THE ROLE OF STUDY ORIENTATION AND CAUSAL ATTRIBUTION IN MATHEMATICS ACHIEVEMENT

by

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Signed: ~~Moodaley.~~ **Date:** 29-11-2002.

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ABSTRACT

This study was conducted to investigate and clarify the role that certain study orientation variables play in predicting mathematics achievement. To achieve this, the empirical relationship between study orientation as measured by the SOM (study attitude, mathematics anxiety, study habits problem-solving behaviour and study milieu) and achievement in this subject was investigated for grade 9 learners from five racially integrated, secondary schools in the Northern Cape. The role of gender and culture as possible moderator variables was considered. A series of hierarchical regression analyses were performed to determine the percentage of the criterion (mathematics achievement) variance that could be explained by study orientation in mathematics. This investigation was augmented by the further exploration of learners' perceived causes of their achievement in mathematics. Once again, the contribution of the attribution of causes (internal or external factors) to the variance in mathematics achievement for both gender and culture was investigated. The results emphasized the importance of the set of study orientation variables as predictors of achievement in mathematics for both genders and all three culture groups. Study milieu and problem-solving behaviour appeared to be the most significant (at the 1% level) individual predictors of mathematics achievement for both genders and both black and white grade 9 learners. The causal attribution of achievement scales jointly contributed significantly to the explanation of the variance in mathematics achievement for the following groups: male, white and coloured learners with positive perceptions of their achievement in mathematics and male, white and black learners with negative perceptions of their achievement in mathematics. The external factor only contributed significantly to the explanation of the variance in mathematics achievement for the white learners with positive perceptions of their achievement in mathematics. However, the internal factor made a significant contribution to the explanation of the variance in mathematics achievement for the following groups: the coloured learners with positive perceptions of their achievement in mathematics and both male and female and black and white learners with negative perceptions of their achievement in mathematics.

Key terms: study orientation in mathematics, study attitude, maths anxiety, study habits, problem-solving behaviour, study milieu, achievement in mathematics, locus of causality, gender differences, culture differences.

THE ROLE OF STUDY ORIENTATION AND CAUSAL ATTRIBUTION IN MATHEMATICS ACHIEVEMENT

Introduction

The ability to master mathematical concepts and to perform adequately in mathematics as a school subject has often been referred to as the "critical filter" in the job market. This statement takes on profound proportions when one considers the unemployment figures currently prevailing in South Africa and the associated disinvestment and poor performance in mathematics at the various levels of schooling. In an overview of education in South Africa Strauss, van der Linde and Plekker (2000) re-emphasised the current academic dilemma pertaining to mathematics. This subject still reflects the lowest pass rate of all school subjects for both sexes (males 50%; females 40.9%) and is only surpassed by physical science as the most unpopular subject at the matriculation level.

The fact that South African final year learners performed so poorly in the Third International Mathematics and Science Study (TIMMS), specifically the mathematics and science literacy test, suggests that their general mathematics and science skills are limited, thus falling short of the literacy levels necessary for effective functioning in society (Howie & Hughes, 1998). To improve mathematical performance, Howie, Marsh, Allummoottil, Glencross, Deliwe and Hughes (2000) suggest that emphasis should be placed on improving learners' attitudes and raising the awareness levels amongst parents and communities, about the importance of mathematics. The development of mathematics literacy is a key component to the social upliftment and job creation for the people of South Africa. Then only can South Africa aim to develop the mathematical skills and consequent economic strength required to reach a higher level of competitiveness as a nation in the global economy (Howie et al., 2000).

Study orientation and mathematics achievement

In an attempt to facilitate the identification of contributory factors in the poor achievement of learners in mathematics, Maree, Claassen and Prinsloo (1998) developed a study orientation questionnaire in mathematics (SOM). This questionnaire includes the following fields:
(i) study attitude, (ii) mathematics anxiety, (iii) study habits, (iv) problem-solving behaviour and (v) study milieu (social, physical & experienced) with specific reference to mathematics. Although it is strongly suspected that the SOM will be able to predict achievement in mathematics, these authors were unable to investigate the relationship between the results on

this questionnaire and scholastic achievement in mathematics and urged continued research in this regard.

The SOM is useful in the assessment of study orientation problems among learners and may serve as the basis for improvement in mathematics achievement (Maree et al., 1998). *Study attitude* has bearing on feelings and attitudes toward mathematics that affect learners' motivation, expectation and interest in mathematics (Maree, Prinsloo, & Claassen, 1997). Alkhateeb (2002) concluded that learners' attitudes toward success in mathematics significantly improved as a result of computer use for brief calculus which allowed them to explore, become more proficient and confident in the use of computers. According to Midgley, Arunkumar and Urdan (1996), performance outcomes may be negatively influenced by self–handicapping strategies, which could be used as a mechanism by which negative attitudes become translated into behaviours. Rech and Stevens (1996) found that attitude and socio-economic status amongst black fourth grade learners contributed significantly to the prediction of mathematics achievement. Furthermore, they suggest that increasing the level of mathematics achievement may result in more positive attitudes towards mathematics as the relationship between attitude and ability in the subject was found to be interactive and dynamic. Visser (1989) states that the attitudes of females towards mathematics become more negative between grades 7 and 9 whereas the attitudes of males were consistently more positive. Moreover, fewer sex differences in attitudes came forth among grade 11 learners because the females with negative attitudes toward mathematics dropped the subject after grade 9. In contrast Utsumi and Mendes (2000, p.241) researched attitudes toward mathematics in basic education among grade 6, 7 and 8 learners in Brazil and found:

> This study has revealed that, for this sample, there were no statistically significant differences in attitudes towards mathematics associated to gender. Even though this fact is not very common in the related literature, it seems to show advancement in the relationship between mathematics and female attitudes, being a means to demystify the idea that mathematics is a male domain.

Similarly, Ma and Kishor (1997) reported that the relationship between attitudes toward mathematics and mathematics achievement is the same for males and females.

Mathematics anxiety, panic and concern are often manifested in the form of aimless repetitive behaviours for example nail-biting or excessive sweating, learners become anxious and uncertain when the content of mathematics does not make sense (Maree et al., 1997). According to Ma (1999) mathematics anxiety can facilitate, debilitate or can be unassociated with mathematics performance. In addition, research results indicate that the relationship between mathematics anxiety and mathematics achievement is consistent across gender groups, grade-level groups and ethnic groups. On the other hand Maree (1997) and Visser (1989), found statistically significant differences in anxiety and attitude with regard to gender, girls showing more anxiety and a less positive or more negative attitude. Considering current technological advancement Alkhateeb (2002) stated that mathematics anxiety was significantly reduced when learners were aided by computer. Similarly, females who used the computer were significantly less anxious than those using calculators.

Study habits can be described as a display of acquired, consistent and effective study methods. The culmination of certain study habits is as a result of study attitude toward mathematics (Maree et al., 1997). Cerrito and Levi (1999), found that learners did not spend sufficient time studying due to the fact that they had tremendous freedom with regard to their leisure activities, and therefore chose these activities above being involved with, or studying mathematics. They also found that regular collection, and grading of homework correlated well with increased study time in mathematics. In Australia, Dandy and Nettelbeck (2002), found that learners from Asian (East and Southeast) backgrounds spent more time studying than their Anglo-Celtic Australian peers and subsequently obtained higher mathematics grades. Motivational indices such as high occupational aspirations and study time possibly enhanced achievement for these learners.

Problem–solving behaviour can be described as "thinking about thinking", this includes planning, self-monitoring, self-evaluation, self-regulation and decision making during the process of solving mathematics problems (Maree et al., 1997). According to Miller and Byrnes (2001) self-regulated decision makers value adaptive goals and are competent at regulating their limitations, biases and tendencies toward attaining their goals. They actively participate in their own decision-making process metacognitively (they timeously evaluate their options), motivationally (they are confident about making good decisions) and behaviourally (they seek the necessary knowledge). Thus, the best predictors of achievement behaviour were academic goals and self-regulatory competencies in decision- making. In addition, they also found a basis for asserting that older adolescent girls were more self-regulated in their decision-making than older adolescent boys. Bong (1997) suggests that as learners' perceptions of similarity between problems improved, the generality of their academic self-efficacy judgements also increased. In America, Gallagher and De Lisi (1994) found that gender differences among high ability mathematical learners were due to different solution strategies on maths problems. High ability female learners did better on conventional problems and relied on conventional strategies (generally taught in the classroom), whereas male learners did better on unconventional problems and preferred unconventional strategies. Female learners are better in tasks that require rapid retrieval of information from memory, whereas male learners are better at tasks that require the manipulation of information already in working memory. They suggest that physiological and environmental factors in the use of problem solving strategies may be the result of gender differences. Naglieri and Rojahn (2001) concluded that the fact that girls performed better than boys in planning and attention had important implications for classroom instruction, especially for boys. Also, planning and attention are important processes that could affect academic achievement as well as other areas of daily life. In Spain, Rodriguez-Fornells and Maydeu-Olivares (2000) found that impulsivity/carelessness in problem- solving is effective in predicting academic achievement.

Study Milieu refers to the different environments learners come from. A learner's social, physical and experienced environment forms an integral part of their study orientation. Learners from less stimulating environments are often slower and at a disadvantage than learners from less restricted environments (Maree et al., 1997). Day-care participation during the first three years of life was positively related to the subsequent development of mathematics and reading skills for children from impoverished environments (Caughy, DiPietro, & Strobino, 1994). Also, family income directly influences the quality of the home environment, which affects the resources available to the family for the purchase of books, toys and other items. According to Howie (1996), less optimum study milieu and high mathematics anxiety was characteristic of African language speakers. Church, Elliot and Gable (2001), suggest that perceptions of the classroom environment may lead to achievement goal adoption, similarly, achievement goals lead to performance and intrinsic motivation. According to Daly, Kreiser and Roghaar (1994), asking questions in class allows learners the opportunity to clarify materials, extend their own understanding of lessons and raise personal concerns about class discussions. They found that males and females with higher self-reported grades felt more comfortable asking questions, than learners who reported lower grades. Furthermore, much of the difference in question-asking comfort due to gender is tied to differences among males and females in their self- esteem. Other factors that influenced student question-asking where socio-economic status and family income. Learners from lower status backgrounds were significantly less comfortable asking questions than learners from higher status wealthy families.

Causal attribution and mathematics achievement

One of the most pressing questions associated with the motivation to achieve in a task pertains to the individual's perceived locus of causality of achievement. This causal attribution of scholastic achievement can be very subjective, biased, self–enhancing or self-defensive and may thus play a vital role in both study orientation and achievement in mathematics.

According to Weiner (1986) the logical analysis of the structure of causality yields three dimensions: locus of causality, stability and controllability. These properties are conceived as a bipolar continuum. The three dimensions are labelled with the phrases internal-external, stable-unstable, and controllable-uncontrollable. This allows one to consider where causes are perceived on an internal-external continuum. Furthermore, this author distinguishes between causal factors that are internal, controllable (e.g. effort) and those that are internal, uncontrollable (e.g. ability). Intelligence and task difficulty are examples of causes that may be considered stable, whereas mood and effort are often considered unstable. These dimensions are reliable, general across situations, and meaningful. Success and failure at skill tasks are usually ascribed to ability and effort. Ability is thought to be a fixed property, and the belief that success is caused by hard work usually results in the intent to work hard again in the future. If the causes of prior success are perceived as relatively stable, future success should be anticipated with greater certainty, and there will be increments in aspiration levels. Stipek and Weisz (1981), suggest success and failure experiences have important and enduring effects on perceptions of ability, expectations for success and other cognitions that mediate behaviour in achievement settings. The effect of success or failure on behaviour in achievement contexts depends on the perceptions of the cause of that success or failure. Upon accepting responsibility for success, and understanding that effort and persistence can overcome failure, performance is optimized. Macleod's (1995, p.193) literature survesuggested that from various studies:

> It was found that males were more likely than females to attribute their success to ability (internal and stable), and their failure to lack of effort (internal and unstable). Females on the other hand, were more likely to attribute their success to effort, luck or help from others (external or internal and unstable) and their failures to lack of ability (internal and stable).

Ries and Park (2001), who found that high-ability females regarded hard work as a reason for their success rather than chance or luck obtained similar findings. Males' academic self-efficacy is enhanced, based on their belief in their ability, and is maintained by attributing failure to lack of effort.

The purpose of the present research was to firstly investigate and clarify the role that certain study orientation variables play in predicting mathematics achievement. To achieve this, the empirical relationship between study orientation as measured by the Study Orientation Questionnaire in Maths (study attitude, mathematics anxiety, study habits, problem-solving behaviour and study milieu) and achievement in this subject was investigated for grade 9 learners. In this regard, the role of gender and culture as possible moderator variables was considered. Secondly, the role that the attribution of specific causes (internal and external factors) for perceived performance in mathematics plays in achievement in this subject was investigated. Once again, this relationship was investigated separately for both sexes and the three culture groups.

Method

Participants

All English medium, grade 9 learners from five racially integrated, secondary schools in Kimberley, Northern Cape were included in the study. The sample consisted of 346 learners of which 192 (55,5%) were male and 154 (44,5%) female. With reference to the culture groups, 72 (20,8%) were white, 182 (52,6%) were black and 92 (26,6%) were coloured.

Instruments

The Study Orientation Questionnaire in Maths (SOM) (Maree, Prinsloo & Claassen, 1997) was used to measure study orientation in mathematics. This instrument was designed for South African learners from grades 7 to 12. The questionnaire comprises five fields for grade 7, 8 and 9 learners namely: Study Attitude, Mathematics Anxiety, Study Habits, Problem Solving Behaviour and Study Milieu. For the grade 10, 11 and 12 learners, Information Processing is included as an additional field. This questionnaire utilizes a five point scale [0 = rarely; 4 = almost always]. It is important to note that a high score pertains to a positive study orientation (or an aspect of it), while a low score reflects a negative study orientation (or aspect of it). In this way a high score for Mathematics Anxiety for example points to the relative *absence* of mathematics anxiety.

The questionnaire as a whole reflects reliability coefficients varying from 0,89 to 0,95. It was found that the SOM yielded satisfactory results with regard to the determination of, inter alia, reliability, intercorrelations between the six scales and validity (Maree, Claassen and Prinsloo, 1998). The reliability of the different fields of the test was determined by means of Ferguson's adaptation of the KR-20 formula. This method provides us with a coefficient that represents the degree of internal consistency of the test.

A questionnaire to investigate learners' causal attribution of their achievement (CAA) in mathematics was compiled. This questionnaire was based upon Weiner's (1986) theory of internal and external locus of causality and consisted of 18 items that reflected an equal number of internally and externally attributed factors. Learners were required to rate their own performance in mathematics as either good/above average/average (positive perception of achievement) or poor/below average (negative perception of achievement) and then to indicate the reasons for these results on the questionnaire. A four point scale was used (1 = definitely disagree; 4 = definitely agree). High scores were indicative of a stronger tendency to attribute causes to internal or external factors respectively, depending upon the item.

Information regarding achievement in mathematics was obtained from the relevant schools for both the March and June examinations. A mean score was computed for each learner with respect to these two marks. This mean score was used as the criterion variable, namely mathematics achievement.

Statistical analyses

Hierarchical regression analyses were performed to determine the percentage of the criterion (mathematics achievement) variance explained by study orientation in mathematics (SOM). The second research question pertaining to the possible role that the attribution of causes of achievement (internal and external factors) plays in mathematics achievement was also investigated by means of regression analyses for learners with different perceptions of their achievement (negative and positive). Here too, these analyses were performed separately for the two gender and three culture groups.

By means of the hierarchical regression analyses, the total variance in mathematics achievement explained by all the predictors simultaneously (full model) for the grade 9 learners was originally determined. Subsequently, each predictor variable was excluded to determine the percentage of criterion variance explained uniquely by that particular predictor. Ultimately, all the variables of a particular *set* of predictors were excluded to determine their joint contribution to the variance in mathematics achievement. In this study, the two sets referred to the variables of study orientation (five sub-scales) and those of causal attribution of achievement (CAA) in mathematics (internal and external factors). The percentage variance explained by a specific set of variables is denoted by R^2.

The hierarchical F-test was used to determine whether the contribution made to R^2 by a particular predictor, or set of predictors, was statistically significant. This test was calculated in the following manner:

$$F = \frac{(R^2_{y.1...k1} - R^2_{y.1...k2}) \;/\; (k_1 - k_2)}{(1 - R^2_{y.1...k1}) \;/\; (N - k_1 - 1)}$$

where:

$R^2_{y.1...k1}$ = Squared multiple correlation coefficient for the larger number of independent variables
$R^2_{y.1...k2}$ = Squared multiple correlation coefficient for the smaller number of independent variables
k_1 = Larger number of independent variables
k_2 = Smaller number of independent variables
N = Total number of cases

(Van der Walt, 1980)

Effect size

Effect size was calculated as a measure of practical significance. Cohen (Steyn, 1999) provides information about the method according to which effect sizes can be calculated in a determined case, as well as guidelines to evaluate the effect sizes.

In hierarchical regression analyses, it is necessary to calculate the effect size of the contribution that a specific predictor or set of predictors provides. The effect size gives an indication of the contribution to R^2 in terms of the proportion unexplained variance of the full model. According to Van der Westhuizen, Monteith and Steyn (1989) the effect size of individual contributions can be determined in terms of f^2 and with the following formula:

$$f^2 = \frac{R^2 - R_1^2}{1 - R^2}$$

where:
R^2 = proportion variance explained by the full model
R^2_1 = proportion variance explained by the smaller number of independent variables

According to Cohen, the following values can be used as a guideline:

f^2 = 0,01 : small effect

f^2 = 0,15 : medium effect

f^2 = 0,35 : large effect

All statistical analyses were done with the assistance of the SAS computer programme (SAS Institute, 1995). In this study the 1%-level of significance was used.

Results and Discussion

The mean mathematics percentage mark of the total sample in the March and June examinations was 41,67% (SD = 21,80). In the further analysis, it appeared that, in this sample, the girls (mean = 44,64%) outperformed the boys (mean = 39,33%) at the grade 9 level. Performance differences were also evident for the different culture groups (whites = 52,21%; blacks = 35,95% and coloureds = 44,93%). When one considers the fact that 40% is regarded as the pass mark for mathematics at the Higher Grade in grade 12, these results are suggestive of poor achievement in mathematics and are therefore supportive of other researchers (Howie, 1996; Strauss et al., 2001) in this regard.

Study orientation and achievement in mathematics:

To investigate the relationship between study orientation and achievement in mathematics hierarchical regression analyses were performed for the two genders and three culture groups separately. In addition to these analyses, the interrelationships between predictor variables and those between predictors and the criterion were determined.

For both genders a Pearson's product-moment-correlation coefficient was used to determine the relationship between predictor variables internally and between predictors and the criterion. The results are reflected in Table 1.

Table1. Intercorrelations between variables for boys (n=192) and girls (n=154)

Gender	Girls					Boys				
Variable	SA	MA	SH	PSB	SM	SA	MA	SH	PSB	SM
1 Achievement in Maths	36*	35*	33*	37*	32*	51*	52*	52*	55*	58*
2 Study Attitude (SA)	-	36*	72*	59*	34*	-	45*	83*	73*	46*
3 Mathematics Anxiety (MA)		-	33*	18	60*		-	41*	39*	65*
4 Study Habits (SH)			-	74*	35*			-	86*	50*
5 Problem Solving Behaviour (PSB)				-	28*				-	46*
6 Study Milieu (SM)					-					-

N.B. Decimals have been omitted

* p <= 0,01

These results suggest that all the predictor variables correlated significantly (at the 1% level of significance) with mathematics achievement for both sexes. Furthermore, the coefficients all appeared to be positive, thus suggesting that high scores obtained on the SOM scales were associated with high marks in mathematics for both boys and girls.

Subsequently, hierarchical regression analyses were performed for both sexes to investigate the contributions made by the different scales of the SOM to the explanation of variance in mathematics achievement.

The results of these analyses are reflected in Table 2.

Table 2: Contributions made by the SOM scales to R^2 for both genders

Variable in analysis	*Female*					*Male*			
	Variable omitted	R^2	*Contribution to R^2*	*F*	f^2	R^2	Contribution to R^2	*F*	f^2
1. sa+ma+sh+psb+sm	-	0,4890				0,2640			
2. sa+ma+sh+psb	sm	0,4322	0,0568	18,93*	0,11	0,2148	0,0492	12,30*	0,07
3. sa+ma+sh+sm	psb	0,4542	0,0348	11,60*	0,07	0,2225	0,0415	10,38*	0,06
4. sa+ma+psb+sm	sh	0,4852	0,0038	1,27		0,2461	0,0179	4,48	
5. sa+sh+psb+sm	ma	0,4754	0,0136	4,53		0,2548	0,0092	2,30	
6. ma+sh+psb+sm	sa	0,4717	0,0173	5,77		0,2541	0,0099	2,48	

Key: [sa=study attitude; ma=mathematics anxiety; sh=study habits; psb=problem-solving behaviour; sm=study milieu]

* $p \leq 0{,}01$

Concerning the **female learners**, the results indicate that the SOM scales jointly explain 48,9% (R^2 = 0,4890) of the variance in the grade 9 learner's mathematics achievement. This calculated R^2 value is significant at the 1%-level of significance [F = 20,672; p = 0,0001]. When the contributions of the individual SOM scales to R^2 are investigated for this group, it becomes apparent that only two scales namely, study milieu (sm) and problem-solving behaviour (psb) contribute significantly (at the 1% level) on their own to the explanation of the variance in achievement in mathematics. Study milieu (sm) explains 5,68% of the variance in mathematics achievement while problem-solving behaviour (psb) explains 3,48% of this variance.

For the **male learners**, the results indicate that the SOM scales jointly explain 26,4% (R^2 = 0,2640) of the variance in mathematics achievement for the grade 9 learner. This calculated R^2-value is significant at the 1%-level [F = 7,391; p = 0,0001]. Upon further investigation into the contributions made by the individual scales, it becomes apparent that the same two scales as those in the case of the female learners namely, study milieu (sm) and problem-solving behaviour (psb), contribute significantly (at the 1% level) on their own to the variance in mathematics performance for the grade 9 learner. Study milieu (sm) explains

4,92% of the variance while problem-solving behaviour (psb) explains 4,15% of the variance in mathematics achievement.

According to the guidelines provided for the different effect sizes, it is clear that the contributions made by the statistically significant SOM scales reflect small to medium effect sizes.

With respect to the three culture groups, Pearson's product-moment-correlation coefficients were once again used to determine the nature of the relationships between predictor variables internally and between predictor variables and the criterion for white, coloured and black grade 9 learners. The results of this analysis appear in Table 3.

Table 3: Intercorrelations for white (n=72), coloured (n=92) and black (n=182) learners

	Whites					Coloureds					Blacks				
Variables	SA	MA	SH	PSB	SM	SA	MA	SH	PSB	SM	SA	MA	SH	PSB	SM
1 Maths Ach.	58*	58*	56*	60*	68*	44*	33*	43*	39*	40*	39*	38*	37*	43*	35*
2 SA	-	53*	82*	71*	58*	-	36*	72*	57*	34*	-	38*	79*	69*	35*
3 MA		-	51*	42*	74*		-	17	05	68*		-	39*	34*	52*
4 SH			-	80*	62*			-	82*	32*			-	79*	38*
5 PSB				-	62*				-	27				-	30*
6 SM					-					-					-

Key: SA=Study Attitude; MA=Mathematics Anxiety; SH=Study Habits; PSB=Problem Solving Behaviour; SM=Study Milieu

N.B. Decimals have been omitted

* $p \leq 0,01$

All predictor variables correlated significantly (at the 1%-level of significance) with mathematics achievement. Furthermore, all coefficients are positive, thus implying that high scores on the predictor variables will essentially lead to high scores on the criterion variable.

Subsequently, hierarchical regression analyses were performed to investigate the contributions made by the different SOM scales to the explanation of the variance in mathematics achievement. These analyses were performed for each culture group separately and the results are reflected in Table 4.

Table 4: Contributions made by the SOM scales to R^2 for the culture groups

Variable in analysis	White					Black				Coloured			
	Variable omitted	R^2	Contribution to R^2	*F*	f^2	R^2	Contribution to R^2	*F*	f^2	R^2	Contribution to R^2	*F*	f^2
1. sa+ma+sh+psb+sm	-	0,5837				0,3244				0,2807			
2. sa+ma+sh+psb	sm	0,5367	0,0470	7,83*	0,12	0,2518	0,0726	18,15*	0,11	0,2638	0,0169	2,11	
3. sa+ma+sh+sm	psb	0,5310	0,0527	8,78*	0,13	0,2831	0,0413	10,33*	0,06	0,2394	0,0413	5,17	
4. sa+ma+psb+sm	sh	0,5836	0,0001	0,02		0,3096	0,0148	3,70		0,2806	0,0001	0,01	
5. sa+sh+psb+sm	ma	0,5791	0,0046	0,77		0,3124	0,0120	3,00		0,2764	0,0043	0,54	
6. ma+sh+psb+sm	sa	0,5717	0,0120	2,00		0,2957	0,0287	7,18*	0,04	0,2770	0,0037	0,46	

Key: [sa=study attitude; ma=mathematics anxiety; sh=study habits; psb=problem-solving behaviour; sm=study milieu]

* $p \leq 0,01$

With respect to the **white learners**, the results in Table 4 firstly reflect that the SOM scales jointly explain 58,37% (R^2 = 0,5837) of the variance in mathematics achievement for the grade 9 learner. This calculated R^2 value is significant at the 1%-level of significance [F = 14,579; p = 0,0001]. Secondly, when the contributions of the individual SOM scales to R^2 are investigated, it once again becomes apparent that the study milieu (sm) and the problem-solving behaviour (psb) scales individually contribute significantly (at the 1% level) to the variance in achievement in mathematics. Study milieu (sm) explains 4,70% of the variance in mathematics achievement while problem-solving behaviour (psb) explains 5,27% of the variance in mathematics achievement.

With respect to the **black learner**, the results reflected in Table 4 indicate that the SOM scales jointly explain 32,44% (R^2 = 0,3244) of the variance in mathematics achievement for this cultural group. This calculated R^2 value is significant at the 1%-level of significance [F = 9,027; p = 0,0001]. An investigation into the contributions made by the individual scales of the SOM reflects significant (at the 1%-level) contributions to R^2 by three scales namely, study milieu (sm), problem-solving behaviour (psb) and study attitude (sa). Study milieu (sm) explains 7,26% of the variance in mathematics achievement, problem-solving behaviour (psb) explains 4,13% of the variance while study attitude (sa) explains 2,87% of the variance in grade 9 black learners' achievement in mathematics.

With respect to the **coloured learners**, the results indicate that the SOM scales jointly explain 28,07% (R^2 = 0,2807) of the variance in mathematics achievement for the grade 9 learner from this cultural group. This calculated R^2 value is also significant at the 1%-level of significance [F = 4,603; p = 0,0013]. Upon consideration of the contributions made by the individual predictors to R^2 it is apparent that none of these predictors contribute significantly to the variance in mathematics achievement for the grade 9 learner from this cultural group.

According to the guidelines provided for the different effect sizes, the contributions made by the statistically significant SOM scales once again reflect small to medium effect sizes.

Causal attribution and achievement in mathematics:

The second research question pertaining to the possible role that the locus of causality of achievement plays in the prediction of achievement in mathematics for the grade 9 learner, was subsequently investigated.

The learners were firstly requested to indicate whether they evaluated their achievement in mathematics as good/above average/average (positive perception of achievement) or below average/poor (negative perception of achievement). The total group was then divided into two smaller groups on grounds of these indicated perceptions of achievement/non achievement. Both groups were then requested to indicate which factors (internal or external) played a role in their achievement/lack of achievement in mathematics. Following this, the role of these factors in predicting actual achievement in mathematics was investigated for the two groups. This investigation was done by means of hierarchical regression analyses for the two gender and three culture groups separately.

Table 5 indicates the results of this investigation with respect to gender.

Table 5: Contributions made by the internal and external factors to R^2 for the two genders

Variable in analysis		*Female*				*Male*			
analysis analysis	Variable omitted	R^2	Contribution to R^2	*F*	f^2	R^2	Contribution to R^2	*F*	f^2
Positive: perception of achievement in mathematics									
1. cef+cif	-	0,0363				0,1139			
2. cif	cef	0,0334	0,0029	0,18		0,1043	0,0096	0,96	
3. cef	cif	0,0231	0,0132	0,83		0,0568	0,0571	5,71	
Negative: perception of achievement in mathematics									
1. cef+cif		0,1984				0,1014			
2. cif	cef	0,1962	0,0022	0,24		0,0861	0,0153	1,70	
3. cef	cif	0,1121	0,0863	9,59*	0,11	0,0378	0,0636	7,07*	0,07

Key: [cef=external factors; cif=internal factors]

* p≤ 0,01

Although the results reflected in Table 5 suggest that the causal attribution of achievement (CAA) scales jointly explain 3,63% (R^2 = 0,0363) of the variance in mathematics achievement for grade 9 female learners with a positive perception of their achievement in mathematics, this calculated R^2 value is not significant at at least the 5%-level [F = 1,053; p =

0,3556]. However, this does not appear to be the case with the male learners with positive perceptions of their achievement in mathematics. According to the results, the CA scales jointly explain 11,39% ($R^2 = 0,1139$) of the variance in the mathematics achievement of these grade 9 learners. This calculated R^2 value is significant at the 5%-level [$F = 4,693$; $p = 0,0121$]. Neither of the individual scales contributes significantly to the variance in mathematics achievement for either the female or the male learners with positive perceptions of their achievement in mathematics.

It is significant to note that the CA scales jointly do not contribute significantly to the explanation of variance in mathematics achievement for the female learners with negative perceptions of their achievement in mathematics, but that they do make a significant (at the 5% level) contribution to the variance in mathematics achievement for the male learners with negative perceptions of their achievement in mathematics [$F = 4,739$; $p = 0,0112$]. Upon consideration of the contributions made by the individual scales, it is apparent that only the internal factor scale (cif) contributes significantly (at the 1% level) to the variance in mathematics achievement for both sexes with negative perceptions of their achievement in mathematics. This scale explains 8,63% and 6,36% of the variance in mathematics achievement for the female and the male learners in this group respectively.

According to the guidelines provided for the evaluation of effect sizes, it is clear that the contributions of the statistically significant CA scales reflect small to medium effect sizes.

The results with respect to culture groups are reflected in Table 6.

Table 6: Contributions made by internal and external factors to R^2 for three culture groups

Variable in analysis	White					Black				Coloured			
	Variable omitted	R^2	Contribution to R^2	F	f^2	R^2	Contribution to R^2	F	f^2	R^2	Contribution to R^2	F	f^2
Positive: perception of achievement in mathematics													
1. cef+cif		0,2774				0,0383				0,1756			
2. cif	cef	0,0520	0,2272	11,96*	0,31	0,0380	0,0003	0,02		0,1484	0,0272	1,29	
3. cef	cif	0,2773	0,0001	0,01		0,0150	0,0233	1,66		0,0061	0,1695	8,07*	0,21
Negative: perception of achievement in mathematics													
1. cef+cif		0,4038				0,1341				0,0869			
2. cif	cef	0,3468	0,0570	2,71		0,1329	0,0012	0,15		0,0717	0,0152	0,80	
3. cef	cif	0,1484	0,2554	12,16*	0,43	0,0673	0,0668	8,35*	0,08	0,0687	0,0182	0,96	

Key: [cef=external factors; cif=internal factors]

* $p \leq 0,01$

With respect to the **white learners**, the results in Table 6 indicate that the CAA scales jointly explain 27,74% (R^2 = 0,2774) of the variance in mathematics achievement of the grade 9 learners with positive perceptions of their achievement in mathematics. The calculated R^2 value is significant at the 1%-level of significance [F = 6,527; p = 0,0040]. Upon consideration of the contribution of the individual predictors to R^2, it is evident that the external factor scale (cef) makes a significant contribution to the explanation of variance in mathematics achievement for the white grade 9 learners with positive perceptions of their achievement in mathematics. This scale independently explains 22,72% of the variance in mathematics achievement.

In the **black** group with positive perceptions of their achievement in mathematics, neither the CAA scales jointly, nor the individual scales independently, made a significant contribution to R^2.

Concerning the **coloured learners** with positive perceptions of their achievement, the results in Table 6 indicate that the causal attribution of achievement (CAA) scales jointly explain 17,56% (R^2 = 0,1756) of the variance in mathematics achievement for the grade 9 learner in this category. This calculated R^2 value is significant at the 5%-level of significance [F = 3,728; p = 0,0341]. When considering the contributions made by the individual predictors to R^2, it is evident that the internal scale (cif) makes a significant contribution (at the 1%-level) to the explanation of the variance in mathematics achievement in this group. This scale independently explains 16,95% of the variance in mathematics achievement.

With respect to the **white learners** with negative perceptions of their achievement, the results in Table 6 indicate that the causal attribution of achievement (CAA) scales jointly explain 40,38% (R^2 = 0,4038) of the variance in mathematics achievement for the grade 9 learner in this group. This calculated R^2 value is significant at the 1%-level of significance [F = 9,142; p = 0,0009]. In this group too, the internal factor scale (cif) makes a significant individual contribution (at the 1%-level) to the explanation of the variance in mathematics achievement. This scale independently explains 25,54% of the variance in mathematics achievement.

The results in Table 6 reflect the following with respect to the **black learners** with negative perceptions of their achievement in mathematics: The CAA scales jointly explain 13,41% (R^2 = 0,1341) of the variance in mathematics achievement for this group. This calculated R^2 value is significant at the 1%-level [F = 6,812; p = 0,0018]. Once again the internal factor scale (cif) is the only individual scale that contributes significantly (at the 1% level) to the explanation of the variance in mathematics achievement for this group. This scale independently explains 6,68% of the variance in mathematics achievement.

With respect to the **coloured learners** with negative perceptions of their achievement in mathematics, the results reflected in Table 6 indicate that the CAA scales jointly do not make a significant contribution to the said variance. The calculated R^2 value is not significant at at least the 5%-level of significance [$F = 1,952$; $p = 0,1550$].

Conclusions and Recommendations

This study was prompted by the persistent poor mathematics results obtained by South African learners in mathematics. The importance of this subject as a school subject to the future career development of learners and ultimately to the economic growth of this country cannot be overestimated.

This study aimed at (i) exploring the relationship between study orientation (comprising of study attitude, mathematics anxiety, study habits, problem solving behaviour and study milieu) and achievement in mathematics and (ii) determining whether the locus of causality of achievement in mathematics could predict ultimate achievement in this subject.

The findings in this study once again reiterated the poor achievement levels in mathematics for especially the coloured and black learners in grade 9 in the Northern Cape. No significant differences were identified with respect to achievement in mathematics for the two genders. These results are supported by Howie et al. (2000); Howie and Hughes (1998) and Visser (1987, 1989). The largest differences in this regard occurred with respect to the three culture groups. The coloured and black learners achieved significantly lower marks in mathematics. These results seem to reiterate those found by Grobler, Grobler and Esterhuyse, (2001); Rech and Stevens (1996) and Moller (1994).

For both boys and girls all the fields of the SOM correlated positively with achievement in mathematics. It could therefore be concluded that for both sexes, a positive study attitude, lower maths anxiety, better study habits, more effective problem solving behaviours and more conducive study milieus were related to better achievement levels in mathematics.

The hierarchical regression analyses with respect to study orientation and achievement in mathematics, emphasized the importance of the set of study orientation variables as predictors of achievement in mathematics for both genders and all three culture groups. In both sexes and across all three culture groups, the set of study orientation scales contributed significantly (at the 1% level) to the explanation of variance in mathematics achievement for grade 9 learners. Grobler, Wessels and Heyns (1994) found similar results with a sample of grade 11 learners. Study milieu and problem-solving behaviour appeared to be the most significant (at the 1% level) individual predictors of mathematics achievement for both genders and both black and white grade 9 learners. In addition to these two individual predictors, study attitude also contributed significantly (at the 1% level) to the explanation of variance in mathematics achievement for the black learners. No significant individual study orientation predictors of mathematics achievement were identified for the coloured learners. The results with respect to study milieu appear to be supportive of those cited by Church, Elliot and Gable (2001) and Daly, Kreiser and Roghaar (1994) and those with respect to problem-solving behaviour reiterate those found by Rodriguez-Fornells and Maydeu-Olivares (2000).

According to Maree and Schoeman (1997), learners either believe that success and failure lie beyond their control or that they exercise control over the factors that influence their achievement. They maintain that these causal attributions are likely to play a large role in the learner's attitude towards, and ultimate achievement in, the subject. The significant contributions made by *study milieu* and *problem-solving behaviour* to the explanation of the variance in mathematics achievement emphasized this hypothesis and instigated the investigation into the role that locus of causality of achievement plays in the prediction of ultimate achievement in this subject. These two scales are closely related to external and internal locus of causality respectively and for this reason, the results of the causal attribution of achievement questionnaire primarily focused upon this dimension of Weiner's (1986) theory of causality.

The CAA scales jointly contributed significantly to the explanation of the variance in mathematics achievement for the following groups: male, white and coloured learners with positive perceptions of their achievement in mathematics and male, white and black learners with negative perceptions of their achievement in mathematics. The external factor only contributed significantly to the explanation of the variance in mathematics achievement for the white learners with positive perceptions of their achievement in mathematics. However, the internal factor made a significant contribution to the explanation of the variance in mathematics achievement for the following groups: the coloured learners with positive perceptions of their achievement in mathematics and both male and female and black and white learners with negative perceptions of their achievement in mathematics.

Although these results appear to be supportive of the hypothesis that locus of causality plays a significant role in the ultimate achievement in mathematics for a large proportion of the grade 9 learners, these results should be viewed as an introduction to further investigations. Due to the limited scope of this article, the more detailed dimensions of stability and controllability upon the internal-external continuum were neglected.

The results obtained with respect to the different culture groups (especially the black learners) must be interpreted against the background that the learners in the current sample were all from racially integrated (traditionally Model C) schools and that their learning and teaching environments may therefore differ considerably from the traditional township environments.

The results of this study suggest that by addressing the significant predictors of achievement in mathematics, namely study orientation and causal attribution of achievement, a profound contribution may be made to the improvement of academic results in this subject for both genders and across three culture groups in equivalent schooling systems.

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OPSOMMING

Hierdie studie is onderneem om die rol wat sekere studie-oriëntasie veranderlikes in die voorspelbaarheid van wiskunde prestasie speel, te ondersoek en te verklaar. Ten einde dit vas te stel, is die empiriese verband tussen studie-orientasie, soos gemeet deur die SOW (studie-ingesteldheid, wiskunde- vrees, studiegewoontes, probleem-oplossingsgedrag, en studie-omgewing) en prestasie in hierdie vak vir graad 9-leerders van vyf rasgeïntegreerde, sekondêre skole in die Noord-Kaap, ondersoek. Die rol van geslag en kultuur as moontlike bemiddelende veranderlikes is in ag geneem. 'n Reeks hiërargiese analises is gemaak om die persentasie van die kriteria (wiskunde prestasie) variansie vas te stel, wat deur studie-oriëntasie in wiskunde verklaar kon word. Hierdie ondersoek is uitgebrei deur die verdere verkenning van oorsake van leerders se wiskunde prestasies, soos deur hulleself waargeneem. Die toerekening van oorsake (interne of eksterne faktore) tot die varianse in wiskunde prestasie vir sowel geslag as kultuur, is bykomend ondersoek. Die resultate beklemtoon die belangrikheid van die stel van studie-oriëntasie veranderlikes as aandiuders/voorspellers van prestasie in wiskunde vir albei geslagte en al drie kultuurgroepe. Studie-omgewing en probleemoplossingsgedrag blyk die belangrikste (op die 1% peil) individuele aanduiders van wiskunde prestasie vir albei geslagte en sowel swart as wit graad 9-leerders te wees. Die oorsaaklike toerekening van prestasie maatstawwe het gesamentlik betekenisvol bygedra tot die verduideliking van variansie in wiskunde prestasie vir die volgende groepe: manlike, wit en gekleurde leerders met negatiewe persepsies van hul prestasie in wiskunde. Eksterne faktore het slegs bygedra tot die verklaring van die variansie in wiskunde prestasie vir die wit leerders met positiewe persepsies van hul prestasies in wiskunde. Interne faktore het nietemin 'n betekenisvolle bydra tot die verduideliking van variansie in wiskunde prestasies vir die volgende groepe gemaak: die gekleurde leerders met positiewe persepsies van hul prestasies in wiskunde en sowel manlike as vroulike en swart en wit leerders met negatiewe persepsies van hul prestasies in wiskunde.

Kernwoorde: studie-oriëntasie in wiskunde, studie-ingesteldheid, wiskunde-vrees, studiegewoontes, probleemoplossingsgedrag, studie-omgewing/milieu, lokaliteit van oorsaaklike verband, geslagsverskille, kultuurverskille.