Materials Development and the ATE Program

Gloria Rogers[1]

The Evaluation Center
Western Michigan University
Kalamazoo, MI 49008-5237

Fall 2001[2]

[1] Dr. Gloria Rogers is Vice President for Institutional Research, Planning and Assessment at Rose-Hulman Institute of Technology. She has been an external evaluator for the ATE center, the "National Center of Excellence for Advanced Manufacturing Education" at Sinclair Community College, and a project, "Building A National Employer-based Technical Education System" administered by Educational Development Center, Inc.
[2] Edited by the WMU Evaluation Project, January 2002.

Materials Development and the ATE Program
Executive Summary

The development of high-quality materials to support the delivery of curricula and promote educational change is critical to the goals of the National Science Foundation (NSF) Advanced Technological Education (ATE) program. Several curriculum development models were reviewed and adapted into a comprehensive framework to guide the development and assessment of high-quality materials under this program. The framework indicates that high-quality materials should:

- Reflect the results of a formal needs analysis
- Be industry verified
- Reflect learning goals and objectives
- Be developed/adapted as a part of a systematic curriculum development process
- Support and identify instructional strategies including pedagogy and assessment
- Undergo pilot and field-testing
- Be continuously evaluated
- Be revised based on evaluation evidence

In the analysis of survey results and site visit reports provided by the Western Michigan University (WMU) evaluation project, there was not ample evidence to make a general judgment of the status of materials development for the ATE program using this framework. In some instances, there was no data available, and in other cases, the evidence was too vague to justify interpretation. Conclusions reached include:

1. Materials developed focused primarily on course and/or module development.
2. Although content experts were generally consulted in the identification and/or verification of skills that were the focus of the materials, there was little evidence that they were involved in the evaluation of the materials after their development.
3. There was only some evidence that professional curriculum designers and/or a systematic curriculum development process was used in the development of materials.
4. Although 14 percent of the materials have been commercially published, most of the materials had not been disseminated beyond the *project*.
5. *Project* personnel generally judged the effectiveness of materials developed based on anecdotal or indirect measures and not direct measures of student learning through pilot and field-testing.
6. Generally, grantees fell considerably short of their goals for production of materials.
7. There was little evidence that sites were using external standards of best practice for the development of materials in either print or digital format.

Based on the search of the literature, survey results, and site visit reports; the following recommendations are made to improve the outcomes of the ATE program related to materials development:

1. Those submitting proposals to the ATE program that have materials development as a focus should be directed to (or NSF should provide) resources identifying best practices in the development of high-quality text and digital materials.
2. The review criteria for funding should require that materials development proposals show an understanding of the processes required for the development of high-quality materials and that the budget and time line are realistic for the deliverables indicated.
3. The current reporting process for funded *projects* should be revised to include reports on the materials development processes included in the framework provided for best practice. This information will encourage accountability and reinforce the need to use best practices. It will also provide NSF with the data needed to assess the overall effectiveness of ATE funding in producing high-quality materials.
4. NSF should provide workshops for ATE *projects* that have materials development as one of their primary objectives.

Materials Development and the ATE Program

Introduction to Materials Development

This issue-oriented paper was written to provide a framework for the development of high-quality curriculum materials that can serve as a guide for those who are considering developing a proposal to the ATE program[3] and to guide NSF in the review of proposals and evaluation of funded *projects* (i.e., projects and centers). To accomplish this, a review of relevant literature and an analysis of the current ATE *projects* survey and site visit reports was made. General observations and recommendations for improvement are included in the paper.

Review of the Literature

Current ATE program focus on materials. The ATE program makes two types of grants: projects and centers. Projects are generally smaller grants, shorter in duration, and more focused on one or more ATE program tracks (curriculum and educational materials development, professional development for educators, technical experiences, laboratory development, and dissemination). Centers are more comprehensive than projects and are funded for a longer duration of time. There are two types of centers: National Centers of Excellence and Regional Centers for Manufacturing or Information Technology Education. The ATE proposal solicitation states that National Centers for Excellence "must have a national impact" and typically engage in the full range of activities associated with the projects. It explicitly states that Centers of Excellence "are expected to develop high-quality educational materials, courses, and curricula; to provide professional development for educators to support the utilization of these resources; and to disseminate their products through commercial publishers, journals, conferences, workshops, electronic networks, and other means."[a] In relation to educational materials, ATE guidelines indicate that Regional Centers should undertake activities that address, "academic program reform, such as using industry and skill standards and other input from industry in program development, adapting and implementing exemplary educational materials and practices developed elsewhere . . . "[b]

The convention of using the italicized *projects* will be used in this paper to refer to all funded activities (both projects and centers). The term projects (unitalicized) will be used to refer to the smaller grants, and centers will refer to the larger, comprehensive grants.

The ATE program's central goal is "producing more science and engineering technicians to meet workforce demands, and improving the technical skills and the general STEM preparation of these technicians and the educators who prepare them."[c] It is designed to promote improvement in the education of science and engineering technicians at the undergraduate and secondary school levels. Activities that are eligible for funding include, "the design and implementation of new educational materials, courses, laboratories, and curricula; the adaptation of existing exemplary educational materials, courses and curricula in new educational settings; . . . and the broad dissemination of exemplary educational materials and pedagogical strategies that have

---

[3] Please see the attached overview document (*The ATE Program: Issues for Consideration)* accompanying this paper for a detailed description of this program and its evaluation.

been developed and previously funded ATE awards."[d] The NSF-ATE guidelines encourage proposals that will produce educational materials that can be used beyond the grantee institution. Proposals are also encouraged that adapt and implement "high-quality" educational materials that have been developed by previously funded *projects*.

In the program description for those *projects* that have indicated that materials development was a focus, the following guidelines are given:

> Proposed activities should affect the learning environment, course content, and experience of instruction for students preparing to be science and engineering technicians. Projects often result in textbooks, laboratory experiments and manuals, software, CD-ROMs, videos, and other courseware. Such products are expected to be field-tested in diverse locations and widely disseminated through commercial publishers, conferences, workshops, electronic networks, journal articles, and other means. Educational materials and curricula that offer student innovative, high-quality learning experiences through distance education are encouraged. A project's focus may range from the adaptation of existing educational materials to the creation of entirely new ones; from a few modules at a single educational level to a comprehensive curriculum for multiple years; and from a single subject to the integration of several disciplines.[e]

The guidelines allow for a range of materials development efforts—from materials that are developed for local use only for program improvement with limited dissemination to materials that are developed for commercialization with broad dissemination. The review criteria developed by NSF for the evaluation of proposals includes criteria related to materials development. In particular, reviewers are asked to consider, "What is the potential for the project to produce widely used products that can be disseminated through commercial or other channels? Are plans for producing, marketing, and distributing these products appropriate and adequate?"[f]

Evolution of NSF-ATE proposal guidelines. An analysis of the NSF-ATE 1994-2001 proposal guidelines was done to determine whether or not the guidelines had changed over time with regard to the emphasis on materials development and the review criteria for proposals. It was found that the guidelines related to materials development were unchanged from 1994-1996. In 1997, the general review criteria for proposals were changed to add, "What is the potential for the project to produce widely used products through commercial or other channels?" This was the only criterion that had direct reference to the production of "products" that would include materials. In 1998, there was a change in the wording of the guidelines for projects. From 1994-1997 the guidelines stated,

> Of particular interest are projects that are designed to produce major changes and significant improvement beyond the recipient institution and which will produce materials used regionally or nationally.

In 1998 and 1999, this wording was changed to read,

> Projects must produce major changes and significant improvement beyond the recipient institution and produce materials used nationally.

This change reflects a shift from encouraging projects to requiring projects to produce materials for use beyond the local setting.

The 2000 guidelines omitted the above wording and were changed to reflect the longevity of the ATE program and the need to encourage others to adapt and implement "high-quality materials" that had already been developed under the ATE and other programs. The "adaptation and implementation" section of the guidelines encouraged projects that involved an innovative use or extension of these materials in a setting different from the one in which they were created. This included the adaptation and field-testing of existing materials. The guidelines also encouraged proposals that would take materials that were developed for use in one technical field and adapt and implement them in a different technical field. A new category of awards was also added in 2000 that was focused on "articulation partnership." Among other things, projects funded under this category were encouraged to develop or adapt "high-quality STEM educational materials, courses, and methods for use in two-year college courses that serve prospective teachers."

The review of guidelines reflected a progression of expectations and goals of the ATE program. In the beginning, projects were encouraged to develop "high-quality" materials for dissemination. In 1998-1999, the guidelines for projects were changed to read, "must . . . produce materials used nationally." In 2000, after six years of funded *projects*, the guidelines were again changed to encourage proposals that took advantage of materials already funded under the NSF-ATE and other programs through adaptation and implementation in new settings.

Materials development defined. The ATE driver "materials development" is defined as the preparation, adaptation for implementation and/or testing of one or more courses, modules, process models, and/or other instructional or assessment units.[g] Materials are curriculum products that result from curriculum development processes and provide the bases for instructional decisions.[h] From this perspective, the products or materials are the artifacts of the curriculum development process and reflect the decisions made throughout the process.

Curriculum materials, curriculum processes, and educational change. Educational materials are the primary media by which curriculum is documented and disseminated. A discussion of curriculum is essential to understand the materials development process. What defines curriculum is not easily answered. Henson cites 13 different definitions of what comprises the concept of "curriculum." All of the definitions reviewed have in common the fact that each reflects values and beliefs about the focus of the educational process and the needs being served.[i] Taba offers two definitions of curriculum:[j]

> Curriculum is a plan for learning.
>
> A curriculum usually contains a statement of aims and of specific objectives; it indicates some selection and organization of content; it either implies or manifests certain patterns of learning and teaching, whether because the objectives demand them or because the content organization requires them. Finally, it includes a program of evaluation of the outcomes.

English defines the curriculum as, “the work plan or plans developed by or for teachers to use in classrooms by which the content, scope, and sequence of that content, and to some extent the methodology of their teaching, is defined and configured.”[k] His definition is derived from a historical context where the word “curriculum” was synonymous with texts. He views curriculum as a document of some sort that focuses and connects the work of the classroom teacher.

In addition to the components of curriculum mentioned in the definitions above, curriculum must also meet the needs of those it serves. One variable in curriculum development that complicates the process of development is the complex and forever changing environment within which it occurs. To be effective, the curriculum needs to be flexible to adapt to the changes in society at large, the local community, and the students themselves.[l] The inability to adjust to these changes renders the curriculum ineffective to meet the needs of those it serves.

The development of curriculum materials is an integral part of the curriculum development and educational change processes. Curriculum processes are those procedures involved in creating, using, and evaluating the curriculum that is represented in various products or materials. These materials may include syllabi, curriculum guides, courses of study, resource units, lists of goals and objectives, texts and other documents that deal with the content of the education.[m] To evaluate the products or materials generated by the curriculum process, it is important to understand the steps taken in the systematic development of curricula. If materials generated are the products of a systematic curriculum process that is validated by a model for curriculum design, the likelihood that the materials will be of high quality is greatly enhanced.

Curriculum development is also a vehicle for educational change.[n] The ATE program promotes both innovation and adaptation for improvement and is designed to effect change in the scope and quality of technician education. Developing and disseminating high-quality educational curriculum materials is one of the mechanisms funded to promote this change.[o]

Educational change as used here is consistent with the definition employed by Bridges.[p] He makes an important distinction between “change” which is external to the individual and “transition” which is an internal or a psychological process. Curriculum materials are the vehicle for transporting the curriculum to the classroom teacher and student and should be designed in such a way as to effect the desired change in instruction and learning by enhancing the likelihood that the users of the materials can transition smoothly from the old curriculum to the new.

Materials also inform the multiple stakeholders in the educational process of the focus and scope of intended educational outcomes. Stakeholders in the ATE program should be able to examine the materials produced and identify instructional processes and the knowledge and skills that the intended target group is expected to achieve through the use and/or application of the materials.

The development of a framework to evaluate materials produced under the ATE program needs to take into consideration that not all materials that are developed under this program are designed to be commercialized and broadly disseminated. However, if the funded *project* has identified “materials development” as an area of focus, there should be an expectation that they will meet the criteria stated in the ATE program guidelines referred to earlier.

To establish a framework that can be used to guide and evaluate the educational materials development process, several curriculum models were reviewed. The purpose of the curriculum models is to describe a set of logical relationships that link together relevant features of the curriculum development process. These models are useful in the planning and evaluation of the effectiveness of curriculum materials. One model is a curriculum model that was chosen from several general models that ranged from simple to complex in their organization. Oliva's curriculum model was chosen because it is comprehensive and often cited by experts. [q,r] This model is compared to the "Systematic Curriculum and Instructional Development (SCID)" model. [s] The SCID model was developed to incorporate the critical tasks needed to develop competency-based education (CBE) curriculum and instructional materials for workforce training. The SCID model is the basis for the DACUM (Developing A Curriculum) process that has been utilized in several of the ATE *projects* to analyze job or occupational skills needed for expert workers.[t] The general model and the SCID model are compared in Table 1. This table identifies the common elements essential to the curriculum development process that can inform the development of a framework for the analysis of the materials development objective of the ATE program.

To facilitate the comparison, the Olivia model was placed in the left-hand column and the SCID model was mapped across to the right column. The purpose of the SCID model is more focused on workforce training and includes more detailed steps, whereas the Olivia model has fewer steps that encompass more than one step in the SCID model. The only significant element that was not comparable in the two models was that the Olivia model contains the need for an explicit statement concerning the aims and philosophy of education (including beliefs about learning).

Table 1. Comparison of Curriculum Development Models

Olivia Model	SCID Model
1. Statement of aims and philosophy of education, including beliefs about learning	
	1. Curriculum analysis
2. Specification of needs	a. Needs analysis
3. Specification of curriculum goals (long term, attainable)	b. Job analysis
4. Specification of curriculum objectives (ability of student to perform selected tasks, measurable)	c. Task verification
	d. Selection of tasks for training
	e. Standard task analysis (identification of performance steps and decisions, essential knowledge, industry standards, etc., needed to develop accurate and relevant teaching and learning materials.)
	f. Literacy task analysis–optional (knowledge category broken down appropriate skill set—communication, mathematics, science, computer, and decision-making.)

Olivia Model	SCID Model
5. Organize and implement the curriculum; formulate and establish the curriculum structure	2. Curriculum design (based on information collected in phase 1)
8. Choice of educational strategies or delivery systems	a. Determine training approach
	b. Development of learning objectives
	c. Development of performance measures
	d. Development of training plan
	3. Instructional development
6. Specification of instructional goals for each level and/or subject	a. Development of a competency profile (competency-based programs) or develop a curriculum guide (for traditional programs)
7. Specification of instructional objectives for each level and/or subjects	b. Development of learning guides/modules (competency-based programs) or lesson plans (for traditional programs)
	c. Development of supporting media
	d. Pilot test and revise the materials
9a. Preliminary selection of evaluation techniques	
	4. Training implementation
10. Implementation of instructional strategies	a. Implement the training plan (bring together resources)
	b. Conduct the training
9b. Final selection of evaluation techniques	
11. Evaluation of instruction 12. Evaluation of curriculum	c. Conduct formative (in-course) evaluation of students and instructor performance
	d. Document training (student achievement and instructor performance)
	5. Program evaluation
	a. Conduct summative evaluation
Feed back results to improve curriculum and instruction[u]	b. Analyze and interpret information

Each of the curriculum development models emphasizes the importance of needs analysis, specification of goals and learning objectives, curriculum design based on needs analysis and goals, development of appropriate instructional strategies, formative and summative evaluation, and improvement of the curriculum based on evaluation evidence. Each of the components of the curriculum development process should be reflected in the curriculum materials. Based on the models cited and the ATE focus on technician training, the checklist below illustrates the necessary components for the development, implementation, and improvement of effective, high-quality educational (curriculum) materials. For the development of high-quality materials to support the curriculum development process, materials should:

1. Reflect the results of a formal needs analysis	✓
2. Be industry verified	✓
3. Reflect learning goals and objectives	✓
4. Be developed/adapted as a part of a systematic curriculum development process	✓
5. Support and identify instructional strategies including pedagogy and assessment	✓
6. Be pilot and field-tested	✓
7. Be continuously evaluated	✓
8. Be revised based on evaluation evidence	✓

The elements of the checklist are described below:

1. *Reflect the results of a formal needs analysis.* Educational materials should be developed based on the needs identified by the appropriate stakeholders. In most cases, the needs are identified by the industry partners for whom the technician training is targeted. In some incidences, needs analysis might also refer to analyzing the strengths and weaknesses of the current curriculum or anticipation of future needs for technical preparation.
2. *Be industry verified.* The context of the materials should reflect industry practice, and the competencies contained in the materials should be consistent with the needs for technicians in high technology fields and be reviewed and validated by the industry partner. The materials should anticipate the needs of industry and not only reflect industry practice. Industry shifts more quickly than materials can.
3. *Reflect learning goals and objectives.* Learning goals and objectives should be clearly articulated and measurable.
4. *Be developed/adapted as a part of the curriculum development process.* There has been a formal, systematic curriculum development process followed in the preparation of the educational materials.
5. *Support and identify instructional strategies including pedagogy and assessment.* Educational materials should include instructional and assessment strategies that can be utilized in delivering the curriculum. The relationship among materials, pedagogy and assessment is complex and the educational materials developed need to carefully consider all three and their alignment.
6. *Be pilot and field-tested.* Materials are validated for understanding, appropriateness for multiple users, and effectiveness in promoting learning locally and at selected test sites before publication and general dissemination.
7. *Be continuously evaluated.* Processes are in place to evaluate materials on an on-going basis during the implementation phase.
8. *Be revised based on evaluation and research evidence.* Formative evaluation is conducted throughout the development process, and evaluation findings are regularly used to guide creation and revisions of the materials. Additionally, research should be undertaken on how the materials are working in terms of teacher understanding, student learning. Industry should play an important role in validating the outcomes of the materials

Although the depth of these processes may vary from those *projects* developing materials that are expected to have broad impact through dissemination and/or commercialization and *projects* developing materials primarily for local use or for use within the *project* (e.g., program improvement), the breadth of application of the processes on the checklist should be addressed in some way in all materials development.

State of the ATE Program Related to Materials Development: Survey Results[v]

A review of the current state of the ATE program was done by examining the results of the 2001 ATE survey developed, with input from NSF, by the Western Michigan University (WMU) evaluation project at The Evaluation Center. Eighty-one *projects* participated in the survey (70 projects and 11 centers), and 75 *projects* (64 projects, 11 centers) or 93 percent responded to the survey. All *projects* sampled had been active for at least one year. Ninety-six percent of the 2001 sample was also sampled in 2000. Respondents were asked to complete the "Materials Development" section of the survey if the development of materials was a focus of their *project*. Sixty-two *projects* (83%) completed the materials development section of the survey. The length of time the *project* had been in existence was not taken into consideration in the analysis other than that they all had been in existence at least one year. The materials development section of the survey focused on four dimensions: (1) type of materials developed, (2) stage of development, (3) category of usage, and (4) indicators of quality. Results of each of these will be discussed separately.

Type of materials and stage of development. Respondents were asked to indicate the type of materials developed. Types of material were classified as (1) course, (2) course adaptation for implementation, (3) module development, and (4) other. Course adaptation refers to a major revision of an existing course for implementation. Module development is a component that can be used in more than one course. The "other" classification was comprised of materials developed that were not discipline specific (e.g., cooperative learning, diversity). The stages of development were: (1) draft stage, (2) being field tested, and (3) completed. A total of 3,969 materials were reported in these three categories (not mutually exclusive). Of this total, 36 percent of the responses were in the "draft" category. Forty percent of the responses were in the "field test" category with the remaining 24 percent being in the "complete" category.

Because the "being field tested" category is not mutually exclusive from the "draft stage" category, the categories "draft stage" and "completed" were combined to give a closer estimate of the total number of materials being developed. Table 2 indicates the total numbers reported to be in draft or complete stages and the percent of contribution the centers and projects made toward the total.

Table 2. Types of Materials and Stage of Development

	Total Reported in Draft or Complete Stage	Center % of Total	Projects % of Total
Courses	475	39	61
Course adaptation	177	36	64
Modules	1,617*	75	25
Other	106	4	96
*Note: One center reported 720 modules in the draft stage of development. The average number of modules reported by the 9 other centers was 23. If this number were substituted for the 720 to try to correct for the outlying number, the percentage of modules in draft or complete stage would be Centers: 56% and Projects: 44%.			

Category of usage. The survey asked respondents to indicate how the materials developed were being used in terms of their target audiences. The use of the materials developed was classified in three ways: (1) local use—materials that were developed to support program improvement and were used within the *project*, (2) elsewhere—materials used at sites that were not a part of the *project*, and (3) commercially published. These classifications were not mutually exclusive. The survey results indicate that the majority of materials developed are used locally, and few have been commercially published. More than 1,700 of the materials were reported in use at least locally. If one presumes all materials developed will be used at least on a local basis, then 35 percent of this total was used at sites other than the *projects*, and 14 percent were commercially published.

In order to better understand the target audiences for the materials developed, respondents were asked to provide information for up to 5 of the most important materials they developed or were developing. Sixty-two *projects* provided one or more examples of materials development. Respondents provided information on 190 incidences of material development: 76-course development, 10-course adaptation, 72-course modules, and 32-other. Approximately 80 percent of the developed materials were targeted at the associate degree level, and the materials represented 17 discipline areas. Of the 190 products reported, 18 percent were prepared for K-12, 44 percent for first-year college, 36 percent for second-year college, and 2 percent for upper-level college.

Quality of materials development work. The status report to NSF (2001 survey results) points out that the measures of quality chosen can serve only as proxies for evidence of quality. The survey focused on validation practices on the assumption that good practices are likely to lead to good products. The quality measures identified are consistent with elements of the materials development framework described above. The survey focused on three measures of material quality:

1. Use of industry or other relevant standards as a guide to the development of materials
2. Measures of student success
3. Extent to which the materials were tested both for development and validation purposes

Two items were used as indicators of use of industry or other standards as a guide to materials development:

1) Verification by industry regarding alignment of materials with workforce and skill needs.
2) Use of applicable student and industry-based standards or guidelines to guide materials development.

Respondents were asked to indicate the frequency with which they used each measure. The response categories were each time, most times, less than half the time, almost never or never, and not applicable. The results are summarized in Table 3. Based on additional data analysis, 73 percent of the projects and 80 percent of the centers reported that they used one of the two practices all the time. Only 4 percent of the projects reported that they never or nearly never apply such developmental practices.

Table 3. Frequency of Use of Industry Standards or Other Relevant Guidelines for Developing Materials. n=62, 52 projects (P), 10 centers (C)

Practice	Used Each Time or Most Times %	Less Than Half the Time, Almost Never or Never %	NA %
1. Obtain verification by industry regarding alignment of materials with workforce and skill needs	79 (P) 100 (C)	10 (P) 0 (C)	11 (P) 0 (C)
2. Use applicable student-and industry-based standards or guidelines to guide materials development	88 (P) 100 (C)	6 (P) 0 (C)	6 (P) 0 (C)

Most materials are developed to enhance student learning in targeted technical areas. As indicated in the 2001 survey report, the variety of materials being developed warrant different approaches to the assessment of student learning. The assessment of student learning is important to the materials development process. There were five items developed as indicators of good assessment practice that can both document student achievement and serve as a guide to instructional processes and accountability. The items used were:

1. Assess student success (knowledge and skills) in comparison with industry/business standards (American Electronics Association Standards, American Chemical Society Standards, etc.)
2. Assess student success (knowledge and skills) in comparison to educational standards (STEM foundation standards, AMATYC, National Council of Teachers of Mathematics Standards (NCTM), National Research Council Science Education Standards, etc.)
3. Assess student success (knowledge and skills) in comparison with nontechnical skill standards (e.g. SCANS)
4. Assess student success (knowledge and skills) in comparison with other nonproject or nonparticipating students
5. Assess improvement of student performance in the workforce

The survey results are summarized in Table 4. Upon further data analysis, it was found that 50 percent of the projects and 60 percent of the centers applied one or more of the identified student measures each time. At the other end of the spectrum, 40 percent of projects and 40 percent of centers made little or no use of these student assessment techniques, though they deem them applicable.

Table 4. Frequency of Use of Measures of Student Success. N=62, 52 projects (P), 10 centers (C)

Practice	Used Each Time or Most Times %	Used Less Than Half the Time, Almost Never or Never Used %	NA %
1. **Assess student success (knowledge and skills) in comparison with industry/business standards**	54 (P) 70 (C)	23 (P) 20 (C)	23 (P) 10 (C)
2. **Assess student's success (knowledge and skills) in comparison with educational standards**	50 (P) 70 (C)	32 (P) 30 (C)	18 (P) 0 (C)
3. **Assess student success (knowledge and skills) in comparison with nontechnical skill standards**	44 (P) 90 (C)	36 (P) 10 (C)	20 (P) 0 (C)
4. **Assess student success (knowledge and skills) in comparison with other nonproject or nonparticipating students**	42 (P) 40 (C)	33 (P) 60 (C)	25 (P) 0 (C)
5. **Assess improvement of student performance in the workforce**	34 (P) 60 (C)	34 (P) 40 (C)	32 (P) 0 (C)

The third measure of quality is the extent to which the materials were tested for development and validation purposes. On the survey, a distinction was made between pilot testing and field-testing. Pilot-testing is defined as those methods used by developers to try out the materials to ensure that they are understood, properly employed, and learned. Field-testing is routinely done when the materials are believed to be ready for dissemination. The purpose of field-testing is to take the completed product and have others try it outside the development site. The field-testing process is designed to determine if materials are clearly understood by those not involved in the development process and whether or not the anticipated learning is taking place. Respondents were not asked to comment on the results of the testing, only whether or not they had conducted testing.

The data indicate that 80 or more of the *projects* pilot-tested or locally field-tested their materials all or most of the time. However, only 70 percent of the centers and 48 percent of the projects field-tested their materials externally each or most of the time. This may reflect the fact that many *projects* are focused locally at the site of development or within the *project* schools. It may also be related to where the *projects* are in the development process.

Respondents were asked to select one item that they had developed and indicate what they believed was the most compelling evidence for its quality. Although four of the six measures of student success referred to student knowledge and skills, an analysis of 50 written responses indicated that there was almost a total reliance on statements of satisfaction by users rather than on concrete, direct evidence of the quality of the outcomes. Seventeen respondents indicated the enthusiasm and/or interest of students, teachers, employers, and/or publishers was the most compelling evidence of quality. Eight mentioned enrollment, graduation, and/or placement rates as measures of quality. Only four respondents mentioned evidence of outcomes from field or pilot testing (2 of 10 centers and 2 of 40 projects). The sampling of comments below is indicative of the range of responses concerning evidence of quality:

> *Both students and teachers have expressed an interest in the module and have shown interest in using the module when teaching this topic.*
>
> *Our students enter the workforce with knowledge and skills necessary to be productive workers quickly.*
>
> *It has received good reviews from presentations at peer review conferences.*
>
> *This program, which originated two years ago continues to be funded at an increased level of funding for each of the three years.*
>
> *Our retention rate increased from an average of about 50 percent from first to second semester, to over 90 percent with the new curriculum.*
>
> *The most compelling evidence for its quality is the number of publishers who would like to have this in their product line.*
>
> *Growing number of hits on the website.*
>
> *Clarity of the module and the supporting documentation attests to the quality of this module.*

State of the ATE Program Related to Materials Development: Site Visit Reports

Teams of evaluators and content/process experts visited 3 centers and 10 projects to collect in-depth information concerning the status of the ATE program. The site visit teams used common procedures and format, and each submitted a report of its findings that included the status of each of the ATE drivers (program improvement, profession development, collaboration, and materials development). Each site visit report was analyzed to identify the materials development process used. It was not always clear what part of the curriculum and materials development process was begun/completed prior to the funding of the center/project, so there was no attempt to limit the analysis to only those products produced as a result of the grant. The analysis focused on the materials development process and the content of the materials developed. In particular, the following evidence was sought:

What processes were used in the curriculum development?

- Needs analysis conducted
- Curriculum model or architecture used
- A review process for materials developed
- Content experts or educational consultants involved

Did the content of the material include

- Industry or relevant standards?
- Well-defined, clearly understood learning objectives?
- Identification of student activities?
- Pedagogy?
- Assessment methods?

A review of the site visit reports found that in some cases there was not enough information on materials development in the report to adequately analyze the process. However, the analysis did reveal several generalizations about materials development at the sites visited. It is cautioned that the absence of evidence does not necessarily indicate that the particular element was not included in the materials prepared by the site, only that there was no evidence in the report that it was included.

Needs analysis. Evidence of a formal process used by the site to determine the needs of industry was absent in most cases. The level of industry involvement varied from making suggestions as members of advisory boards to verifying the competencies during the materials development process. For the most part, evidence would suggest that input was given AFTER the proposal was funded and not the impetus for the proposal.

Curriculum model or architecture used. There was evidence of the use of a curriculum model or architecture in only one center and three of the projects. In two of the cases, these curriculum models were provided as a part of the institutional or state requirements for the approval of new courses or curricula. The local curriculum development guidelines were general in nature but systematic in their structure.

A review process for materials developed. Specific evidence was found that eight of the thirteen sites visited had some type of process of review for their materials. There was no evidence that these reviews were systematic based on standards of good practice for curriculum materials development. The nature of the reviews varied from advisory board review (some members of whom were adjunct faculty at the institution) to review by industry partners who were associated with the site. In some instances, the curriculum materials were reviewed by faculty at other sites and comments provided to the developer even though the reviewer did not implement the material in his/her own classes.

Content experts or educational consultants involved in materials development. Evidence was found that all the centers and six of the projects visited used content experts in the preparation of their materials. Expert participation ranged from involvement of those practicing in the field to utilizing industry-based curriculum materials as the bases for the content of course and module materials development. Only one center and one project were cited as utilizing curriculum or educational experts in the development of their materials.

In a review of the site visit reports, it was generally found that there was not enough information to evaluate the existence of content elements of the curriculum. The exception to this was in the area of the use of standards that is reported below.

Standards included. Standards refer to any formal analysis of the competencies that are needed in the workforce. Standards can be national standards (e.g., SCANS), industry-based standards, competencies developed locally through a formal process (e.g., DACUM), or state standards for education. All of the centers and nine of the projects visited used industry or related standards in the development of their materials. One project reported that they had consulted their advisory board on establishing technician and workplace standards and that skill standards were discussed with an external evaluator. However, there wasn't any evidence that the site visitors could report that any formal standards had been incorporated into the curriculum. It should be noted that in several cases an ATE project would use standards that had been developed by another ATE project or center as the basis for their educational development efforts. Several of the sites visited adopted curriculum and materials that were developed by industry to meet specific educational needs.

General Observations

The following general observations about materials development are made based on the review of materials related to the program and the review of literature.

Time to production. The development of quality materials for broad dissemination and/or publication takes time, and time is of the essence in a rapidly changing technological environment. One site reported that after several years of producing high-quality materials, they had reduced their cycle for production from one and a half years to one year per module.[w] In most cases, it is over a year before grantees are even ready to begin to produce materials. Expectations for the development of quality materials to support the training of technician must be tempered with the complex and time-consuming process of quality materials development and the expectations that the materials will be kept current with the rapidly changing industries that they support. The fact that many *projects* fell short of their production goals could be contributed to the lack of understanding of the complexity of the materials development process.

Structure of the materials design team. At this point, there has been no discussion of who should comprise the *project* group charged with developing instructional materials. The "Instructional Design Symposium" was held at the ATE center, Maricopa Advanced Technology Education Center (MATEC), in February 2001. The symposium brought together personnel from the ATE centers that were involved in instructional design to discuss common challenges. One of the teams of curriculum developers formed discussed the challenges of module design.[x] One issue discussed was how best to staff and organize the writing, editing, production, and testing of modules. The result was a consensus that the production of modules should have the following elements:

- Design team that consists of at least
    - Instructional designer
    - Faculty content expert
    - Industry content expert
- An established process that includes
    - Specific subject matter and competencies
    - Learning activities
    - Assessments (traditional and alternative)
- A time line that includes
    - Development
    - Verification of module by appropriate experts
    - Pilot testing of modules

The Symposium team also addressed the challenges of keeping the modules current. This was identified as a critical element in the credibility of the overall process. There was little evidence that many of the ATE grantees involved curriculum designers in the development of curriculum materials. For those *projects* that are focusing on materials development, this could be a significant help in assuring the quality of the curriculum products. Those grantees that have utilized instructional design and content experts and have produced high-quality materials can be used as models for other grantees in the development of materials.

Format and type of materials. In some cases, the site visit reports did not indicate the nature of the materials developed. There was evidence that materials generally consisted of various forms of syllabi, course outlines, texts for students, laboratory manuals, student guides, faculty guides, and public relations/informational materials. There wasn't ample evidence to generalize about the type of material that was being produced, but several of the sites visited had only produced course outlines or expanded syllabi for dissemination to other campuses within the *project*. Some sites had produced CD-ROMs or developed interactive web sites. Others had created a combination of text and digital media to transport the curricula.

Evaluation of quality. Although many materials have been developed in various formats, there is no evidence that the quality of the materials has been evaluated objectively. For example, for educational software, the NSF-funded NEEDS project provides guidelines for the quality of electronic educational courseware. The guidelines are outlined in criteria for a national award for excellence, the "Premier Award for Excellence in Engineering Education Courseware."[y] These award criteria are applicable to any educational courseware and provide a useful guide for evaluating electronic delivery systems. The criteria include the expanded topics of instructional design, software design, and content.

Evaluation of effectiveness. The use of an external evaluator was often cited as the source of the evaluation of effectiveness of the materials. However, this person was usually not on-site and wasn't involved in an on-going basis, but visited the site once or twice a year, perhaps meeting with the visiting team or advisory board. When the site reports discussed the role of these evaluators, their role was generally to assess how well the overall goals were being met and not the evaluation of educational outcomes. Often the evaluators were reported to have developed surveys and other data collection instruments for the project/center. There was little evidence that there was a well-developed effort to assess and evaluate student learning or the impact of the funded work on workforce preparation.

Recommendations

The following recommendations are made to promote the likelihood that funded *projects* will produce high-quality materials that will promote the goals of the ATE program:

1. Those submitting proposals to the ATE program that have materials development as a focus should be directed to (or NSF should provide) resources identifying best practices in the development of high-quality text and digital materials.

Evidence indicates that some grantees do not realize the complexity of the materials development process. The development of high-quality materials is a time consuming, systematic process that requires resources and realistic expectations of what can be accomplished in a limited period of time. For the ATE program to achieve its goal of producing more science and engineering technicians to meet workforce demands through "the design and implementation of new educational materials, courses, laboratories, and curricula; . . . and the broad dissemination of exemplary educational materials" there needs to be a realistic understanding on the part of the proposers of what the process entails and the resources that will be needed to accomplish it. It is not clear that many grantees have experience in writing or publishing educational materials for dissemination. In order to achieve a "high-quality" product, NSF will need to take the lead in providing standards for best practice and direct proposal writers to those standards. This could be implemented by asking one of the *projects* that have developed high-quality, exemplary processes for materials development to document and publish the process used along with some practical advice and lessons learned. The guidelines provided should be geared toward the unique challenges of trying to keep current with the rapidly changing needs of technology education. Guidelines should also reflect the depth and breadth of materials that are produced for the ATE program and the various settings and resources available that are represented by the grantees.

2. The review criteria for funding should require that materials development proposals show an understanding of the processes required for the development of high-quality materials and that the budget and time line are realistic for the materials deliverables indicated.

There needs to be a mechanism in place to ensure that the *projects* funded have a high likelihood of success, if they are proposing to develop educational materials. Evidence should be in place that those who are submitting the proposal understand the challenges of developing high-quality materials and have identified resources needed to help in that process. It is recommended that this be an explicit part of the review process. If the proposal is of general high quality and does not contain evidence of that understanding, it is further recommended that NSF work with the principal investigator to ensure there is a systematic process in place and that resources are available to produce high-quality materials.

3. The current reporting process of funded *projects* should be revised to include reports on the materials development processes included in the framework provided for best practice. This information will encourage accountability and reinforce the need to use best practices. It will also provide NSF with the data needed to assess the overall effectiveness of ATE funding in producing high-quality materials.

Because materials produced by the ATE *projects* are the primary vehicles for change outside the funded *project*, it is important to be able to evaluate the quality of the processes used to produce the materials. Although the use of valid processes is not a guarantee of high-quality materials, there is an implicit assumption that the use of systematic, proven processes will lead to a quality product. Given this, for each *project* that has as one of its primary goals to develop materials for broad dissemination and/or publication, it is recommended that the ATE program include in its reporting expectations that the grantee report on the processes used in development.

4. NSF should provide workshops for ATE *projects* that have materials development as one of their primary objectives.

Workshops should be sponsored by NSF and offered to all grantees who have identified materials development as one of their deliverables. This workshop could be held annually before the beginning of the annual funding cycle. The workshop could be organized and facilitated by the ATE centers that have been successful in the production of high-quality materials through the use of well-defined systematic processes. This would link the work of previously funded ATE *projects* to good practices and provide examples and lessons learned that would be meaningful to grantees. It is suggested that the workshop be highly interactive and involve facilitators who represent process experts (e.g., DACUM leaders, curriculum designers) as well as the successful grantees. Examples should be provided for course, modules, and curriculum as well as various media (print, digital). These workshops would reduce that likelihood that many of the grantees will experience "false starts" or consume valuable time in seeking out appropriate resources.

---

[a] Advanced Technological Education (ATE) Program Solicitation, NSF 00-62, 2000, p.6.
[b] Ibid, p. 7.
[c] Ibid, p. 4.
[d] Ibid, p. 5.
[e] Ibid, p. 5.
[f] Ibid, p. 17.
[g] *Survey 2001: The status of ATE projects and centers,* The Evaluation Center, Western Michigan University, Kalamazoo, Michigan.
[h] Sowell, E. J., *Curriculum: An integrative introduction*. (1996). NJ: Prentice-Hall Inc., 11.
[i] Henson, K. T. (2001). *Curriculum planning: Integrating multiculturalism, constructivism, and education Reform.* New York: McGraw-Hill Companies, Inc., 10.
[j] Taba, H. (1962). *Curriculum development: Theory and practice*. New York: Harcourt, Brace, Jovanovich, Inc.
[k] English, F. W. (2000). *Deciding what to teach and test: Developing, aligning, and auditing the Curriculum.* New York: Corwin Press, Inc., 17.
[l] Henson, p. 14.
[m] Sowell, pp. 11-12.
[n] Fullen, M. (1993). *Change forces: Probing the depths of educational reform.* Bristol, PA: The Falmer Press.

[o] *Advanced Technological Education (ATE) Program Solicitation*, Washington DC: NSF (00-62, 2000), p. 4.
[p] Bridges, W. (1991). *Managing transitions: Making the most of change.* Reading, MA: Addison Wesley, 3.
[q] Oliva, P. F. (1992). *Developing the curriculum.* New York: Addison Wesley Educational Publishers, Inc.
[r] Henson *op cit.*
[s] Norton, R. E. (1997). *DACUM handbook*. OH: Center on Education and Training for Employment, College of Education, the Ohio State University.
[t] In the DACUM process, a trained facilitator meets with a committee of 5-12 expert workers from the area of analysis and develops a job profile. The two-day workshop culminates in a detailed and graphic portrayal of the duties and tasks performed by the workers involved. Lists of the general knowledge and skills, worker behaviors, tools/equipment/materials/supplies, and future job trends/concerns are also identified. (Norton)
[u] Although this step is not included in the text description of the model, the feedback loop is included in the graphical model.
[v] For a complete discussion of survey results with associated tables, see *Survey 2001: The Status of ATE Projects and Centers*, Kalamazoo, Michigan: The Evaluation Center, Western Michigan University.
[w] *Instructional Design and Curriculum Development Symposium Summary Report to the National Science Foundation*, Spring 2001.
[x] Ibid.
[y] http://www.needs.org/engineering/premier/2000/criteria.html