

**ATE**  
**Materials Development**  
**Processes Report**

**Submitted by**  
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## Table of Contents

Executive Summary.....	ii
Introduction .....	1
Methodology.....	2
Table 1: ATE Exemplary Materials Ratings .....	3
Results .....	4
Table 2: Applied Materials Development Process Models .....	6
Comparison with Theoretical Materials Development Models .....	13
Systematic Curriculum and Instructional Development (SCID) .....	13
Understanding by Design (UBD) .....	15
Integration of the Development Models .....	17
Table 3: Integrated Template.....	20
Template Analysis of ATE Processes.....	21
Table 4: Template Related Themes .....	21
Delineation .....	22
Evidence .....	23
Implementation.....	24
Summary and Recommendations .....	25
Summary .....	25
Recommendations .....	26
References .....	28
Appendices .....	29
(A) Materials Development Process Questions.....	30
(B) Applied Development Processes Model: Marine.....	32
(C) Applied Development Processes Model: Environmental.....	36
(D) Applied Development Processes Model: Electromechanical.....	40
(E) Applied Development Processes Model: Engineering .....	46

## Executive Summary

This report describes the development processes used to create four materials which were rated by external experts as very good to excellent. It presents descriptions of the actual processes the ATE projects used and relates the models inferred from these applied processes to two theoretical frameworks (models) for materials development: Understanding by Design (Wiggins & McTighe, 1998; 2001) and Systematic Curriculum and Instructional Development (Norton, 1997). Finally, the theoretical and applied processes are combined to produce an integrated template to inform and guide ATE materials development.

This report is one in a series relating to the materials development component of the ATE program. An earlier report identified the 4 best materials developed by ATE projects from a restricted set of materials. The restricted set included only those 27 instructional materials suitable for review and sent in by projects indicating involvement in materials development on the yearly ATE evaluation survey. The materials were evaluated by an external set of instructional and industrial experts using a comprehensive scoring process that included the use of a multicomponent rating rubric (<http://www.wmich.edu/evalctr/ate/ATE%20Rubrics.pdf>). To prepare this present report, the four projects that had produced the most highly rated materials were contacted and asked to describe the processes they used to develop these exemplary materials.

The following recommendations are based on the findings listed above. The recommendations are proposed in general, not as specific tasks. The implementation of the recommendations could assume several pathways, such as proactive Web- or brochure-based dissemination of the various types of information in this report, changing the ATE program solicitation, or holding information sessions at ATE PI meetings focused on materials development processes.

- Projects developing materials (and reviewers of proposals) should
  - be aware of the substantial time and resource commitment required by the development process and plan accordingly
  - recognize that materials development processes have different perspectives and select what is appropriate for context-specific goals
  - recognize and plan for the challenges other projects have experienced in previous materials development efforts (as outlined in Table 2) when developing their proposals
- As shown by the comparison to the theoretical models and as depicted in the relationships to the integrated template, more attention and effort should be devoted to the instructional practices necessary to accurately and successfully convey content to students. Structures used to guide development should attend to both content and pedagogy.
- Assuming that mastery of content is expected of community college faculty and substantial time and effort is needed to change teaching practices, professional development related to developed materials is especially important.

- As demonstrated in the ATE applied processes, projects should have discussions with both publishing companies and potential users prior to development of materials, especially if materials to be developed differ substantially from conventional materials. While initial publisher input is useful, serious efforts to secure funding from publishers should be made by projects during development as a more stable indicator of support.
- Development of modules, as opposed to complete curricula, may also increase the use of unconventional materials. Modules have the benefit of increased flexibility and if created with recommendations for coherent organization (e.g., the alternate instructional sequences of (SC ATE) ET core modules), can maintain the pedagogical structure of a complete curriculum.
- Piloting draft materials using appropriate comparison groups provides different types of information than perceptual data gathering. Both are necessary. Therefore, materials development processes need to support increased comparative testing. In other curricular development efforts, comparative data (provided new materials are effective) are used to increase publishing and sales opportunities.

## ATE Materials Development Processes Report

The National Science Foundation's Advanced Technological Education (ATE) program stems from a national interest in developing and using technology to meet the nation's educational and workforce needs. Funded via a Congressional mandate, the ATE program was designed to (1) produce more science and engineering technicians to meet workforce demands and (2) improve the technical skills and the general science, technology, engineering, and mathematics (STEM) preparation of new technicians and the educators who prepare them. The majority of ATE funding is directed at the community college level in order to strengthen and expand the scientific and technical education and training capabilities of individuals at these institutions. More specifically, the objectives of the ATE program are to

- Develop model instructional programs in advanced-technology fields
- Provide professional development to faculty and instructors in advanced-technology fields
- Establish innovative partnerships between associate degree granting colleges, businesses, industries, and other public and private sector entities that need and employ skilled technicians as part of their workforce
- Develop and disseminate instructional materials

As part of the ATE program, NSF included funding for evaluation to assess the impact and effectiveness of the ATE program. The evaluation, conducted by The Evaluation Center at Western Michigan University and the University of Minnesota, has sought to answer four basic questions deemed important to ATE and its stakeholders:

1. To what degree is the program achieving its goals?
2. Is the ATE program making an impact and reaching the intended individuals and groups?
3. How effective is the ATE program when it reaches its constituents?
4. Are there ways the program can be improved significantly?

The evaluation study results presented here are related to the materials development portion of the ATE program and therefore only one part of the evaluation of the overall ATE program. Furthermore, this study is only one report in a series of reports concerning the evaluation of materials development in the ATE program. The evaluation of the materials development portion of the ATE program has several components:

- Development of a curricular materials evaluation system
- Use of the system by external experts to evaluate selected ATE-developed materials
- Consideration of the processes used by ATE projects to develop materials
- Development of a device to assess student facility in workplace-based problem solving
- Development of other assessment devices
- Implementation of an experimental study examining the effect of ATE-developed materials on students in comparison with the effect of traditional materials

The first report in the series of ATE materials development evaluation reports described the development of the materials rating system and the results from external expert ratings of ATE

developed materials. The second described the development of the problem-solving assessment device. This report considers the processes used by ATE projects to develop materials.

This study has three purposes. One purpose is to describe the actual processes (models) used by the ATE projects in creating materials identified by external experts in the first materials development evaluation report as high quality. The second purpose is to examine the relationship between these applied models and the two theoretical models: Understanding by Design (UBD) (Wiggins & McTighe, 1998; 2001) and Systematic Curriculum and Instructional Development (SCID) (Norton, 1997). The third purpose is to provide a comprehensive template for ATE materials development by integrating the applied and theoretical models.

### **Methodology**

As described above, the first purpose of this study was to describe the actual processes (models) used by the ATE projects in creating materials identified as high quality by external experts. It is important to keep in mind that identification as high quality by the external experts does not necessarily imply that better outcomes would be obtained by students using these materials. Nor does it imply that use of the materials development processes by others would necessarily result in materials that would be rated as high quality by external experts. Development processes, by necessity, interact with unique and specific contextual factors such as staff, materials, subject matter, etc., in the production of materials. While the products were rated as high quality, the processes used to produce them may or may not be. Although the applied models may have had limitations, these processes did result in materials perceived as high quality. Therefore, it is likely that the processes include elements that would be useful to others in their attempts to produce high quality materials.

As described in a previous ATE materials development evaluation report, 65 projects and centers had reported being involved in materials development on the yearly ATE survey. Of these, 37 responded to a request to send in a copy of their best material to be reviewed. Preliminary review reduced the number of materials to 27 judged suitable and sufficiently complete for review. Of the 27 materials, 23 were judged adequate or better overall. Of these 23, 14 received overall ratings of good or better; 2 were judged excellent, 2 as good to excellent, and 10 as good. Four materials stood out as being of exceptional quality because they scored considerably higher than the other rated materials. Each of these materials was rated as of excellent or good-to-excellent quality. Table 1 provides an overview of these four materials.

**Table 1: ATE Exemplary Materials Ratings**

<b>Overall Team Rating<sup>a</sup></b>	<b>Subject Area</b>	<b>Material Type</b>	<b>Material Format</b>	<b>Funding Type</b>	<b>Start Date</b>	<b>Award Amount to Date</b>
4.0	Engineering Technology	Multiple Modules	Combination: Texts & Packets	Center	Sep-99	\$ 2,000,000
4.0	Electrical - Mechanical Engineering With Ethical Case Studies	Multiple Modules	Text(s)	Center	Sep-98	\$ 2,000,000
3.5	Engineering Technology (Marine)	Course	Packet	Center	Sep-2000	\$ 2,000,000
3.5	Environmental Science	Course	Text	Project	Oct-2001	\$ 1,000,000

<sup>a</sup>Team ratings could range from 0–4

These four highly rated materials form the basis for this report about materials development processes. In an effort to conceptualize the model of each applied development process, the PIs of each of the four identified ATE projects were contacted and asked if they would be willing to describe the processes used to develop their materials. All agreed and were sent a list of evaluator-developed questions related to the development process. This set of questions is provided in Appendix A. The PIs had the opportunity to respond to the questions in writing and/or to be interviewed over the telephone. Some PIs suggested that others on their team should be involved in the discussions so they were included as well. When the development process was captured via a phone call, extensive notes were taken. In the case of e-mail replies, detailed responses were sent to the evaluators by the PIs or others. The materials themselves, artifacts about the development process, and Web sites about the materials were also viewed. All information was converted into detailed descriptions of the development processes. Each description was sent to the ATE project for PI (and sometimes staff) comments, suggestions, and assurance of accurate portrayal. The detailed descriptions were then converted into a large table that summarized the development processes across the four materials. This summary table was also shared with the ATE projects to ensure accurate portrayal.

The second purpose was achieved by comparing the four applied processes with those included in two extant theoretical models. The applied models were inferred from the development process information provided by the four ATE projects. The two theoretical models were selected from two different traditions of curricular development and therefore as representative of different perspectives. The SCID model is one that is prevalent in technical and vocational education and is the model described in previous evaluation materials (Rogers, 2001) as one that would be beneficial for ATE projects. The second model, UBD, was selected because it is referenced extensively in NSF’s Instructional Materials Development Program as an important and beneficial model for developing STEM curricular materials.



The third purpose was accomplished by integrating the two theoretical and the four applied models. Combining the theoretical and applied models provided a comprehensive array of possible development processes. The comprehensive, integrated materials development processes template was constructed by combining the elements of the four applied models used by the ATE projects with those of the two theoretical models. The elements (from all six models) were carefully considered and grouped into unique themes representing all of the different procedures used or suggested. Therefore, this final integrated template provides a comprehensive list (derived from sound theory and the applied processes that resulted in highly rated ATE materials) of the possible issues a materials developer could consider. Examination of the elements across models enables the identification of common and unique themes. The number of elements within each theme indicates how common it is across the processes. Unique elements may be relevant for developing particular materials and in certain situations. Once the integrated template was formed the four applied ATE development process models were considered in relation to it.

Summaries of findings and the recommendations were derived from consideration of all the information gathered throughout the development of the ATE project process descriptions as well as through consideration of the theoretical models and integrated template.

## **Results**

The first purpose of this report was to provide descriptions of the processes used to develop the four materials rated highly by external experts. The detailed descriptions of each development process are provided in Appendices B-E. The summary, Table 2: Applied Materials Development Process Models, is presented below. As can be seen, the table provides a description of each material and its goals followed by the development process divided into antecedent, transition, and use sections. These sections are followed by resources and lessons learned sections. The information in the table highlights the unique and diverse nature of the development processes used by the different projects. For example, one of the major differences is the range in number and types of persons responsible for the development. There appears to be somewhat of a continuum with the Environmental Science I (environmental) materials being designed mostly by the PI of that ATE project, followed by the Underwater Technology and Vehicle Design (marine) being designed by a pair of authors (later joined by a third), then the interdisciplinary teams used in the Electrical and Mechanical Principles materials (electromechanical), to the large faculty group used in the Engineering Technology Core (engineering). The development processes for the last two materials listed in the table had a goal of faculty development, which was not part of the processes for the first two listed materials. Not surprisingly, the projects that involved more people and had more goals also had higher costs.

Transitions were generally similar across projects although they differed in detail. All materials were subjected to various review procedures and subsequent revisions. All of the projects also used people in addition to the developers such as content experts, high school teachers, professional colleagues, editors, or publication coordinators. As might be expected, the two projects with larger sets of people involved in the development process experienced more

changes related to personnel than the development projects with fewer people involved in the actual development work.

All of the materials were tried out with students and revised based on the perceptions of the implementers and their students. No formal studies were conducted comparing students using the new materials with students using traditional materials. It is reasonable to assume, however, that many of the instructors involved would include in their mental perceptions a comparison of how students performed using the new materials as contrasted with student performance using former materials.

**Table 2: Applied Materials Development Process Models**

<p><i>Description of Materials submitted:</i></p> <p><b>Format:</b></p>	<p><b>TITLE:</b> <i>Introduction of Underwater Technology and Vehicle Design (Marine)</i></p> <p><b>Chapters 4 (Design), 6 (Structure and Water Pressure), and 7 (Power)</b></p> <p>Textbook (partial)</p>	<p><b>TITLE:</b> <i>Environmental Science I</i></p> <p><b>(Environmental)</b></p> <p><b>First course of a three course sequence</b></p> <p>Lab Manual/enhanced Syllabus</p>	<p><b>TITLE:</b> <i>Module D: Electrical and Mechanical Principles</i></p> <p><b>(Electromechanical)</b></p> <p><b>Module (integrated across disciplines) that could be used as a course or independently to cover a topic</b></p> <p>Workbooks (Instructor &amp; Student) /Ethics workbook (Supplemental)</p>	<p><b>TITLE:</b> <i>Engineering Technology Core and Technology Gateway Instructor Guide and Kit</i></p> <p><b>(Engineering)</b></p> <p><b>Modules for preengineering technology (3 courses over 1 semester) and engineering technology (11 courses over 3 semesters) integrated across several disciplines</b></p> <p>Modules (Instructor guide and student handouts)</p>
<p><b>GOALS</b></p>	<ul style="list-style-type: none"> <li>• Edit, expand, illustrate, and rework curriculum modules from MATE's intro to sub. tech. course into book format utilizing Knowledge and Skill Guidelines (KSGs)</li> <li>• The book would be supplementary (for CC/Univ teachers and students; as the text evolved, the audience grew to include HS students) and designed to build on basic understandings, fill gaps, and motivate students.</li> <li>• Use course and curriculum as a model to disseminate to teachers through summer institutes for faculty development.</li> </ul>	<ul style="list-style-type: none"> <li>• Develop sequence of three Environmental Science courses             <ul style="list-style-type: none"> <li>• That would provide basic ecological principles to 2-year assoc degree students in Forest Resources Technology program</li> <li>• That would transfer to 4-year institutions as lab science credits</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Use of an interdisciplinary team to “force” faculty from different discipline areas to come together and talk</li> <li>• Use of the studio idea (lecture and lab in same environment)</li> <li>• Develop curriculum based on Middlesex team ideas (through the “authoring guide” but compared with other authoring guides to ensure comprehensiveness)</li> </ul>	<ul style="list-style-type: none"> <li>• Faculty development</li> <li>• Content integration across disciplines</li> <li>• Just-in-time teaching</li> <li>• Retention of students</li> <li>• Dev. 1<sup>st</sup> year of gen. ed. content for differing majors in engineering tech program</li> <li>• Assoc degree Engineering Tech programs within SC Tech college system were the target.</li> </ul>
<p><b>PROCESS</b></p>	<p><u>Antecedents</u></p> <ul style="list-style-type: none"> <li>• Industry-guided KSGs were developed and used as a guide.</li> <li>• Bohm and Jensen’s (1997) text was the catalyst for</li> </ul>	<ul style="list-style-type: none"> <li>• Discussions with Forest Resources Technology students clarified the need to include a science component and environmental science topics.</li> </ul>	<ul style="list-style-type: none"> <li>• The “studio” idea and integration (through the “just in time” model) were new concepts.</li> <li>• Content was available in other formats (very generally</li> </ul>	<ul style="list-style-type: none"> <li>• Identified need for a curriculum that would increase the quantity, quality, and diversity of engineering tech students (and make the first year general</li> </ul>

	<b>(Marine)</b>	<b>(Environmental)</b>	<b>(Electromechanical)</b>	<b>(Engineering)</b>
	<p>developing curriculum modules to be used in a course for cc students.</p> <ul style="list-style-type: none"> <li>• KSGs and skill competencies guided needs assessment indicated the need for this type of materials.</li> <li>• The success of the modules and course was the catalyst for turning course material into a book and contracting with Bohm and Jensen to do so.</li> <li>• The demand for Bohm and Jensen’s “Build Your Own Robot” book with “lay” (non-marine) people expanded the audience for MATE’s book.</li> </ul>		<p>throughout textbooks). The studio and integration were new, giving rise to an activity-based learning module within the context of a realistic project.</p>	<p>education component more meaningful to reduce dropout)</p> <ul style="list-style-type: none"> <li>• Site visits clarified the priority of staff development (faculty buy-in was harder to achieve at a later time)</li> <li>• Workplace research by interdisciplinary teams guided the development of competencies in all disciplines.</li> <li>• Exploration of competency model templates before faculty decided upon one</li> <li>• A desire to connect curriculum to the workplace led to research into problem-based learning models, the insight that most models were within a single discipline, and training of faculty in problem-based learning.</li> </ul>
<u>Transitions</u>	<ul style="list-style-type: none"> <li>• The reorganization, amplification, and clarification of some topics as well as an increasing supply of relevant, interesting, and appropriate information/topics demanded flexibility.</li> <li>• As the project grew (with this increasing amount of information), adjustments included more time, additional reviewers, and a third author (a current reviewer) with expertise in science content and teaching.</li> <li>• Great interest from high school teachers and students in the material, and ROV-focused institutes and competitions required the inclusion of additional concepts and</li> </ul>	<ul style="list-style-type: none"> <li>• Ideas and information were leaned from a wide variety of print, electronic, and human resources.</li> <li>• The development process was later summed up by the NCSR Curriculum Development Model in that it involved a DACUM, new scientific research, a testing component, a revision process, and a publication process.</li> <li>• Development, teaching, and revision were conducted by the PI with occasional input from university researchers, local agencies, life science colleagues, and individual students.</li> </ul>	<ul style="list-style-type: none"> <li>• The P.I. contacted lead authors with whose work he was familiar.</li> <li>• Additional authors were located via advertising.</li> <li>• Interested potential authors were required to have an interdisciplinary team.</li> <li>• “Just in time” notion was difficult since one activity may require an activity from another area requiring new thinking about equal time across subjects).</li> <li>• Teams developed modules in four content areas (engineering technology, math, science—mostly physics and some chemistry—and English).</li> <li>• Middlesex team wrote the authoring guide, provided professional development, templates, and pamphlets.</li> </ul>	<ul style="list-style-type: none"> <li>• A faculty-driven process was used.</li> <li>• Used a team management approach for project staff/Pis and faculty teams</li> <li>• Guided by a full-time curriculum development specialist</li> <li>• Faculty development workshops, time for workplace research, and faculty collaboration throughout the curriculum development process</li> <li>• Faculty development was intense for 3 years.</li> <li>• For the next 3 years, ATE faculty were engaged in 2-4 project-specific activities each year.</li> <li>• SCATE continues to work with faculty 3-4 times each year.</li> </ul>

	<b>(Marine)</b>	<b>(Environmental)</b>	<b>(Electromechanical)</b>	<b>(Engineering)</b>
	<p>more detailed explanations to support the wide range of people interested. Note: MATE's next step is to adapt the book's content into modules that are lined with high school standards.</p>		<ul style="list-style-type: none"> <li>• Deadlines and schedules were created.</li> <li>• Fictitious but grounded company information provided context for problem-based activity scenarios.</li> <li>• Some authoring team members dropped out, so Middlesex experts filled those roles.</li> <li>• The Middlesex team reviewed and edited materials at different stages.</li> <li>• Middlesex team was required to be flexible with deadlines.</li> <li>• Provided small advance with larger payment upon delivery/other encouragement for teams to finish</li> <li>• Goal of teaching entire two-year program in an integrated fashion was not realized.</li> <li>• Some teams/authors remained off track, and Middlesex was required to educate the authors since many were more familiar with traditional instruction (activities as supplementary rather than integral).</li> <li>• Met with lead authors after delivery of the first package</li> <li>• The Middlesex team reviewed drafts and provided commentary.</li> <li>• Despite some interdisciplinary connections, many departments did not come together. The English department was the exception (prompted by industry commentary on student deficits and support for improved writing and presenting skills).</li> </ul>	<ul style="list-style-type: none"> <li>• Multicollege communication via conference calls, teleconferencing, and e-mail was vital to the process.</li> <li>• The first year of the project was dedicated to a focused study of current practice and completing a gap analysis.</li> <li>• As this "ET Core" curriculum began to evolve, the entrance competencies for the ET Core became the exit competencies for another curriculum component now called the Technology Gateway.</li> <li>• This component of the SC ATE curriculum was an afterthought designed to address faculty concerns about the number of students enrolling in the state's technical colleges without the skills to be successful in ET.</li> <li>• A curriculum oversight team worked with this large framework and determined that the curriculum should include communications in addition to mathematics, physics, and engineering technology and that learning should flow from an exploration of the major systems in physics. Interdisciplinary teams were formed to address competencies. By using just-in-time instruction in mathematics, the curriculum could be designed for students to begin studying physics in the first semester.</li> </ul>

	(Marine)	(Environmental)	(Electromechanical)	(Engineering)
				<ul style="list-style-type: none"> <li>• The industry-type problem scenarios were guided by research and served as a vehicle for the integration of multiple disciplines.</li> <li>• Following faculty training on the concept of problem-based learning, a SC ATE model of PBL was developed.</li> </ul>
<b>Revisions</b>				
<i>In Writing</i>	<ul style="list-style-type: none"> <li>• An advisory committee consisting of experts in subsea technology, science, and teaching; teachers (and their students) participating in the Summer Institutes for Faculty Development and students enrolled in the <i>Introduction to Submersible Technology</i> courses at MPC reviewed the text.</li> <li>• Comments and suggested edits were reviewed by authors and incorporated.</li> <li>• The revised text was reviewed yet again by members of the advisory committee with the appropriate expertise.</li> </ul>		<ul style="list-style-type: none"> <li>• Critiques of the first outline, a day-long critique, at the 80% completion point, and of the final product</li> </ul>	<ul style="list-style-type: none"> <li>• Two industry focus groups in different parts of the state provided feedback on problem scenarios</li> <li>• A national peer panel reviewed the curriculum and provided feedback and suggestions for improvement.</li> <li>• The Advisory Board was instrumental in identifying ways to "market" the curriculum.</li> <li>• The National Visiting Committee, identified steps in the iterative curriculum development process and the national relevance of this effort, which led to national dissemination.</li> <li>• Project PIs, staff, NSF program officer, National Visiting Committee, and external evaluators all visited classrooms to get feedback from students.</li> <li>• In addition, student surveys, first pencil &amp; paper and later on-line, were used to collect additional data and feedback.</li> </ul>
<i>In Use</i>	<ul style="list-style-type: none"> <li>• High school, community college, and university instructors participating in a faculty development summer institute were given draft</li> </ul>	<ul style="list-style-type: none"> <li>• Completed course materials were taught at Everett Community College. After testing, the instructor submitted questions, comments, student</li> </ul>	<ul style="list-style-type: none"> <li>• Writing institution unsuccessfully attempted an elaborate piloting procedure.</li> <li>• They then opted to use it in class and gather student</li> </ul>	<ul style="list-style-type: none"> <li>• Pilot tests of completed semesters of curriculum informed development of remaining portions of the curriculum.</li> <li>• Faculty involved in curriculum</li> </ul>

	<b>(Marine)</b>	<b>(Environmental)</b>	<b>(Electromechanical)</b>	<b>(Engineering)</b>
	<p>copies of the text to “test” in their classrooms and provide feedback from both teacher and student perspectives. Of those given copies, at least 12 “tested” them.</p> <ul style="list-style-type: none"> <li>• Draft copies of the text were also used in MPC’s <i>Introduction to Submersible Technology</i> course (each of the last three semesters the course was offered).</li> <li>• Feedback from these teachers and students has been/is being incorporated into the book.</li> </ul>	<p>reactions, etc. back to the PI; these formed the basis of the first revision.</p> <ul style="list-style-type: none"> <li>• In addition, the course was simultaneously being taught (by the PI) at Chemeketa Community College where it was constantly revised and updated.</li> <li>• Also, portions of the course (and occasionally, the entire course) were taught by participants in NCSR’s professional development institutes (“Ecosystem Institute”) at their home institutions. Their feedback was used in revisions.</li> </ul>	<p>perceptions of “liking it” with faculty responses to additional questions. Suggestions regarding implementation and errors were required from all who received the sample module.</p>	<p>development were also on ATE teaching teams, pilot testing the product.</p> <ul style="list-style-type: none"> <li>• Two colleges pilot tested the ET core curriculum the first year. With additional sites in following years.</li> <li>• Initial pilot tests were at volunteer sites in South Carolina. Expansion involved 9 of 16 SC technical colleges.</li> <li>• Student data were used to measure improvement in retention, demographics, and success.</li> <li>• High school faculty tested the Technology Gateway for applicability for dual credit use in high schools.</li> </ul>
<b>Resources</b>				
<u>People</u>	<ul style="list-style-type: none"> <li>• Content experts</li> <li>• Authors Bohm and Jensen</li> <li>• Third author, Moore</li> <li>• Editors and a graphics/layout designer</li> <li>• Several people researched and maintained the database of interested and/or potential buyers.</li> <li>• High school, community college, and university instructors</li> </ul>	<ul style="list-style-type: none"> <li>• Occasionally, Life Science colleagues, and individual students</li> <li>• Local agencies (e.g., Department of Public Works, Native American tribes) assisted in identifying field sites.</li> <li>• NCSR director (final editing)</li> <li>• Web consultant</li> <li>• Kinko’s (copying)</li> <li>• Staff assistant</li> <li>• Curriculum consultant</li> </ul>	<ul style="list-style-type: none"> <li>• Curriculum design person (1 year)</li> <li>• Assessment-of-student-learning consultant</li> <li>• Instructional designer with expertise in developing industrial training</li> <li>• Publications coordinator writer/editor</li> <li>• Partners and people from Middlesex and close by</li> <li>• Additional nonlocal authors</li> </ul>	<ul style="list-style-type: none"> <li>• Project director</li> <li>• Full-time curriculum specialist (5 years)</li> <li>• A writer/editor (3 years)</li> <li>• Consultants and workshop presenters</li> <li>• Engineers from industry</li> <li>• National content and curriculum experts</li> <li>• Faculty, department heads, and the peer group of chief instructional officers from all 16 technical colleges (and <math>\geq</math> 125 faculty)</li> <li>• Two national, multidiscipline peer review teams</li> <li>• Project staff specialists</li> <li>• High school faculty</li> </ul>
<u>Time</u>	<ul style="list-style-type: none"> <li>• Not counting time to develop the curriculum modules, 9 months originally set aside (project currently in 4<sup>th</sup> year)</li> <li>• Most time is spent by the authors, Bohm and Jensen—and now Dr. Steve Moore (a professor at California State</li> </ul>	<ul style="list-style-type: none"> <li>• 0.25 FTE per year (of the first two years of NSF funding) was spent developing <i>Environmental Science I</i></li> <li>• PI efforts accounted for approximately 95% of the total development time with the remaining 5% divided among</li> </ul>	<ul style="list-style-type: none"> <li>• Main team had release time (3 contact hours in fall and spring)</li> <li>• Stipends for faculty time for 4-6 weeks in the summer</li> <li>• Faculty at other institutions had release time or a stipend</li> </ul>	<ul style="list-style-type: none"> <li>• Two years (supported by a planning grant) organizing the colleges and conducting preliminary research into what needed to be done.</li> <li>• Time resources used with faculty are also discussed under the “process” section in the “transitions” subsection, and are further</li> </ul>

	(Marine)	(Environmental)	(Electromechanical)	(Engineering)
	University, Monterey Bay, the third author—to research, write, review, and revise the text and illustrations.	the various people mentioned above. • (**note** testing and revision are not included in this estimate).		mentioned under the “resources” section and “people” subsection in terms of time invested by hired project staff.
Money	<ul style="list-style-type: none"> <li>• \$40,000 originally was set aside for Bohm and Jensen to research, write, review, and revise as well as work with and manage the “production” team on editing and graphics.</li> <li>• As the project has evolved, additional funds were spent on Bohm and Jensen as well as Moore.</li> </ul>	<ul style="list-style-type: none"> <li>• 0.25 FTE costs</li> <li>• (Estimated \$5,000) to purchase teaching materials (field and laboratory instrumentation, audiovisual materials)</li> <li>• (Estimated \$20,000) to construct an outdoor aquatic ecology laboratory</li> </ul>	<ul style="list-style-type: none"> <li>• Cost of release time (3 contact hours fall and spring)</li> <li>• Stipends for 4-6 weeks in summer</li> <li>• \$1,000 per team member for external authoring teams</li> <li>• \$500 extra for the lead author for a completed module</li> <li>• Copying, printing, binding costs as well as equipment costs for some teams</li> <li>• AVG COST/MODULE: \$4,500</li> </ul>	<ul style="list-style-type: none"> <li>• The \$1.5M faculty development project included \$1,027,712 in nonpersonnel costs (however, this total includes faculty release time that was part of "participant support" for the project).</li> <li>• For the SC ATE Center of Excellence, roughly half of the \$5M award, \$2,780,600 was for personnel costs excluding most faculty release time other than senior personnel. \$2,219,400 was for other costs including faculty release time.</li> </ul>
Other	<ul style="list-style-type: none"> <li>• KSGs</li> <li>• Original Bohm and Jensen book</li> </ul>	<ul style="list-style-type: none"> <li>• Texts (e.g., materials developed for <i>Principles of Ecology</i> and <i>General Biology</i> and the Botkin and Keller textbook—<i>Environmental Science</i>) and electronic media</li> </ul>		<ul style="list-style-type: none"> <li>• Institutional/administrative support (including conceptual buy-in, meeting space, enabling faculty participation, and release time)</li> <li>• Vital technology infrastructure that enabled multicollege communications</li> </ul>
Advice/ Lessons Learned	<ul style="list-style-type: none"> <li>• <b>Obstacle:</b> The original time line was unrealistic.</li> <li>• <b>Obstacle:</b> Reviewers’ comments prompted a reevaluation of audience and purpose.</li> <li>• <b>Solution:</b> Begin with the end in mind, display this prominently, and use it to guide the process.</li> <li>• <b>Solution:</b> Don’t be naïve—recognize your limitations (people’s time) and content knowledge).</li> <li>• <b>Solution:</b> Set a realistic time line, realizing that it <u>WILL</u> take</li> </ul>	<ul style="list-style-type: none"> <li>• Find the time to “do it right”</li> <li>• Obstacles were activity-specific and required further research, problem solving, and adjustment.</li> <li>• Carefully consider your audience—write with the students in mind.</li> <li>• Keep up to date on recent developments and incorporate them into the curriculum.</li> <li>• Course materials should include “messages” from the developer to whoever is teaching from the materials. In our case these take the form of “Notes to Instructors”</li> </ul>	<ul style="list-style-type: none"> <li>• Be very realistic. Don’t commit to more than you can do.</li> <li>• This was a big project (teams all over) and difficult.</li> <li>• If a large portion of faculty want to write, about a third may do so, less than that will sign on, and less than that can be expected to deliver a finished product.</li> <li>• Learned not to be in publishing business as not aware of how difficult publishing can be.</li> <li>• Disappointment that no commercial publisher was interested in the materials since they were such a departure</li> </ul>	<ul style="list-style-type: none"> <li>• Money for support staff is key.</li> <li>• Money for faculty development, workplace research, and faculty collaboration was very important.</li> <li>• Hiring people to extract and package faculty’s understanding of both content and student knowledge is vital.</li> <li>• <b>Obstacle:</b> Suspicions of new materials lacking rigor and full content coverage</li> <li>• <b>Obstacle:</b> Uniqueness of materials require instructor training</li> <li>• <b>Obstacle:</b> Questions on delivery cost (new v. traditional approaches)</li> </ul>



	(Marine)	(Environmental)	(Electromechanical)	(Engineering)
	<p>longer than you think and could cost more than you originally anticipated.</p> <ul style="list-style-type: none"> <li>• <b>Solution:</b> Do not announce a publication date for a book until it's on its way to the printer.</li> </ul>	<p>and may include sources for “hard-to-find” materials, outlines for introductory lectures, suggested audiovisual materials, keys to exercises, Web resources, literature cited, connections between lecture and laboratory, pedagogical suggestions, or anything that will assist an instructor in the effective delivery of the materials to students.</p> <ul style="list-style-type: none"> <li>• Curriculum development is a “process,” not an “event.” Good curriculum takes much longer than anyone could ever imagine.</li> <li>• Laboratory development is particularly time-consuming when truly new materials are being developed.</li> </ul>	<p>from mainstream materials and it was uncertain as to how they would sell.</p> <ul style="list-style-type: none"> <li>• The materials would require a change in instruction.</li> <li>• Fewer of these types of programs (than general math or English) meant fewer people are buying texts.</li> <li>• Biggest disappointment was the failure of authoring teams to stick to deadlines. Rather than follow the predetermined schedule of 6 months, some took 2 years; others never finished or were dropped from the project.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Solution:</b> <i>Workplace research</i> (for understanding the relative importance of topics of course content); <i>peer review</i> (validated that content standards were being met and demonstrated alignment with accreditation criteria).</li> <li>• <b>Solution:</b> An ATE Teaching Team training course for potential instructors of new materials.</li> <li>• <b>Solution:</b> Cost/benefit analysis</li> <li>• <b>Question:</b> How should the curriculum be published and made available?</li> <li>• <b>Question:</b> How much technology/media support would be available or needed?</li> <li>• <b>Question:</b> What would be involved in national development?</li> <li>• <b>Solution:</b> In-house publishing (since not in textbook form) in hard copy, on the project Web site, and boxed as sets of teacher resources and student handouts.</li> <li>• <b>Solution:</b> Develop and follow a technology plan, connect it to the budget process, and list equipment for each problem scenario.</li> <li>• <b>Solution:</b> Couple dissemination with team training.</li> </ul>

The advice obtained from the different projects was generally similar. All reported that curriculum development was much more difficult than they had envisioned. The project PIs wanted others to be more realistic in their goals for development and to plan for much more time than might be expected. Another bit of advice was that materials that represented more significant departures from existing curricula or procedures were more difficult to develop and disseminate. They also mentioned that the versatility and adaptability of modules made them more easily accepted by people in the field than complete curricula.

### **Comparison with Theoretical Materials Development Models**

The second purpose was to compare the processes used by the ATE projects to theoretical models of materials development. Although there are many different approaches to curriculum development, as described previously the two deemed most relevant to ATE are *Understanding by Design* (UBD) (Wiggins and McTighe, 1998; 2001) and *Systematic Curriculum and Instructional Development* (SCID) (Norton, 1997). These models are described below and the approaches taken in the ATE projects compared to them.

#### ***Systematic Curriculum and Instructional Development (SCID)***

The SCID model was developed to incorporate the critical tasks needed to develop competency-based education curriculum and instructional materials for workforce training. It 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. This process is described by Norton (1997) and has been detailed in prior ATE evaluation efforts including the issue paper on Materials Development by Gloria Rogers and the brochure on effective materials development, both of which are available on the ATE evaluation Web site (<http://www.wmich.edu/evalctr/ate/>). The several components of the SCID development process are outlined below.

#### **1. Curriculum Analysis**

- Needs analysis
- Job analysis
- Task verification
- Selection of tasks for training
- Standard task analysis (identification of performance steps and decisions, essential knowledge, industry standards, etc., needed to develop accurate and relevant teaching and learning materials)
- Literacy task analysis (knowledge category broken down into appropriate skill set communication, mathematics, science, computer, and decision making)

#### **2. Curriculum design (based on information collected in phase 1)**

- Determine training approach
- Develop learning objectives
- Develop performance measures
- Develop training plan

### **3. Instructional development**

- Develop a competency profile (competency-based programs) or develop a curriculum guide (for traditional programs)
- Develop learning guides/modules (competency-based programs) or lesson plans (for traditional programs)
- Develop supporting media
- Pilot test and revise the materials

### **4. Training implementation**

- Implement the training plan (bring together resources)
- Conduct the training
- Conduct formative (in-course) evaluation of students and instructor performance
- Document training (student achievement and instructor performance)

### **5. Program evaluation**

- Conduct summative evaluation
- Analyze and interpret information

The following paragraphs relate the ATE applied materials development models, as described in table 2, to the elements of the SCID model in the order outlined above. Overall, the development of the four ATE materials included many SCID model elements. As mentioned above, the four materials used different formats and were developed in different ways with sometimes different goals, so it is to be expected that their development processes would differ. Despite this, all of the projects employed some form of curriculum analysis as suggested by SCID although some projects were more formal and intensive in their analysis than others. The degree of formality matched the complexity of the development teams and goals. Larger groups of developers with more complex goals had more formal and intensive needs analysis processes. All curriculum analyses included at least discussion with industry representatives in an attempt to align the materials with job needs as recommended by SCID.

The SCID model calls for curriculum and instructional design following curriculum analysis. In all of the ATE materials development processes the curriculum design and the instructional design were considered more or less simultaneously. In general, there was less emphasis on providing information for instructors on how to use the materials than on providing the materials and making them self-explanatory. This is consistent with the content-oriented expertise of the materials developers and the independent nature of instruction in the community college environment. Instruction was related through the different philosophies of instruction upon which the materials were based such as “just in time learning” or “problem based learning.” All of the materials were pilot tested by the developers during the development process.

Few of the projects used a formal curriculum implementation model involving training and therefore were not consistent with the SCID model’s expectation for training implementation. These implementation differences were in keeping with the projects’ lack of emphasis on providing information for instructors referenced above under curriculum and instructional design, although aspects of this were present. Notably, the two ATE projects with professional development goals, and especially the engineering technology core project, included extensive

training. Despite the lack of formal training involved in some of the development processes, all projects shared their materials with others, in some way, often in informational exchange settings. Additionally all of the materials were tried out in classrooms other than those of the developers.

No project met the SCID model's expectations for program evaluation. Full scale formal evaluation of the developed materials was not implemented by any of the ATE projects. However, the projects have been conducting an incipient type of informal evaluation of their development processes and results through their continuing revisions of their curriculum. For example, the electromechanical project is repackaging its material in more traditional ways (not interdisciplinary), which requires reflection on the essential elements of the materials.

Overall, this synopsis shows that the materials development efforts are much more consistent with the early stages of the SCID model than they are with the later stages. There was much more consistency with SCID curriculum analysis, curriculum design, and instruction implementation expectations than occurred for training implementation and program evaluation.

### ***Understanding by Design (UBD)***

Wiggins and McTighe (1998; 2001) offer a different perspective on materials development than SCID although there are several similar elements. The Wiggins and McTighe model is often called "backwards design" because they advocate beginning curriculum development by specifying what the students should understand and be able to do and what will be acceptable as evidence of student achievement, rather than first designing lessons or listing content. These outcomes should then be translated into assessments that provide valid evidence that students have achieved the outcomes. The UBD model also encourages focusing on essential skills and concepts by considering all potential topics through four filters, which are listed below.

***Filter 1. To what extent does the idea, topic, or process represent a "big idea" having enduring value beyond the classroom?*** Enduring understandings go beyond discrete facts or skills to focus on larger concepts, principles, or processes.

***Filter 2. To what extent does the idea, topic, or process reside at the heart of the discipline?*** Involving students in "doing" the subject, provides them with insights into how knowledge is generated, tested, and used.

***Filter 3. To what extent does the idea, topic, or process require uncoverage?*** What abstract ideas in the unit or course, what concepts and principles are not obvious and may be counterintuitive or based on alternative conceptions?

***Filter 4. To what extent does the idea, topic, or process offer potential for engaging students?*** Having students encounter big ideas in ways that provoke and connect to their interests (as questions, issues, or problems), increases the likelihood of student engagement and sustained inquiry.

Wiggins and McTighe point out that “understanding” can mean many things to many people. They argue that to demonstrate real understanding of an area, students should be able to comprehend and enact each of the following: explanation, interpretation, application, perspective, empathy, and self-knowledge. They believe that these six facets of understanding should be incorporated into student assessments and therefore into curriculum materials designed to help students attain these outcomes. They go on to point out that these six divisions are somewhat artificial and that there is the possibility of larger or finer divisions. Using these six facets to focus outcomes upon which to build curriculum implies a very active, performance-based curriculum, which requires that students construct their own understanding.

- *Explanation* is understanding revealed through performances and products that clearly, thoroughly, and instructively explain how things work, what they imply, where they connect, and why they happened. It is describing what is seen and linking it to some law.
- The goal of *interpretation* is meaning-making (e.g., rendering a concept personalized, accessible, and/or translated) rather than explanation. It connects the explanation to a broader context.
- *Application* is the ability to use knowledge effectively in new situations and diverse contexts.
- *Perspective* implies that the student can consider concepts from different vantage points.
- *Empathy* is similar to perspective but implies the ability to understand another person’s feelings and world-view without necessarily agreeing with them.
- *Self-knowledge* implies that students recognize their own patterns of thought and how these might affect understanding.

The development processes used by the ATE projects incorporated some elements of the UBD model. All four materials developers considered the ultimate behaviors the students would have to exhibit; this consideration is similar to the first UBD filter “having enduring value beyond the classroom.” Consideration of ultimate behaviors also relates to the second UBD filter about whether ideas/topics “reside at the heart of the discipline.” Processes similar to these two filters would be the development of industry-based knowledge and skill guidelines by the underwater vehicle materials, the DACUM and expert opinion processes used in the environmental science material, the selection and integration performed in the electromechanical technology materials, and the workplace research and heavy involvement of faculty experts used in the engineering technology materials.

The ATE developers gave less emphasis to the “uncoverage” and “engagement” filters in the four projects’ processes. The notion of uncovrage was not really mentioned in any of the descriptions of the ATE project materials development processes, but all projects incorporated experts from the various fields who might be aware of topics worthy of uncovrage. In terms of the fourth filter, student engagement, only the engineering technology project delineated instructor behaviors that would facilitate the attainment of the specified outcomes. Instead, the

ATE projects' development processes allowed for the planning and incorporation of content and experiences (laboratories) they thought would lead to these behaviors. The environmental science project held discussions with students, and all projects, despite not focusing on student engagement per se, involved people with teaching experience who would be likely to know what might be engaging for students.

None of the projects began developing their materials by determining what evidence of student achievement would be acceptable and designing assessments accordingly as suggested in UBD. Putting aside the timing difference, however, most of the developed materials had assessments that were more "authentic" than traditional multiple choice tests. Examples would be the building of the ROVs in the underwater vehicle materials or the projects required in the engineering technology materials.

All of the projects had development processes that allowed them to incorporate active, constructivist-oriented activities as suggested by UBD, but the direct relationship of these activities to the six UBD facets of understanding is mixed. The processes employed by all of the ATE projects resulted in materials that had students demonstrate understanding through explanations, interpretations, and applications as described in the UBD facets. Students also were required to demonstrate these facets in at least pseudo real world settings, e.g., laboratories that would match a work environment. There was very little evidence, however, that the materials development processes included activities that would result in having students demonstrate understanding via the last three UBD facets—having perspective, empathy, and self-knowledge—except through the variety of settings, situations, and types of people portrayed in the materials.

In summary, the ATE materials development processes moderately matched with the UBD model. Each ATE development process produced curricula that would encourage active learning and that utilized somewhat authentic assessments. Although the processes involved some of the ideas incorporated in the four filters, they were not involved to the depth recommended by UBD. The first two filters (extent the idea, topic, or process represents a "big idea" and gets to the heart of the discipline) were considered in some depth, uncoverage received minimal consideration, and there was some evidence of consideration of engagement, although instructional strategies were not considered (except in the engineering materials). The ATE processes produced materials that focused more closely on the first three facets (explanation, interpretation, and application) than the last three (perspective, empathy, and self-knowledge).

### **Integration of the Development Models**

The third purpose was to integrate the elements of the applied and theoretical models. It is clear from the information in the preceding paragraphs and table 2 (curriculum development processes across the four materials) that a variety of processes or models are available. It is difficult to develop ATE materials because they are formulated within such unique situations, e.g., different subjects, resources, audiences, etc. These unique situations may require the use of context-specific development models, therefore developers may be unable to find a single model directly applicable to their situation. The models presented thus far, when taken together, provide a balanced perspective. The SCID and UBD models provide theoretically based

recommendations, while the ATE models are grounded in practice. Therefore, an integrated template incorporating elements of the different models may be useful. This integrated template identifies areas where applied and theoretical processes overlap and new ideas for ways in which models can be more practically implemented. Each model discussed above has its own perspective, together they provide unique and common elements that could be considered in developing materials. Combining the theoretical and applied models provides a comprehensive array of possible development processes. Examination of the elements across models enables one to identify common and unique themes. It is possible to infer that themes with more elements are more universal to the development of high quality materials in general. This examination also highlights themes with unique elements that may be relevant for developing particular materials and in certain contexts.

The first step in developing the integrated template was to create broad categories within which to organize process elements. The goal was to create categories applicable and relevant to each of the six different models. Since these six models operate from differing perspectives, the categories needed to be of a sufficiently wide scope. Examining the development processes for similarities revealed that, in general, these processes included three major components: planning or delineation of what should be accomplished, determining if it was accomplished, and specifying how it should be accomplished. The names chosen for this broad categorical organization of the different elements were delineation, evidence, and implementation.

It is important to point out that the three categories on the template are an organizational structure for all of the six models and therefore may not directly capture the nuances of an individual model. In particular, the UBD model with its "backwards" design process contains extra detail in the evidence category. The inclusion of the UBD element "six facets of understanding" in the evidence category of the template is meant to imply what the student should know and be able to do and what would constitute acceptable evidence that the student goals have been achieved as well as how to assess them.

“Delineation” refers to the processes used to determine the knowledge and understanding that students will need to be effective technicians in their field of interest. “Evidence” includes any processes that provide information about the quality or effectiveness of the materials, especially their effectiveness with students (e.g., what will indicate that students have mastered the knowledge/arrived at an understanding?). Finally, “implementation” refers to the development processes addressing the pedagogical concerns of guiding students in knowledge acquisition / deeper understanding.

The second step in developing the integrated template was to organize all the elements of each model into separate, model-specific columns according to the three categories. This step enabled similar and distinct elements to be portrayed in a manner conducive to theme development within the three categories (i.e., delineation, evidence, and implementation).

The third step in developing an integrated template was to examine the elements within each category and order them (vertically) into horizontal themes. Juxtaposition of the different materials development models as presented in Table 3 reveals shared and unique elements across the models. Shared elements within a category were combined as one theme (e.g., “Fill niche”

from the marine development process was combined with “Fill in gap in the field” from the electromechanical process), while novel elements of a model (e.g., “Site visits” from the engineering process) were retained as separate themes. All elements contributed by each model were utilized in the integration.

Each theme is indicated by a unique number identifier, and the elements composing that theme are located in the same row. Each row crosses each of the six models to indicate any elements that relate to the theme of that particular row. In this way one is able to follow a theme along a row and determine which models contributed elements to that specific theme. Likewise, each element contributed by a model is separated from the next with a bullet point. This separation enables one to quickly note the quantity and breadth of elements contributed to themes by the two theoretical and four applied models. Finally, the themes are listed in order within each category, with those consisting of the greatest number of elements appearing first within each category.

This integration produced an overall template that combined the elements of the more theoretical materials development models with the elements of the exemplary ATE applied development models. The end result is a theoretical and practical template of 28 themes against which development process elements can potentially be compared.

This template is intended to serve current and future materials developers. These developers will be able to consider the elements of this integrated model and determine if and how each element should be included in the development of their materials.



**Table 3. Integrated Template**

Integrated Template		Theoretical Models		Applied Models			
Theme	Category	UBD	SCID	Marine	Environmental	Electromechanical	Engineering
1	Delineation	*Authentic, discipline-based work	*Job and needs analysis *Task analysis (relevancy) *Task selection			*Job task analysis *Realistic projects	*Workplace research *Authenticity of work
2		*Standards	*Task analysis (industry standards)	*Industry KSGs	*DACUM	*Authoring Guide	
3		*Enduring ideas	*Task analysis (essential knowledge)		*Discipline-specific content		
4		*Engaging		*Intrinsically motivating			*More meaningful general education
5		*Regional topic opportunities		*Audience interest (potential market for book)	*Articulation concerns		
6		*Uncoverage	*Task verification				
7				*Fill niche		*Fill gap in field (content & format)	
8		*Outcomes specified					
9		*Teacher expertise and interest					
10					*Discussions with students		
11							*Site visits
12	Evidence	*Feasible/student friendly	*Formative evaluation	*Reviewer comments and revisions	*Occasional reviewer input	*Piloting procedure *Student opinions *Reviewer critiques *Revised to be more unidiscipline, yet job-related *Team meetings	*National peer review panel *Student comments
13			*Curriculum design		*Curriculum consultant	*Authoring guide *Curriculum design person	*Use of curriculum development specialist *Competency model template
14		*Continuum of assessment types *Authentic work	*Performance measures				
15				*Based on existing materials	*Modified existing course		
16						*Interdisciplinary	*Integration of content *Interdisciplinary
17		*Six facets of understanding					
18		*Sufficient					
19		*Valid/reliable					
20			*Develop learning objectives				
21			*Pilot test and revise materials				
22	Implementation	*Instruction to achieve outcomes *Direction/hook *Essential and enabling knowledge/skills *Exploration	*Instructional development *Develop competency profile or curriculum guide *Develop learning guides or lesson plans			*Requiring adherence by teams of experts to authoring guide *Lecture and lab together in "just-in-time" learning	*Problem-based learning
23					*Faculty expert	*Curriculum/instructional design person	*Faculty driven development *Continued faculty development/input *Curriculum development specialist
24			*Decide upon training approach *Training plan *Training implementation (implement, conduct, formatively evaluate, and document)				
25			*Program evaluation (summative with analysis and interpretation)				*2 national multidisciplinary review teams (experts in content, curriculum development, or workforce training) *Retention data
26		*Research-based strategies					
27		*Rethink/revise *Exhibit/evaluate					
28					*Extensive piloting and revision with classes		

## Template Analysis of ATE Processes

The Integrated Design Processes Template provides a basis to help understand the processes used in ATE materials development and this section presents the areas of emphasis of each of the four projects' development processes in relation to the template. Keep in mind that this template is limited by the information provided by each site. Additionally, all inferences are based on evaluator interpretation of each ATE projects' descriptions of their development processes. This examination will focus on the areas of emphasis of each project's processes compared to the other applied models. These areas of emphasis will be examined across the three categories of the integrated template. Only materials indicating a strong emphasis within a given category will be included in this depiction. Table 4 highlights the categories in which the applied models displayed their respective emphases.

**Table 4: Template Related Themes** (Some applied models contributed more than one element to the "Themes Represented" column. The numbers contributed are indicated in parentheses following the theme. Only materials indicating a strong emphasis are included in that respective category.)

Category	Materials	Themes Represented	Detailed Evidence from Table 2
<b><i>Delineation</i></b>	Marine	2 "standards..." 4 "engaging..." 5 "regional topic opps ..." 7 "Fill niche"	<ul style="list-style-type: none"> <li>▪ Industry-based KSGs w/professionals</li> <li>▪ Promote intrinsic motivation</li> <li>▪ Considered potential audiences of hobbyists and high school teachers</li> <li>▪ Gap in ocean eng. &amp; marine science</li> </ul>
	Environmental	2 "standards..." 3 "enduring ideas..." 5 "regional topic opps..." 10 "discussions w/students..."	<ul style="list-style-type: none"> <li>▪ DACUM, sci. ed. standards, research</li> <li>▪ Major natural resource areas, provide missing content, basic ecological ideas</li> <li>▪ Attention to articulation concerns</li> <li>▪ Student discussions clearly the catalyst for course development</li> </ul>
	Electromechanical	1 "authentic, disciplined-based work..." (2) 2 "standards..." 7 "Fill niche"	<ul style="list-style-type: none"> <li>▪ Analysis of on-job tasks combined with efforts to translate into realistic projects</li> <li>▪ Industry stds./professional organizations as basis for over 200 competencies</li> <li>▪ Lack of interdisciplinary/timely content</li> </ul>
	Engineering	1 "authentic, disciplined-based work..." (2) 4 "engaging..." 11 "site visits"	<ul style="list-style-type: none"> <li>▪ More meaningful first-year experience w/ industry-type scenarios; workplace research to I.D. competencies</li> <li>▪ Enhance real-world use understanding</li> <li>▪ Faculty learned from other institutions</li> </ul>
<b><i>Evidence</i></b>	Electromechanical	12 "flexible..." (5) 13 "curr. Design..." (2) 16 "interdisciplinary..." (1)	<ul style="list-style-type: none"> <li>▪ Team meetings, piloting, student opinions, reviewer critiques, refocusing</li> <li>▪ Curriculum design person (1 year)</li> <li>▪ Unite disciplines/integrate content</li> </ul>
	Engineering	12 "flexible..." (2) 13 "curr. Design..." (2) 16 "interdisciplinary..." (2)	<ul style="list-style-type: none"> <li>▪ National peer panel/student comments guided revisions</li> <li>▪ Curriculum design person (5 years)</li> <li>▪ Unite disciplines/integrate content</li> </ul>
<b><i>Implementation</i></b>	Engineering	22 "instructions to achieve outcomes..." 23 "faculty... curriculum/instruction design person..." (3) 25 "program evaluation..." (2)	<ul style="list-style-type: none"> <li>▪ Interdisciplinary, problem-based learning</li> <li>▪ Faculty development (skills, input, support); curriculum development specialist</li> <li>▪ Two multinational, interdisciplinary teams to review; student retention info.</li> </ul>

The following text provides additional details about the relationships outlined in table 4. Greater detail on the specific elements mentioned can be found in table 2 and Appendices B-E. The degree of commonality of the themes is suggested by the number of elements that contributed to the theme across the models. For example, three of the most common themes are theme 1 from delineation, theme 12 from evidence, and theme 22 from implementation. It is necessary to clarify that the number and diversity (across models) of elements within a theme is an indication only of commonality (not necessarily importance) of that theme. Because importance of a theme could only be determined through causal analyses controlling for contextual factors, all elements were retained. For example, the theme containing the element “Six facets of understanding” from the evidence category may be vitally important (depending on the materials development process, goals, and context) despite containing only one element.

### *Category 1: Delineation*

As depicted in table 4, each of the ATE applied models contributed equally to the themes within the delineation category with each contributing four elements. Interestingly, delineation was the only category in which the contributions of all four applied models were essentially equal. Delineation activities appear to be handled in a variety of ways. There was substantial overlap in methods, but each conducted unique activities to determine its objectives and strategies for development. Note, for example, that three of four development efforts emphasized theme two, standards. The fourth did not come at development from that perspective. Yet it too was thorough in delineation efforts.

In examining the ATE **marine materials** development process, it is apparent that the emphases of this process remain strongly rooted within the delineation category of the integrated template. Within this category, the marine development process adhered strongly to theme two “**standards . . .**” developing and utilizing industry-based Knowledge and Skill Guidelines (KSGs) with assistance from professionals working in the field and using these KSGs to identify requirements or competencies to guide curriculum development. The marine materials development process also exemplified theme four “**engaging . . .**” with the intention to motivate students to pursue additional learning upon witnessing the real world application of learned content and theme five “**regional topic opportunities . . .**” in incorporating considerations of potential audiences into the development process (e.g., hobbyists and high school teachers). Finally, the marine development process adhered to theme seven “**fill niche . . .**” by striving to create materials for a niche not filled by current courses in ocean engineering and marine science (see Appendix B for full details on the marine development process).

The delineation category was also an area of emphasis for the **environmental materials** development process with themes two “**standards . . .**,” three “**enduring ideas . . .**,” five “**regional topic opportunities . . .**,” and ten “**discussions with students**” surfacing as examples of the specific emphases of this process. Utilization of the DACUM model, science education standards, and current research were elements of this development processes’ incorporation of theme two. The environmental development process exemplified theme three by drawing discipline-specific content from the major natural resource areas of forestry, fisheries, wildlife, and agriculture, by striving to provide the missing science content noted by students, and via

planning to include basic ecological principles within the materials. Attention to the transferability of laboratory science credits to four-year institutions and clear descriptions of student conversations being the main, if not sole catalyst for materials development provide solid evidence of inclusion of themes five and ten, respectively, in the materials development process (see Appendix C for full details on the environmental development process).

The **electromechanical materials** development process displayed several emphases in the delineation category, specifically with two aspects of theme one “**authentic, discipline-based work . . .**,” theme two “**standards . . .**,” and theme seven “**fill niche . . .**” Indicative of theme one, the process involved an analysis of the tasks performed during industry jobs and efforts to translate these into realistic projects intended to simulate workplace scenarios. Representative of theme two, the development process involved a combination of faculty and industry representatives utilizing a job task analysis, surveys from industry, standards of professional associations, and industry standards to delineate more than 200 competencies (NJCATE, 2003). Adherence to theme seven was demonstrated via acknowledgement of shortcomings within available curricula in providing interdisciplinary content knowledge in a timely fashion within scenarios designed to utilize such knowledge. This acknowledgement was followed by intentions (via the development process) to fill that niche and move beyond single-discipline-specific classes (see Appendix D for full details on the electromechanical development process).

The **engineering** process of materials development also strongly emphasized the delineation category of the development process. Two aspects of theme one (“**authentic, discipline-based work . . .**”) and themes four (“**engaging . . .**”) and eleven (“**site visits**”) were strengths of this process. Within theme one, this process strove to engage and retain students via a more meaningful first-year education component involving industry-type scenarios. Workplace research was also utilized to more clearly differentiate the competencies students would need to be successful in workplace settings. Exemplifying theme four, efforts were made to ensure the materials would enhance first-year student experiences and perceptions of real-world use as well as retain these students in following years. Faculty visits to several other educational institutions that had or were developing curriculum to learn from their experiences (e.g., the difficulty of post hoc attempts at faculty buy-in) indicated efforts to adhere to theme eleven (see Appendix E for full details on the engineering development process).

### ***Category 2: Evidence***

Within the evidence category, as depicted in table 4, the ATE applied models contributed unequally numbers of elements to the themes (only the electromechanical and engineering materials are depicted in the table as they were considered to have emphasized this category). All applied models contributed to theme 12 although the electromechanical process contributed 5 elements compared with the contributions of 1 or 2 elements of the other 3 processes. The electromechanical and engineering applied models contributed 8 and 6 elements, respectively, to the category as a whole while the marine and environmental models contributed 2 and 3 elements, respectively. Notably, 6 of the 10 themes were not supported by any of the applied models. This lack of support suggested less emphasis on themes related to evidence in the applied models.

When one examines the evidence category, the **electromechanical** and **engineering** materials development processes surface as suggesting particularly strong emphases. Interestingly, the processes employed by these two development efforts emphasized exactly the same themes within this category and were strikingly similar in the aspects within each theme to which each process adhered. While the projects may have defined the aspects of each theme slightly differently or with varying levels of specificity, the general processes are nearly identical. The themes adhered to are twelve “**flexible . . .**,” thirteen “**curriculum design . . .**,” and sixteen “**interdisciplinary.**” Theme twelve was considered by the engineering development process via revisions based upon a national peer review panel and student comments following extensive piloting. The electromechanical process also adhered to theme twelve utilizing team meetings for interdisciplinary module development teams to receive feedback from the Middlesex team, piloting procedures, solicitation of student opinions, reviewer critiques, and subsequent (after limited success in marketing novel interdisciplinary materials) revisions to focus materials within a single discipline yet remain occupation-related. Demonstrating consideration of theme thirteen, both development processes utilized a curriculum design person. This person played a much larger role in the engineering materials development process (5 years of continually creating, testing, and modifying curricula) than in the electromechanical materials development process (1 year with subsequent hiring of an assessment expert). Finally, adherence to theme sixteen was consistent among the engineering and electromechanical materials development process as both strove to unite traditionally distinct disciplines and integrate content.

### ***Category 3: Implementation***

As depicted in table 4, the ATE applied models also contributed unequally to the themes within the implementation category (only the engineering materials are depicted in the table as they emphasized this category). No theme included contributions from all applied models. The marine model contributed no elements to the themes within this category, the environmental model contributed 2, the electromechanical model contributed 3, and the engineering model contributed 6 elements.

Further examination of the implementation category demonstrates that the **engineering** materials development process emphasized themes twenty-two “**instruction to achieve outcomes....**,” twenty-three “**faculty...curriculum/instruction design person...**” and twenty-five “**program evaluation (summative with analysis and interpretation)....**” Specifically, within theme twenty-two the engineering development process endeavored to foster interdisciplinary problem-based learning to connect learning experiences more closely to occupation-based scenarios. Within theme twenty-three the engineering materials development process began (largely derived from site visit data) with faculty development efforts to facilitate skill development, elicit faculty input, and garner support for and understanding of the interdisciplinary effort to develop materials. These efforts continue although with decreased frequency. The use of a curriculum development specialist also persists. Consistent with theme twenty-five, the development process incorporated two multinational interdisciplinary teams of experts (in content, curriculum development, or workforce training) to summatively review materials. In addition, the engineering development process utilized student retention statistics as an indicator of quality of materials.

## Summary and Recommendations

### *Summary*

In summary, this report has three distinct aspects. It provides detailed and summarized descriptions of the actual processes and experiences involved in developing ATE curricular materials rated as high quality by external experts. It relates these applied process models to two theoretical curriculum development models. Finally, it presents an integrated template of materials development that incorporates the elements of all six development processes (two theoretical and four applied) and describes the emphases of the ATE applied processes in relation to that integrated template. All of the descriptions and relationships were considered in making the following summary statements.

- No, one, consistent materials development process was employed across the four ATE projects that had produced high quality materials as judged by external experts.
- The development processes used in the four ATE projects incorporated different elements of the SCID and UBD curriculum development processes.
- Development of materials was viewed as very demanding and time-consuming by the ATE materials developers. In most instances the actual time and resources required to produce a quality product greatly exceeded expectations.
- Based on the comments from project staff about their development processes, as more people are involved in the development teams, more effort is required in terms of coordination and communication.
- Each of the four ATE projects materials development processes emphasized producing materials that were goal- or outcome-oriented.
- The four ATE projects' materials development processes appeared to place more emphasis on developing content than pedagogy. For instance, there was minimal mention of instructional design by the applied processes in the delineation category; only two of the four applied models included instructional guides (suggesting those producing lower quality materials may be less likely to do so); and only one of the applied models mentioned an instructional expert in the implementation category. Limitations were also noted in the quality and quantity of assessments (see also Keiser, Lawrenz, & Appleton, 2004).
- Only one applied development process included summative evaluation and extensive faculty development components in both content and pedagogy.
- Based on the comments from the PIs and the range of conventional to innovative types of materials produced by the four ATE projects, the more instructional materials differ from conventional materials, the more time and effort is needed in “preparing” instructors to accept them.

- Most revisions of the ATE materials were based on student and teacher perceptions of success. Changes based on these types of insights are effective as evidenced by the high quality of the materials developed using these techniques. However, other elements of the development processes also contributed to the high quality of the materials, and changes based solely on perceptual insights may not be sufficient in all cases.
- Comparative pilot testing was rarely done, leaving minimal evidence upon which to determine advantages or disadvantages of newly developed materials in comparison with traditional materials. Experience with comparison sites in assessing ATE materials for a forthcoming report suggests that instructors may be willing to provide class time if the evaluator is willing to provide useful data by which the instructor may examine student progress either toward a criterion or comparatively. Experience also indicates that both instructors and students may be willing to complete such assessments outside of class time in exchange for useful data and monetary compensation, respectively.
- As suggested by PI comments, modules or shorter materials that can be used in parts were reported as easier to disseminate. The materials developers thought this was because instructors could incorporate these types of materials slowly while continuing to use existing, more familiar materials.
- Based on the success of the materials developers finding publishers, it appears that publishing companies prefer more traditional materials to those experimenting with more major renovations, probably due to the perceived, increased likelihood of sales.
- Both theoretical and applied models displayed differing materials development emphases as indicated by the integrated template and supported by the rich descriptions in the appendices of this report. The comparison of the applied models to the integrated template revealed that while models typically emphasized different areas, each individual model only used a portion of the processes revealed by a combined examination of the models.

### ***Recommendations***

The following recommendations are based on the findings listed above. The recommendations are proposed in general, not as specific tasks. The implementation of the recommendations could assume several pathways, such as proactive Web- or brochure-based dissemination of the various types of information in this report, changing the ATE program solicitation, or holding information sessions at ATE PI meetings focused on materials development processes.

- Projects developing materials (and reviewers of proposals) should
  - be aware of the substantial time and resource commitment required by the development process and plan accordingly
  - recognize that materials development processes have different perspectives and select what is appropriate for context-specific goals
  - recognize and plan for the challenges other projects have experienced in previous materials development efforts (as outlined in Table 2) when developing their proposals

- As shown by the comparison to the theoretical models and as depicted in the relationships to the integrated template, more attention and effort should be devoted to the instructional practices necessary to accurately and successfully convey content to students. Structures used to guide development should attend to both content and pedagogy.
- Assuming that mastery of content is expected of community college faculty and substantial time and effort is needed to change teaching practices, professional development related to developed materials is especially important.
- As demonstrated in the ATE applied processes, projects should have discussions with both publishing companies and potential users prior to development of materials, especially if materials to be developed differ substantially from conventional materials. While initial publisher input is useful, serious efforts to secure funding from publishers should be made by projects during development as a more stable indicator of support.
- Development of modules, as opposed to complete curricula, may also increase the use of unconventional materials. Modules have the benefit of increased flexibility and if created with recommendations for coherent organization (e.g., the alternate instructional sequences of (SC ATE) ET core modules), can maintain the pedagogical structure of a complete curriculum.
- Piloting draft materials using appropriate comparison groups provides different types of information than perceptual data gathering. Both are necessary. Therefore, materials development processes need to support increased comparative testing. In other curricular development efforts, comparative data (provided new materials are effective) are used to increase publishing and sales opportunities.
- As demonstrated by the integrated template's combination of applied and theoretical model processes and the subsequent comparisons of the applied processes to the template, no single model supports all possible themes. Within each category, no individual model is comprehensive. Also, the rich descriptions attached as appendices show that context is very important and development should be viewed within the context. Curriculum materials developers should be careful to consider a variety of materials development process models to cover the many areas that may apply to their curriculum development effort.



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# APPENDICES

**APPENDIX A**  
***Materials Development Process Questions***

**NSF#:** \_\_\_\_\_

**Respondent:** \_\_\_\_\_

As you know your materials received very high ratings in our evaluation. We believe we could learn much from you about how to develop materials. To accomplish this we would like your answers to the following questions about the methods you used to develop your materials. We will also be asking you about how your materials are being used. Our goal is to better understand the processes that produce exemplary curricula. We plan to share the information you provide with others through the evaluation Web site and perhaps through brochures and other publications.

Throughout this process please feel free to offer any additional insights that you think will be helpful. We would also appreciate receiving any written documentation or materials you have about your development process.

Thank you for your time and efforts in this endeavor!

**PLEASE DESCRIBE HOW YOU WENT ABOUT DEVELOPING YOUR MATERIALS:**

***Goals/Procedures/Aims***

Did you follow a planned development process? If so what?

Did you have a more ad hoc process? If so what sort of issues ideas or incidents caused you to move forward in the process?

What did you start with? Were there existing materials? Was there an existing course or model to work with? Were there prior ideas of what was needed?

What were your initial plans and goals for the materials? How did these evolve as you developed the materials?

***Resources***

What resources were necessary to support the process?

People? Experts in content, industry, curriculum, instruction, assessment, development processes, instructional design, cognition and learning, others?

Did you involve people in any other ways? (e.g., editing/formatting/proofing, pictures, graphics, IT, word processing)

What other types of people did you involve (e.g., potential instructors, students, commercial publishers, community, recruitment office, student services)?

Time? How much time was devoted to the development process? How was the time split up among the different types of people involved?

Money? What funds were required or used in addition to those spent on personnel costs?

***Revision Process***

What did your revision process entail?

Did you do any field tests or pilot tests? If so explain.

Were students involved in these field or pilot tests? If so how?

***Advice/Lessons***

What questions/obstacles arose during this curriculum development process? How did you address them?

What advice would you give to someone else developing curriculum?

Describe any lessons you learned during this process.

What written materials do you have that you'd be willing to share?

**QUESTIONS ON CURRENT USE OF MATERIALS:**

*Information in this section will be utilized as we move from analyzing the processes involved in the creation of high quality curricula to determining the outcomes of students using curricula deemed "high quality." This next step in the evaluation will compare students using ATE-developed materials with those using traditional materials.*

How are your materials currently being used? Course, module, supplement?

Where are they being used? (Specific locations?)

How many students are presently using them at these different sites?

What is the academic level of these students?

Who would you recommend contacting at those sites?

What instruments are you aware of for assessing the outcomes of your materials?

Do you know of any sites using similar but different materials?

How would the materials of those sites be similar? In what ways would they differ?

ANY ADDITIONAL COMMENTS: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

## APPENDIX B

### *Applied Development Processes Model: Marine*

#### GOALS

The plan was to edit, expand, illustrate, and rework the curriculum modules that had been developed for MATE's *Introduction to Submersible Technology* course (taught at Monterey Peninsula College [MPC], the MATE Center headquarters) into a book format with the help of an advisory committee and a "production team" of editors and graphic artists. The subsea technology curriculum modules were developed using the MATE Center's Knowledge and Skill Guidelines (KSGs) for marine occupations and skill competencies as a guide. The goal was to use the MPC course and the subsea technology curriculum as a model that could be disseminated to teachers through MATE's Summer Institutes for Faculty Development.

Our initial goal was to provide community college/university level teachers and students who want to try their hand at designing and building an underwater vehicle with a resource book that gives them an introduction to underwater technology, electronics, engineering, physics, etc. at a level that will allow them to build an (noncommercial level) ROV. The intent was not to replace existing science, electronics, or engineering textbooks, but rather to build on the basic understandings from those subject areas and motivate students to pursue additional learning or fill gaps in their understanding once they see the real-world application of these subjects.

#### PROCESS

##### Antecedents

A major goal of the MATE Center is to assess marine workforce needs and create curricula and programs to meet those needs.

One of the methods used by the Center to accomplish this is the development and use of industry-based Knowledge and Skill Guidelines (KSGs). KSGs are developed with the help of professionals working in the field and describe what workers need to know and be able to do in order to perform their jobs well. The MATE Center has developed KSGs for ROV technicians, hydrographic survey technicians, and marine technicians who work aboard research vessels, among others. These KSGs have been used, in turn, to identify requirements, or competencies, that are common to two or more occupations.

The KSGs and competencies provide educators with a foundation for building and modifying curricula and programs to meet the needs of students entering marine science and technology fields. The competencies in particular are a critical link between the workplace and the classroom, since they connect job requirements to educational subject areas.

We started with the curriculum modules that had been developed for MATE's *Introduction to Submersible Technology* (see the first Goals/Procedures/Aims question above). The idea for these modules (and the course) came from the book, *Build Your Own Underwater Robot and Other Wet Projects* by Harry Bohm and Vickie Jensen. While this book is primarily intended for middle school-aged students and not designed as a classroom textbook, we felt that the material

could be adapted and expanded for a community college student audience and course. We contacted then contracted with Bohm to develop the subsea technology modules.

While courses in ocean engineering and marine science are offered at a number of colleges and high schools across the country, to our knowledge prior to our efforts nothing quite like our curriculum and course—and now resource book—existed. Our ideas of what was needed—for both students and the marine industry—came from our KSGs and skill competencies.

Given the success that Bohm and Jensen’s “Build Your Own Robot” book had with underwater technology enthusiasts and backyard hobbyists as well as other “lay” (i.e., nonmarine) people of all ages, we recognized that these folks were also part of our audience. We needed to make sure that the book catered to them as well.

### **Transitions**

However, as we learned along the way, our plan also needed to be flexible. As chapters of the book took shape, the need for reorganization as well as amplification and clarification of some topics became apparent. In addition, more and more relevant, interesting, and appropriate information and examples found their way into the text. In other words, the project grew. This meant revising the original plan to include (1) more time; (2) additional reviewers; and (3) a third author to bring in expertise in science content and teaching.

What we didn’t anticipate was the great interest that high school teachers—and students—had in the material, our ROV-focused Summer Institutes for Faculty Development, and our regional and national ROV competitions. We realized that the book also needed to support their interest. As such, some concepts needed to be added or explained in better detail.

### **Revisions**

#### *In Writing*

The text was/is reviewed by an advisory committee that consists of experts in subsea technology, engineering, science, and teaching; teachers (and subsequently their students) who participated in our Summer Institutes for Faculty Development; and students enrolled in the *Introduction to Submersible Technology* course at MPC. Comments and suggested edits were reviewed by the authors and incorporated. The rewritten text was then sent to a member(s) of the advisory committee with the appropriate expertise for yet another review and comment.

#### *In Use*

High school, community college, and university instructors participating in our ROV-focused Summer Institutes for Faculty Development also reviewed the text. For example, the goal of our 2001 Summer Institute for Faculty Development was to provide participants with the curriculum materials, background information, and hands-on experiences that would support them in developing their own *Introduction to Submersible Technology*-type course or incorporating the material into an existing course or program. Draft copies of the text were provided, the idea being that these teachers would “test” out the material in their classrooms and provide feedback from both their and their students’ perspective.

Draft copies of the text were used in MPC's *Introduction to Submersible Technology* course (each student participating in the class received a copy) each of the last four semesters that the course has been offered. In addition, at least twelve of the teachers who participated in MATE's 2001 Summer Institute for Faculty Development have used draft copies of the text in a new or existing course. Feedback from these teachers and students has been/is being incorporated into the book.

## RESOURCES

(1) more time; (2) additional reviewers; and (3) a third author to bring in expertise in science content and teaching.

### People

Experts in content, subsea technology, the marine industry, curriculum development, and education served on an advisory committee, providing input and reviewing the text as it took shape. We also added a third author to bring in expertise in science content and teaching.

We do involve people in other ways. We have a “production” team—editors, a graphics/layout designer, and several people who research and maintain our database of interested and/or potential buyers (i.e., education institutions, bookstores, hobby shops, etc.).

High school, community college, and university instructors participating in our ROV-focused Summer Institutes for Faculty Development also reviewed the text.

### Time

Originally—and not including the time that went into developing the curriculum modules—nine months were set aside to expand the modules and complete the book. However, as we progressed and things evolved, we realized that the process was going to take longer. We are currently entering the fourth year of the project.

The majority of time is spent by authors Bohm and Jensen—and now Dr. Steve Moore, a professor at California State University, Monterey Bay, the third author—to research, write, review, and revise the text and illustrations.

### Money

Originally \$40,000 was set aside for Bohm and Jensen to research, write, review, and revise as well as to work with and manage the production team on editing and graphics. As the project has evolved, additional funds have been spent on Bohm and Jensen and are now being spent on Moore.

## DESCRIPTION OF PRODUCT

A resource book that gives high school/community college/university level teachers, students who want try their hand at designing and building an underwater vehicle, underwater technology enthusiasts, and backyard hobbyists as well as other “lay” (i.e., nonmarine) people of all ages an

introduction to underwater technology, electronics, engineering, physics, etc., at a level that will allow them to build a (noncommercial level) ROV.

## LESSONS LEARNED

Time, money, and expertise . . . Our original time line for completing the book was unrealistic, given how the original concept for the book “grew” and the fact that we are perfectionists—we want to put out the best product possible. For example, several reviewers pointed out inconsistencies in the amount of time spent on each subject (i.e., some subjects received a great deal of attention whereas other, equally important subjects received far less). In addition, our science reviewers noted a number of concepts that should be explained earlier in the text and in greater detail. We knew at that point that it was time to take a step back and reevaluate our intended audience and purpose.

We decided to bring one of our reviewers on board as a third author. Moore is providing the scientific content expertise that we lacked, as well as the experience of teaching students the subjects addressed in the book.

At the start, really think through and identify your audience, purpose, and what you want the final product to look like. Write these on a piece of paper and display it prominently in your workspace. Use this information to help you pull together a team of experts in content and pedagogy who are committed to providing input in a timely manner and helping you to get the project completed. Don't be naïve—recognize your limitations (people's time and content knowledge). Set a realistic time line, realizing that it WILL take longer than you think—and could cost more than you originally anticipated.

Also, do NOT announce a publication date for a book until it's on its way to the printer.

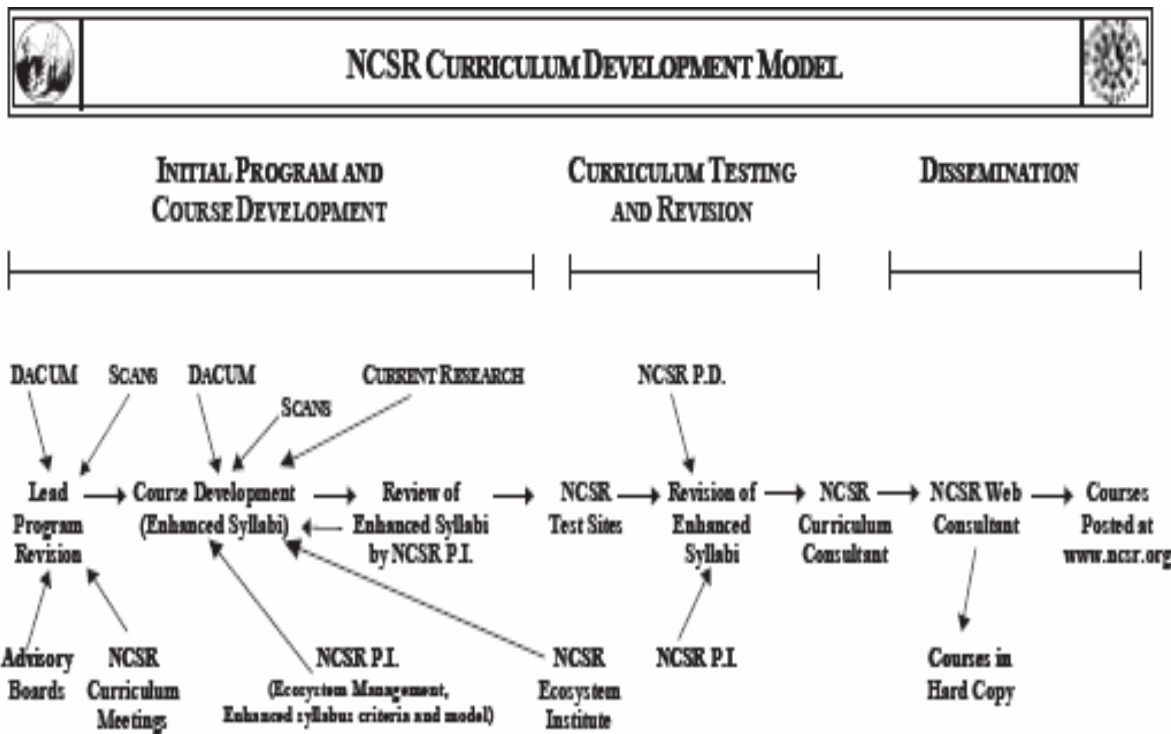


**APPENDIX C**  
*Applied Development Processes Model: Environmental*

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*Caveat:* These responses pertain only to the NCSR materials reviewed by Western Michigan University (i.e., *Environmental Science I*), which in this case is the first course of a three-term sequence. Also, since the PI developed and taught from these materials at Chemeketa Community College, his responses are from the perspective of curriculum developer, faculty member, **and** NCSR Principal Investigator.

\*\*\*\*\*



From: <http://www.ncsr.org>

(\*Note\* Information is presented as first person from the perspective of the PI).

**GOALS**

- To develop a sequence of three transfer-level environmental science courses that would
1. Present basic ecological principles to two-year associate degree students enrolled in the Forest Resources Technology program
  2. Transfer to 4-year institutions as laboratory science credits

These goals remain today. In addition, as a result of what NCSR has been able to accomplish, these courses (or portions of them) are now being used in natural resource programs across the nation.

## PROCESS

### Antecedents

The single event that resulted in the initial development of the course (and, coincidentally our proposal to NSF that would eventually establish NCSR) was the enrollment of a handful of Forest Resources Technology students in a *Principles of Ecology* course that I had developed earlier at Chemeketa. Discussions with these students made it clear that the program lacked a science component and that environmental science topics were not being covered. Since natural resource management as a discipline was becoming a more science-based endeavor, the need was apparent to me and I proceeded with developing and teaching the courses.

Although hardly prescriptive, the development of these materials roughly followed the [NCSR curriculum development model \(see above\)](#) beginning with the identification of “lead programs” in major natural resource areas: Forestry, Fisheries, Wildlife, and Agriculture.

I started with some of the materials developed for *Principles of Ecology* and *General Biology*, but to a great degree I was building “from the ground up.” General course topics were derived from the chosen textbook, (Botkin and Keller – *Environmental Science*). Ideas for laboratory activities, audiovisual materials, and lectures were derived primarily from a lifetime of professional and personal interest in the subject.

### Transitions

There was certainly an ad hoc element as well. Ideas and information were gleaned from a wide variety of print, electronic, and human resources.

Using input from DaCUM’s (Developing a Curriculum) program advisory boards, program faculty, and NCSR personnel, these programs were evaluated and revised to meet NSF/ATE program guidelines. Where necessary, existing courses were revised and resequenced, prerequisites were clarified, and new courses that needed to be developed were identified. Course revision and new course development was conducted by faculty in lead programs using input from a number of sources including DaCUM’s, science education standards, and current research. NCSR’s P.I. provided a summary of ecosystem management as a guiding theme and criteria for the documentation of curriculum development efforts (i.e., enhanced syllabi).

University researchers were occasionally contacted for information or to review single laboratory activities. Individual students were occasionally asked to “dry run” laboratories before they were taught. Local agencies (e.g., Department of Public Works, Native American tribes) assisted in the identification of field sites.

Development, teaching, and revision were conducted by me. Occasional input from research scientists was required for some laboratories, but most research was conducted via print and electronic media. Life science colleagues would occasionally be asked about methods of instruction, wording, etc.

## **Revisions**

### *In Writing*

Enhanced syllabi were reviewed by the P.I. and returned to the originators for revision.

### *In Use*

Completed enhanced syllabi were then sent to community colleges with similar programs (test sites) where they were to be reviewed and implemented to the greatest degree possible. Results from this testing process were used by a curriculum consultant under the supervision of NCSR's P.D. and P.I. to make final modifications to the enhanced syllabi.

See [NCSR curriculum development model \(above\)](#). Once course materials were completed, the course was "exported" in its entirety to Everett Community College in Everett, Washington, where it was taught in an environmental science class there. After testing, the instructor submitted questions, comments, student reactions, etc., back to me; and these formed the basis of the first revision. In addition, the course was simultaneously being taught (by me) at Chemeketa Community College where it was constantly revised and updated. Also, portions of the course (and occasionally, the entire course) were taught by participants in our professional development institutes ("Ecosystem Institute") at their home institutions. Their feedback was used in revisions. Students attended classes at Chemeketa and at the test site (Everett Community College) and were asked for feedback on the course.

## **RESOURCES**

### **People**

Occasionally, university researchers, Life Science colleagues, and individual students were utilized. Local agencies (e.g., Department of Public Works, Native American tribes) assisted in the identification of field sites.

NCSR Director (final editing), Web consultant (formatting and electronic posting on Web site), Kinko's (copying), staff assistant (some word processing), and curriculum consultant (modifying enhanced syllabi per use feedback)

### **Time**

This is very difficult to assess. Release time from full time teaching (0.5 FTE) allowed me to develop, test, and revise these materials; but I was also serving as NCSR's P.I. during that time.

I would estimate that in the first two years of NSF funding, at least half of my nonteaching time (0.25 FTE per year) was spent developing *Environmental Science I*. Laboratory development is particularly time consuming when truly new materials are being developed. My efforts accounted for approximately 95 percent of the total development time with the remaining 5 percent divided among the various people mentioned above. Testing and revision are not included in this estimate.

### **Money**

To purchase teaching materials (field and laboratory instrumentation, audiovisual materials) (estimate \$5000)

To construct an outdoor aquatic ecology laboratory (estimate \$20,000)

**Other**

Print (e.g., materials developed for *Principles of Ecology* and *General Biology* and the Botkin and Keller textbook– *Environmental Science*) and electronic media served as sources of research for laboratories.

**DESCRIPTION OF PRODUCT**

These materials could comprise a single course. The focus (of the three-course sequence *Environmental Science* introduced by the Environmental Science I course) is on ecosystem management, goals of maintaining existing biodiversity, evolutionary and ecological processes within ecosystems, and accommodating human uses within these constraints. The environmental materials are in the form of a lab manual/enhanced syllabus with a primary audience of 1<sup>st</sup> year CC/TC students. A textbook, *Environmental Science: Earth as a Living Planet* (2003, 4<sup>th</sup> ed.) by D. Botkin and E. Keller is also central to the course.

These materials are the first in a sequence of three 4-credit courses addressing environmental topics. Each 4-credit course has weekly requirements of three hours of lecture and a three-hour lab.

Final enhanced syllabi are either posted on NCSR’s Web site by a Web consultant or produced in hard copy or both.

**LESSONS LEARNED**

Other than finding the time to “do it right,” the only obstacles were activity-specific and required further research, problem solving, and adjustment.

Carefully consider your audience—write with the students in mind.

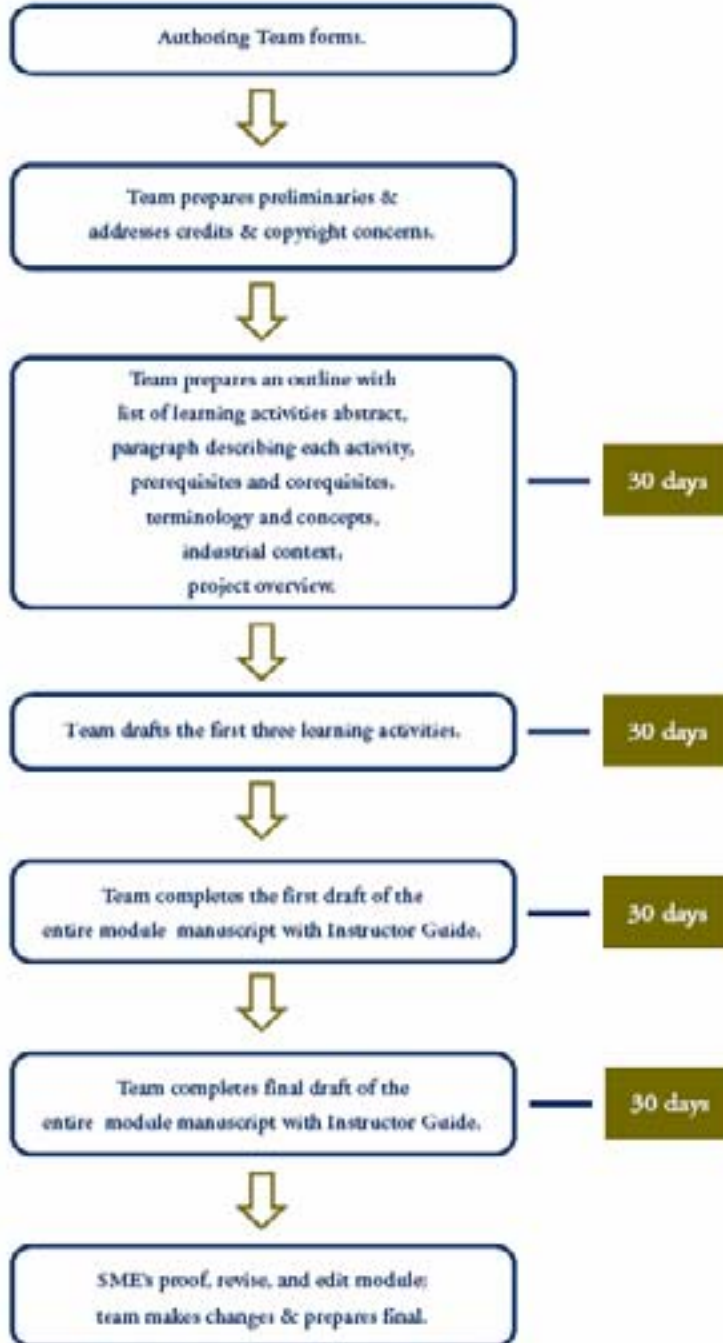
Keep up to date on recent developments and incorporate them into the curriculum.

Course materials should include “messages” from the developer to whoever is teaching from the materials. In our case these take the form of “Notes to Instructors” and may include sources for hard-to-find materials, outlines for introductory lectures, suggested audiovisual materials, keys to exercises, Web resources, literature cited, connections between lecture and laboratory, pedagogical suggestions or anything that will assist an instructor in the effective delivery of the materials to students.

Curriculum development is a “process,” not an “event.” Good curriculum takes much longer than anyone could ever imagine.

**APPENDIX D**  
*Applied Development Processes Model: Electromechanical*

*SUGGESTED MODULE DEVELOPMENT PROCESS OUTLINE AND TIME FRAME*



(SMEs = Subject Matter Experts)

Requested from:

<http://www.njcate.org/content/services/authguide.htm>

## **GOALS**

The curriculum development process was a planned one. The authoring guide (constructed based on the Middlesex team's thoughts and ideas and compared with other similar guides to ensure the inclusion of all essential ideas) set all parameters for writing.

Use of an interdisciplinary team was planned as a method to remedy the disconnect between discipline areas. In this way the curriculum model forced interaction between faculty of different disciplines. The team prepares preliminaries and addresses credits, curriculum fit, selection of project, preliminary list of competencies to be addressed, and copyright concerns. The goal was that these faculty would come together and talk.

The PI liked the studio idea and thought it would fit his students (do things quickly and get right into the application of concepts). In the middle '90s there was a lot of talk about disconnect, and he wanted everything to come together (e.g., discipline areas, theory, and application).

## **PROCESS**

### **Antecedents**

The "studio" idea and integration (through "just in time" model) were new concepts.

Content was available in other formats (very generally throughout textbooks). The studio and integration were new, giving rise to an activity-based learning module within the context of a realistic project.

### **Transitions**

The PI contacted lead authors whose specialty and quality of work he knew. Some of these authors he knew within the engineering technology community through ABET, and others he knew locally.

In outlining the types of materials they were hoping to develop, the potential authors became excited. These potential authors then had to assemble an interdisciplinary team (developing by oneself was not allowed) with which to work. Some dropped out because they were unable to assemble a team, but others sent in vitas and the authors were then selected. The interdisciplinary team at Middlesex made these selections. For some areas they advertised through the engineering tech list serve and on their Web site.

The "just in time" notion was difficult (e.g., to teach physics would require math, possibly necessitating a math activity). Nine hours as 6 hours of physics and 3 hours of math required readjusting the notion of equal time spent among subject areas.

Modules were developed by an interdisciplinary team of subject matter experts in four content areas (engineering technology, math, science—mostly physics and some chemistry—and English). An assembled team of subject matter experts at Middlesex would read/review everything. This team wrote the authoring guide (can be requested at NJCATE Web site) and

did professional development to demonstrate how to use it and the process of how to develop curriculum. A template for the modules went with the guide as well as several modules that were written by the Middlesex team to be used as an example. They also developed pamphlets for writing instructional modules.

Deadlines and schedules were created (a month for the first set, including an industrial context situation outline involving one technical activity and two support activities teaching science and math). They made up their contexts. The initial thought was to have industry provide situations, but authors ended up tailoring fictitious but grounded (e.g., in actual company research) situations. Students would get the background on the company within which their activity was set. Some of this background was real and some contrived, but industry partners reviewed the contexts for modules.

Some members of the authoring teams dropped out; fortunately, the Middlesex team was able to fall back on their content specific experts. The Middlesex team reviewed materials at different stages and revised and edited the materials created by external teams.

While authoring teams were provided with strict contracts, the Middlesex team had to be flexible since many teams missed deadlines but had promising beginning products.

Monetarily, authors were given a small advance with the understanding that the “larger” payment was contingent upon delivery of the finished product. To encourage authors to complete modules, strict contracts were issued; additional time was given; and payment was in increments, with the larger payment given upon completion of the module.

The goal was to teach the whole two-year AA program in this integrated fashion, but they were not successful. They were able to create only part of this two-year program, and the modules that were created are spread out across that time frame.

They tried to follow the authoring guide and accompanying template.

Some teams/authors remained off track, and many treated this curriculum development endeavor as similar to writing a lab activity. They were more familiar with the lab activity creation process. Middlesex’s idea was that most learning would happen through activities within the context of a larger project, but the authors were more familiar with a textbook providing the content and activities as supplementary. Also, Middlesex had to educate the authors that under the studio approach the activities were to be self-contained with references introduced if more information was needed.

After the first package they got together with the lead person and some subset of the team to go through a critique at a one-day meeting. Following this meeting the teams had a better idea of where to go/what to do.

Following the day-long critique, the authors had to provide another draft at the point of 80 percent completion. The Middlesex team reviewed these drafts and sent them back with

comments. At this point (after 6 months of work) authors were expected to deliver a finished product, yet many took more time.

While some faculty champions of the idea of integrated disciplines emerged and worked together, whole departments often did not. The need for increased English/communication skills was backed up by industry's commentary on student deficits in these areas and support of improved writing and presenting skills for students. In response the English department created new courses (research, composition, and presentation) and essentially accomplished one of the PI's goals as material was changed to become integrated with tech.

### **Revisions**

#### *In Writing*

Critiques were conducted of the first outline, a day-long critique, the 80 percent completion critique, and the critique of the final product.

#### *In Use*

The materials were evaluated three times. The institution at which the writing was being done did some pilot testing. They had an elaborate piloting procedure, but it didn't work. They then decided to use it in class, gathering student indications of whether they liked it as well as faculty responses to additional questions. Suggestions were requested regarding implementation and errors, with requirements for all who received the sample module to provide feedback on it.

## **RESOURCES**

### **People**

They had a curriculum design person for 1 year while formulating a template. They then hired an assessment of student learning consultant, because the curriculum is competency based. Every module has these and assessment had to match the competencies. They had a debate on assessments, and a consultant helped develop these. An instructional designer with expertise in developing industrial training helped with the template on instructional design. Finally, they had and continued to have a publications coordinator writer/editor.

Initial modules were written by partners and people from Middlesex and close by. Additional authors were recruited through advertising and were not local.

### **Time**

The main team had release time in the form of 3 contact hours both in fall and spring and stipends for faculty for 4-6 weeks in the summer.

Faculty had release time or a stipend (for other institutions).

### **Money**

The main team had release time—3 contact hours release time fall and spring—and stipends for 4-6 weeks in the summer. External authoring teams received \$1,000/team member, plus \$500 extra for the lead for a completed module. Copying, printing, binding costs also. Teams needed some equipment. Average cost per module: \$4,500.



## DESCRIPTION OF PRODUCT

The modules are integrated and authored by an interdisciplinary team. Learning modules had to include ethics and soft skills (employability). The modules are stand-alone, project-centered, and activity-based. The total curriculum is spiral and materials are revisited frequently.

The modules can be combined into a course or used independently to cover a topic. Within the modules there are activities of various sorts, and these activities aid in the completion of an overarching project and could be put together by content area within or across modules. For instance, Middlesex put all English/communications modules together and published them as a technology communications course.

Middlesex was proposing a studio approach (modeled after RPI's [\[Rensselaer Polytechnic Institute\]](#) idea). Instead of the traditional lecture and lab (where exercises/labs frequently seem routine and sometimes disconnected from lecture content), the studio format would require 5 hours in a place resembling a lab yet conducive to lecturing. All the equipment students need is present and available for use; and short segments of lecture (e.g., 5-20 minutes), such as an introduction to a topic or clarification during work on activities, are provided as needed. Instructors work closely with groups of 3-4 students in a team approach to learning. The idea of studios is that the same environment be used for lecture and lab. In the studio approach students are not just engaged in "canned" experiments, but rather learn the materials through the activities.

A key aspect is the "just in time" delivery of educational material based on industry standards. Instructors provide activities (e.g., involving math, physics, English or ethics, and soft skills) to students as they need them en route to completing a project. This method of delivery of relevant instruction according to information needed to complete an application is intended to reduce the time between learning and application.

In addition, there are topics (e.g., in math or English) not necessary for completing a project, but important for students to learn. These topics are taught as stand alone activities, not integrated into the project to provide information missing elsewhere. This process remedies the dilemma of covering equal amounts of content from the four areas when all four areas do not fit equally into the projects.

## LESSONS LEARNED


Advice is to be very realistic; don't commit to more than you can do. This was a big project with teams all over, and it was difficult: if a large portion of faculty want to write, about a third may do so, less than that will sign on, and a lower percentage than that can be expected to deliver a finished product.

This PI also learned not to be in the publishing business, since he was not aware of how difficult publishing can be.

One disappointment was having no commercial publisher. The publications coordinator/writer/editor was trying, but commercial editors were not interested. The materials were such a departure from mainstream materials that publishers weren't able to see how many they could sell. The materials were so different that they would require a change in instruction. Since there are fewer of these types of programs (than general math or English), fewer people are buying texts.

The biggest disappointment was authoring teams not sticking to deadlines. People did not necessarily stick to the predetermined schedule of 6 months. Some took 2 years, while some never finished or were dropped from the project.

**APPENDIX E**  
*Applied Development Processes Model: Engineering*

						
	Spring '97/ Fall '97	Fall '98	Fall '99	Fall '00	Fall '01	
	Spring '98	Spring '99	Spring '00	Spring '01	Spring '02	
COMPETENCIES Mathematics Science Communication Technology	Pre-ET Electrical Mechanical	Thermal Fluids	Optics Materials			
PROJECTS Scenarios Workshops	Pre-ET Electrical Mechanical	Thermal Fluids	Optics Materials			
PILOT TESTING		Pre-ET Electrical Mechanical	Thermal Fluids	Optics Materials		
REVISIONS		Pre-ET Electrical	Mechanical Thermal	Fluids Optics Materials		
SOUTH CAROLINA IMPLEMENTATION			Pre-ET Electrical Mechanical	Thermal Fluids	Optics Materials	
NATIONAL PEER REVIEW			Pre-ET Electrical Mechanical	Thermal Fluids Optics Materials		
WORKING PRODUCTS			Pre-ET			ET Core
Grant Year	1-2	3	4	5	6	

From: <http://scate.org/pdfs/timeline.pdf>

## GOALS

The initial plan was to develop curriculum for the first year of study in a 2-year engineering technology program that would address the general education content required for all the different majors in engineering technology. The associate degree engineering technology programs offered within the 16-college SC Technical College System were the target audience for this product.

SCATE felt strongly that any curriculum development should begin first with faculty development. Its plan was to prepare a cadre of reform-ready faculty who would then be the leaders in the curriculum development and implementation process.

Content integration across disciplines was determined to be the ideal approach. Creating a framework for just-in-time teaching was also a goal.

Retention of students was a key objective.

## PROCESS

### Antecedents

The project started with an identified need for a curriculum that would lead to an increase in the quantity, quality, and diversity of students being attracted to and retained in engineering technology majors. Since most drop-outs occur in the first year of study in engineering

technology, the team sought to create a curriculum that would address the first-year general education component in a more meaningful way.

Project personnel visited several other projects where curriculum was being or had been developed to benefit from the experiences of others. For example, beginning the SC ATE project with faculty development was a direct result of observing the difficulties others were having in getting faculty buy-in after curriculum was developed. Workplace research conducted by interdisciplinary teams helped guide development of competencies in all disciplines. Several models of competency templates were explored before faculty developed a competency template that would be used throughout the SC ATE curriculum development process. A desire to tie the curriculum to the workplace led to research into problem-based learning. Most problem-based learning models were within a single discipline.

Faculty were provided with training (available commercially from Skylight and others) to help them understand the concept of problem-based learning.

### **Transitions**

A faculty-driven process was used.

SC ATE used a team management approach, with teams being made up of project staff/PIs and faculty. The process started with the desire to create a new curriculum that would better meet the learning needs of students. One of the first steps was to hire a full-time, knowledgeable, and experienced curriculum development specialist to guide the process.

In the technical college environment, faculty neither have the time nor expertise to manage and execute a project like this. Faculty have valuable content and student knowledge, but this knowledge needed to be extracted and packaged by professionals with different skill sets.

Faculty development through workshops as well as time for workplace research and faculty collaboration throughout the curriculum development process was very important. Faculty development was very intense for 3 years, with multiple in-depth workshops, workplace research, and retreats. Faculty development has never really ended, but the focus shifted to those faculty who are teaching or who plan to teach the SC ATE curriculum. For the next 3 years, ATE faculty (as they are now called) were engaged in 2-4 project-specific activities each year. SCATE continues to work with faculty 3-4 times each year.

This process also involved multicollge communications via conference calls, teleconferencing, and e-mail. Without any of these technological ingredients, the project would not have been successful.

The first year of the SC ATE Center of Excellence project was dedicated to a focused study of current practice and completing a gap analysis.

As this "ET Core" curriculum began to evolve, the entrance competencies for the ET Core became the exit competencies for another curriculum component now called the Technology Gateway. The Technology Gateway is a preengineering technology curriculum that is designed

much the same way as the ET Core and addresses the needs of students who are slightly under-prepared for entrance into engineering technology programs. This component of the SC ATE curriculum was an afterthought designed to address faculty concerns about the number of students enrolling in the state's technical colleges without the skills to be successful in ET.

A curriculum oversight team worked with this large framework and determined that the curriculum should include communications in addition to mathematics, physics, and engineering technology and that learning should flow from an exploration of the major systems in physics (electrical, mechanical, fluid, optics, thermal, and materials). Interdisciplinary teams were formed to address competencies in each of these physical systems. By using just-in-time instruction in mathematics, the curriculum could be designed for students to begin studying physics in the first semester. Traditionally, physics courses follow mathematics courses. With the SC ATE approach, the two are taught concurrently.

The SC ATE team chose to be informed by the problem-based learning (PBL) research but to use PBL with industry-type problem scenarios as a vehicle for the integration of multiple disciplines.

Following faculty training on the concept of problem-based learning, a SC ATE model of PBL was developed.

### **Revisions**

#### *In Writing*

Two industry focus groups were convened in different parts of the state to provide feedback on problem scenarios. A national peer review panel made up of content, curriculum development, instruction, and workforce development experts convened twice to review the curriculum and provide feedback and suggestions for improvement.

The Advisory Board was instrumental in helping identify ways to "market" the curriculum by including components of interest to various constituencies (e.g., equipment lists to assist with high school implementation). The National Visiting Committee was instrumental in identifying steps in the iterative curriculum development process and the national relevance of this effort, which led to national dissemination.

Project PIs, staff, NSF program officer, National Visiting Committee, and external evaluators all visited classrooms to get feedback from students. In addition, student surveys, first pencil & paper and later on-line, were used to collect additional data and feedback.

#### *In Use*

A concurrent engineering model was used throughout where one completed semester of the curriculum was being pilot tested and feedback used to inform the ongoing development of remaining portions of the curriculum. Faculty involved in curriculum development were also on ATE teaching teams pilot testing the product. Two colleges pilot tested the Technology Gateway, while two other colleges pilot tested the ET Core curriculum the first year. Additional pilot sites were identified in the following years.

Initial pilot tests were at volunteer sites in South Carolina. Expansion from those initial sites ultimately involved 9 of the state's 16 technical colleges.

Student data have been used to measure improvement in retention, demographics, and success.

Also, high school faculty tested the Technology Gateway for applicability for dual credit use in high schools.

## RESOURCES

### People

Human resources included a project director.

A full-time curriculum specialist was hired for 5 years, with almost all of her time dedicated solely to the actual work of creating, testing, and modifying the curriculum products.

A writer/editor worked with the project for 3 years. At least 1 year of that time was dedicated to editing and publishing the 2 curriculum products.

Consultants and workshop presenters were engaged to address topics such as teamwork, learning theory and teaching methodologies, technology, assessment of student learning, problem-based learning, and technical communication (communication across the curriculum).

Engineers from industry helped develop real industry problems for academic use in a way that would align the curriculum with industry needs.

Also, in the curriculum review process, national content and curriculum experts were engaged to assess and suggest improvements to the product.

Faculty, department heads, and the peer group of chief instructional officers from all 16 technical colleges were engaged in various ways throughout the development process. No fewer than 125 faculty across the SC technical college system were involved in the development of the curriculum, all of whom were potential instructors of the curriculum. Industry focus groups provided feedback on problem scenarios.

Two national, multidiscipline peer review teams evaluated the entire curriculum and made suggestions for improvement. Members of the national peer review team were all widely recognized for their expertise in content, curriculum development, or workforce training.

Editing, formatting, etc. were handled by project staff specialists.

High school faculty were also engaged to examine and test the Technology Gateway.

### **Time**

Two years were spent organizing the colleges and conducting preliminary research into what needed to be done. A planning grant supported this work.

Time resources used with faculty are also discussed under the “process” section in the “transitions” subsection, and are further mentioned under the “resources” section and “people” subsection in terms of time invested by hired project staff.

### **Money**

The \$1.5M faculty development project included \$1,027,712 in nonpersonnel costs (however, this total includes faculty release time that was part of "participant support" for the project).

For the SC ATE Center of Excellence, roughly half of the \$5M award—\$2,780,600—was for personnel costs excluding most faculty release time other than senior personnel, \$2,219,400 was for other costs including faculty release time.

Money for support staff is key.

Money for faculty development workshops, workplace research, and faculty collaboration throughout the curriculum development process was very important.

### **Other**

Institutional/administrative support is vital. This support ranged from conceptual buy-in to providing meeting space and enabling faculty participation in all project activities, including release time for faculty.

Vital technology infrastructure that enabled multicollge communications via conference calls, teleconferencing and e-mail was provided by the colleges and South Carolina's technical college system office.

## **DESCRIPTION OF PRODUCT**

These materials (in the form of modules, an instructor guide, and student handouts) were designed as a (1) preengineering technology, problem-based curriculum that integrates mathematics, communication, and technology; and (2) a first-year, problem-based general education curriculum for engineering technology students that integrates mathematics, physics, communication, and technology. These modules are typically taught over the course of three semesters. The primary audience is first year community college or technical college and high school students.

The curriculum has been published in hard copy and is also available on the project Web site (<http://scate.org/Educators/CProd/>).

## ADVICE/LESSONS LEARNED

Start with a clear vision of what the curriculum is to accomplish. Involve faculty early and to the extent possible. Involve as many faculty as possible to foster buy-in. Teach faculty and project PIs/staff to work effectively in teams. Don't assume that participants come with these critical skills. Working effectively in diverse teams may take more time but results in a better product that will better serve a diverse audience. Hire specialists to direct the work: faculty neither have the experience in curriculum development nor the time to do the job right without help. Provide assistance for faculty and industry partners so that you use their time wisely: "pick their brains" but then let staff do the bulk of the work, taking it back to the stakeholders often for feedback.

Institutional buy-in at all levels is essential to support faculty buy-in. Effective communications at EVERY level from faculty member to president of the college is very important. One person in the chain of command can derail months of work. This is particularly true of middle managers who may not understand the objectives and often view innovations as disruptive and sources of more work for them.

### *Obstacles and Solutions:*

**Obstacle:** Suspicions of traditional academicians that the new curriculum and teaching approach was less rigorous and lacked full content coverage. **Solution:** Workplace research helped faculty understand the relative importance of topics of course content; peer review validated that national association standards were being met in content areas and demonstrated alignment with accreditation criteria such as the Technology Accrediting Commission of the Accreditation Board for Engineering and Technology (TAC/ABET).

**Obstacle:** The uniqueness of the curriculum would require that instructors be trained in the methods used in the curriculum such as teamwork, integrating content, problem-based learning, etc. **Solution:** An ATE Teaching Team training course was developed and made available to those who plan to teach the curriculum. With the curriculum demand now expanding across the nation, this training is now being converted to an electronic format that can be accessed on demand.

**Obstacle:** Many question the cost of delivery of the new curriculum compared with traditional approaches. **Solution:** Attempts have been made to conduct a cost/benefit analysis, but the number of variables makes this a difficult study. Gains in retention and graduation rates are impressive, however, and may ultimately answer the cost/benefit question.

### *Questions and Solutions:*

**Question:** How should the curriculum be published and made available? **Solution:** Commercial publishing was explored, but since the curriculum consists of a framework and instructor resources rather than a textbook, in-house publishing appeared to be the better approach. The curriculum has been published in hard copy and is also available on the project Web site. The Technology Gateway is boxed as classroom sets of teacher resources and student handouts.

**Question:** How much technology/media support would be available or needed? **Solution:** A technology plan was developed and followed during the curriculum development process. This



plan drove the budget process for technology funding for implementation sites. In addition, the teacher's guide for the curriculum includes an equipment list for each problem scenario.

**Question:** What would be involved in national development? **Solution:** Coupling the ATE Teaching Team training class with dissemination of the curriculum materials. "Adapt and implement" partners from across the country have purchased the curriculum and have been provided with faculty training as part of the package. This national dissemination is one of the objectives since the SC ATE Center of Excellence received funding to serve as a National Resource Center for Engineering Technology Education. This model will be expanded with completion of the training CD, which is the first step in the development of an interactive, on-line course.