

Analysis of Students' Attitudes on Mathematics Achievement- Factor Structure Approach

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ABSTRACT The purpose of this study was to identify the number of factors (mathematics self-concept, parents' level of education, home background, teaching, school climate and attitude) that represent relationships among sets of interrelated variables of students' attitudes on mathematics achievement. The study examined the contribution of each factor by explaining the variance of students' mathematics achievement and the total variance that could be explained by the determined factors. An inferential analysis was conducted by sampling 321 respondents randomly in a survey design. Based on the Scree test and Eigenvalues, over one eight factors were retained. These factors accounted for 60.1 percent of the variance. The combination of items with loadings greater than 0.49 were considered as separate factors. The results showed that seven of the eight factors under study totally accounted for approximately one fifth of the variance in mathematics achievement (20.7 percent). Mathematics self-concept, home background, teaching, and attitude explained 12.3%, 5.1%, 1.6% and 0.9% of the variance respectively. It is worth mentioning that school climate did not enter in the equation. The findings are important for the South African educational system since changing self-concept and attitude of students towards mathematics and improving the teaching procedures in the classroom are much easier to achieve than changing background factors affecting students' performance.

INTRODUCTION

The Trends in International Mathematics and Science Study (TIMSS) and Progress in International Reading Literacy Study (PIRLS) are the largest and most comprehensive international studies that South Africa has ever participated in. In these international studies, students' achievement in mathematics, science and reading comprehension have been subjected to comprehensive analysis. In addition, numerous background variables affecting students' achievement have been investigated using background questionnaires. Although enormous valid data has been collected in the above mentioned studies, the number of secondary data analysis carried out on the available data is relatively less. It is on this basis that the current study is anchored.

Review of Literature and Various Theories

South African literature indicated that there is a positive relationship between students' achievement in mathematics and home background variables such as: parents' level of education, number of books at home and possessing dictionaries, computer and study desk (Easton-Brooks and Davis 2009). However, South African students who come from a family with the highest level of education of both

parent and who possess all the three education aids, including more than 200 books at home, score much lower (Easton-Brooks and Davis 2009).

The mathematics achievement score of students who benefited from high self-concept was much higher than that of those who had medium or low self-concept (Akiba et al. 2008). Moreover, these investigations indicated that students who have positive perceptions or attitudes towards mathematics showed better achievement in both mathematics and science (Ismail and Anwang 2009). Although 54 percent of South African students have a high positive attitude towards mathematics, their average mathematics achievement was much lower than the international average or even the performance of their counterparts in other countries (Khatoon and Mahmood 2010).

Following the findings of Ismail and Anwang (2009) suggesting that schools made no difference, extensive research has been carried out on in-and-out of school variables affecting students' achievement. Considerable research has examined the relationship between students' characteristics such as self-concept, attitudes towards mathematics, home background as well as motivation and students' subsequent academic performance. In general, a consistent pattern of attitudes towards school subjects and achievement in the respective subjects has been con-

firmed through a large number of studies (Karimi and Venkatesen 2009). Khatoon and Mahmood (2010) showed that there is a positive relationship between mathematics attitudes and mathematics achievement. According to Goe and Croft (2009), those who have positive attitudes toward mathematics have a better performance in this subject. In contrast with these findings, Boyd et al. (2008) showed that for the third grade students there was no significant relationship between students' attitude toward mathematics and students' achievement in this subject. Psychologists define 'attitude' as any strong belief or feeling or any approval or disapproval toward people and situations (Boyd et al. 2008). We have favourable or unfavourable attitudes towards people, politics, academic subjects, etc. People favour the things they think are good and helpful and oppose the things people think are bad and harmful (Boyd et al. 2008). In this context, students' attitude towards an academic subject is a crucial factor in learning and achievement in that subject.

An important factor in academic achievement may be in whether a student views herself or himself as strong or weak in a specific subject. Khatoon and Mahmood (2010) mentioned that students develop ideas, feelings and attitudes about school subjects over time and from a variety of sources. Among the other major findings, students generally had positive attitudes towards mathematics and science, although less so in countries where science is taught as separate subjects with the eighth grade (Khatoon and Mahmood 2010). Karimi and Venkatesen (2009) refer to them as environmental effects. Karimi and Venkatesen (2009) add that environmental effects may come from extra-parental influences such as peer groups and social pressures. In addition to home background and attitudes towards the subject, press variables (or home-school interface), such as friends and pressure for learning mathematics (Karimi and Venkatesen 2009), are among the factors that construct students' attitudes towards and beliefs about mathematics (Ismail and Anwang 2009). Research evidence shows that if an important person encourages somebody to behave in a certain way, he or she will accept it (Ismail and Anwang 2009). The influence of an important person is so strong that even the individual may change his or her attitude in agreement with that of the important person's (Ismail and

Anwang 2009). Akiba et al. (2008) showed that school climate was influenced by the educational background of students and school climate in turn influences teaching.

The relationship between mathematics self-concept and mathematics achievement is another area that has been investigated by researchers (Akiba et al. 2008). Ismail and Anwang (2009) state that there is a great deal of research which shows that self-concept is perhaps the basis for all motivated behaviour. It is the self-concept that gives rise to possible selves and it is possible selves that create the motivation for behaviour. Most findings in this area showed that those who have higher self-concept, that perceives themselves more confident in math, have higher scores in mathematics (Boyd et al. 2008).

Following these uncorrelated findings particularly in international literature, the current study intended to subject the variables under the South African context.

Purpose of the Study

The present study has two purposes:

- To identify a number of factors that represent the relationship among sets of interrelated variables of students' attitudes towards mathematics achievements using Principal Component Factor Analysis.
- To examine the contribution of each factor in the explanation of the variance in the students' mathematics score and to determine the total variance that could be accounted for by these factors using Multiple Regression Analysis.

Significance of the Study

Mathematics achievement involves a complex interaction of factors that have specific direct effects and/or indirect effects through other factors on school outcome. Although the relationship between mathematics achievement and factors such as self-concept, home background, and attribution has been studied widely, it is important to explore the factors that contribute most to the South African students' mathematic achievement. This would help fill the existing gap in the research carried out within this area of South Africa. In addition, it could pave the way for more comprehensive research on the

comparison of national and international research findings.

RESEARCH METHODOLOGY

Participants consisted of 321 intermediate phase learners (Grade 4-Grade 6). All learners/ participants completed a questionnaire concerning their motivation in mathematics and a test for achievement in the mid of the second term of the school year. The questionnaire for motivation comprised of five scales measuring: a) achievement goals (mastery goals) b) performance goals c) self-efficacy. d) fear of failure and e) interest. Specifically, the questionnaire comprised of 31 Likert-type 5-point items (1-strongly disagree and 5 strongly agree). The five-item subscale measuring mastery goals as well as the five-item measuring performance goals were adopted from Patterns of Adaptive Learning Scales (PALS); respective specimen items in each of the two subscales were "One of my goals in mathematics is to learn as much as I can" (Mastery goal) and "One of my goals is to show other students that I'm good at mathematics" (Performance goal). The five items measuring Self-efficacy were adopted from the Patterns of Adaptive Learning Scales (PALS); a specimen item was "I'm certain I can master the skills taught in mathematics this year" (Akiba et al. 2008). Students' fear of failure was assessed using nine items adopted from the Herman's fear of failure measure (Akiba et al. 2008); a specimen item was "I often avoid a task because I am afraid that I will make mistakes". Finally, the researchers used Ismail and Anwang's (2009) seven-item scale to measure students' interest in achievement tasks; a specimen item was "I found mathematics interesting". These 31 items were randomly spread throughout the questionnaire to avoid the formation of possible reaction patterns.

For students' achievement, the researchers of this study developed a three-dimensional test measuring students' understanding of fractions with each dimension corresponding to three levels of conceptual understanding (Ismail and Anwang 2009). The tasks comprising the test were adopted from published research and specifically concerned the measurement of students' understanding of fractions as part of a whole as measurement equivalent fractions, fraction comparison and addition of fractions with common

and non common denominators (Ismail and Anwang 2009). For the analysis of teachers' instructional practices, the researchers developed an observational protocol for the observation of teachers' mathematics instruction in the 15 classes during two 40-minute periods.

The observational protocol was based on the convergence between instructional practices described by Achievement Goal Theory and the Mathematics education reform literature. Specifically, the researchers developed a list of codes around six structures based on previous literature (Boyd et al. 2008), which influenced students' motivation and achievement. These structures were: Task, instructional aids, practices towards the task, affective sensitivity, messages to students, and recognition.

Preliminary Analysis

Thirty-six items from the Student Questionnaire were relevant to the study. To determine whether there was an underlying structure, a factor analysis was performed. First the correlation matrix was examined to determine its appropriateness for factor analysis. The On-Diagonal values in the anti-image correlation matrix or Kaiser-Meyer-Olkin (KMO) values for each of the 36 items were more than 0.45. In addition, as indicated in Table 1, the value of the test statistic for sphericity based on a Chi-Square transformation of the determinant of the correlation matrix was large (683.0) and the associated significant level was small (0.000). Given these results, it was concluded that this data do not produce an identity matrix and is approximately multivariate normal. Furthermore, the correlation matrix contained sufficient co-variation for factoring. The data was then subjected to Principal Component Factor Analysis with Varimax Rotation.

Table 1: KMO and Bartlett's Test

Kaiser-Meyer-Olkin	Measure of Sampling Adequacy.	.59
Bartlett's Test of Sphericity	Approx. Chi-Square	683.00
	Df	259.00
	Sig.	.00

Based on the Scree Test and Eigenvalues, over one-eight factors were accepted as the most interpretable ones. These factors accounted for 53.5 percent of the variance. With respect to the

first aim of the study, confirmatory factor analysis was conducted in order to examine whether the factor structure yields the five motivational constructs expected by the theory (Ismail and Anwang 2009). By maximum likelihood estimation method, three types of fit indices were used to assess the overall fit of the model; the chi-square index, the comparative fit index (CFI), and the root mean square error of approximation (RMSEA). The Chi square index provides an asymptotically valid significance test of model fit. The CFI estimates the relative fit of the target model in comparison to a baseline model where all of the variable in the model are uncorrelated (Akiba et al. 2008). The values of the CFI range from 0 to 1, with values greater than 0.95 indicating an acceptable model fit. Finally, the RMSEA is an index that takes the model complexity into account; an RMSEA of .05 or less is considered to be as acceptable fit (Khatoon and Mahmood 2010). In addition, some items were grouped together because they had high correlation. Then in line with the motivation theory, a five-factor model was tested. Items from each scale are hypothesized to load only on their respective latent variables. The fit of this model was ($\chi^2 = 691.104$, $df = 208$, $p < 0.000$; CFI=0.770 and RMSEA=0.086). With the addition of correlations among the five factors the measuring model has been improved ($\chi^2 = 343.487$, $df = 198$, $p < 0.000$; CFI=0.931 and RMSEA=0.049).

FINDINGS

Aim 1: To identify a number of factors that represent the relationship among sets of interrelated variables using Principal Component Factor Analysis

The data showed that factor loadings range from 0.399 to 0.862. Students' interest is positively correlated with self-efficacy and negatively correlated with fear of failure. In addition, self-efficacy is negatively correlated with fear of failure. In conclusion, the existence of the five factors and their correlations has been verified in a different social context which supports the results of other studies (Khatoon and Mahmood 2010).

To examine the aim further, the researchers used analysis of variance (ANOVA) using LSD

(Least significant difference) on the scores of each of the motivational constructs and the achievement test to search for differences between 15 classrooms. Significant differences between classrooms were found in all five motivational constructs; namely, mastery goals ($F = 3.274$, $p < 0.000$), performance goals ($F = 6.018$, $p = 0.000$), self efficacy beliefs ($F = 3.368$, $p < 0.000$), fear of failure ($F = 2.545$, $p = 0.002$), interest on mathematics ($F = 4.377$, $p < 0.000$) and achievement ($F = 3.111$, $p < 0.000$). The LSD method showed that students in class 14 declared the highest interest on mathematic and the highest self-efficacy beliefs. Students in class 3 were characterized by the highest performance goals, students in class 10 by the highest mastery goals, and students in class 11 by the highest fear of failure.

The factors of mathematics self-concept, home background and students' attitudes towards mathematics had the highest correlations with the math score 0.353, 0.302, and 0.216, respectively. In addition, the correlation between self-concept and students' attitudes was high (0.452). Correlations between the other two factors, that is, school climate and external motivation, with the mathematics score were not significant.

Controlling home background did not have much effect on the correlation between mathematics self-concept and the mathematics score, nor the correlation between students' attitudes and the mathematics score and the obtained indices were 0.31 and 0.207 respectively. However, after controlling the home background factor, the correlation between mathematics self-concept and students' attitudes increased from 0.452 to 0.47. Controlling mathematics self-concept resulted in a decrease in the correlation between students' attitudes and home background (from 0.116 to 0.009), home background factor and the mathematics score (from 0.302 to 0.248), as well as students' attitudes factor and the math score (from 0.216 to 0.069).

This shows that the relationship between students' attitudes toward mathematics and home background factors, the relation between students' attitudes toward mathematics and mathematics achievement, as well as the relationship between home background factor and mathematics achievement depend on math self-concept.

Aim 2: To examine the contribution of each factor in the explanation of the variance in the students' mathematics score and to determine the total variance that could be accounted for by these factors using Multiple Regression Analysis

In order to determine how much of the variance in mathematics score could be explained by the above-mentioned factors Multiple Regression Analysis was utilized. The results of this analysis showed that seven of the eight factors under study totally accounted for approximately one-fifth of the variance in mathematics score (20.8 percent). The first factor that significantly entered into the regression equation was mathematics self-concept. Mathematics self-concept accounted for more than half of the explained variance (12.5 percent). The second factor that entered into the regression equation after controlling self-concept was home background and it explained 5.4 percent of the variance in mathematics score. The third and fourth factors that entered into the regression equation, that is teaching and students' attitudes toward mathematics, explained significant proportions of the variance in the mathematics score (1.4 and 0.9 percent of the variance respectively). The last three factors with entered into the regression equation (attribution, External motivation and press factors) also explained small but significant proportions of the remaining variance in the mathematics score (0.4, 0.2 and 0.2 percent respectively).

School climate factor is the only factor that did not have a significant effect on mathematics achievement. It is worth mentioning that the Standardized Regression Coefficients (Beta) for teaching (-0.135), external motivation (-0.071) and attribution (-0.052) factors were negative. And finally, the overall multiple regression equation that assessed the joint significance of the complete set of predictor factors was significant [$F(7, 3687) = 139.24, p < .01$].

The lowest and highest tolerance and VIF values for the seven factors were 0.62 and 0.948 as well as 1.055 and 1.614 respectively. All the tolerance and VIF values are acceptable and it can be concluded that each factor is completely uncorrelated with the other independent factors. The inspection of the respective scatter plots for the standardized predicted values against standardized residuals shows that the relationship

between the dependent variable and the seven factors is linear and the variance of the residuals at every set of values for the dependent variable is equal.

DISCUSSION

Education is a complex process and many factors directly or indirectly affect school outcomes. As a result it is difficult to properly define the major factors influencing students' achievement. This study, similar to abundant research carried out in this field, revealed a significant effect of mathematics self-concept (Boyd et al. 2008), home background (Karimi and Venkatesen 2009), students' attitudes towards, teaching, attribution (Boyd et al. 2008), press variables (Boyd et al. 2008) and external motivation on mathematics achievement. The proportion of the variance accounted for by mathematics self-concept was more than twice as much as the variance explained by home background. In addition, the proportion of the variance accounted for by self-concept is almost 50 percent of the total variance explained by the other seven factors for the total sample. This is similar to Boyd's et al. (2008) that in developing countries school has a great influence on students' achievement after accounting for the effect of home background. Self-concept is not innate but is developed by the individual through interaction with the environment and reflecting on the interaction.

In general, self-concept refers to a complex system of learned beliefs, attitudes and opinions that each person holds and is perhaps the basis for all motivated behaviour. Karimi and Venkatesen (2009) state that there is an increasing body of research which shows that it is possible to change self-concept. Self-change is not something that people can wield but rather it depends on the process of self-reflection. Through self-reflection, people often come to view themselves in a new more powerful way and it is through this new more powerful way of viewing the self that people are able to develop possible selves. In addition to the self-concept factor, students' attitudes toward mathematics are the most important characteristic that has positive Standardized Regression Coefficient in predicting students' mathematics achievement. In general, the implication of these findings could serve as a guideline for teachers, edu-

cational practitioners and curriculum developers so that they can ensure that the utilized educational policies, methodologies and activities would help students improve their academic self-concept as well as positive attitudes toward school subjects, including mathematics.

CONCLUSION

In the present study the researchers examined students' motivational environments by analysing questionnaire data and observations as a means towards identifying teachers' practices associated with the students' highest and lowest motivational constructs and achievement. The model found in this study that correlates the five motivational constructs is in line with other studies. The higher correlations identified in this study were between self-efficacy and fear of failure. As it was expected, correlation between mastery and performance goals was small. These findings confirm earlier findings.

RECOMMENDATIONS

The findings of the present study are important for the South African education system due to the fact that changing academic self-concept and attitude of students towards mathematics and improving the teaching procedures in the classroom are much easier to achieve than changing background factors affecting students' performance. The obtained results could serve as a basis for developing a hypothetical model for studying the direct and indirect effects of

the afore-mentioned factors on mathematics achievement using Path Analysis or Structural Equation Modeling. Further investigation of teachers' practices in the classroom that are associated with students' motivation and achievement is important.

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