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Perception of Teacher, Home Support and Achievement in Attitudes towards Science

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Abstract

This study investigated the relationships of attitudes towards science with perception of the science teacher, home support and science achievement among a sample of Secondary Two (8th Grade) students. Using the full LISREL model, it was found that the perception of the science teacher was the most significant factor in the development of positive attitudes towards science. Achievement in science was also a significant factor for both girls and boys. Home support was, however, a significant factor for girls but not for boys.

Descriptors: Attitudes towards science, perception of teacher, home support, achievement, LISREL model

Introduction

In the quest for educational excellence, academic achievement features most prominently among all the other educational outcomes. It is thus encouraging to note that in recent years, scientific attitudes are increasingly researched into as an important educational outcome.

In some bivariate studies of attitude and achievement, correlation coefficients as high as 0.45 have been reported (Hough and Piper, 1982). Data from a longitudinal study by Simpson and Oliver (1990) also supported a strong attitude-achievement relationship. Eisenhardt (cited in Schibeci, 1984) in his study involving 70,000 students, concluded that achievement influenced attitudes more often than the reverse.

Marjoribanks (1976) in his multivariate study reported a significant link between attitudes and achievement. He found that at different ability levels, increases in achievement were related to increments in attitude scores.

Attitude towards school subjects is an important and desirable educational outcome. Mager (1968) affirmed that the development of positive attitudes towards school subjects is essential. Students with a positive attitude towards a subject are more likely to continue their learning in that area, both formally and informally, after the direct influence of the teacher has ended. Attitude is not immutable and is often communicated to others in a variety of ways throughout life. Therefore, it is imperative to study the determinants of attitudes towards science as a school subject and to inculcate positive attitudes towards science as an important objective for science education.

Attitude can be considered as having three components: cognition, affect and behaviour (Triandis, 1978). Attitudes are influenced by direct experiences with the attitude object and by interactions with relevant others. Achievement in science provides direct experiences with the attitude object, which might result in change in students' beliefs, feelings and intended behaviours.

Other factors that contribute to the development of students' attitudes are the social

interactions which provide information, in the form of attitudes, beliefs, and behaviours of relevant others (Applebee et al., 1989). Home support, in the context of the social and psychological stimulation accorded to the student's academic development by parents or guardian in the home, and the perception of the science teacher, are among the most influential in attitude formation (Ekstrom et al., 1988; Carlson, 1991; Caplan et al., 1992). These variables were, therefore, used in this study.

Some research studies reported gender differences in attitudes towards science, with boys scoring higher than girls (Keeves, 1973; Gardner, 1974; Fraser et al., 1987; Maehr and Steinkamp, 1983). Research is needed on the cognitive and social differences that are related to attitudes towards science among boys and girls.

Purpose of the Study

There are a number of bivariate studies in the area of attitudes and achievement. Research pertaining to attitudes with Piagetian tasks, scientific ability, intelligence and socio-economic status have been reported (Lawson et al., 1975; Hodson and Freeman, 1983; Fraser et al., 1987; Malone and Fleming, 1983). However, more studies have been done using achievement as a criterion rather than attitudes. Furthermore, there is a paucity of causal studies on the cognitive and social factors that are related to attitudes towards science.

The study used causal modelling procedures to investigate the relationships of attitudes towards science (viewed as criterion variable) with perception of the science teacher, home support, and achievement. The research questions examined in this study were:

(1) Did the perception of the science teacher, home support and achievement influence attitudes towards science?
(2) Did these factors influence attitudes towards science to the same degree for both boys and girls?

Methodology

Sample

The study was conducted at the Secondary Two level in Singapore. A sample of 426 girls and 463 boys of mean age 14 were selected. Using the Student Data Bank of the Ministry of Education, the sampling involved selection of schools which reflected the characteristics of the population of the 14-year-old Secondary Two students in Singapore.

Instruments

To ensure more valid and discriminating measures appropriate to the socio-cultural characteristics of the educational system, instruments were developed to collect the data. In the construction of the affective items, cognitive statements were avoided (eg staying near a nuclear reactor is not good). The statements were moderately worded. Affective items calling for a personal or emotional reaction were written to establish conceptual validity. A five-point Likert scale (Strongly Agree, Agree, Undecided, Disagree, Strongly Disagree; or Never, Seldom, Sometimes, Often, Always) was used for recording the students' reaction towards each item.

The "attitudes to science" instrument measured interest in science, enjoyment of science, career preference for science, and self-perception of ability to learn science. The questionnaire asked students to indicate their honest feelings about statements such as:

I enjoy science lessons.
I would enjoy being a scientist.

The "perception of the science teacher" instrument measured the students' perception of the teacher's enthusiasm and competence and whether they viewed their science teacher as encouraging, caring and supportive in the course of teaching. Examples of statements in this instrument are:

Our science teacher makes science

experiments exciting.
Our science teacher shows concern for us.

The home environment instrument measured the social and psychological stimulation accorded to the student's academic development by parents or guardian in the home. The following are two statements from this instrument.

Do your parents/guardian spend time with you?
Do you talk to your parents/guardian about school?

Items in the science achievement test were based on instructional objectives common in all schools. A table of specifications was drawn up for the test to ensure content validity in the criterion-referenced test.

After careful development and proof-reading, these instruments were administered to the sample of students.

Procedure

Optical scan sheets were used to expedite data collection and to eliminate human errors in data entry. Only two researchers were in charge of the administration to the whole sample so as to standardise administration procedures as much as possible.

Method

The research design involved the covariance structure model or the full LISREL model. The measurement model was combined with the structural equation model. The full model allowed for measurement errors in the latent variables and errors in equations (residuals) and provided for the estimation of relationships. The unknown parameters were estimated so that the covariances and variances of the variables in the model matched the data.

The structural equation model is:

$$\eta = \Gamma\xi + \zeta$$

where η is the endogenous (dependent) variable; Γ is the coefficient matrix of the exogenous (independent) variables (ξ); and ζ is a random vector of residuals.

The measurement models for y and x are:

$$y = \Lambda_y\eta + \varepsilon$$
$$x = \Lambda_x\xi + \delta$$

where the parameter matrices Λ_y and Λ_x are the regression matrices of y (observed dependent variables) on η, and x (observed independent variables) on ξ, respectively. The ε's and δ's are the errors in variables or measurements.

In the presentation of the path analysis diagram, the conventions used in the LISREL 7 manual (Jóreskog and Sórbom, 1989) were used. Observed variables were enclosed in rectangles; unobserved (latent) variables were enclosed in circles. In this model, the observed variables were the science achievement test and the factor scores for the attitudes towards science, perception of the science teacher and home support instruments. Attitudes towards science was the endogenous variable whose variation was hypothesised to be explained by the exogenous variables in the system.

Paths, in the form of unidirectional arrows, were drawn from the variables taken as causes (independent) to the variables taken as effect (dependent). The non-existence of an arrow between two variables meant that they were assumed not to be directly related.

Since constraints are imposed on θ_ε or θ_δ, the normal theory standard errors in LISREL are valid only when the covariance matrix is analysed (Jóreskog and Sórbom, 1989). To obtain correct standard errors and chi squares, the covariances were analysed.

The assumptions made in the covariance structure model are: the residuals are uncorrelated with the exogenous variables; the errors of measurement are not correlated with the residuals and the latent variables; and the latent variables and residuals are measured as deviations from their means.

The unknown parameters were estimated using the maximum likelihood method of LISREL 7 (Jóreskog and Sórbom, 1989). Since there were

no replicate measures for η, ξ_1, ξ_2 and ξ_3 (attitudes to science, achievement, perception of the science teacher and home support, respectively), these variables were considered fallible measures. The factor score reliabilities were used rather than the assumption of an arbitrary value of 1.00. The error variance was equal to the product of the variance in the y or x variable and (1 – Reliability). The error variances were used as fixed values in Θ_ε and Θ_δ, and the structural parameters Γ were estimated directly with LISREL.

Six schools and 28 classes were involved in the study. Since LISREL cannot model a two-stage cluster design, no allowance was made for the design effect of the sample employed in the analysis carried out.

Results

Since raw scores for an achievement test do not accurately reflect the true trait of a person, a more appropriate scoring procedure using item response theory was used (Lord, 1980; Hambleton and Swaminathan, 1985). ASCAL, a program from MicroCAT (Assessment Systems Corporation, 1989) was used to estimate the item response theory parameters for the three-parameter model for the science achievement test. Items which did not converge well and those with high χ^2 values were not selected for computing the maximum likelihood thetas. In item response theory, there is no equivalent measure of reliability. The item response analog of test score reliability and the standard error of measurement is the test information function (Hambleton and Swaminathan, 1985). Using classical theory, the alpha reliability of the 36-item instrument was found to be 0.69.

The other instruments were subjected to maximum likelihood factor analysis using STATA (Computing Resource Center, 1992), a statistical analysis package for personal computers. The number of factors was determined using the large sample χ^2 significance test associated with the maximum likelihood solution, which is considered to be the most satisfactory solution from a statistical standpoint, provided that the assumptions of the method are adequately met (Kim and Mueller, 1978). The number of factors retained was usually more than the number of factors expected. The minor factors were ignored on substantive grounds, and where appropriate, the major factors were subjected to varimax or promax rotation to assess their factor structure.

Since it was not appropriate to sum all the variables to construct the factor scale when the factor loadings were not uniform, regression scoring was used for the instruments. The reliability coefficients of the factor scores for the attitudes to science (19 items), perception of the

Table 1: Covariance Matrices by Gender

		Att	Ach	Tr	Home
Girls (N = 426)	Att	.93			
	Ach	.15	.91		
	Tr	.34	–.11	.84	
	Home	.13	.05	.13	.99
Boys (N = 463)	Att	.94			
	Ach	.24	1.04		
	Tr	.43	–.11	.97	
	Home	.11	.03	.17	.75

Notes: Att – Attitudes towards Science
Ach – Achievement in Science
Tr – Perception of the Teacher
Home – Home Support

Table 2: Descriptive Statistics by Gender

	Variable	Mean	Std. Dev.	Min	Max
Girls (N = 426)	Att	–.14	.96	–3.22	2.38
	Ach	–.10	.95	–3.73	2.41
	Tr	.01	.92	–3.51	2.05
	Home	–.10	1.00	–2.71	2.32
Boys (N = 463)	Att	.14	.97	–3.02	2.41
	Ach	.12	1.02	–3.28	3.04
	Tr	.01	.98	–3.09	2.18
	Home	.10	.87	–2.91	2.32

science teacher (12 items) and home support (10 items) instruments were 0.96, 0.93 and 0.88, respectively.

The covariance matrices among the *x* and *y* variables for girls and boys were computed. The covariance matrices are shown in Table 1. The descriptive statistics for the variables in the two groups are summarised in Table 2. (In item response theory, the normal range of achievement scores is from –4 to +4, with a mean of 0. Regression scores on attitudes, perception of the teacher, and home support are standardised.)

It was found that boys had higher means than girls for attitudes towards science, science achievement, and home support. However, the girls had slightly better perceptions of their science teachers than did the boys.

Multi-sample LISREL analysis was used to test whether there was any significant difference between the covariance matrices of the observed variables *x* and *y* for the girls and boys. It was found that $\chi^2_{13} = 266.56$ ($p < 0.00$). Thus, the hypothesis that the covariance matrices of the observed variables were the same could be rejected.

Using the LISREL program, the structural

Table 3: Maximum Likelihood Estimates (Standardised Solution and Unscaled Solution) for Girls and Boys (significant parameter estimates in asterisks; standard errors in brackets)

Parameters	Girls	Boys
Standardised Solution:		
Achievement to Attitude	.48*	.37*
Teacher to Attitude	.60*	.53*
Home Support to Attitude	.21*	.01
Unscaled Solution:		
Achievement to Attitude	.57 (.05)	.42 (.06)
Teacher to Attitude	.65 (.04)	.54 (.05)
Home Support to Attitude	.21 (.04)	.01 (.05)
Measurement Error in Attitude	.03	.03
Measurement Error in Achievement	.28	.32
Measurement Error in Teacher	.06	.07
Measurement Error in Home	.12	.09

parameters and the measurement errors for the variables were determined. The maximum likelihood estimates for the standardised solution and the unscaled solution are shown in Table 3. The difference in structural parameters between the girls and the boys were computed and so were the *t*-values. (See Table 4.)

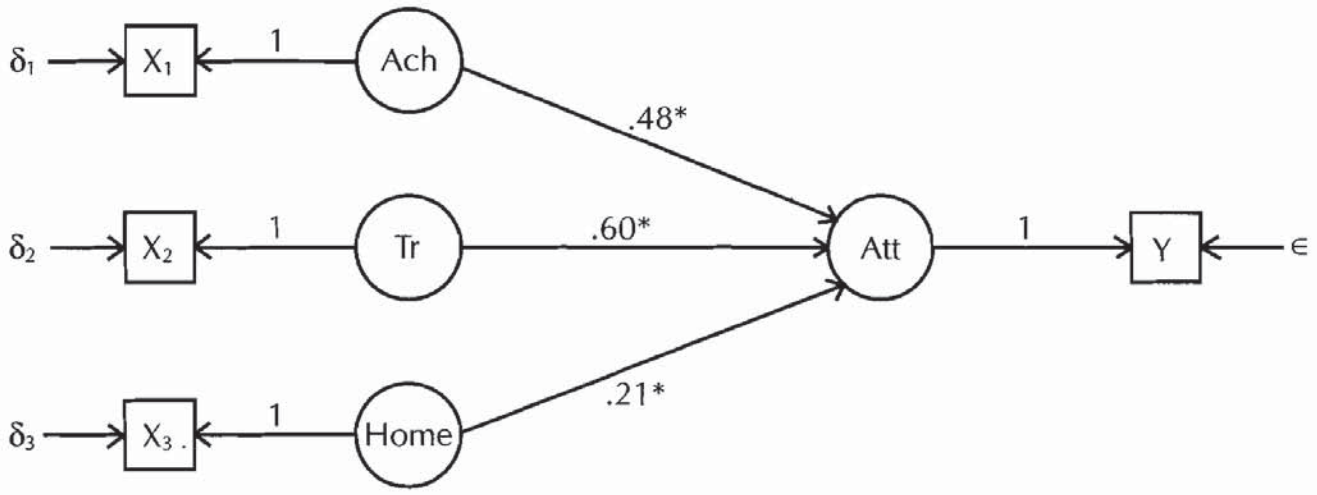
For the girls, the total coefficient of determination for the *y* variable was 0.97, and the total coefficient of determination for the *x* variable was 1.00. The squared multiple correlations for the observed variables were 0.70, 0.92 and 0.89, respectively, for achievement in science, perception of the science teacher and home support. The total coefficients of determination for the *y* and *x* variables were high. The large values indicated that the observed variables were reasonably good measurement instruments for the latent variables.

The squared multiple correlation for the structural equation indicates the proportion of variance in the endogenous variable accounted for by the variables in the structural equations. The squared multiple correlation for the structural equation for attitudes towards science was 0.65. The total coefficient of determination

Table 4: Difference in Parameters Between the Girls and Boys (standard errors in brackets; significant differences marked with asterisks)

Parameters	**Difference**	***t***
Achievement to Attitude	.16 (.08)	2.06*
Teacher to Attitude	.12 (.06)	1.87
Home Support to Attitude	.20 (.07)	3.06*

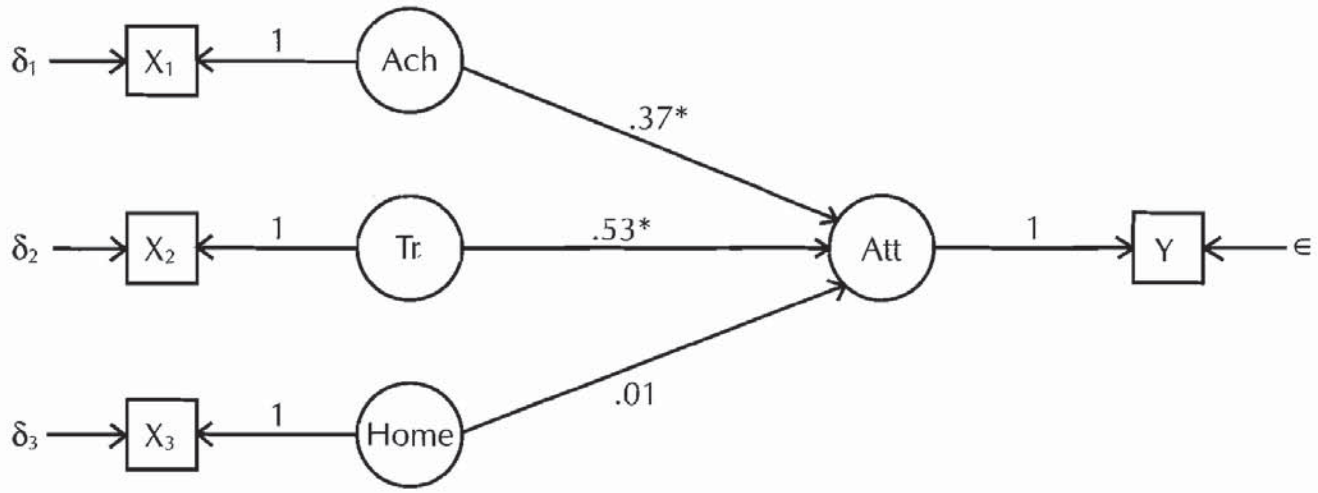
Figure 1: Path Diagram for Attitudes Towards Science Model for the Girls



Notes:

X_1 – Science Achievement Test
X_2 – Perception of the Science Teacher Instrument
X_3 – Home Support Instrument
Y – Attitudes towards Science Instrument
Ach – Science Achievement
Tr – Perception of the Science Teacher
Home – Home Support
Att – Attitudes towards Science

Figure 2: Path Diagram for Attitudes Towards Science Model for the Boys



Notes:

X_1	–	Science Achievement Test
X_2	–	Perception of the Science Teacher Instrument
X_3	–	Home Support Instrument
Y	–	Attitudes towards Science Instrument
Ach	–	Science Achievement
Tr	–	Perception of the Science Teacher
Home	–	Home Support
Att	–	Attitudes towards Science

for the structural equation was also 0.65. The value was reasonably high considering the number of exogenous variables involved in the study.

For the boys, the squared multiple correlation and the total coefficient of determination for the *y* variable was 0.96. The squared multiple correlations for the *x* variables were 0.69 for the science achievement test, 0.93 for the perception of the science teacher and 0.88 for home support. The squared multiple correlation for the structural equation was, however, 0.37.

Figures 1 and 2 show the path diagram of the causal model for the attitudes towards science for the girls and boys, respectively. The standardised solution is shown. The significant paths in which $|T| > 1.96$ are superscripted with asterisks. Each element in Λ_x and Λ_y has been set equal to 1 to fix the scales of measurement in the latent variables.

For both the girls and the boys, the most important exogenous variable influencing their attitudes towards science was their perception of the science teacher, followed by their achievement in science. Home support was a significant exogenous variable for the girls but not for the boys.

The effect of the exogenous variables on the endogenous variable for both the girls and the boys was in the same order. There was no significant difference between the structural parameter from the perception of the science teacher to attitudes, but there were significant differences in the structural parameter from achievement to attitudes, and from home support to attitudes between the girls and the boys. All the structural parameters for the girls were larger than those for the boys. Hence, the total coefficient of determination for the structural equation for the girls was larger than that for the boys.

Discussion

As reported by many researchers, eg Simpson and Oliver (1990), the study showed gender differences in attitudes towards science. From Table 2 it can be seen that boys possessed significantly more positive attitudes towards science and had higher science achievement scores than girls. Boys also received or perceived better home support than girls. However, girls had better perceptions of their science teachers.

The less favourable home support for girls could have been a reflection of the traditional Eastern view held by many parents that sons should be given preferential treatment over daughters. If girls were to receive better home support, their attitudes towards science would be better. The influence of home support on attitudes for girls is in agreement with some studies which placed a high premium on the educational stimulation and the emotional support of parents (Ekstrom et al., 1988; Carlson, 1991). Although boys received better home support, it appears that the better home support they received did not result in the development of better attitudes towards science (Table 3). The differential effect of home support on attitudes towards science for girls and boys could be due to the difference in their psychological and emotional constitution. Perhaps more definitive statements could be made if interaction effects of gender and the other factors are considered.

The results above indicate that the perception of the science teacher and achievement in science significantly influenced attitudes to science for both girls and boys. In addition, home support significantly influenced attitudes towards science for girls but not for boys. It is interesting to note that although the mean for the home support for girls was lower than that for boys, its influence on attitudes towards science was significant compared to the higher mean for the boys and its insignificant effect on attitudes to science. Most probably there are other causal influences on attitudes towards science which are more significant for boys than girls.

Of the three exogenous variables, the effect of the perception of the science teacher on attitudes towards science was the most important. Therefore, the enthusiasm and competence of science teachers and the encouraging, caring and supportive role teachers play are very critical to the development of the attitudes of students towards science. Hence, science teachers can play an important role in the classroom by facilitating the formation and change of attitudes throughout students' lives.

The analysis confirmed that achievement in science constitutes direct experience with attitudes to science. Performing favourably in science helps influence one's attitudes towards science. With achievement having a significant effect on attitudes, more consideration and understanding should be given in the planning for and teaching of students of lower ability.

Conclusion

The analysis shows that perception of the science teacher and science achievement did influence attitudes towards science. In addition, home support influenced the attitudes towards science for the girls.

This analysis underscores the important roles that science teachers and parents play in the lives of their students/children.

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