IDENTIFIED PROBLEMS IMPEDING EFFECTIVE EVALUATION OF TERTIARY BRIDGING MATHEMATICS PROGRAMS

GAIL GODDEN
University of Central Queensland, Rockhampton

JOHN PEGG
University of New England, Armidale

Mathematics bridging programs and related assistance schemes for mathematically underprepared students have become essential features of many tertiary institutions. Often unstated, but nevertheless intended, the principal goal of such programs is to provide a service which gives the mathematically underprepared student the same opportunity to satisfactorily complete their chosen tertiary qualification as the mainstream student. Evaluating the effectiveness of each bridging program therefore necessitates determining whether this goal is being reached. Long-term or longitudinal studies are strongly recommended. However, there is little evidence in the literature that formal evaluation of such programs is occurring to any great degree. Why is this so?

This paper takes up this question and reports on one aspect of a large study which involved the synthesis of research evidence concerning bridging mathematics programs in the USA and Australia. Several important reasons for the limited nature of evaluations are identified. The paper concludes by suggesting that evaluation, in the traditional sense, may be incompatible with the successful conduct of tertiary mathematics assistance programs.

Many tertiary students find themselves mathematically underprepared for their chosen studies. This problem occurs primarily for three reasons. First, the mathematical skills of the student are deficient. Second, the depth of treatment (exposure) to various mathematics topics is limited. Third, there is an increasing reliance on mathematics techniques and concepts in subjects and courses not traditionally mathematically orientated. Tertiary institutions have responded in a myriad of ways to this issue, with varying degrees of formality. However, the responses may be broadly classified in terms of preparatory, bridging or concurrent programs.

To provide a home for such programs, some institutions have established a physical facility: a unit or centre, which conducts some or all of these services, and provides "drop-in" assistance. In Australia, these programs and centres are referred to collectively as "bridging mathematics". They are now so prolific as to have specific forums in place to discuss relevant issues: for example, the *Australian Bridging Mathematics Network Conference* . The United States of America has also a well-established and extensive "developmental mathematics" scene, based mainly at the two-year colleges. Where specific centres exist in the US, mathematics is frequently not the major emphasis. Instead a large range of services is covered in a whole-person approach. Although this is true of some centres in Australia, most centres (variously named Mathematics Learning Centres, Remedial Mathematics Units, etc) are restricted to mathematics. A similar situation exists in New Zealand. Variety again exists in the strength of administrative ties between each program or centre and the relevant institution's mathematics department.

Much assistance is provided concurrently with the students' 'regular' undergraduate (or postgraduate) coursework. Formal means include interventionist strategies where the students attend compulsory or voluntary sessions dealing with background mathematics. Informally, 'drop-in' centres allow students to arrive as and when the need for assistance arises. Short intensive bridging courses prior to semester commencement are a common form of assistance, particularly in Australia. Semester-long preparatory courses and distance education versions of these have also been established in this country, in an attempt to pre-empt some of the mathematics difficulties students face and to lessen their impact. In any case, the emphasis is on individualised and small group attention, and is very much student-centred. A variety of teaching resources and modes are employed in any one session or contact. Flexibility is of the essence.

EXISTING EVALUATION

The need for evaluation

The rationale for evaluating bridging mathematics programs lies partly in the identification of sound educational practice. That is, identifying effective techniques in terms of producing optimal results in students, possibly with respect to time-effectiveness. Other purposes include: the notion of feedback and review aspects which the evaluative process should provide; and, the justification of the viability of the programs to those in higher authority.

Forms of evaluation

Types of evaluations which have been taking place include those which focus on the results of the program itself, or the results of the first mathematics subject, and those which consider the completion rate of the tertiary course for which the student was aiming. Evaluations have often been of an informal nature, for example, student evaluation questionnaires, simply observing mathematics results of students, and feedback from staff who teach mathematics-based subjects.

Methodology

The most common method of formal evaluation has been of a pre-test/post-test nature. This has potential validity problems. To rely on this form of evaluation alone is often misleading (Budig 1986, in Tomlinson 1989). Regression of test scores towards the mean is clearly a confounding factor. This is especially true when mature age students, who have been absent from formal mathematics instruction for some time, are considered. An alternative approach, which overcomes this problem, uses the fact that some students do not take advantage of remedial/preparatory programs when indicators suggest that they should. Comparisons are then made with students in the programs.

Results

No definite trend on the effectiveness of bridging programs can be discerned from the literature. At an individual level, students have satisfactorily completed the programs and continued on to complete tertiary studies. However, when results of a program are viewed overall, there is disagreement as to the effectiveness of the programs in the studies reported. The increase in students' mathematical prowess for the group as a whole may well have improved but the level of their mathematical ability may still be below that of mainstream students with whom they are to be compared. Barling & Jones (1991) for instance, found that it took a time-period of around eighteen months before students generally reached the standard of their initially better prepared peers. Students entering the programs who had seen the material previously, and/or were of relatively high placement levels on entering tertiary education have been seen to fare better. However, the evidence is not conclusive in some cases, and not comparable in others.

IDENTIFIED PROBLEMS/ISSUES

Introduction

Insight into some reasons why evaluations are not up to standard or are lacking in critical features has been provided by Bers (1987):

> In many places, uncertainty about program goals precludes identifying criteria for measuring 'success'. Faculty and staff are more concerned with meeting students' needs than with evaluating the results of their efforts. Reliance on 'soft money' or limited institutional funds further impedes evaluation activities ... The uncertain status of remedial programs and faculty in many institutions makes staff weary of submitting to evaluations which might suggest programs are ineffective, particularly when there is fear that program continuation is at stake ... Where programs are under pressure to provide evaluations, researchers or program staff might be tempted to select a particular variable ... and use this as a measure of program success or failure.
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> (pp.2-5)

This paper now looks at these and other issues confronting mathematics bridging educators attempting evaluation of their programs.

Clarity of real aims

An essential task which should be carried out for each mathematics bridging program is the definition of the program's aims and objectives, otherwise "success" cannot be determined. Is the program intended: to improve a student's skills in specific topics; to prepare a student for entry to certain regular courses; to improve a student's chances for the current regular course; and/or, to enable a student to have the same chance of satisfactory completion of the regular course as the mainstream student? It is the latter aim which is often not clearly defined and yet is the long-term goal of many programs (e.g., Ross & Roe 1986, Wepner 1987).

Students' perceptions of needs may undergo a number of changes as they progress through both the assistance program and their regular course, and at any one time may be quite unlike their real needs. Their urgency is to cope with the current or imminent mathematical skills with which they are presently confronted. The staff, on the other hand, wish to ensure the students grasp the concepts and gain wider perspectives on the topics. Thus the students are actually aiming for different results compared to the staff, causing conflict and frustration in both. 'Success' for students is in coping satisfactorily with current or imminent work and not to be constantly floundering. 'Success' for staff is that students have gained some insight so they have the grounding needed to do 'different' questions and a basis upon which to build. However, 'success' for the programs must be measured on what the program staff are actually aiming for, if only implicitly: the long-term goal of mainstream levels of successful course completion. Importantly, this is similar to the aim of those in higher authority concerned with the extent of increase in student retention and graduation (Akst 1985). Since the objectives of a program should determine its evaluative process, evaluating this type of success indicates that longitudnal studies are a necessity (e.g., Wright & Cahalan 1985). Unfortunately, this type of evaluation is not generally undertaken (e.g., Atweh 1981, Wepner 1987), and has been, even more rarely, built-in to the program itself.

Spontaneous pragmatism of some programs

The establishment of some mathematics bridging programs, particularly in the past, has been of a hurried nature, in response to an immediate need. Little provision, if any, has been therefore possible in the initial stages of development, for the building-in to the program of an evaluative process. The instruction techniques used have been dependent on that which was available at the time, and able to be put into effect immediately. Changes have been made as and when possible, both from a time aspect, and from the point of view of funding. Such spontaneous responses to the mathematics underpreparation problem have contributed to the variety and uniqueness aspect of the programs overall.

Flexibility of teaching/learning modes

Another evaluation problem stemming from a less than concrete base is the flexibility for which such programs are renowned. Since a student-centred approach is of priority in these programs, the teaching techniques used tend to be dictated by the individual student's needs including background mathematics and learning styles. Thus for each student in any one session a variety of resources and instruction modes may be used. These include guided reading and solution to problems, Computer Enhanced Learning, video- or audio-tapes, one-to-one tutoring, small group discussions, and sometimes (usually infrequently), lectures.

Comparability across programs

Due to the uniqueness of almost every program, and the flexibility of instruction modes which may have been used, it is almost impossible to compare programs in a traditional investigative manner. The uniqueness occurs in a number of ways: namely, whether the type of approach is for skills alone or also for concepts; the type of evaluative technique which was most applicable for each of the programs; the duration and timing of the assistance given; and, the students themselves. The students are of a much less homogeneous mathematical background than in other educational settings. Part of the reason is the predominance of mature-age students who have a wide range of mathematics backgrounds and length of time since recent mathematics practice. How the program actually attracts students often determines where in the range that program's students fit. An additional aspect is the attraction to (particularly preparatory) programs of would-be students who would never have considered attempting further studies had they not been exposed to this opportunity. The students of various programs also differ in their requirements with regard to content to be covered, depending on their intended, or current, tertiary course.

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assistance and the commencement of the regular course; and, the length of time devoted to remediation during the course, are potentially quite dramatic.

Comparing the effectiveness of programs from one country to another is made more difficult by different topics and levels of mathematics being taught in secondary and tertiary institutions and by different purposes for the programs.

Complexity within programs

The huge variability of students has been mentioned previously. The individualised approach to student assistance within just one session makes any traditional approaches to evaluating instructional techniques impractical at the very least. More than one method of evaluation is necessary since there is usually more than one objective. Statistical testing is thwarted by the interaction or confounding of treatments, since isolation is impossible (e.g., Bers 1987). Therefore, any tests on just one variable will be invalid. A lack of generalisation to the group as a whole plagues even phenomenological investigations.

Attrition

One of the major problems for researchers comparing their results, is the necessity to be precise in their descriptions of the characteristics of the target group of students and any comparison groups. Researchers need to define carefully any terminology and assumptions used, including how they have accounted for attrition. Kulik , Kulik & Schwalb (1983), in conducting a meta-analysis of evaluations of (US) programs for high-risk students, were enormously restricted by the inadequacies of reports from this perspective. There are two main aspects to attrition of students from bridging mathematics programs. Where more than one course of preparation/remediation is conducted within the program, reports made concerning the second course (which then reflect on the whole program) frequently neglect to mention that the "success" rate does not take into account those students who "dropped out" before the second course commenced. Comparisons with other programs are then invalid. Precise details of the setting in which the evaluations being reported took place are essential.

The second aspect provides a disturbing vagueness to the entire bridging mathematics scene. When students leave after a remediation or preparation program, and are not able to be traced again at that institution, have they merely not continued, and therefore not succeeded in completing a tertiary course, or have they in fact enrolled elsewhere? (and did they complete the tertiary course satisfactorily?) (Bers 1987). Such questions must largely remain unanswered, and so the effectiveness of these programs can never be determined with a high degree of certainty.

Ethical considerations

Comparison of groups of students by teaching technique introduces concerns about the ethics of providing suspected "better" services to one group over another. However, some investigators have attempted carefully designed comparisons. A major ethical problem not unique to bridging mathematics is that of withholding some form of assistance from a control group. Where control groups have been used in evaluations on bridging mathematics programs, the students in the control groups are those students who should have taken advantage of the program and did not (e.g., Budig 1986, in Tomlinson 1989). This is a very restrictive process.

Since students have a limited time in which to remediate or prepare for their mathematics requirements, it seems unreasonable to expect any additional time constraints to be placed upon them, as may occur with evaluation techniques. The staff suffer time limitations, also since their availability to students is of paramount importance. Therefore, they usually cannot afford time on additional projects, unless alternative staffing arrangements are made.

Staffing issues

A high proportion of staffing is on a fractional basis, with a leaning toward females. Major sources of staff are the mathematics department (and this may be provided reluctantly) and secondary teachers. The requirement of a teaching background in mathematics may often assume less importance than having empathy for the students' predicaments. Specific training is more 'on-the-job' than formal, although some response to this void is now being made, particularly in the US. This background, and the added problem of students needing assistance *now,* makes staff availability low for such activities as research, including evaluative studies. The low image which these programs have in the academic world is reflected in how poorly the worth of research in the area is considered. This is evident in the minimal extent to which research on bridging mathematics is published. Therefore, the staff struggle with the obvious need to evaluate their programs and the practical priority on which such evaluation appears to be placed.

Funding

One of the major reasons why staffing is limited is the difficulty in attracting sufficient funds to satisfactorily conduct the programs. Part of this is due to the methods in which funding is obtained and apportioned throughout the institutions. Another reason is the poor image which bridging mathematics often has in a tertiary institution (Godden & Pegg (in press)).

The lack of available funding causes further troubling repercussions. In fact, it creates and is part of a rather vicious circle. Without the funding to carry out substantial evaluations on the effectiveness of the programs, both as sound educational practice and for justification to those in higher authority, only minimal evaluative efforts are made by most of the educators. Thus the programs, not adequately evaluated, may whither due to lack of noticeable effectiveness. A corresponding reduction in funding due to the perceived low viability ensues. Optimal teaching/learning techniques remain unidentified, thus the chance of being time- and effort-effective, which is so necessary under the limited conditions of these programs, is lost.

CONCLUSION

One of the major strengths of bridging mathematics programs is their flexibility and student-centred approach. Unfortunately, it is this very strength which is a major downfall in terms of evaluating their effectiveness. Such a weakness cannot be ignored. Evaluations are considered essential. However , this paper has shown that obstacles to substantial evaluation exist at every turn. Perhaps the challenge to overcome some of the obstacles is actually defeating the purpose of the great strengths of these programs. That is, traditional evaluative techniques employed in secondary and tertiary educational settings are just not possible. The sacrifices are too great and contrary to the aims of the programs. In attempting to minimise bias, maintain validity, and strive for some degree of replicability, the educator risks losing the essence of the support and assistance so necessary for these students. Why compromise a set of processes which for the *individual* student is often quite rewarding and in a number of cases, given time, produces results akin to that of mainstream students? The individual 'success' may well be more important than some statistical improvement in test scores of a large group.

Given that the desire and/or necessity to evaluate the programs is strong, perhaps what is really needed is a new set of procedures specifically tailored to the area of bridging mathematics. These procedures would need to take into account the unique conditions which are the mainstay of the programs and the constraints applicable to them. Kinsler & Robinson (1990) concluded, about developmental education generally, that "Research in the field is new and the area is wide open" (p.354). We would add that not only is the research aspect "new" but that the techniques should be 'new' also.

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