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MATHEMATICS AND SCIENCE IN PRIMARY TEACHER EDUCATION: THE DESIGN OF A PROJECT TO ENCOURAGE REVIEW AT THE INSTITUTIONAL LEVEL

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Introduction

Over the past two decades evaluation has been one of the growth industries in education. A major impetus for this development, particularly in the United States of America, has been the mandating of evaluations for major *policy* initiatives at federal and state levels (House, 1981). One result of such legislation has been that academics and private organisations have been engaged, often on long term assignments, to pass judgements on the worth of interventions designed to improve the quality of education made available in educational systems. Features of this approach to evaluation have been that they are large scale, well funded, and conducted by experts who have no stake in the programs. Invariably such evaluations have policy makers and politicians as their major audiences, and their major concern is with accountability, making judgements regarding the worth of programs which reflect given policies.

Under these conditions a large 'feed back loop' exists involving the following stages: (a) mandating of evaluation, (b) conduct of the evaluation study and recommendations to federal or state authorities, (c) decision making regarding policy at the system (federal or state) level, (d) development of new policy, and in some cases, programs at this level, and (e) dissemination of the new arrangements to sites at which the implementation is to occur. Power is centralised and the evaluator can be perceived as the servant of administrators at the system level. Those at the individual site level, have little or no say in the conduct of the evaluation, or the directions of educational changes which might result from the recommendations from such evaluations.

A contrasting approach is often found in evaluations conducted at local site levels, where the evaluator may be closely associated with *program* implementors, and the information collected cycles through a small feed back loop for decision making. Such evaluations are site specific, and evaluation procedures may be informal. Under these arrangements, power is distributed, and the evaluators can be perceived as servants of local program developers.

An assumption underlying this approach is that each program is unique, and that neither the results of the evaluation nor decisions regarding the form of the resulting changes in the program are transferable to other sites.

Arrangements somewhere between these two extremes, which involve system level support for an evaluation design involving cross-site evaluation of programs with provision for individual feedback to individual sites based on the findings are rarely documented. This paper describes such an arrangement.

During 1984, a nationally funded Project was undertaken on the nature of primary preservice teacher education in Australia. The Project concentrated on the nature of mathematics and science in primary preservice courses, with a view to providing information which could be used by the institutions during program improvement processes.

Parties to the Evaluation

System level authorities directly involved in the Project were the Commonwelath Tertiary Education Commission (CTEC) and the Victorian Post-Secondary Education Commission (VPSEC). The Commissions provided funding for the Project and, through negotiation with the evaluators, suggested a format for the Project which encouraged an emphasis on the collection of information of direct relevance to individual institutions.

The institutions were universities and colleges offering preservice primary level teacher education programs. These institutions are funded by the CTEC which channels finances through its State counterpart such as the VPSEC. Nevertheless, each institution is relatively autonomous in termsa of the range of programs offered within state and federal accreditation guidelines.

The Project Team was located in the Centre for Program Evaluation (CPE) at Melbourne College of Advanced Education. The Centre is an autonomous entity which had carried out several large scale evaluations of policy and program impact in Australian since 1980.

The Project was negotiated in late 1983 between CTEC, VPSEC and CPE, and reflected a general concern in the educational community about the teaching of mathematics and science in schools. The Project was seen by administrators at federal and stage levels as one aspect of a concerted attack on the problem through the provision of primary teachers better prepared to teach these subjects to students in the 5-12 year age range. At this early stage, the nature of the Project was not specified. However, the CTEC showed that it was concerned that the results of the study became well known to those in the institutions, that is, that effective dissemination became a key aspect of the study.

This was an insightful and gratifying perspective from a national coordinating authority for it set the tone for the development and execution of a Project in which interaction between the evaluators and institutions was a key feature.

Through subsequent discussions within CPE, a basic premise emerged for the Project which was that knowledge about mathematics and science education could be gathered and transferred in ways that would encourage teacher educators to use the information in a variety of ways; to reflect upon their procedures, to implement programs which incorporated new approaches, and to develop arguments for additional resources. These uses were consistent with forms of knowledge utilization suggested by Pelz (1978) and others in the context of the use of research findings in organisations.

Subsequently, a plan evolved which took account of suggestions of the CTEC, and the basic premise outlined above. The plan had four phases, as follows:

(1) *planning.* This involved setting up a Project Team, and a Steering Committee with representatives of the CTEC, VPSEC, institution and other interested parties.[1] In addition each institution offering a course in primary teacher education in Australia was asked to nominate a contact person to assist the Team.

(2) *consultation.* In this phase, teacher educators were asked to offer opinions about priorities for the Project. This extended the commitment to interaction with the primary audience for the Project beyond the need for effective dissemination to decision making about the issues to be investigated. These opinions and the views of the Steering Committee were used by the Team in making final decisions about future directions for the Project.

(3) *knowledge gathering and analysis.* The Project Team collected information on issues suggested in the consultation phase and subjected this information to a variety of analyses.

(4) *dissemination.* This involved a review of the literature on educational change, particularly that relating to the impact that a 'temporary system' like the Project Team could have on promoting change (see for example Miles, 1964). A set of dissemination strategies was developed, given the resources of the study, in an effort to maximize the flow of information about the Project to institutions.

Phases (2), (3), and (4) are discussed in greater detail below.

Consultation

Given that institutional personnel, particularly mathematics and science educators responsible for planning and delivering courses in these subject areas were to be the primary audience for the study, the first question faced by the Project Team was; "What knowledge would be of most worth to this audience in reviewing existing programs taken by prospective primary teachers?" It was

[1] Following an expression of interest from the New South Wales Higher Education Board, a representative of the Board (Dr R Perry) jointed the Steering Committee and assisted the Team with the Project.

decided to use some of the resources of the Project to obtain information from Victorian teacher educators to answer this question. (Due to resource restrictions, the majority of the Project was conducted in Victoria). Using the results of a survey developed for this process (see Appendix), the Team was able to draw up a set of priority areas for investigation. The three major areas were:

(1) a systematic study of preservice mathematics and science programs in campuses offering primary teacher education courses.

(2) an analysis of beginning primary teachers' opinions of their initial teaching experience, and their reflections on the adequacy of aspects of their preservice training in the light of their initial teaching.

(3) the Project Team collected information on issues suggested in the consultation phase and subjected this information to a variety of analyses.

It can be seen that teacher educators were most anxious to obtain information about the processes and products of courses, that is, the ways in which courses were organised, and the outcomes of these courses in terms of teacher performance in the schools. Teacher educators were less interested in the Project Team undertaking a systematic study of inputs, the secondary school characteristics of entrants, particularly mathematics and science backgrounds, into the courses. These were seen by institutional personnel as a 'given', something unlikely to change or be influenced by data from the Project. In any case, most colleges and universities monitored the input characteristics of their students. As an aside, the study of input characteristics has been a strong agenda item for system level policy makers for some time. Underlying this interest there has been an implicit assumption that this is one area in which coordinating authorities could put pressure on individual colleges and universities to modify course arrangements. The reality is that individual institutions have favoured fairly open policies on entry characteristics, and any condition specifying essential school level pre-requisites in mathematics and/or science is most unlikely to be adopted.

Knowledge Gathering and Analysis

Gathering. A key question in this phase of the study was the nature of the information to be collected. It became clear that different types of information were needed as data bases for each area of investigation.

Broadly, the Project Team collected two types of knowledge. The first was Lindblom and Cohen (1979) call 'professional social enquiry'; this includes seminal writings in the field under review, and original research. For this Project, knowledge of recent developments in teacher education was used to structure data collection instruments, and then again to set up frameworks for analyses of the data collected. This approach was used to collect data related to the first two areas of investigation outlined in the consultation phase, above.

The second type of knowledge collected has been referred to by House (1979) and others as 'craft knowledge'. This is knowledge created by practitioners in local settings and includes approaches to curriculum development and teaching which, mainly through informal evaluation and review, are deemed to be acceptable practice. The Team took the view that the transfer of knowledge from practitioner to practitioner per medium of the Project was the most legitimate method of providing data for the third area of investigation outlined in the consultation phase.

In practice, the following data collection took place.

(1) the systematic study of the mathematics and science programs involved visits by Project Team members to the 14 Victorian sites at which primary preservice courses are offered. During the visit, all members of the mathematics and science staffs were interviewed using a prearranged schedule developed for the purpose. In addition, documents were collected and facilities examined.

The visits were designed to collect information on: how mathematics and science programs related to the primary teacher education program; the structure of mathematics and science programs with particular reference to the personal development and curriculum studies components; and teaching strategies used in teaching mathematics and science subjects. In addition to factual information, the interviews were structured to seek opinions about the present structure of programs and future directions for these programs.

Reliability of the information to be obtained was uppermost in the minds of the Project Team. The development of a systematic interview schedule and additional information from documentation and observation were methods used to reduce the changes that the data collected was a time reflection of the situation at each site.

(2) Opinions of beginning teachers were collected in group meetings with a sample of Victorian teachers in the June to August period of 1984. Project Team members took the teachers through an individual questionnaire completion exercise after explaining to them the nature and importance of the study.

The explanation procedures were designed to encourage a serious approach to the completion of the survey in order to develop a valid data base for analysis.

The questionnaire included items designed to elicit information about the teaching of mathematics and science in schools, support for this teaching by colleagues and difficulties encountered, and the match between current needs as beginning teachers and the extent to which preservice courses had prepared them to meet these needs. In addition, teacher attitudes towards mathematics and science and mathematics and science teaching were canvassed.

(3) The compilation of craft knowledge relied heavily on the support of the contact person in each institution, for it was impossible for the Project Team to visit all institutions across Australia to gather this information.

Extensive use was made of the telephone, using techniques suggested by Frey (1983) to make arrangements for contact persons to assemble information about programs judged by each institution to be good examples of course development and/or implementation.

After these data had been assembled, members of the Team made visits to some institutions to gather first hand information on some programs. The selection of programs for further study was guided to some extent by the opinions of contact persons regarding the quality of each program. Unfortunately, due to the limited resources, the Team was unable to visit all institutions that appeared to be operating interesting programs.

Analysis. The research information collected lent itself to a cross-sectional analysis over the three major data collecting approaches outlined above. Six major themes emerged, upon which reports were developed, and which formed the basis of the dissemination of findings.

The themes were:

(1) Beginning Teachers in Schools

(2) Acquisition and Transfer of Teaching Skills and Approaches

(3) Relating and Integrating: Relationships between Programs and Within Courses

(4) Structure of Programs

(5) Mathematics and Science Aptitudes and Attitudes of Beginning Teachers, and

(6) Information Sharing between Primary Mathematics and Science Educators.

For each theme, the Project Team developed a short paper outlining the findings. The data were collected using both quantitative and qualitative methods. While analysis techniques for the quantitative information are reasonably well developed, the treatment of large quantities of qualitative data collected from a set of parallel sites posed some problems in terms of distillation of material to illustrate the most salient features. Fortunately, recent guidelines developed by Huberman and Miles (1982), and Miles and Huberman (1984) were available upon which to base the analysis. This involved transforming raw data which appeared in notes taken on site visits into more compressed forms. Much of the analyses consisted of the development of charts and tables in which comparative data from the sites were displayed in simple arrays. The final displays rely to a large extent on the previous development of a framework for the analyses, and a common approach for the collection and writing up of site reports.

In addition to the research papers, two directories were assembled, one for mathematics and the other for science. These contained information collected through the contact persons about exemplary programs in mathematics and science education from across the country.

Dissemination

Several strategies were used to disseminate the findings of the Project. In addition to preliminary visits to Victorian institutions and contacts by telephone to colleges and universities interstate, periodical newsletters were used to inform staff *about* the Project.

When the products of the study became available in draft form, a conference was held to discuss some of the findings, and tentative recommendatons for review of existing courses. The conference, held in Melbourne in November 1984, brought together representatives from interstate institutions as well as from the 14 Victorian campuses.

Each session was devoted to one of the six major themes which was used to organise the data analysis. A feature of most of these sessions was the presentation of practical examples of exemplary practice by staff from various institutions, which drew attention to ways of implementing recommendations to general problems uncovered in the data analysis. This technique was used to increase the likelihood that institutions would try new approaches in their own sites.

In addition, conference participants had an opportunity to consider the recommendations put forward by the Project Team before the final report of the Project was prepared.

In preparing documents which arose from the Project, the Team became aware that a variety of audiences now existed for the study. Four documents were written in an attempt to meet the needs of these audiences. The documents were: directories of exemplary and innovative practice, one for mathematics and the other for science; a main report; and a project summary. The directories and the main report had mathematics and science educators in tertiary institutions as its main audience. The project summary was developed for a more diverse assembly which included administrators at system and institutional level in addition to a large number of people outisde primary teacher education who sought information on the Project's findings.

The main report and project summary contained sections devoted to recommendations, and in keeping with the emphasis on dissemination, audiences for each recommendation were identified and listed in a table in each document. In addition to the major audience, staff in mathematics and science departments, other groups for whom some of the recommendations had particular relevance were: education departments; school teachers, particularly those supervising teaching practice; primary teacher education course committees and school experience departments.

Conclusion

For those in the Project Team, an a priori commitment to an interactive study involving intensive consultation and dissemination led to an unexpectedly heavy workload. In consultation, writing to 52 institutios and setting up contacts was a major task in itself. Dissemination of information also ate heavily into Project resources. For example the November conference required, in addition to travel and accommodation arrangements, that draft papers and ancillary material be available in mid October. The net result was that the Team devoted less time than expected to knowledge gathering and analysis, this phase being restricted to a seven month period in a Project of 11 months duration. A large amount of data collected in this phase remains unanalysed, and there is important information contained in the extensive data bases which should be examined in the near future.

The worth of the Project ultimately should be judged on the ways and extent to which the knowledge gathered and disseminated affects practice in primary teacher education. The Project Team has acted as an agent responsible for the transfer of information and ideas across institutions. While some of these ideas, in the form of curricula and teaching strategies, could be adopted and implemented as a whole, most of the information requires individual institutions to take further developmental action. We know from previous research that the mere availability of suggestions for change do not necessarily mean that a review of present arrangements will occur which will take into account the suggestions offered. Factors embedded at the local level of a cultural and political nature will affect decision making (see, for example McKibbin and other, 1981), even when the information is in a form which encourages adoption.

With this in mind CPE has, in 1985, set up a small study ot assess the impact of the Project. The study aims to measure the 'levels of use' of information from the Project by individuals and groups in Victorian institutions, based on previous work by Hall and others (1975) and Owen (1983).

These results, in addition to throwing light on the effects of this Project should be of interest to scholars of knowledge dissemination, and administrators concerned with promoting change in tertiary institutions. For if this Project is seen ot have had a major impact, the strategies used are a blueprint for conducting other studies designed to have a large scale influence on the design and implementation of courses in tertiary institutions.

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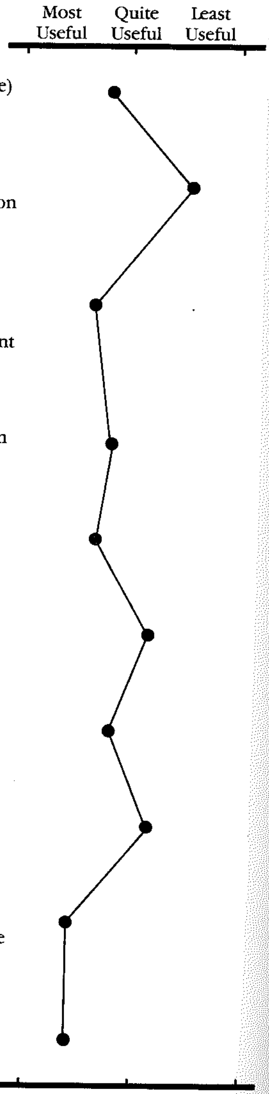
APPENDIX
SURVEY OF ISSUES

PERCEIVED USEFULNESS OF INFORMATION ON VARIOUS TOPICS AMONG MATHEMATICS AND SCIENCE EDUCATORS (N = 98)



(1) REVIEW OF RESEARCH
A review of recent studies in primary mathematics (or science) teacher education in countries with comparable educational systems (e.g. USA, United Kingdom).

(2) STUDENTS SCHOOL BACKGROUNDS
An analysis of the secondary school level mathematics and science backgrounds of entrants into primary teacher education in Victoria.

(3) DESCRIPTIVE ACCOUNTS; COURSE PLANNING AND DEVELOPMENT
A description of how other institutions have planned and developed the mathematics (or science) component of their primary teacher education program (aims, organisation, content etc).

(4) SYNTHESIS AND COMPARISON OF COURSES ACROSS INSTITUTIONS
A systematic synthesis and comparison of the nature and form of mathematics (or science) components of primary teacher education programs across institutions in Victoria.

(5) OPINIONS ABOUT FUTURE DIRECTIONS
An analysis of the opinions of teacher educators about where primary mathematics teacher education (or primary science teacher education) should be heading over the next decade.

(6) DESCRIPTIVE ACCOUNTS; COURSE EVALUATION
A description of how other institutions have carried out evaluations of their primary mathematics teacher education programs (or primary science teacher education courses).

(7) FRAMEWORKS FOR CONTENT ANALYSIS
A framework by which teacher educators could analyse the content and sequence of their own mathematics (or science) programs in primary teacher education.

(8) DESCRIPTIVE ACCOUNTS; STUDENT PROGRESS
A description of how other institutions have monitored the progress of students (knowledge, attitudes, and skills) in primary mathematics (or science) teacher education programs.

(9) GRADUATES OPINIONS OF COURSES
An analysis of beginning teachers' opinions of their primary teacher education programs in mathematics (or science), in the light of their initial teaching experiences.

(10) DESCRIPTIVE ACCOUNTS; METHODS OF TEACHING AND LEARNING
A description of how other institutions have used innovative teaching strategies in their mathematics (or science) programs in primary teacher education.

Note: mean values. No sig differences between maths educators and science educators

WHAT WE DON'T KNOW ABOUT C.A.I.

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Studies of Computer Assisted Instruction (CAI) to date, appear to have concentrated on comparisons of CAI with other modes of instruction; differences in time required for completion of lessons; student personality; student attitudes to CAI; and the number of students who can successfully work together on the one CAI task. It is fair to claim that the most important information is yet to come, for there are many other variables of CAI that need to be researched, as the following questions suggest.

1. Are there differences in student performance in groups given a print-out of the CAI lesson on paper, and in those groups who refer only to the monitor? One of the criticisms that has been levelled at CAI is that students do not have a permanent record of the lesson, and thus, at a later date, cannot revise the work covered in a CAI lesson. It could be expected that retention would improve if the students had a permanent record of the lesson. This requires testing, however.
2. Do the graphics and sound capabilities of computers benefit learning from CAI lessons, and in what instances do they exert negative effects? The trend in software currently being marketed for microcomputers has been to display as much graphic information as possible, and to provide associated noises for the duration of the programme. It is possible that over-use of graphics and sound reduces the effects of CAI. This, also, need priority in educational research.
3. Do differing user-interfaces interfere with student performance? Expected sources of interference are the keyboard commands of software packages, and the keyboard layouts of different brand computers. Should there be an effect due to differing user-interfaces then the continued use of CAI necessitates an Australian standard to be established for the keyboard layout, and for the programme commands used by software authors.
4. Are there long-term effects on students' social behaviour as a result of the use of CAI, and if so, up to what frequency of use of CAI are there no negative effects? Feldman and Sears (1970) showed that there were some short-term effects of CAI on student behaviour, but this was with first grade students. The same may not hold for older students, and merits investigation.