Gender, Courses and Curricula effects on Students' Attitudes to Mathematical Modelling in 16-19 Mathematics Programmes.

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Abstract:
In 1993, Mathematical modelling was codified as a compulsory core component of all U.K "A' level mathematics curricula. This study examines the attitudes (enjoyability, anxiety and confidence) of 269 students to mathematical modelling in 16-19 mathematics programmes. The students' attitudes were found to be multidimensional and varied significantly across the sub-scales.
Gender and curricular factors and the effect of course combinations taken by the students showed mixed results.

Introduction.

Mathematical modelling, which has now entered the compulsory SCAA (1993) core for all 'A' levels, is concerned with the process of application of mathematics to problems which arise outside mathematics, eg in other academic disciplines such as science and economics, or in daily life activities such as shopping or budgeting. Mathematical modelling has been an issue in mathematics education since the 1970s, when it found early implementation in Ormell's AO project (Ormell, 1971). Some signs of modelling could also be traced to the early SMP 'A' level texts with no real project work or assessment, and many argued at that time that modelling could not be examined. The recent impetus for integration of modelling in pre university mathematics programmes arose because of: (a) the introduction and effectiveness of coursework lower down the school at GCSE, (b) the growing importance of motivation, (c) international experiences, eg the Wiskobas, etc. movements in Holland and (d) the growing activity of projects such as Spode, MAP, and others in the U.K (Williams, 1989; Spode group, 1989).
Small scale surveys of new "A' level mathematics curricula (e.g SMP 16-19, ME I) incorporating modelling have been reported with increased students' accessible, improved students' interest and confidence in mathematics (Kitchen, 1993).

Aims of the Study.

This study is designed to investigate the issue of motivation, cited as one major goal for incorporating modelling as a core component in all '/\ level mathematics curricula, aimed at developing new attitudes in students (Blum, 1993). Three types of students' attitudes (Enjoyability, Anxiety and Confidence) to mathematical modelling were investigated. Influences of gender, course combinations and the examination syllabuses offered on the students' attitudes were also investigated as explanatory variables.

Method.

Instrument: The Students Attitudes Scale to Mathematical Modelling (SASMM) has been developed to measure students' level of enjoyability, degree of anxiety and confidence developed through mathematical modelling learning activities. Items of the scale focused on real life situations, technology, practical activities, groupwork, communication and modelling processes (Haines and Izard, 1993; Clatworthy, 1989). Factor analyses were used in establishing the construct validity of the scale with most items having significant loadings (.49 to .83). The SASMM was further validated in a test, retest with 35 students within a two week interval. The reliability coefficients of the items (0.31 to 0.85) and factors (0.50 to 0.78) were significant (table I). The overall reliability coefficients for the sub-scales were 0.65, 0.63 and 0.56 for enjoyability, anxiety and confidence respectively.

Table I. Factor Descriptions, Means, Standard Deviations and test-retest (r).

Factor	Number of Items. (% of variance)	Mean N=269	s.d	(r) N=35
Enjoyability Sub-scale.				
Real life applications of maths (E1).	4 (21.3)	3.59	.62	.68
Communications -Oral presentation skills (E2).	4 (10.5)	3.03	.73	.73
Participation in group activity (E3).	3 (8.7)	2.83	.81	.58
Tables and Graphs (E4).	2 (8.0)	3.29	.79	.72
Communication -Seeking clarification (E5).	2 (6.9)	3.07	.71	.57
Technology (E6).	2 (6.3)	3.86	.82	.74
Anxiety Sub-scale.				
Communication and Mathematical modelling processes (A1).	7 (41.1)	2.10	.74	.68
Real life applications of maths (A2).	6 (9.5)	1.64	.65	.52
Tables and Graphs (A3)	3 (5.4)	1.56	.72	.50
Technology (A4)	2 (4.8)	1.45	.73	.69
Confidence Sub-scale.				
Real life applications of maths (C1).	8 (44.9)	3.38	.72	.78
Communication and mathematical modelling processes (C2).	7 (7.9)	3.27	.71	.58
Tables and Graphs (C3).	2 (5.8)	3.87	.82	.58
Technology (C4)	2 (5.0)	3.95	.88	.51

With these results and for research purposes, the SASMM was considered a reasonable measure of these types of attitudes.

The Sample: The SASMM was administered to students in six colleges through their teachers within greater Manchester area during 1993-94 academic session. 269 students completed the questionnaire consisting of 195 boys and 74

girls. 235 students registered for the GCE '/\ levels and 34 for the BTEC Diploma in Engineering. 42.4% of the sample were at the Lower sixth level, 45.7% at the Upper sixth, 5.6% and 6.3% in BTEC 1 st and 2nd year respectively.

Design of Analyses: Since the same student responded to the items, the data represented repeated measures of each item and therefore each factor. Multivariate analysis of variance (MANOVA) was our choice of test statistic. On the enjoyability sub-scale, a 2 by 6 design tests gender effect, a 5 by 6 design tests course effects and a 6 by 6 design tests curricula effects (Winer, 1971). Similar designs were used to explore the influences of other variables on differences in the learners' anxiety and confidence factors.

Results.

Differences in Attitudes: On the enjoyability sub-scale: a) Students' level of enjoyment on the 'use of technology' is the best, followed by the 'real life applications of mathematics; b) Mathematical activities involving the use of 'tables and graphs' are indicated to be enjoyed more than 'seeking clarification' and 'individual oral presentations' and c) Students have indicated most dislike for 'participation in group activities'.

The students' level of anxiety is highest on communication and mathematical modelling processes followed by real life applications of mathematics. The students' level of confidence with respect to the use of technology and, tables and graphs is higher than their level of confidence with respect to either real life applications of mathematics or communication and mathematical modelling processes.

Gender and Attitudes: Boys indicated higher degree of enjoyment than girls on 4 factors: communication involving oral presentation, participation in group activity, tables and graphs, and use of technology.

The girls clearly enjoy better than the boys seeking clarification. Girls also indicated more anxiety and less confidence than boys on real life applications of maths, use of technology, communication and mathematical modelling processes; the reverse is the case on the use of tables and graphs.

Course Combinations Offered and Attitudes: No one course combinations had consistently produced better students' attitudes. However, the pure maths and statistics group of students have the best degree of enjoyment on table and graphs, the BTEC maths group has the least degree of enjoyment on real life applications of maths and participation in group activities.

On confidence, tables and graphs differentiates the pure/statistics and pure/applied maths students from the others; and on technology, the pure maths with application

students have the least confidence.

Examination Syllabus/Curricula Materials and Attitudes: On examination variable: a)Students using the SMP 16-19 curriculum materials indicated a higher degree of enjoyability on the real life applications of maths, use of technology, graphs and tables factors; b) students using the Oxford/Cambridge SMP materials indicated low degree of enjoyability on participation in group activity but high interest on technology; c) Students offering the NEAB syllabus indicated an extremely low degree of enjoyability in seeking clarifications and d)The BTEC group of students indicated low level of enjoyability on the real life applications of mathematics but a high degree of enjoyability on participation in group activity.

Conclusions.

The data reported here indicated that students' attitudes (enjoyability, anxiety and confidence) to mathematical modelling is a multi-dimensional construct. The constructs of the students' attitudes reflect: Real life applications of mathematics, Communication skills, Mathematical modelling processes and skills, Use of graphs and tables and, Technology (calculators and computers). Although the level of the students' attitudes to these factors of mathematical modelling is moderate, it is not the same across the factors. Students' enjoyability and confidence are best on the factors of technology and graphs/tables; and least on real life applications, communication and mathematical modelling processes.

Tentatively, we would add that gender is a significant variable in explaining for differences in attitudes found in this study. In this pilot sample, girls had lower degree of enjoyment than boys on all factors except in seeking for clarifications and were less anxious than boys on the use of tables and graphs. The influences of course combinations on students' attitudes showed mixed results. On the other hand, the influences of examination syllabus on students' attitudes - enjoyability and confidence was suggestive. Students' ability was suspected to have had some influence on students' attitudes and need to be taken into account for comparability across the different examination syllabus. This needs further investigation with a larger and more carefully constructed sample.

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