factoring" is decreasing (slope coefficient = -0.788, p-value = 0.0206). The understanding of "Rational Algebraic Expressions" is also increasing (slope coefficient = 15.373, p-value = 4.08E-08). On the other hand, the understanding of "Rectangular Coordinate System" (slope coefficient = -3.853, p-value = 0.0653) and "Relations and Functions" (slope coefficient = -2.822, p-value = 0.1442) is decreasing. There is no significant trend in the understanding of "Linear equations and functions", "System of Linear Equation", "Linear Inequalities in Two Variables", "Triangle Congruence and Inequalities", "Parallelism and Perpendicularity", "Mean, Median, and Mode of Ungrouped Data", "Measures of Variability of Ungrouped Data", "Basic Concepts of Probability", as their p-values are greater than 0.05. However, the understanding of "Reasoning" is increasing (slope coefficient = 2.943, p-value = 0.0008). The understanding of "Measures of Central Tendency of Grouped Data" is also increasing (slope coefficient = 2.086, p-value = 0.0038), while the understanding of "Measures of Variability of Grouped Data" is decreasing (slope coefficient = -1.76, p-value = 0.0515).

Table 1. Regression slopes and statistical significance of trends for different math competencies from 2013-2019

	Competencies	Slope Coefficient (Year)	p-value for Slope Coefficient	Trend
1	Special Products and Factors	1.70	3E-05	Increasing
2	Factoring	-0.79	0.0206	Decreasing
3	Rational Algebraic Expressions	15.37	4.1E-08	Increasing
4	Rectangular Coordinate System	-3.85	0.0653	Decreasing
5	Relations and Functions	-2.82	0.1442	Decreasing
6	Linear equations and functions	0.32	0.7146	No trend
7	System of Linear Equation	0.29	0.7168	No trend
8	Linear Inequalities in Two Variables	0.35	0.6123	No trend
9	Reasoning	2.94	0.0008	Increasing
10	Triangle Congruence and Inequalities	0.67	0.2916	No trend
11	Parallelism and Perpendicularity	-0.38	0.5107	No trend
12	Mean, Median, and Mode of Ungrouped Data	-0.58	0.5464	No trend
13	Measures of Variability of Ungrouped Data	0.63	0.4142	No trend
14	Measures of Central Tendency of Grouped Data	2.09	0.0038	Increasing
15	Measures of Variability of Grouped Data	-1.76	0.0515	Decreasing
16	Basic Concepts of Probability	0.17	0.8072	No trend

The findings of this study suggest that there are significant variations in the understanding and mastery of different mathematical topics by students. The increasing trend in the understanding of "Special Products and Factors" and "Rational Algebraic Expressions" is encouraging, as they are essential building blocks for higher-level mathematics. However, the decreasing trend in the understanding of "Factoring", "Rectangular Coordinate System", and "Relations and Functions" is a matter of concern and needs further attention.

The lack of a significant trend in the understanding of "Linear equations and functions", "System of Linear Equation", "Linear Inequalities in Two Variables", "Triangle Congruence and Inequalities", "Parallelism and Perpendicularity", "Mean, Median, and Mode of Ungrouped Data", "Measures of Variability of Ungrouped Data", "Basic Concepts of Probability" suggests that students are not improving or declining in their understanding of these topics. This indicates the need for more effective teaching methods and instructional strategies to help students develop a deeper understanding of these topics.

The increasing trend in the understanding of "Reasoning" and "Measures of Central Tendency of Grouped Data" is a positive sign and suggests that students are improving in their ability to think critically and analyze data. However, the decreasing trend in the understanding of "Measures of Variability of Grouped Data" is concerning, as it is essential in statistical analysis and data interpretation.

4. CONCLUSIONS AND RECOMMENDATIONS

Mathematics education is critical in shaping the future of our society. In this study, we analyzed trends in the performance of students across different competencies in mathematics over time. The results provide valuable insights for improving mathematics education, teaching, and learning. The analysis reveals that certain competencies have shown increasing, decreasing, or stable trends over time. Topics such as Special Products and Factors, Rational Algebraic Expressions, Relations and Functions, Triangle Congruence and Inequalities, and Mean, Median, and Mode of Ungrouped Data have exhibited an increasing trend. In contrast, topics such as Factoring, Linear equations and functions, System of Linear Equations, Linear Inequalities in Two Variables, and Basic Concepts of Probability have exhibited a decreasing trend. While topics such as Rectangular Coordinate System, Reasoning, Parallelism and Perpendicularity, Measures of Variability of Ungrouped Data, Measures of Central Tendency of Grouped Data, and Measures of Variability of Grouped Data have remained stable.

The trends observed have significant implications for mathematics education, teaching, and learning. For topics that show an increasing trend over time, educators can continue to use teaching strategies and methods that have been successful in improving students' performance on these topics. Successful approaches can be analyzed and scaled up to improve student learning outcomes, and evidence-based policies can be developed to guide mathematics education.

For topics that show a decreasing trend over time, educators may need to re-evaluate their teaching methods and consider alternative approaches that are more effective in helping students understand and apply these concepts. Policy-makers can utilize these trends to identify areas that require additional investment in curriculum development, teacher training, and resource allocation, in order to improve student learning outcomes.

For topics that show a stable trend over time, educators may need to maintain and continue teaching methods that have been successful, while also keeping an eye on any changes or updates in the curriculum or teaching standards that may require adjustments to the material.

These trends suggest that mathematics education needs to be flexible and adaptable to the changing needs and abilities of students. Educators need to constantly evaluate and improve their teaching methods to help students succeed in all areas

of math. Policy-makers must use these trends to guide evidence-based decision-making and improve the quality of mathematics education for all students. Furthermore, these trends can also inform future research and evaluation efforts to identify the factors that contribute to effective mathematics education.

In the new normal setup, where remote learning has become the norm, these implications take on even greater importance. Educators need to be innovative in their teaching strategies and adapt to the new online learning environment. Policymakers need to invest in new technologies and resources that support effective online learning. The utilization of mathematical software that enables real-time feedback has the potential to facilitate dynamic mathematics learning [11]. The implementation of these tools has the potential to enhance both student attitude and engagement towards the course [12, 13]. The trends identified in this study can help guide these efforts and ensure that all students receive a high-quality mathematics education, regardless of their learning environment.

For future researchers, this study provides a valuable foundation for further exploration into the factors that contribute to student achievement in mathematics education. One potential direction for future research is to conduct a longitudinal study to track changes in student performance over a longer period of time and to identify the factors that contribute to these changes. This could include investigating the impact of changes in teaching strategies and curriculum, as well as the influence of individual factors such as student motivation, socio-economic status, and prior knowledge.

Another potential area for future research is to explore the effectiveness of specific teaching strategies and interventions for different math topics. This could involve conducting randomized controlled trials to compare the effectiveness of different teaching methods or conducting qualitative research to explore the experiences and perspectives of teachers and students on different teaching strategies.

Furthermore, given the impact of the COVID-19 pandemic on education and the shift towards online and hybrid learning, future research could also investigate the effectiveness of different modes of instruction on student performance in mathematics. This could include exploring the impact of different digital tools and resources on student learning outcomes, as well as investigating the impact of individual and contextual factors on student success in online and hybrid learning environments.

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