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ABSTRACT

This paper discusses the lack of and the need for program evaluation models for mathematics education and points out generic approaches to program evaluation. This project attempts to develop a mathematical approach to program evaluation that can be applied to an integrated preservice program for mathematics, science, and technology education teachers. Guiding questions for the overall project include: (1) How can program evaluators approach their task in a way that is valid for mathematics specialists; specifically, how can program evaluation be approached in a way that reflects the values of the mathematics education community? and (2) What is the role of the evaluator in content-responsive program evaluation? (Contains 13 references.) (ASK)

Content-Responsive Program Evaluation:
An Integrated Preservice Example

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In an age of accountability it becomes increasingly important to document what we do and how well we do it. Program evaluation provides a comprehensive view of the effectiveness of a newly implemented (or well-established) curriculum or other program, and is a means of providing the accountability that is often expected by administrators and the public. Program evaluation can also provide data useful in the successful propagation of reform efforts, whether they are at the school, higher education, or pre- and inservice teacher education levels.

The Problem: A Lack of Program Evaluation Models Specific to Mathematics Education

As mathematics educators—content specialists dedicated to the subject we teach—we would naturally look for models of program evaluation within our field. Alas, there are few. Indeed, a search of related literature revealed only three "how-to" guides on program evaluation in mathematics.

Mathematics Program Evaluation

The first such guide is a publication of the National Council of Teachers of Mathematics (NCTM) titled *How to Evaluate Your Mathematics Program* (1981). This 19-page booklet consists of a set of 21 standards for school mathematics programs established by a collaborative in Maryland, and grouped into the following categories: instruction, curriculum and instructional materials, the teacher, and physical facilities and equipment. Since this document was published several years earlier than NCTM's *Curriculum and Evaluation Standards* (1989) and the ensuing reform efforts, a current program would have somewhat different goals and objectives from those indicated in these standards.

The second mathematics-specific guide is a joint project of NCTM and the Association for Supervision and Curriculum Development, titled *A Guide for Reviewing School Mathematics Programs* (1991). This document is more extensive in scope, including curricular goals by grade levels and aspects of school administration, but remains little more than a survey-type instrument. In general this 65-page document is of limited use in investigating the interrelatedness of factors that results in the success (or failure) of a program.

The final mathematics-specific guide is also from the Association for Supervision and Curriculum Development, the *Mathematics Assessment Process: A Curriculum Alignment Strategy* (1992). The result of an extensive project with national consultants, this two-volume publication takes the idea of program evaluation much further. This assessment process differs from the other two in that its stated purpose is to assist in making changes in a mathematics program to help the program become more aligned with the NCTM *Standards*. Thus, this mathematics program evaluation is intended to do more than assess the current status of a program, and is in fact designed to help guide a program toward very specific goals.

In summary, none of these examples provides a comprehensive guide for overall evaluation of mathematics programs. They are either limited in scope, in evaluation activities, or in grade level applicability, and essentially provide instruments rather than an approach or model. Lacking a specific model for mathematics program evaluation, we turn naturally to the more general program evaluation literature.

Generic Approaches to Program Evaluation

Approaches to program evaluation abound, and are categorized differently by various researchers. One of the most commonly known distinctions is that of summative and formative evaluation as first delineated by Scriven (1967). Summative evaluation occurs after a program is completed and is used to determine the program's effectiveness, while formative evaluation occurs while a program is in progress and is used to change or further develop the program in some way.

Fitz-Gibbon and Morris (1987) present a very positivistic approach to program evaluation. They offer six ways to design an evaluation: (1) true control group, pretest-posttest; (2) true control group, posttest only; (3) nonequivalent control group pretest-posttest; (4) single group time series; (5) time series with nonequivalent control group; and (6) before and after. These designs assume an experimental orientation to program evaluation, and can only be effectively implemented in nearly ideal conditions.

Stecher and Davis (1987) as well as Worthen, Sanders, and Fitzpatrick (1997) go beyond these approaches to present a continuum from more positivistic to more naturalistic orientations. The *objective-oriented* approach emphasizes the goals and objectives of the program and attempts to measure the success of the program in terms of its goals. In this type of evaluation, the evaluator takes on the role of measurement specialist.

The *management-oriented* approach is guided by the decision needs of the program—data are gathered in relation to issues on which changes are already being contemplated or at crucial steps in implementation or progress. Effective program management is a goal, and the evaluator must work backwards from clear decision points to determine what information is needed to inform the decision-making process.

The *consumer-oriented* approach concentrates on providing information that will be useful to those who are in a position to take action based on the data. The emphasis is on people, and the evaluator involves user groups throughout the evaluation.

The *participant-oriented* approach puts the evaluator in the position of seeking understanding of all evaluation questions from the point of view of all participants, program staff, administrators, and others. This approach uses more qualitative data collection methods, and therefore is functional in less focused evaluations.

The *expertise-oriented approach* is the term Worthen et al. (1997) use to denote the oldest and perhaps best known form of evaluation, in which a professional in the particular field is called upon to evaluate the specific program. In this approach, an expert or a team of experts in the relevant field is called upon to provide professional, subjective judgements about the program being evaluated. A review for accreditation is one example that would fall under this category of evaluation. *Adversary-oriented approaches* make up the other category offered by Worthen et al. (1997). This approach borrows ideas from the field of law, in that the evaluation plan attempts not only to generate but also balance opposing viewpoints on a program. This process often involves conducting open "hearings" in which all viewpoints are freely expressed.

Worthen et al. also provide a chapter in which they evaluate the contributions of the six categories of approaches presented. They point out that program evaluation is a relatively new field, and that it is not considered yet to be a "full-grown discipline" (p. 172). They continue by stating that the approaches presented do not meet the criteria to be considered scientific models. Further, these categories of approaches are not theories, since they are not nor can they be written in axiomatic style, and they do not allow us to make predictions or conjectures of any sort. They conclude that these approaches are simply useful information. Indeed, they point out that the field continues to expand, and that it will be much longer before we can attempt to put together all we know about program evaluation into a model.

The Accompanying Paradigm Shift

The varying approaches to evaluation in fact reflect a philosophical shift that has been underway for some time in the field of program evaluation. Greene (1994) describes the evolution of program evaluation in terms of an underlying move through several philosophical paradigms. Greene essentially explains that the goal-oriented approach reflects a postpositivist philosophical framework; the decision-oriented approach shows a pragmatic viewpoint; and the user-oriented and responsive approaches demonstrate an interpretivist framework.

Greene (1994) mentions several program evaluation researchers who have made significant contributions toward the paradigmatic shift. Stake's *responsive* evaluation (1975, as cited in Greene, 1994) was one model that helped move program evaluation toward the interpretivist paradigm. The responsive approach is focused on identifying and addressing the concerns of all the stakeholders in a program, and examines those concerns in terms of program improvement.

Another milestone in the evolution of program evaluation was, according to Greene (1994), Eisner's acknowledgement of the evaluator in the evaluation (1991, as cited in Greene, 1994). Eisner's approach focuses on interpretation and judgement by a *connoisseur*—an expert in the field of the program being evaluated.

Greene further explains that we have moved beyond interpretivism to an era when critical theory is being applied to program evaluation, specifically through the work of Guba and Lincoln (1989, as cited in Greene, 1994) in what they call *fourth-generation* evaluation. Greene explains that this approach uses a *constructivist* framework, which "requires that evaluation catalyze social action" (p. 540). If indeed the content-responsive model is to focus on some aspect of mathematics program improvement, it is to do so with the expectation that those engaged in the program will in fact improve it—which we believe may be the type of social action intended by Guba and Lincoln. Indeed, Greene describes the role of the evaluator in fourth-generation evaluation as one who facilitates social change, a role similar to that we envision for the evaluator in content-responsive evaluation.

These three approaches—Stake's responsive approach, Eisner's connoisseur-evaluator approach, and Guba and Lincoln's fourth-generation approach—will be the focus of our endeavor to create the content-responsive approach to program evaluation.

Need for a Mathematics-Specific Approach: What Hasn't Worked for Mathematics

The need for a mathematics-specific approach arises from concerns that are often expressed by mathematics specialists when program evaluations are undertaken. One problem is that the program evaluator is often an outsider—not a mathematician. Lacking knowledge of mathematics itself and not sharing the values and culture of mathematics education, the evaluator tends to look at more general questions, concentrating on the success or failure of documented forms of goals and focusing perhaps on resources (supply and demand issues). Another problem with nonmathematical program evaluation is that too great an emphasis is put on what we might call "appeal" questions. That is, there may be a focus on issues of satisfaction, which might translate, for example, to an analysis of levels of mathematics anxiety among students. Similarly, there can be a focus on reform issues only (rather than an overall view of the program), especially at a time when everyone is clamoring to prove that programs are in fact reform oriented. This fact calls for an approach to evaluation that we as mathematics specialists can undertake ourselves, and one in which we can have faith as mathematical thinkers. Furthermore, a mathematics specialist will know how to make specific recommendations for program improvement, thereby increasing the likelihood that an evaluation report will be used.

Research Questions

This project attempts to develop a mathematical approach to program evaluation, which will then be applied to an integrated preservice program for mathematics, science, and technology education teachers. Guiding questions for the overall project are as follows:

1. How can program evaluators approach their task in a way that is valid for mathematics specialists? Specifically, how can program evaluation be approached in a way that reflects the values of the mathematics education community?
2. What is the role of the evaluator in content-responsive program evaluation?

Developing the Content-Responsive Approach

In this section we will explore the way that we propose to apply mathematics to the field of evaluation, thus creating a mathematically sound model for evaluation of mathematics and/or mathematics education programs. Also, we will discuss several specific models from the generic program evaluation literature that will require further examination in the development of the content-responsive model.

The Metaphor in Mathematics

Both Lynch (1996) and Worthen et al. (1997) mention the contributions of Smith (1981), who writes of various metaphors that have or can be applied to the field of evaluation. For instance, the adversary-oriented approach mentioned earlier was developed using the metaphor of a trial or hearing, with advocates for multiple perspectives presenting their cases to a jury of sorts. Other metaphors abound, including ideas from fields such as investigative reporting, architecture, geography, philosophy, literary and film criticism, and watercolor painting (Smith, 1981).

Problem Solving. Given that we are searching for an approach suitable to the field of mathematics, and one that would be viewed as credible by content specialists in mathematics, it would seem appropriate to identify a mathematical metaphor for evaluation. The metaphor we propose is that of problem solving—a nonalgorithmic approach to mathematical tasks, and one that seems to have relevance to evaluation functions. Certainly, this metaphor is accessible and credible to mathematicians.

Problem-solving literature in mathematics education generally points to one common conception of problem solving: the procedure offered by Polya (1957) in the oft-cited volume *How to Solve It*. Specifically, Polya identifies four stages of problem solving: (a) understanding the problem, (b) devising a plan; (c) carrying out the plan, and (d) looking back to review the procedure and outcome (pp. xvi-xvii). These stages have direct application to the program evaluation process, and indeed, imply that that the evaluation of a program is in fact a problem to be solved.

Understanding the problem. First, we must understand the problem of program evaluation. The tradition of program evaluation is that the evaluation report gives a pronouncement as to whether a program is successful or not, and makes some recommendations for improvement based on that fact. The focus of the evaluation process, however, is on determining how well the program is achieving its goals—the recommendations come as a result of that assessment. Indeed, it seems that the problem being addressed by typical program evaluations can be phrased as a question: "Is this program good?" We propose that the question be changed, that we instead begin to focus on a question that presents a real problem: "How can this program be improved?" This question gets more directly at the point of program evaluation in the first place, but it goes beyond just that by streamlining the evaluation process. That is, rather than first determining the worth of a program and then developing recommendations for improvement, the application of the problem solving process to this new question puts the evaluator and participants in a new position, with a different stance. Indeed, a focus on improvement automatically shifts the evaluator and participants into a problem-solving mode. Having developed this new understanding of the problem of program evaluation, we must look at the next of Polya's stages and devise a plan for solving the problem of program improvement.

Devising a plan. Many mathematicians and educators have developed problem-solving strategies that lead the problem solver through Polya's stages. For example, Posamentier and Krulik (1998) present the following heuristics for devising a plan: working backwards, finding a pattern, adopting a different point of view, solving a simpler (analogous) problem, considering extreme cases, intelligent guessing and testing, organizing data, and using logical reasoning. Such strategies are frequently mentioned in the mathematics education reform documents (including the NCTM

Standards [1989]) that are currently calling for a problem-solving emphasis in the teaching and learning of mathematics. The problem-solving vocabulary is a part of the mathematics educator's everyday language; problem-solving skills are what we address in our classrooms every day, as well. In terms of devising a plan, then, it seems logical to apply these very strategies (with which we are so familiar) to the problem of program improvement.

Some problem-solving strategies such as organizing data and working backwards are fairly obvious aspects of any evaluation. However, the direct application and open acknowledgement of these processes would contribute to a more active view of program evaluation, and would greatly streamline the evaluation process.

Carrying out the plan. Another key aspect of the application of problem solving to contribute to a more active view of the evaluation process is the fact that problem solving includes the act of *solving* a problem—that is, a plan is designed *and* it is carried out. In the content-responsive model proposed here, the carrying out of the plan means utilizing the heuristics in ways that will reveal useful information about the program and lead to ideas for program improvement. It is at this point that the role of the evaluator becomes key. Should the use of the heuristics—that is, the application of the working backwards procedure, or the adoption of a different point of view—be entirely up to the evaluator, entirely up to the program administrators, or some combination of these two? On the one hand, if the evaluator alone takes on this part of the process, the evaluation would end up looking more like one using the expertise-oriented approach. On the other hand, if left solely to the program administrators, the evaluation would lose the valued insight of the mathematics specialist in the evaluator role—a point that has been argued throughout this paper.

Looking back to review procedure and outcome. This stage of Polya's problem solving process involves evaluation of the outcome and of the process used to reach that outcome. As applied to program evaluation, this will involve looking to see if the use of problem-solving heuristics produced actual program improvements. That is, the evaluator and program administrators will review the plan that was designed to improve the program, asking questions about its efficiency and productivity, and will examine the changes implemented to determine if improvements did in fact result.

Overall, the metaphor of problem solving should contribute significantly to the field of mathematics education and that of program evaluation itself. Specifically, if program evaluators work with program administrators and other stakeholders to solve the problem of program improvement in the context of the program at hand, then the evaluation process will come to be viewed as a more positive and productive experience—a mathematically sound venture that effects productive change.

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