The role of cognitive preference in students' choice of Mathematics units at the year 11/12 levels

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Abstract

This paper reports on the first phase of a national study, currently in progress, designed to investigate factors that influence students' choice of mathematics courses at the upper secondary school level. In this first phase, an instrument was developed and trialled which incorporated a number of "cognitive preference" items based on the Myers-Briggs Inventory of Psychological Type and also the CareerMate counselling instrument. Outcomes of this first phase indicate that several dimensions of personality appear to be most relevant to students' course selection choices.

Introduction

Within the last few years, Commonwealth and State governments have encouraged schools and education systems to devise ways to increase the participation rates of young people in advanced mathematics and science courses – the most recent effort in this direction being the publication of the Brennan Report (Brennan, 1994).

The available research base on science and mathematics participation rates and subject choice that might inform direction in this matter has been mainly quantitative in orientation (Rosier, 1980; Dekkers and de Laeter 1983; Kalmus, 1985; Dekkers, de Laeter and Malone, 1991), although sociological research which is qualitative in nature has appeared recently, providing evidence of social and curricular influences on patterns of subject choice. Typically, sociological research has involved a consideration of belief systems and other values influenced by the individual's social and personal context including the family, community values, school climate, social class, pressure groups, role perception, gender and learning style (Eccles, 1985; Ainsley, Jones and Navaratam, 1990; Ramsden and Ramsden, 1990; Johnson and Spooner, 1992). The limited psychological research which exists has examined the premise that individuals possess intrinsic motivational factors which form personality and which influence vocational choice (Briggs-Myers and Myers, 1980; Baker, 1985; Osipow, 1990; Herr and Cramer, 1992). Little research appears to have specifically addressed the role played by personality in school subject choice - particularly "cognitive preference" - a term which refers to a person's preferences when confronted with alternatives and provides an insight into why particular choices are made (Bargar and Hoover, 1984).

Recent quantitative research has indicated that, despite an increase in the total number of young people staying on to the final years of school, the number of students undertaking advanced mathematics has not increased proportionately (Dekkers et al, 1991). Unfortunately, the patterns of participation and participation rates identified in these quantitative studies have never been unravelled, carefully explained and documented by directly consulting the students themselves – a criticism that applies equally to the qualitative research findings which, typically, have used means other than case-studies to gather data. Consequently, identified patterns of increased participation in some senior school courses (notably Chemistry), the

failure by others (notably Physics) to appeal to students, and a general drift to less rigorous mathematics courses remain unexplained. Finally, despite an increase in the total number of students competing for places in higher education, the decline in the number and quality of applicants for mathematics and science in tertiary courses also requires analysis and explanation. The Brennan report *Science and technology education: Foundations for the Future* (1994) identifies one of the six major areas of action needed to promote science and technology in schools and tertiary institutions as "the investigation of the decision making process which turns students 'onto' or 'off' science as a further education or career option". Such an investigation prompted the present study and became its broad goal. The first phase of the study is the subject of this paper.

Aims of the first phase

These were to:

- determine the most efficient method for sampling Western Australian Year 10, 11 and 12 students to ensure a representative sample,
- devise and appraise an instrument that would take into account a variety of sociological and psychological factors which could affect students' choice of mathematics subjects.

This instrument facilitated the identification of a number of students in three Australian states who, in later phases of the study, were to be the subject of case studies with a view to developing hypotheses regarding such choice patterns and to answer the following research questions:

1 Which sociological factors (e.g. family, community values, school climate, social class, pressure groups, role perceptions, gender) are perceived by Year 10, 11 and 12 students as being important in determining their choice of, or avoidance of, mathematics subjects at the upper school level?

2 Which cognitive preference factors (e.g. judgment, attitudes, feelings, sensitivities) are perceived as important?

3 Which of the factors identified in 1 and 2 above are most significant?

4 What role do these perceptions play in subject selection?

This paper addresses only the initial phase of the study – selection of the sample and construction of the instrument

The cognitive preference model

One feature in the design of the instrument set it apart from others that the investigators had examined in the literature survey. It involved the inclusion of items to determine students' "cognitive preference". Concerning this person characteristic, Ramsden and Ramsden (1990) demonstrated that the Myers-Briggs Inventory of Psychological Type (MBTI) could be used to discriminate between different groups of students to provide an insight into subject choice patterns by relating cognitive style or psychological type to a preference for particular types of curricula. Baker (1985) also used the MBTI in a study that indicated the emergence of a pattern of characteristics for males and females that were associated with mathematics and science.

The CareerMate counselling instrument (Denham, 1993) is also capable of identifying correlations between dimensions of cognitive preference and the choice of particular mathematics and science subjects (Cavanagh, 1993). CareerMate has four dimensions of cognitive preference, each being explained by two descriptors at either end of a continuum (Experience Preference: sensing - intuition; Energy Projection: extroversion - introversion; Helping: thinking - feeling and Closure: judging -

perceiving). Paper and pencil item versions of the four bipolar-style MBTI dimensions are available in CareerMate, and appropriate parallel items to these were introduced into the instrument (a total of eight items, two on each of the four bipolar dimensions). There is a fifth dimension which is concerned with neuroticism which has applications in counselling but was not regarded as particularly relevant to the subject choice process.

The somewhat odd terminology used in conjunction with the preference dimensions in CareerMate is the same as that in the MBTI and has been retained for historical reasons and to retain the relationship with Jungian typology which is at the root of these models. CareerMate embodies recent research into the concept of personality and is not open to the same level of criticism often levelled at the MBTI or other models purporting to type personality (McCrae and Costa, 1989; Pittenger, 1993). The value of using the best features of both the MBTI and CareerMate to develop a set of questionnaire items lies in the career education foundations of the final product which provide a theoretical basis sufficiently broad to accomodate the research associated with subject selection and other phenomena such as gender differences.

Methodology for Phase 1

In this phase, it was important that both urban and rural, government and independent schools carrying a full range of upper school mathematics subjects be included, and that a reasonable number of students, both male and female, studying these subjects were available for selection. Accordingly, a stratified probability sampling procedure was used to ensure that these sub-groups within the population and other variables (ethnic mix, socio-economic status of students) were represented. A two-stage cluster design with schools selected with probability proportional to their enrolment size at the first stage, then intact classes of students at the second stage, was employed.

The Sample

Following written invitations, a total of 20 schools agreed to participate in the study. This number was reduced to 17 for researcher convenience when it was found that this lesser number of schools provided an adequate balance of the variables under consideration. Nine government schools (six urban, three rural); four Catholic (two urban, two rural) and four independent (two urban, two rural) were involved. These numbers were roughly in the proportion 4:1:1 for government, Catholic and independent schools which is the actual ratio in most Australian States. A total of 67 classes were selected involving 1565 students (200 in Year 10 from seven classes, 697 in Year 11 from 30 classes and 668 in Year 12 from 30 classes). This final sample possessed proportional representation from the various sub-groups, with the class being the primary sampling unit.

Year 10, 11 and 12 students in Western Australia were selected because they would provide the most relevant information for the study. Year 10 students proceeding on to post-compulsory schooling are encouraged to plan their study program for the following year; Year 11 students are living with their subject choice decisions, while Year 12 students have the opportunity to reflect on these decisions and their experiences in the previous two years. While the general conclusions from some of the research findings suggest that students' subject preferences are set before Year 10, others support the notion that personality factors, socialisers and role stereotyping can shape subject preferences well beyond Year 10. Information gained from the sample will shed further light on these claims and on the reasons for subject choice through a direct approach to a sample of students themselves. The findings of the study will then be used to probe subject choice factors more

extensively with a wider sample of students from each of the three states.

The sampling technique used was most efficient and will allow for the exploration of factors at three levels (students, courses, schools) during later phases of the study. It incorporates the following key features:

- a large number of schools and students in each of three different Year levels (to attain generalisability of findings),
- the use of a multiple outcomes measure in the form of a questionnaire covering key sociological and psychological reasons for students' subject choice,
- the use of quantitative analytic methods to analyse student responses to questionnaire items and to explore the interrelationships between them at each level of analysis.

Instrumentation

The second goal of Phase 1 – construction of the survey instrument – took up the major part of the duration of this phase. Three instruments were actually developed – one for each of Years 10, 11 and 12 in order to provide items aimed at the three Year levels and covering the different mathematics subjects studied in these years in Western Australia. An extensive survey of the literature formed the basis for the development of the instruments. Each consisted of four sections – the first seeking bio-data and previous academic achievement in mathematics from students. The second section sought students' reasons for choosing or not choosing mathematics subjects; the third section contained the cognitive preference items, while the final section sought information about significant individuals who may have influenced students in making their choice decisions.

The questionnaires were trialled with appropriate student groups from schools in the Perth metropolitan area and modified on the basis of the feedback obtained from these pilot sessions. Draft questionnaires were examined by "experts" as a check on the face validity of the instruments; the construct validity of the instruments was verified and the instruments' reliability was determined by the split-half technique.

Appraisal

The gender-dependent correlation between certain aspects of cognitive preference and particular subjects identified in this study, indicates a relationship between the two variables, and suggests that when a student is choosing mathematics courses, cognitive preferences may be related to the choice. The trait-and-factor approach to career education as described by Herr and Cramer (1992) is based on the premise that there is a direct relationship between personal attributes and features of particular vocations, and that consideration of these factors is an integral component of vocational choice decision making. Subject choice decisions are of a similar nature to vocational choice decisions and it would be expected that the theoretical basis for the trait-and-factor approach would apply. Second, Crawley and Coe (1990) used the 'theory of reasoned action' to derive and verify a mathematical relationship between intentions to enrol in a high school science course and a variety of personal factors, including the student's 'favourableness or unfavourableness' towards a particular behaviour. Cognitive preference is a similar attribute to favourableness towards a particular behaviour. The students investigated by this study have shown that at the age of making subject choice decisions, they had identifiable cognitive preferences and certain groups of boys and girls made specific choices.

Of interest is the relationship between the gender of the student and the preference for either *thinking* or *feeling*, with more than 33% of the girls favouring *feeling* compared with 9% or less of the boys. This is significant

because the students who were currently studying the more rigorous mathematics courses, generally did not have a preference for *feeling*.

The preferences of the academically capable girls who chose alternative mathematics subjects require further comment. These girls were characterised by a negative preference for being innovative; theory and solution oriented, logical and analytical, flexible, spontaneous and easy-going. They displayed a preference for being feeling, caring, people-oriented, punctual, orderly, planned and decisive, suggesting that they may consider some mathematics subjects as being likely to involve them in activities which would not satisfy their cognitive preferences.

One possible means of encouraging the group of academically capable girls who did *not* choose the higher mathematics subjects to do so would be to change the girls' perceptions of the subjects. Presumably their past experiences in these subjects, or their expectations of future experiences, have created attitudes that further study of such subjects may not provide the same level of personal satisfaction as that to be gained from alternative subjects. The incorporation of people-oriented content and teaching strategies into lower and upper school subjects could allow these girls to express the need for being caring and nurturing, which might effect a change in their attitudes towards mathematics.

Another means of increasing participation concerns preferences for being punctual, orderly, planned and decisive - generally a characteristic of academically capable girls. This is in contrast to the boys who generally did not share this preference and instead displayed a preference for being flexible, spontaneous and easy going. This difference has implications for the classroom climate. It could be expected that the girls would be more comfortable in an orderly predictable environment and would be uncomfortable with disorganisation or distractions to their learning. If the boys preferences were allowed to dominate it is likely that the girls would experience some frustrations.

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