Education (Malta) Vol. 5 Nº 1, 1993 pp. 10-16

Attitude and Achievement in Mathematics: A Maltese Study of First Year Secondary Students

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Introduction

The usefulness of mathematical knowledge in today' s society is well-documented. Access to power is nowadays determined to a large extent by success in mathematics. Fennema (1980) and Jacobs (1983) both speak of mathematics as the 'critical filter' which determines entry into most of the higher paying careers and professions, and Steinkamp *et al.* (1985, p.259) view mathematics as 'a pivotal discipline related to a broad range of occupational choices'. Mathematics avoiders are cut off from full participation in society (Morris, 1981), and Lorcher (1989) suggests that failure in mathematics not only leads to failure in school but also to a life-long feeling of intellectual inferiority. However, in spite of the fact that mathematics occupies one of the highest positions on educational agendas all over the world, many students the world over are underachieving in mathematics examinations (Shan & Bailey, 1991). This anomaly has long baffled mathematics educators convinced as they are that the number of persons who can understand and enjoy mathematics by far exceeds the number of those who do so at present.

Research in mathematics education has for years focused on devising ways and means of improving the quality of mathematical education and consequently raising students' mathematical performance to more acceptable levels. For instance, both Cheung (1988) and the National Council of Teachers of Mathematics (NCTM) (1987) emphasise the importance of assessing students' dispositions towards mathematics as one of the bases for improving the quality of mathematics instruction. Such recommendations fall within the parameters of a growing body of research examining the relationship of students' attitudes to achievement in mathematics to which Buchanan (1987) refers. In line with this trend, the present paper sets out to investigate the relationship between general attitude and general achievement in mathematics1 . In particular, it examines this relationship with respect to Maltese first year students in state secondary schools 2.

Attitude And Achievement in Mathematics: A Brief Review

(a) Causality: a common assumption

Much of the research carried on attitude towards mathematics and on the relationship between attitude and achievement in mathematics is based on the assumption that attitude affects achievement (Aiken, 1970; Schofield, 1982; Quinn & Jadav, 1987). For instance, Suydam and Weaver (1975, p.45) write:

> Teachers and other mathematics educators generally believe that children learn more effectively when they are interested in what they learn and that they will achieve better in mathematics if they like mathematics.

Similarly, Costello (1991, p. 122) speaks of 'a common and reasonable belief that positive attitudes, particularly liking for, and interest in, mathematics, lead to greater effort and in turn to higher achievement'. However, he concedes that even if there exists evidence in favour of the assumption that improved attitudes towards mathematics result in improved attainment, the link between attitudes and achievement is not as close as one might expect.

(b) Correlational studies

Generally, the relationship between attitude and achievement in mathematics remains unclear (Buchanan, 1987; Schofield, 1982). While some studies report significant relationships between attitude towards mathematics and mathematics achievement, others do not (Brassell *et al.*, 1980). In his reviews of studies examining the relationship between attitudes and achievement in mathematics, Aiken (1970, 1976) usually cites low positive correlations which do not always reach the level of signifi-

cance. The Assessment of Performance Unit (APU) (1981) reports that researchers tend to find positive moderate correlations of little predictive value between the two variables. However, Norwich and Jaeger (1989) warn that a number of criticisms have been levelled at studies investigating this relationships. They claim that both methodological (lack of statistical vigour) and conceptual (lack of theoretical framework) limitations have been suggested to account for the low to moderate correlations between attitudes and achievement.

Working on data gathered during the Second IEA Mathematics Study (SIMS) conducted in Hong Kong, Cheung (1988) reports low positive correlations ranging from 0.007 to 0.424 between mathematics achievement and the various attitude dimensions investigated. The greatest reported correlation in Cheung's study is associated with mathematics achievement and students' own perceptions of their abilities in doing mathematics. On their part, Fennema and Sherman (1977) also consider confidence in learning mathematics and mathematics achievement (correlation coefficient approximately 0.40) to be more highly correlated than any other affective variable and achievement. This low trend of association is confirmed by Joffe and Foxman (1986) who point out that some APU findings reveal the weak relationship that exists between students' perceived difficulty, usefulness and enjoyment of mathematics and mathematics achievement.

(c) Variables affecting the relationship

Schofield (1982, p.283) opines that his findings on elementary school children suggest that 'the relationship between attitude and achievement...(in mathematics)...varies quite markedly according to a number of factors'. Time of school year when data is gathered, children's academic ability, school level, and children's sex may well be some of these mediating factors. For instance, Schofield (1982) concludes that mathematics attitude and achievement at elementary school level are more strongly related when pertinent data is gathered late in the school year in comparison to when it is collected early in the scholastic year. Reporting on male form one students, Buhagiar (1990) notes that with low achieving students (not necessarily in mathematics) the correlation between attitude towards mathematics and achievement on linear and two-dimensional measurement items is stronger than with the higher achieving ones.

(i) Gender issues

There are indications that the relationship between attitude and achievement in mathematics is stronger in the case of boys, even if studies do exist which show exactly the opposite. Preece (1979) comments that girls' mathematical skill does not appear to reflect their attitude to the subject as it does for boys, and Schofield (1982), reporting low and sometimes even negative correlations between positive attitude and achievement in the case of girls, maintains that attitude and achievement are more strongly related for boys than girls. In contrast, Aiken (1976) refers to a study by Behr (1973) which concludes that the correlation between attitude and achievement is generally somewhat higher for girls.

Maltese research in mathematics education at undergraduate level provides some relevant contributions. Calleja's (1993) investigation of the relationship between attitude and achievement in mathematics at Form one junior lyceum level gives different results for male and female students. He reports that while girls' performance in the annual national mathematics examination is significantly related to their general attitude towards mathematics, this association is not significant for the boys. In contrast, research by Scicluna and Sharples (1993) shows that the general attitude towards mathematics of Form one junior lyceum girls is not significantly related to their mathematics achievement on national annual examinations. However, they claim that this relationship grows stronger by the time girls are at Form two, even if it still remains not significant.

(ii) Form level

The literature review indicates that the relationship between attitude and achievement in mathematics appears to get somewhat stronger as students move up the academic ladder. However, Aiken (1970) cautions that these studies lack consistency in their findings. A study on elementary school children by Schofield (1982) highlights this trend which however fails to reach statistical significance at the 0.05 level. Aiken (1970), while writing (p.559) that 'the correlations between attitude and achievement in elementary school, though statistically significant in certain instances, are typically not very large', reports (p.560) that a number of studies on junior-high school students show 'significant correlations between performance in mathematics and measures of attitudes and anxiety toward mathematics'. With older students, Aiken (1970) cites evidence from a longitudinal study at high-school level by Anttonen (1968) showing moderate correlations between atti-

tude and achievement in mathematics.

Local undergraduate research supports studies suggesting that with the older secondary students the link between the two variables under investigation is apparently stronger. From a study on Form three junior lyceum students, Potter and Templeman (1992) conclude that students' preference of mathematics in comparison to other school subjects is significantly related to mathematics achievement. In particular, they maintain that the higher the preference given to mathematics by the students the better their performance in the national annual examination in mathematics. Research by Mifsud and Schembri (1992) on Form four junior lyceum students points towards a significant positive relationship between students' performance in the national end-of-year examination in mathematics and their attitude towards mathematics.

(d) Causality

Even though the study of causal relationships between attitude and achievement in mathematics is beyond the scope of Buhagiar's research (1990), the author feels that a short pertinent note is due here in view of the fact that causality is briefly referred to in the discussion of the present findings. While Neale (1969) opines that the influence of attitude towards mathematics on mathematics achievement seems to be modest at best, the Cockcroft Report (1982, p.61), quoting from a commissioned study 3, warns 'against over-optimism in assuming a very direct relation between attitude and achievement'. Quinn and Jadav (1987) conclude that apparently no powerful causal relationship exists between achievement and attitude in mathematics at the elementary grade level. Their conclusion corroborates the research findings of the studies they reviewed. Although positive correlations between attitude and achievement are reported, these studies provide little direct evidence on the existence and direction of a causal relationship between attitude and achievement.

However, some research indicating a causal link between the two variables exists. For instance, Mukherjee and Umar (1978) report that improved children's attitudes towards mathematics are reflected in attainment. Again, a study on grade seven children concludes that increases in students' self-confidence as learners of mathematics and in their perception of the usefulness and creativity of mathematics would eventually lead to improvement in mathematics achievement (Cheung, 1988).

Methodology

In this paper, while children's general attitude towards mathematics was gauged by their performance on an attitude questionnaire, the students' marks on the national annual mathematics examinations were taken to reflect their general mathematics achievement.

(a) Instruments: investigating attitude and achievement

A 16 item (8 'positive' and 8 'negative' statements) Attitude Test was constructed to provide a concise summary of early-teens students' general attitude towards mathematics. Test respondents had to indicate their preference to each of the 16 statements from a three-point Likert-scale labeled 'agree', 'disagree' and 'unsure'. Responses were scored 2, 1 or 0 according to whether these reflected respectively a positive, a neutral or a negative attitude towards mathematics. The higher the raw score on the test (minimum = 0, maximum = 32) the more favourable the student's general attitude towards mathematics was considered to be. The test items dealt with the following four factors: (1) enjoyment of mathematics lessons (9 items); (2) career and leisure interests in mathematics (4 items); (3) content judgment (2 items); and (4) social implications of the subject (1 item).

The reliability of the Attitude Test was investigated using internal-consistency reliability techniques, namely, split-half reliability and Cronbach's estimate of reliability (alpha). Split-half reliability, using the special Spearman-Brown formula, was calculated at 0.89 and Cronbach's alpha was valued at 0.90. Test validation utilised convergent and item validity techniques. Teachers were asked to grade their students according to their perception of the students' general attitude towards the subject. A three grade system (A, B, or C) was used. Teachers' gradings and students' performance on the test were found to be related at the 0.05 level of significance for the total sample. All 16 test items were found to segregate students higher on the scale of the criterion (i.e., the raw score) from those on the lower scale at the 0.001 level of confidence. These results indicate the high reliability of the Attitude Test and point to its validity.

The level of consistency in students' responses on the Attitude Test was checked by means of three pairs of opposite test items. The Spearman rank correlation coefficient was computed for each of the

three pairs. Significant correlations ($p<0.001$) of 0.49, 0.46 and 0.60 suggest that the students gave reasonably consistent responses throughout the questionnaire.

Children's performance in the national 1988\89 end-of-year mathematics examinations (minimum=0, maximum=100) was identified by the present study as an indication of their general achievement in mathematics. Junior lyceum and area secondary students sit for different annual mathematics papers prepared by the Test Construction Unit (TCU) of the Education Department.

(b) Sample

Students (N=374; modal age=11) from eighteen Form one classes in 6 state secondary schools took part in present study. Classes were chosen to match the Form one state secondary schools population during the 1988/89 scholastic year by students ' sex, type of school and academic ability (85 boys & 106 girls in junior lyceums (JL), and 99 boys & 84 girls in area secondaries (AS)). This sample comprised approximately 9% of the target population.

(c) Procedure

Towards the end of the first semester of the 1988/89 scholastic year the Attitude Test was class administered under test conditions to the selected classes. The regular class teachers were not present during testing and students were given assurances of confidentiality and anonymity. However, as the present study was to investigate the relationship between attitude and achievement in mathematics, a *de facto* disregard of students' anonymity had to ensue. The researcher, by means of specially designed index numbers, could back-trace at will the identity of all the respondents. This information was only available to the researcher, and once all relevant data were gathered and matched these special index numbers were eliminated in favour of other index numbers which fully respected the anonymity of the students. The Attitude Test scripts were marked following the procedure explained previously.

The national annual mathematics papers were corrected within each school by mathematics teachers as determined by the respective school administrations following marking schemes set by the TCU. The researcher obtained these marks through the heads of schools.

(d) Research hypothesis

It was hypothesised that, as regards mathematics, general attitude and general achievement are not significantly related in the population being tested. This association was investigated by computing Pearson's product-moment correlation coefficients between each student's corresponding raw scores of the Attitude Test and the annual mathematics examination. The minimum level for accepting or rejecting the null hypothesis was set at 0.05. A number of sub-samples were identified and investigated as detailed below.

(e) Results

Table I lists the correlation coefficients (r) for the following six sub-samples: JL students, AS students, JL boys, AS boys, JL girls, and AS girls. The total sample, and the boys and girls sub-samples could not be investigated as students in junior lyceums and area secondaries sat for different annual examinations. The reported values of r were checked for chance difference from zero by computing the t-statistic (Freund, 1984, p.450). The table also includes the corresponding sample sizes, t-values and their probabilities of committing type I error.

Table I: Performance on Attitude Test and national end-of-year examinations - correlation coefficients

sample	size	r	t-value	probability
JL students	191	0.00	0.00	NS
AS students	183	0.17	2.32	$p<0.05$
JL boys	85	0.12	1.10	NS
AS boys	99	0.20	2.01	$p<0.05$
JL girls	106	-0.06	-0.61	NS
AS girls	84	0.14	1.28	NS

The computed correlation coefficients, invariably low (the highest only 0.20 for the boys area secondary sample), are all positive except for one (girls junior lyceum sample) which is however not significant. The results show that while for junior lyceum students (JL students, JL boys, and JL girls samples) the performance on the Attitude Test is not significantly related to the performance on the national end-of-year junior lyceum mathematics examination, the Attitude Test raw scores of the area secondary students and the boys area secondary samples are significantly positively related to the raw scores obtained on the national end-of-year area

secondary mathematics examination (both $p<0.05$). The relationship for the girls area secondary sample is not significant. Consequently, the null hypothesis is rejected at the 0.05 level of significance only for the area secondary students sample and for boys attending area secondary schools.

Discussion

The results reported above are based upon the assumption that the general attitude towards mathematics of students involved in this study did not change significantly between the administration of the Attitude Test and the holding of the national end-of-year examinations. In this study the children's attitude was investigated some five months prior to the annual testing period. Ideally, the time passage between the two testing points should have been kept to a minimum. Buhagiar (1990) explains that this lack of control in the research design was due to pressures extraneous to the research itself. The relationship between attitude and achievement is a highly complex one involving a number of factors which could easily have been left out or not given due importance in this study. Again, simple bivariate relationships, similar to the ones investigated in this paper, can potentially ignore the more complex and subtle relationships that may exist between attitude and achievement (Schibeci, 1984). Consequently, the interpretation of the present findings cannot exclude the possibility that had the issue been otherwise investigated, different conclusions could have been reached. In view of these limitations, it is recommended that conclusions presented in this paper should be viewed with caution.

Present findings seem to support studies which conclude that the relationship between attitude and achievement in mathematics is weak at best (see reviews by Aiken [1970, 1976] and APU findings reported by Joffe and Foxman [1986]). The low correlations reported in this study, ranging between -0.06 and 0.20, are in line with the APU (1981) conclusion that in mathematics attitudes contribute little to the prediction of performance. In agreement with Preece (1979) and Schofield (1982), the present study reveals stronger relationships between attitude and achievement in mathematics in the case of boys. Considering the various male and female samples in the present study, one notes higher correlations for the male samples (JL boys $r=0.12$; AS boys $r=0.20$) over the corresponding female samples (JL girls $r=-0.06$; AS girls $r=0.14$). Again, the relationship between attitude and achievement is stronger when academically weaker students are involved. All Junior Lyceum samples (JL students $r=0.00$; JL boys $r=0.12$; JL girls $r=-0.06$) have lower correlation coefficients when compared to their area secondary counterparts (AS students $r=0.17$; AS boys $r=0.20$; AS girls $r=0.14$).

Maltese studies examining the relationship between attitude and achievement in mathematics have generally focused on junior lyceum students. Speaking of junior lyceum students, the present study infers no significant correlations between these two variables for both the boys and the girls samples. Calleja (1993), working on Maltese Form one junior lyceum children, agrees only partially with the findings presented in this paper. While he agrees that for the boys the relationship between the two variables is not significant, he claims that it is positively significant for the girls. On the other hand, a study on Form one junior lyceum girls by Scicluna and Sharples (1993) confirms the present findings with regards to the girls.

Buhagiar's research (1990) includes the investigation of the relationship between general attitude towards mathematics and children's performance on measurement concepts. Students' performance on the Attitude Test is also compared in his study to their performance on the first 17 questions of the 'Concepts in Secondary Mathematics and Science' (CSMS) Measurement Test (Hart *et al.*, 1985). These questions deal exclusively with measurement in one and two dimensions. Generally speaking, the relationships inferred in the present paper between general attitude and general achievement in mathematics are in line with those reported between general attitude and achievement in measurement. In particular, the lack of association between attitude and mathematics achievement is reconfirmed for girls. Even if again it has no predictive quality, it is the general attitude towards mathematics of area secondary students, particularly the boys, which best reflects their achievement levels in measurement. Correlation coefficients between attitude and measurement are also low, ranging between -0.16 and 0.26.

Interesting parallels can be drawn between the

findings of a study on Form one children in Hong Kong (Cheung, 1988) and the present Form one study. However, in the light of research indicating that the relationship between attitude and achievement in mathematics apparently gets stronger as students grow older, the age difference between the two studies 4 calls for purely tentative comparisons. Cheung (1988) reports positive correlations between ten attitude scales and mathematics achievement ranging from 0.007 to 0.424. The LIKE (liking mathematics), EASY (easiness of mathematics) and SOC (usefulness of mathematics) scales of the Hong Kong study are very similar to three of the four factors (1, 3 and 4 respectively) measured by the present attitude questionnaire. The correlations between the LIKE and the EASY scales and mathematics achievement are both rather low, 0.098 and 0.185 respectively. On the other hand, the correlation for the SOC scale is at 0.374 the second highest. In the present study, items of factors 1 and 3 (comparable to LIKE and EASY scales respectively) total 11 out of the 16 test items, while there is only one item pertaining to factor 4 (comparable to SOC scale).

Considering the heavy bias of the present test in favour of items similar to the LIKE and EASY scales , one may hazard to say that the low Hong Kong correlations on these scales are reconfirmed by the present findings (highest correlation only 0.20). The item of the Attitude Test investigating children's perception of the social implications of mathematics (i.e., factor 4) is not likely, given its uniqueness, to have been very influential in the overall relationship between attitude and achievement as measured in the present study. In view of the Hong Kong result on the SOC scale, one may tentatively argue that, had the present test contained more items examining children's perception of the usefulness of mathematics, higher correlations would have been obtained in the present findings. None of the ten scales investigated by Cheung (1988) can be associated with factor 2 (i.e., career and leisure interests in mathematics) of the present test.

The present study does not and cannot draw any causal relationships between attitude and achievement in mathematics. Nevertheless, given the extremely moderate relationships inferred between the two variables in this study (highest value of r only 0.20), one may argue that the present findings apparently give weight to studies claiming either no or weak causal links between attitude and achievement in mathematics (e.g., Neale, 1969; Quinn & Jadav, 1987; Cockcroft Report, 1982).

Conclusion

The relationship between Maltese Form one children's general attitude and general achievement is apparently mediated by their sex and their general academic ability level. Comparing corresponding correlation coefficients, one notes that these are higher for the boys and for the students in area secondary schools. The overall academic level of area secondary school students is generally low, however, they need not necessarily be weak in mathematics. The male sex and the area secondary combination produces the strongest correlation, albeit still low (r=0.20), between attitude and achievement. Nevertheless, even for this particular group of children, with just 4% common variance between the two variables under investigation, the significant positive correlation offers no practical predictive value.

Notes

1. This paper presents some findings from research carried out in connection with a Masters of Education degree from the University of Malta (see Buhagiar, 1990).

2. Latest official statistics (1988/89 scholastic year) show that in Malta approximately 68% (boys-59%; girls-75%) of secondary students attend state schools (Central Office of Statistics, 1990). The remaining students receive education provided by the Catholic Church and other private institutions. State school students proceed to single-sex secondary schools after six years of primary co-education. This transition usually takes place when students have already reached their eleventh year. Most year 6 students, towards the end of the scholastic year, sit for a selective examination in five curriculum subjects (Maltese, English, Mathematics, Social Studies, and Religious Knowledge) for admission into the secondary level junior lyceums (JL) which cater roughly for the top half ability group within state education. Successful students must obtain at least a pass-grade in all five subjects, even if the Religious Knowledge examination is taken on a voluntary basis. Students who do not so qualify are channeled into other state secondary schools known as area secondaries (AS) which offer a curriculum geared to the needs of lower achieving students. Mathematics is a compulsory subject at both primary and secondary levels.

3. The committee entrusted with the drawing up of the Cockcroft Report commissioned a study to Dr A. Bell (University of Nottingham) and Dr A. Bishop (University of Cambridge). A summary of this study, entitled *A review of research in mathematical education*, is published by the Shell Centre for Mathematical Education (University of Nottingham).

4. The modal age of the Hong Kong study is 13, while that of the present study is 11.

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Acknowledgments

My thanks are due to Joseph Mifsud and Leonard Bezzina, lecturers at the Faculty of Education, University of Malta, for their comments on reading draft versions of this paper.