Assessing the Effectiveness of the Change to Technology Teacher Education

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Many institutions which formerly prepared teachers of industrial arts are currently implementing technology teacher education programs. As these institutions change to implement technology teacher education, it is important to obtain an accurate assessment of the effectiveness of the innovation. Change in the teacher education curriculum may be assessed in a number of possible ways, each with several potential advantages. However, there is no generally accepted model for assessing the overall effectiveness of such a major change in technology teacher education.

To address this problem, a study was undertaken to develop and verify a set of measures that could be used to assess the effectiveness of the move to technology teacher education. Specifically, the study sought answers to two research questions: "What measurements should be used to determine the effectiveness of the change?" and "How should these measurements be validated?"

Background

The literature relevant to the assessment of change and program implementation may be categorized into three areas: (a) educational program evaluation; (b) program evaluation in higher education, specifically in teacher education; and (c) change and program implementation in teacher education programs. Studies in each of these areas were reviewed to establish the research base for the development of the formative evaluation system for technology teacher education programs.

Educational Program Evaluation

In a literature search for an applicable model for the evaluation of teacher education programs, Ayers, Gephart, and Clark (1989) reported "approximately 40 references to evaluation models" (p. 14). Stufflebeam and Webster (1980) identified and assessed 13 alternative evaluation approaches in terms of their adherence to the definition: "an educational evaluation study is one that is designed and conducted to assist some audience to judge and improve the worth

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of some educational object" (p. 6). Their analysis resulted in three categories of evaluation studies: (a) politically oriented, or pseudo evaluations; (b) question oriented, or quasi- evaluations; and (c) values oriented, or true evaluations. Stufflebeam and Webster addressed the strengths and weaknesses inherent in each evaluation approach in order to provide evaluators with a variety of frameworks for conducting evaluation studies.

However, as Popham (1975) noted, comparing evaluation approaches in order to select the best model is usually a fruitless endeavor. Popham stated:

> Instead of engaging in a game of "sames and differents," the educational evaluator should become sufficiently conversant with the available models of evaluation to decide which, if any to employ. Often, a more eclectic approach will be adopted whereby one selectively draws from the several available models those procedures or constructs that appear most helpful. (p. 21)

Cronbach (1982) echoed this need for eclecticism by noting that "the [evaluation] design must be chosen afresh in each new undertaking, and the choices to be made are almost innumerable" (p. 1). Indeed, an eclectic approach seemed most appropriate for the formative evaluation of the change to technology teacher education.

The review of the evaluation literature identified two approaches that could be combined to develop appropriate instrumentation and procedures. These were the Context, Input, Process, and Product (CIPP) Model originated by Stufflebeam et al. (1971), and the Discrepancy Model proposed by Provus (1971). These models have many commonalities. Both models:

1. Were conceptualized and developed in the late 1960s in response to the need to evaluate projects funded through the Elementary and Secondary Education Act (ESEA) of 1965.
2. Represented efforts to broaden the view of educational evaluation to include more than an assessment of the terminal objectives.
3. Emphasized the systems view of the education by stressing the relationship between context, inputs, processes, and products.
4. Emphasized the importance of collecting information on key developmental factors to aid decision-makers in assessing program progress at a given point (Brinkerhoff, Brethower, Hluchyj, and Nowakowski, 1983).
5. Were concerned with the developmental aspects of program design and implementation, and recommended close collaboration with program developers.
6. Have been used in a variety of evaluation environments (Roth, 1978; Provus, 1971; and Stufflebeam, et al., 1971), though they are not specifically designed for the evaluation of teacher education programs.

The CIPP Model. Bjorkquist and Householder (1990) noted that "programs in which goals are accomplished are usually considered to be effective"

(p. 69). In an overview and assessment of evaluation studies, Stufflebeam and Webster (1980) stated that the objectives-based view of program evaluation "has been the most prevalent type used in the name of educational evaluation" (p. 8). Indeed, prior to the ESEA, educational evaluation had focused upon "the determination of the degree to which an instructional program's goals were achieved" (Popham, 1975, p. 22). However, a group lead by Stufflebeam proposed an evaluation process that focused upon program improvement by evaluating virtually all aspects of the educational program. Stufflebeam (1983) stated:

> Fundamentally, the use of the CIPP Model is intended to promote growth and to help the responsible leadership and staff of an institution systematically to obtain and use feedback so as to excel in meeting important needs, or at least, to do the best they can with the available resources. (p. 118).

In short, the CIPP Model placed a premium on information that can be used proactively to improve a program.

Discrepancy Model. This model was developed to be put in place as the new programs were designed and implemented in the Pittsburgh public schools. A systems approach was used to determine whether program performance met accepted program standards. Provus (1971) conceptualized a three-step process of program evaluation: (a) defining program standards, (b) determining whether a discrepancy exists between some aspect of program performance and the standards governing that aspect of the program, and (c) using discrepancy information either to change performance or to change program standards (p. 183). According to Provus, this operational definition of program evaluation leads to four possible alternatives: (a) the program can be terminated, (b) the program can proceed unaltered, (c) the performance of the program can be altered, or (d) the standards governing the program can be altered (Popham, 1975).

The Discrepancy Model has five stages: (a) design; (b) installation; (c) process; (d) product; and (e) program comparison. Provus (1971) noted that, "at each of these stages a comparison is made between reality and some standard or standards" (p. 46). The first four stages are developmental in nature and designed to evaluate a single program. The fifth stage, which Provus designated as optional, provides information for making comparisons with alternative programs.

Merging the evaluation models. With the commonalities of the two models previously stated and the thoroughness of the CIPP Model reviewed, one might well ask why the two models should be merged. The answer lies in the complementing strengths of the two models. CIPP, with its use of both quantitative and qualitative procedures and its emphasis on proactive evaluation, provides an overarching evaluation model. Because of its thoroughness, it is also extremely expensive and time consuming. As Stufflebeam and Webster (1980) noted, values-oriented studies, such as CIPP, aimed at assessing the overall merit or worth of a program are overly ambitious "for it is virtually impossible to assess the true worth of any object" (p. 18). However, the CIPP model provides an excellent framework for approaching the multitude of possible variables in program evaluation.

What does the discrepancy evaluation model add to this customized assessment approach? Stufflebeam and Webster (1980) stated that question-oriented studies that focus on program objectives or standards "are frequently superior to true evaluation studies in the efficiency of methodology and technical adequacy of information employed" (p. 18). In particular, the discrepancy model championed by Provus adds three useful constructs to the evaluation process:

1. The broadening of the evaluation procedure to include the possibility of altering the standards to conform with reality. In light of the current emphasis on standards external to the program, such as National Council for Accreditation of Teacher Education (NCATE) criteria, this approach seemed particularly appropriate.
2. The emphasis upon high-fidelity implementation addressed major concerns in the change process.
3. The emphasis upon problem solving solutions to program performance alteration appeared to be consistent with the espoused philosophy of technology education.

Since technology teacher education programs are still largely in the implementation stage, assessments of their effectiveness could most profitably focus on discrepancies between the performances and standards that are concerned with the inputs and the processes of the technology teacher education programs. Taken together, it seems reasonable to consider an evaluation approach that focuses on input and process evaluation components as Stufflebeam uses the terms by comparing actual performance with defined standards.

Program Evaluation in Teacher Education

Few studies have related specific program evaluation approaches to the assessment of teacher education programs. Perhaps the dearth of references in the literature to specific evaluation approaches used in teacher education programs is the result of the emphasis placed on the accreditation of those programs. Accreditation procedures require that teacher education institutions periodically undertake systematic formative and summative evaluations. Taking this reality into consideration, Ayers, Gephart, and Clark (1989) proposed the Accreditation Plus Model that integrates the accreditation process and existing evaluation approaches. While focusing on the National Council for Accreditation of Teacher Education (1987) standards and criteria for compliance, the model suggests a process that is "active, continual, and formative" (p. 16).

The Accreditation Plus Model seems to be a logical extension of an already required practice. While this model was designed to be used for the evaluation of professional educational units, the process seems adaptable to the more specific evaluation concerns of technology teacher education programs.

Change and Program Implementation

Gee and Tyler (1976) suggested that "reasonable people will assume moderate risk for great benefits, small risks for moderate benefits, and no risk for no benefit" (p. 2). While this statement makes explicit the personal nature of the change process, organizational characteristics are also important factors in facilitating change. Hopkins (1984) argued that the nature of the educational organization itself is a major impediment to change. He noted that in spite of considerable external pressure for change in teacher education, there were few observable differences in the routines of professors and students. Hopkins made the provocative suggestion that "teacher training institutions as organizations appear unable effectively to manage self-initiated change" (p. 37). Giacquinta (1980), even less charitable, suggested that schools of education find that "change is a necessary, often bitter pill taken for the sake of survival" (Hopkins, 1984, p. 43). These opinions seem to be shared by several state legislatures which have recently mandated changes in teacher education requirements and practices.

A Model for Organizational Change

A model of the innovation-decision process in an organization, developed by Rogers (1983), focuses on the process of adoption, implementation, and the incorporation of the innovation into the organization. The five steps in the model are divided into two stages: initiation and implementation.

Initiation Stage. During this stage, organizational activities center around the information-gathering, conceptualizing, and planning that is required to make the decision to change. The two steps included at this stage are: (a) agenda setting, where the initial idea search occurs and the motivation to change is generated; and (b) matching, where organizational problems and possible solutions are analyzed for compatibility.

The initiation stage is essentially a problem solving exercise. As the organization becomes cognizant of a performance shortfall, it initiates a search of the environment for possible solutions to the problem. For example, industrial arts programs were generally faced with declining enrollments. At the same time, many studies cited the need for students to possess increased scientific and technological literacy. In response, the field started to focus on technology education as an emergent solution to both problems.

Implementation Stage. The second stage, implementation, begins after the decision to make the change has been made by the organization. This stage includes the decisions, actions, and procedures involved in putting an innovation into regular use. The implementation stage includes three steps: (a) redefining/restructuring the innovation and the organization to accommodate the change; (b) clarifying the innovation as it is put into regular use; and ultimately (c) routinizing or institutionalizing the change as an integral part of the ongoing activities of the organization.

According to Rogers (1983) each step is "characterized by a particular range of events, actions, and decisions" (p. 362). Further, the latter steps cannot occur until the issues in the earlier steps have been resolved. Citing the work of Pelz (1981) as a source of support for the model, Rogers noted that innovations imported into an organization "usually occur in the time-order sequence" (p. 366). However, innovations that originated within an organization are not characterized by a similarly clear pattern of adoption. Since technology teacher education programs are currently changing in an attempt to meet largely external innovations (NCATE accreditation standards and state certification requirements), it appears that the time-order sequence is expected to apply. The linear nature of the innovation-decision model highlights the need to nurture the change to technology teacher education throughout the stages of the entire change process.

Summary

In light of the review of literature and the specific goals of this research effort, the decision was made to develop an evaluation design incorporating an eclectic mix of program evaluation approaches, the NCATE accreditation process, and descriptions of the process of change as that process may be expected to occur in teacher education organizations. Stufflebeam's CIPP Model provided an overall framework from which to assess the effectiveness of change to technology teacher education. Provus's Discrepancy Model added the possibility of adjusting the measurement standards to conform to program performance reality. And, because accreditation is an overarching evaluation concern for teacher education, the Accreditation Plus Model suggested a way of integrating program evaluation and accreditation. Further, because technology teacher education programs are presently in the early implementation stage, measures that reflect the process of change seemed to be appropriate for inclusion.

Procedures

A modified Delphi design was used in this study. Nominations of leading practitioners and advocates in technology education who might serve as Delphi panelists were solicited from officers of the Council on Technology Teacher Education and the International Technology Education Association. This process resulted in the selection of a panel comprised of the 22 individuals who were recommended by at least two of the CTTE or ITEA officers.

On an open-ended questionnaire, panelists were asked to suggest criteria and procedures for evaluating the effectiveness of the change from industrial arts teacher education to technology teacher education programs. Fourteen panelists returned the first round questionnaire. The reponses were tabulated, duplications were eliminated, and similar suggestions were combined. This process resulted in a list of 58 criteria and 33 procedures for evaluating the effectiveness of the change to technology teacher education. The criteria were sorted into four categories: (a) the technology teacher education program, (b) faculty members, (c) student skills, and (d) capabilities of graduates.

The second round questionnaire asked the 22 panelists to rate the importance of the 58 criteria and 33 procedures on a scale which ranged from 0 to 10. The instructions defined a rating of 0 as a recommendation that the criterion or procedure be dropped. A rating of 10 meant that the criterion or procedure was considered to be absolutely vital to the assessment of the effectiveness of the change to technology teacher education. Panelists were asked to offer editorial suggestions on the statements of criteria and procedures and also to suggest additional criteria and procedures (and to rate any additional statements).

Eighteen of the 22 second round questionnaires were returned promptly. The responses were tabulated and the mean rating of importance for each item was calculated. The statements of criteria and procedures were then listed in order of their mean rating of importance. The ranked listings for each criterion with a mean value greater than 9.0 on the 10 point scale are included in Table 1.

Table 1
Highly Ranked Criteria and Procedures Sorted by Category

Mean	Criteria and Procedures
Technology Teacher Education Program ...	
9.55	Laboratory instruction provides opportunities for students to reinforce abstract concepts with concrete experiences.
9.50	Instructional strategies emphasize conceptual understanding and problem solving.
9.23	Professional studies component emphasizes the study of technology, including social-cultural affects.
9.22	Laboratories facilitate the learning of broad based technological concepts.
9.22	Instruction incorporates current technological activities.
9.17	Philosophy, mission statement, goals and curriculum emphasize technological skills rather than technical skills.
9.17	Social-cultural impacts of technology are emphasized.
9.12	Field experiences are technology centered.
9.05	Problem solving and decision making abilities are emphasized.
9.00	Curricula are based on recent research findings.
Faculty Members ...	
9.50	Display a positive attitude toward the technology teacher education curriculum.
9.22	Participate in planned professional development activities to update their knowledge and skills.
9.05	Communicate their understanding of the meaning and impli-

cations of technology education both within and outside the classroom.

Students are expected to ...

9.78	Be people oriented.
9.44	Be future oriented.
9.39	Demonstrate the ability to teach problem solving techniques.
9.33	Effectively plan and implement technology education in grades 5-12.
9.28	Develop and implement curriculum material that reflect a broad technological system area.

Table 1 (cont.)

9.28	Demonstrate an awareness of society's reliance on technological systems.
9.22	Plan and implement teaching-learning activities.
9.17	Use a vocabulary that reflects the concepts of technology education.
9.11	Apply current instructional theory.
9.06	Formulate appropriate objectives.
9.05	Be open to change and willing to initiate change.
9.05	Consider global perspectives in technology education.
9.00	Demonstrate a basic understanding of tools, machines and process and their applications in manufacturing, construction, communication, and transportation.
Graduates of the technology teacher education program ...	
9.78	Employ a philosophy which reflects a technological base.
9.61	Teach concepts and use teaching techniques that are technology based.
Procedure Statements ...	
9.50	Examine the curriculum to determine if the philosophy, definition, mission statement, goals and objectives, course content, and learning experience reflect technology education.
9.22	Analyze the courses required in the program, the content contained in each of the courses, teaching strategies and methods, assignments, tests, and student field experience to determine if they reflect technology education.

Developing the Technology Teacher Education Checklist (TTEC)

An initial review of the listing of criteria and procedures identified by the panelists in this research suggested many parallels to the NCATE approved curriculum guidelines as specified in the *Basic Program in Technology Education* (1987). The intent of this investigation was not to duplicate the NCATE assessment process, but to identify essential elements in the implementation of technology teacher education that would serve as key indicators of the effectiveness of the change from industrial arts teacher education. In order to concentrate the assessment effort, therefore, criteria were selected for inclusion in the measurement instrument if they were:

1. Highly ranked within their criteria category but not addressed by NCATE curriculum guidelines;
2. Correlated to NCATE curriculum guidelines for technology teacher education and distinctly different from usual practices in industrial arts teacher education; or
3. Considered to be essential to support the process of organizational change.

Other suggested items were not included in the TTEC because they were measurements of program outcome, such as performance of program graduates. These items were excluded from the measurement instrument since technology teacher education is in the implementation phase, a stage when Hall and Hord (1987) noted that "interpreting any outcome data is extremely risky" (p. 343).

Further, the procedures proposed for this formative evaluation design were purposely limited by the following criteria:

1. The time required for on-site data collection by the external evaluator(s) should not exceed two observer-days.
2. With the exception of interviews and classroom and laboratory observation sessions, the data gathering should not require additional faculty time.
3. Existing data should be used whenever possible.
4. Data gathering should not seriously disrupt on-going instructional activities.

In this way, the evaluation may be conducted in a reasonable time with a minimum of disruption to departmental activities.

Verification of the TTEC

In order to verify the measures selected for inclusion in the checklist, a draft of the TTEC was sent to the panel for editorial suggestions and additional comments. Sixteen of the twenty-two panelists responded. Most respondents suggested editorial revisions or made other comments. Careful consideration was given to these suggestions as revisions were made in the TTEC. The TTEC, revised to incorporate suggestions from panelists, is reproduced below.

Technology Teacher Education Checklist

1. Examine the catalog, a sample of curriculum documents, and a sample of course syllabi to verify the degree to which:
   a. The philosophy, mission statement, and goals and objectives of the program reflect the definition(s) of technology education suggested by ITEA, CTTE, and relevant groups in the state/province.
   b. Study is required in technological systems such as communication, production (construction and manufacturing), transportation, and biotechnology.
   c. Courses in mathematics, science, and computing science are required.

   d. Required full-time student teaching and early field experiences are conducted in an exemplary technology education setting.
   e. Required reading lists provide comprehensive coverage of technology and technology education.
   f. Learning activities and experiences are representative of technology education.
2. Interview the department head with regard to the change to technology teacher education to discern the degree to which:
   a. Funding is adequate to support the current technology teacher education program and plans are in place for periodic replacement and upgrading of facilities and equipment.
   b. Faculty and staff allocations are adequate to serve student enrollments in technology teacher education.
   c. The written departmental plan for faculty professional development and technological updating is adequate to prepare faculty members for contemporary technology teacher education.
   d. Enrollments in the major are adequate, stable, or increasing.
   e. The written departmental implementation plan for technology teacher education addresses the process of organizational change.
   f. Faculty are committed to the philosophy and objectives of technology education.
3. Interview faculty members and review recent annual reports, biodata information, faculty publications, copies of presentations, and manuscripts being considered for publication to verify whether:
   a. Faculty are writing scholarly papers, developing instructional materials, and giving presentations about technology education.
   b. Current faculty research and service activities are directed toward topics and issues in technology education.
   c. Faculty are actively involved in professional organizations in technology education.
4. Observe professional and technical classes to discern the degree to which:
   a. Instructional methods emphasize technological problem solving and decision-making.
   b. Instructional materials reflect contemporary technology.
   c. Major elements of technology education (e.g., systems, environmental and social impacts, and the applications of technological devices) are emphasized in the course activities.
5. Inspect laboratory facilities to ascertain the degree to which:
   a. Laboratories are adequate for effective instruction.
   b. Equipment and space provide students adequate opportunities for experiences in state-of-the-art applications of technology (e.g., CAD/CAM, CIM, robotics, desk-top publishing, lasers, table-top technology, hydroponics).
6. Interview students, and examine student logs and required student work to discern whether:

   a. The elements of technology education are understood and integrated into their total philosophy of education.
   b. They are active in a TECA chapter.
   c. The problem solving process and decision-making rationale are incorporated into grading.
   d. Environmental consequences and social-cultural effects of technology are reflected in student activities.
7. Interview chairs of related departments and administrators (dean, provost, or president) to ascertain the degree of philosophical support that is provided for technology education.
8. Listen to conversations and discussions and observe student activity to discern the degree to which:
   a. The terminology used by faculty and students reflects technology and technology education.
   b. Faculty and students appear to be enthusiastic about technology education.
9. Interview principals who have experience with student teachers and graduates of the technology education program to discern whether the program prepares professionals to:
   a. Plan and implement technology education.
   b. Use problem solving strategies.
   c. Apply current instructional theory.

Using the Instrument

Jordan (1989) began a discussion of evaluation and change by reminding practitioners that:

> One of the axioms of measurement is that assessment is not an end in itself. We evaluate because we wish to know the current state of affairs, but we wish to do that in order to make improvements. Exactly how we wish to improve depends on what we discover. In theory, the process is circular and unending. That is, we should assess and make improvements and then assess the improvements. (p. 147)

With this interaction between evaluation and change in mind, there are several possible ways of using the instrument developed through this research. Perhaps the simplest use would be for an internal or external evaluator to use the instrument as a checklist of what has been accomplished and what is in progress (or still to be initiated). Two more complex uses may include determining if the innovation is in place and using force field analysis to determine sources of resistance.

Determining if the Innovation is In-Place

Hord, Rutherford, Huling-Austin, and Hall (1987) proposed that before assessing program outcomes it is first necessary to determine that the innovation is in fact in place. They indicated two ways of making that determination: (a) first, the level of fidelity of the actual implementation of the innovation can be compared with the intended innovation, and (b) second, the actual levels of use can be determined. Hord et al. proposed that each innovation has essential and related components. The essential components cannot be changed without undermining the nature of the innovation itself. The related concepts allow for local flexibility and, while varied, are still faithful to the innovation design. Hord et al. suggested that assessment of fidelity can be made by developing a checklist that outlines ideal, acceptable, and unacceptable variations of the innovation. In technology teacher education programs, many of the criteria identified through this research may serve as the “essential” components.

The second measure proposed by Hord et al. (1987) to determine whether or not the innovation is actually in place is an assessment of the six levels of use. These levels range from Level of Use 0 (nonuse) to Level of Use VI (renewal) where the “user reevaluates the quality of use of the innovation, seeks major modifications of or alternatives to, present innovation to achieve increased impact on clients, examines new developments in the field, and explores new goals for self and the organization” (p. 55). By using the TTEC to identify the essential components of the change to technology teacher education, an assessment of levels of use from the perspective of the faculty may be an important step in measuring the effectiveness of the change and planning further intervention strategies.

Force Field Analysis

Lewin (1951), the originator of field psychology, proposed that change is the result of competition between driving and resisting forces. Lewin's conceptualization has been adapted to describe the dynamics of a number of management situations in organizational change. Daft (1988) stated that:

> To implement a change, management should analyze the change forces. By selectively removing forces that restrain change the driving forces will be strong enough to enable implementation. . . . As restraining forces are reduced or removed, behavior will shift to incorporate the desired changes. (p. 313)

Miller (1987) suggested that force field analysis could be used to nurture a climate receptive to innovation and creativity. Miller stated:

> The primary function of the force field in idea generation is to present three different stimuli for thinking of new options or solutions. Because the field represents a kind of tug-of-war, there are three ways to move the center line in the direction of the more desirable future:
>
> 1. Strengthen an already present positive force.
> 2. Weaken an already present negative force.
> 3. Add a new positive force. (p. 73)

If these two ideas are taken together, a picture emerges of how force field analysis and the instrument designed through this research could be applied to the transition from industrial arts teacher education to technology teacher education. First, each criterion could be assessed to determine its relative strength as a driving force for change. Additionally, forces unique to the particular implementation may be identified and dealt with. Second, the information generated through the assessment could be used to strengthen the implementation procedures. In this way, the instrument may serve as a game plan for implementation and continued assessment of the change.

Implications

The Technology Teacher Education Checklist, which was the primary outcome of this research, should be useful to the faculty of a technology teacher education program or to an external evaluator in conducting formative or summative assessments of the change to technology education. While its use requires minimal duplication of the NCATE approval procedures, the items in TTEC focus upon key indicators of effective change to technology teacher education. The TTEC might be especially useful in a review of a technology teacher education program, a year or two in advance of the preparation of a curriculum folio to be submitted for consideration for NCATE approval.

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