Secondary Students' Performance Index in Mathematics

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Abstract - *Performance of students in mathematics has been the focus of so many studies in education. Its fluctuating record in national and international arena calls the attention of every researcher in mathematics to refocus their attention to identifying latent that possibly explain this performance. This current study believes that students' performance in mathematics can be predicted by some latent variables. These sets of possibly correlated manifest variables are combined to form latent variables that are transformed into a set of values of linearly uncorrelated variables called principal components. These components would then become the input to the model predicting secondary students' performance in mathematics. Moreover, Regression Analysis was employed to develop a model predicting secondary students' performance in mathematics. The study revealed that peer relation index, luxury index, and personal characteristics were significant predictors of Mathematics performance among secondary students. More so, it supports social-cognitive theory and strengthens its foundation that cognition and social relation greatly determines the behavior and performance of social individuals.*

Keywords*: Mathematics, Students' Performance in Mathematics, Latent Factors, Manifest Variables, Regression Analysis, Social-Cognitive Theory*

INTRODUCTION

Students' academic performance is an important predictor of performance at other levels of education and other important job outcomes, such as job performance and salary [1]. The prediction and explanation of academic performance and the investigation of the factors relating to the academic success and persistence of students are topics of utmost importance in higher education [2]. Researchers have long been interested in exploring variables contributing effectively to the performance of students in mathematics. These variables may be internal or external to the school and affect students' quality of academic achievement [3]. These elements are labeled as student factors, family factors, school factors and peer factors [4]. There are, however, a lot of testable factors that potentially affect the students' performance in mathematics that is not yet fully defined and explored. Thus, this study believes that students' performance in mathematics can be predicted by some of these latent variables or factors present in society.

An increasing and growing literature and body of analysis provide extra factors that might have sway on students' action like gender, family structure, parents' educational level, socio-economic status, parent and student attitudes toward school, and parent involvement [5], [6], [7]. But one of the relevant perspectives in understanding academic performance is social cognitive theory [8]. Specifically, the impact of various demographic, social, economic and educational factors on students' mathematics achievement continues to be of great interest to the educators and researchers.

The formal investigation about the role of the demographic factors to the performance of the students in mathematics was rooted back in the 17th century [9]. Generally, these demographic factors include age, gender, socioeconomic status, parents' education level, and parental profession. Besides, a study shows that the relationship between social status and the academic achievement of students has been discussed for decades [10]. A gap between these variables and how they are integrated into a more advance methodological contribution to the field of education is, however at scarce [11]. By this, a continuing discussion persists on how these variables can be understood in relation to their contribution on the performance of learners especially in the field of mathematics.

Above and beyond the other demographic factors, social interaction of student to their peers affects the academic performance in mathematics. The literature revealed that peer influence accounts 0.56 effect size, while the home environment has an effect size of 0.52 [12]. Almost equal at 0.54 effect size is the socio-economic status of the students' family. Prior to the socio-economic status of the students' family, most of the experts argue that the low socioeconomic status has a negative effect on the academic performance of students because the basic needs of students remain unfulfilled and hence they do not perform better academically [13].

Besides socioeconomic status is one of the most researched and debated factor among educational professionals that contribute towards the academic performance of students in mathematics [14].

The home environment also affects the academic performance of the students' in mathematics. The students whose parents are educated score higher on standardized tests than those whose parents were not educated [15].

Educated oldsters will higher communicate with their youngsters relating to the varsity work, activities and the information being taught at school. They can better assist their children in their work and participate at school [16]. Educated parents can motivate their children for being an example.

With all the contributing factors that affect the students' performance in mathematics, this study was conceptualized to identify latent factors that significantly affect students' performance in mathematics using a more advanced method of analysis. Variables that are considered potential predictors of secondary students' performance in mathematics were identified from a database and strengthen through the help of literature. Thus, the target of this study to convert these set of observations of probably related variables into a group of values of linearly unrelated variables referred to as principal parts. These components would then become the input to the regression model predicting secondary students' performance in mathematics.

OBJECTIVES OF THE STUDY

The objective of this study is to form linear combinations of the identified principal components; and to identify significant predictors of Mathematics performance among secondary students using principal component analysis.

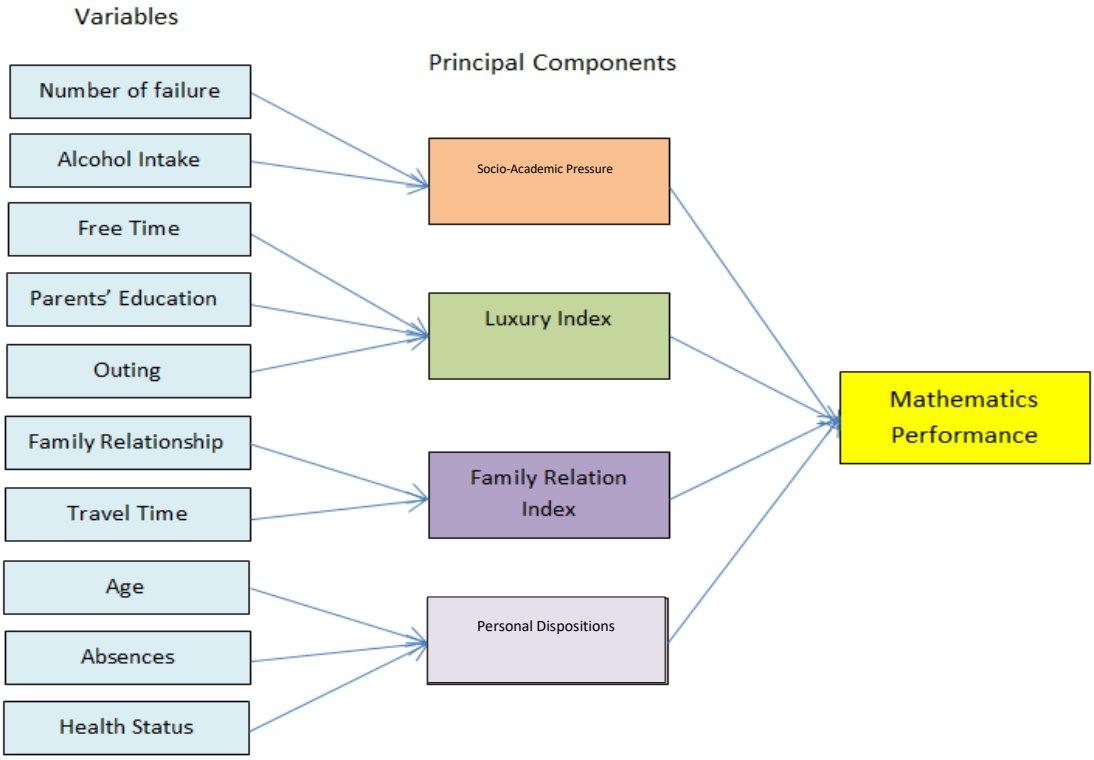

Figure 1. Conceptual framework of the study

FRAMEWORK OF THE STUDY

This study adheres the existence of some personal and social variables that significantly predict mathematics performance of secondary students. This assumption is grounded on the Social Cognitive Theory that favors a model of causation involving triadic reciprocal determinism: behavior, cognition, and personal factors, and environmental influences which all operate as interacting determinants that influence each other of unequal strength. Some may be stronger than others. Nor do the reciprocal influences all occur simultaneously. It takes time for a causal factor to exert its influence and activate reciprocal influences [17].

In the framework, there were 10 identified possible correlated variables which affect the mathematics performance of the students. With these possibly correlated variables, it has been defined into its major components as follows; Socio-academic behavior, Luxury Index, Family Relation Index and Personal Characteristics. These major components determine its relationship to the mathematics performance of the students.

METHODOLOGY

This study used literature search procedures where all information presented are generated through online website surfing or data mining. Data mining process extracted information from a data set and transformed it into an understandable structure for further use.

The process of data mining is applicable to various field in education. [18] Data are commonly retrieved in a data warehouse. Data is processed and treated through data cleaning and data integration to eliminate unreliable data and where multiple data sources could also be combined. Data Selection is where data which is relevant to the analysis task are retrieved from the database.

The data was retrieved from the University of California – Irvine Campus Machine Learning Repository Archive [8] and the contributor is Paulo Cortez from the University of Minho, Portugal. The archive is open data for further analysis and requires only to be acknowledged [24] whenever data is used for analysis.

After the data being gathered, the principal component analysis was used to convert these set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components. Principal Component Analysis reduced the dimensions of a data set. It reduces the info down into its basic parts, stripping away any unnecessary parts. Eigenvalues were used to measure the amount of variation in the total sample accounted for by each factor [19]. If an element features a low eigenvalue, then it is contributing little to the explanation of variances in the variables and may be ignored as redundant with more important factors. Regression Analysis was employed to develop a model predicting secondary students' performance in mathematics.

Table 1. Selected Variables, its details, type of scale and coding

Variables	Details	Type of Scale and Coding
Student's Performance	Students' Final Grade of the Subject	Numeric; continuous
Absences	number of school absences	(numeric: from 0 to 93)
travel time	travel time going to school from home	Numeric; 1 - <15 min., 2 - 15 to 30 min., 3 - 30 min. to 1 hour, or 4 - >1 hour
age	Student's age	(numeric: from 15 to 22)
alcohol intake	workday alcohol consumption	(numeric: from 1 - very low to 5 - very high)
free time	free time after school	(numeric: from 1 - very low to 5 - very high)
Health	current health status	(numeric: from 1 - very bad to 5 - very good)
Outing	going out with friends	(numeric: from 1 - very low to 5 - very high)
ParEdu	Parents' education	numeric: 0 - none, 1 - primary education (4th grade), 2 5th to 9th grade, 3 secondary education or 4 higher education
Failures	number of past class failures	numeric: n if 1<=n<3, else 4
FamRel	quality of family relationships	numeric: from 1 - very bad to 5 – excellent

RESULTS AND DISCUSSION

There were ten identified variables that were considered as potential variables to predict students' performance in mathematics. Intensive reading of literature helped the researcher to better identify, reduce, and finalized a set of data. Though data set is given filtering is still necessary for the finalization of the data for the inclusion in the final analysis.

These variables were being defined and scaled according to their type of variable. Measurement of data was also specified to facilitate analysis of prediction. The entire continuous initial variables in table 1 were standardized to have equal contributions to the analysis. Moreover, this was conducted to ensure easy interpretation of the data set being predictors of the secondary students' performance in mathematics. Standardization transformed the data from its natural scale to facilitate identification of the degree of relationship that the variables contributed to the model.

After the preliminary computation, the analysis revealed that PCA 4 had already reached 91% variability of the variables. This result implies that the defined variables can be classified into four major components and the remaining 9% of the variation will speak for other factors aside from those that are included in this study.

Table 2. Eigenvalue-based for Principal Component Analysis

	PCA 1	PCA 2	PCA 3	PCA 4	PCA 5	PCA 6	PCA 7	PCA 8	PCA 9
Eigenvalue	1.7	1.37	1.22	1.13	1.08	0.9	0.85	0.77	0.71
Proportion	0.35	0.26	0.17	0.13	0.01	0.01	0.01	0.002	0.003
Cumulative	0.35	0.61	0.78	0.91	0.92	0.92	0.93	0.93	0.94

The grouping of the set of variables that can be combined to explain these variables in terms of their underlying dimensions results in the specification of the four major components necessary as input to the desired model results to the following combinations.

Table 3. Principal Component Analysis

Variable	PC 1	PC 2	PC 3	PC 4
No. of Subject Failures	**0.43**	-0.26	0.03	0.27
Alcohol Intake	**0.42**	0.14	-0.24	-0.33
Free Time	0.32	**0.49**	0.19	0.02
Parents' Education	-0.24	**0.44**	-0.46	-0.04
Outing	0.39	**0.40**	-0.06	-0.03
Family Relationship	0.01	0.35	**0.39**	0.44
Travel Time	0.24	-0.29	**0.37**	-0.38
Age	0.37	-0.25	-0.16	**0.53**
Absences	0.21	-0.09	-0.57	**0.12**
Health Status	0.08	0.22	0.23	**0.10**

From table 3, we can define now linear combinations that determine the weight of the components. These four major components were classified and named into terms as follows: Socio-academic Pressure for no. of failure and alcohol intake; Luxury Index for free time, parents education and outing; Family Relation Index for family relationship and travel time; and Personal Dispositions for age, absences, health status.

Linear Combinations of the Identified Principal Components

Socio-academic Pressure = .43*No. of Failure + .42*Alcohol Intake
Luxury Index = .44*Parents' Education + .49*Free Time + .41*Outing
Family Relation Index = .39*Family Relation + .37*Travel Time
Personal Dispositions = .53*Age + .12*Absences + .09*Health Status

Preliminary regression analysis revealed that Socio-academic Pressure, Luxury Index and Personal Dispositions are significant predictors of students' performance in mathematics ($p < 0.05$). Meanwhile, Family Relation Index has been removed as significant predictors leaving three remaining predictors for the desired regression model.

Regression Analysis using the Principal Components as Predictors of Mathematics Performance

Table 4. Predictors of Mathematics Performance among Secondary Students

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	16.21	0.99	16.45	0.00	
Socio-academic Pressure	-2.12	0.24	-8.85	0.00	1.07
Luxury Index	0.22	0.1	2.19	0.03	1.02
Family Relation index	-0.12	0.2	-0.59	0.56	1.00
Personal Dispositions	-0.35	0.09	-4.1	0.00	1.06

Note: Adj - R^2=91%

Lastly, reduced regression analysis was being applied to have the desired regression model which defined the principal components of students' performance index in mathematics. Thus, it shows that Socio-academic Pressure, Luxury Index and Personal Dispositions are significant predictors of students' performance in mathematics.

Reduced Regression Analysis

Table 5. Significant Predictors of Mathematics Performance among Secondary Students

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	15.97	0.89	17.90	0.00	
Socio-academic Pressure	-2.12	0.24	-8.85	0.00	1.07
Luxury Index	0.22	0.10	2.19	0.03	1.02
Personal Dispositions	-0.35	0.08	-4.10	0.00	1.06

Note: Adj - R^2=91%

From table 5, the regression equation was being established and it reveals that 15.97 is the constant average performance in mathematics of secondary students. Moreover, students who had high alcohol intake and an ample number of subject failures contribute a negative effect on the mathematics performance of secondary students.

This result implies that there is a negative effect of socio-academic behavior and personal characteristics among secondary students to their performance in mathematics. It shows that only 0.22 is a positive effect on the mathematics performance of the luxury index.

Regression Equation:

Mathematics Performance

= 15.97 - 2.12 Socio-academic Pressure +
0.22 Luxury Index - 0.3481 Personal Dispositions

The negative contribution of socio-academic behavior and personal dispositions reflects how failure, alcohol intake, and absenteeism reduces learners' performance in mathematics. Undeniably, absenteeism and alcoholism are related factors among young learners. Such a relationship could be caused by some social and economic factors brought about by family problems, peer pressures, and social environment surrounding the learner.

Refusal to be in school is an experience when learners decide to do other things at home or elsewhere than to perform learning tasks at school. Attraction to learning is very slow for some students that oftentimes caused them to retreat instead of motivating themselves to perform better in school. This condition worsens when dealing with the mathematics that is considered by many learners as hard and difficult subject to deal with.

Socio-academic behavior as composed of alcoholism and absenteeism can also sometimes be attributed to how teachers deal with students. Acting as second parents among learners, sometimes teachers are too busy of other school works and preparations that they failed to know the best thing to do in school – learners first. The starting principle of educational reform starts with knowing the needs, background, culture, and dispositions of every learner in the classroom. Learners who failed to meet their expectations of care, love, and attention from teachers will probably be distracted in school. This diminishes their desire to learn and perform in some subjects especially in mathematics – a subject that requires holistic attention in order to find the required solution to a given problem.

Secondary learners, however, are supposed to be responsible for their own learning progress. They are expected to be accountable for their own behavioral response to every event that comes across their way of acquiring knowledge and information in mathematics. Alcohol intake, weak health condition, and absenteeism do not contribute to a better performance in mathematics. Pressure and negative dispositions hinder the learning opportunity that every learner could have attained when they are more physically and emotionally ready for every learning tasks.

On the other hand, the luxury index as defined by the learners' good family relation and travel time supports the learning performance of mathematics among secondary students. First, family relation is the immediate social support that every learner needs in order to comfort themselves whenever difficulty in learning comes. A strong family relation can help learners motivate and surpass learning hardships and can better accomplish academic requirements even in the most difficult subject like mathematics. A strong family bond intensifies learners to maximize potentials as it creates pride not only among themselves but also among family members that contribute to success. Assistance from family members lightens the burden that every learner encountered in their academic tasks.

Relaxation through travel is also considered a helping occasion to better learn and understand things and realities. On one hand, traveling relaxes the mind and prepares it to the next learning engagement. On the other hand, mathematics is an integrative subject that can be seen in so many technological and physical advances that every learner can encounter in their travel. These create a wider creativity and visualization in the mind of the learners once they will be in the classroom. Contextualization of learning mathematics would be better experienced by learners in their exposure to the real application of mathematics outside the classroom. This will further bring them to motivate and perform better in mathematics.

CONCLUSION AND RECOMMENDATION

The topic of students' performance in Mathematics has been widely researched from different perspectives. However, some researchers suggested that correlational–regression methods may be supplemented by the use of structural equation modeling in to elaborate upon and refine a model in determining the performance of the student in mathematics [20]. Thus, this study developed a regression equation which will help to determine the mathematics performance of the students in terms of its factors such as the socio-academic behavior, luxury index, and personal characteristics.

Socio-academic behavior and personal characteristics show a negative impact on the mathematics performance of the students. Behavioral and personal dimensions of learners greatly dictate their performance in whatever area of discipline. Personal dispositions to life define learners' attitude towards learning. A strong positive disposition in life does not only help students' behavioral manifestation, but it will also direct them to better success.

Family relatedness and support show a positive effect on the performance of the students in mathematics. Educated parents can provide such an environment that suits best for the academic success of their children. The class performance of scholars heavily depends upon parental involvement in their tutorial activities to realize the next level of quality in academic success [21], [22], [23]. The social-cognitive theory is strengthened by the result of this study, and its foundation that cognition and social relation greatly determines the behavior and performance of social individuals still holds true even until the present generation of learners. A social model and supportive community push the potentials of the learners to its maximum utilization. A relaxing social environment that lightens the burdens of studies through its constant communication and affirmation of students' desires defines the learning community that every learner need.

Result revealed that there are a lot of factors that can affect the students' performance in mathematics. It is very important to have a clear understanding of the factors that facilitates the academic progress of the students as they are the tools for a better disposition to learn more and better. However, it requires a lot of time and resources for an educator to identify all these factors. The teachers should pay attention to these contributing factors and develop strategies to make sure that the majority, if not all, of the students, will have a better performance in mathematics.

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