A Distributed-Hybrid Approach to Creating a Community of Practice Using NSF Funded Manufacturing Engineering Technology Curriculum Modules

Results of Prior NSF Support

In 1995, the National Center of Excellence for Advanced Manufacturing Education (NCE/AME) was one of the first three national centers established by NSF. In addition to an estimated $1,069,000 in local support from Sinclair Community College, corporate sponsors and sales of products and services, the following NSF grants were awarded to Sinclair.

Table 1. *Prior Related NSF Grants*

Project Title	Project Director	Funding Level	Grant Number	Funding Cycle
National Center of Excellence for Advanced Manufacturing Education	David Harrison	$5,000,000	DUE 9454571 DUE 9714424	1/1/95 – 12/31/01
Completing the Curriculum: Modular Manufacturing Education Model for Advanced Manufacturing Education	Monica Pfarr	$1,800,000	DUE 0071079	7/1/00 – 6/30/03

The three goals of the NCE/AME are to:

- Develop an integrated manufacturing curriculum that is interdisciplinary, competency-based, and occupationally-verified.
- Implement a program in Dayton that will serve as a model partnership for manufacturing and technology education.
- Disseminate best practices in manufacturing education, providing implementation support and faculty enhancement opportunities to partner organizations.

The impact of the NCE/AME has been substantial with 8,600 students directly impacted by products and services. Furthermore, 3,500 individuals employed in business have been directly impacted. Specific outcomes include the following:

- Developed a modularized curriculum development process. This formalized, repeatable approach creates hands-on, competency-based learning materials, where skill-building activities are simultaneously coupled with fundamental theoretical knowledge throughout the educational experience.
- Developed a model manufacturing engineering technology associate degree program in 1997, based on Society of Manufacturing Engineering industry skills standards (SME, 1990, 1994, 1997, 1999). To date, over 4,073 Sinclair students have completed a course where one or more of the modules were taught. In addition, ninety-eight students at the University of

Dayton have taken one or more of the modules and 11,914 students in colleges across the nation have been impacted.

- Developed sixty-two competency-based curriculum modules listed in Appendix A. NCE/AME staff is continuing to collaborate with nearly forty colleges, universities, industries, and high schools to develop, refine, and test modules.
- Sponsored three national conferences that focused on Best Practices in Manufacturing Education, (1998) and development of effective partnerships among tech prep, community colleges, universities, and industry to implement effective models for manufacturing engineering technology programs (1999 and 2000).
- Provided faculty professional development for 4,493 faculty and teachers nationwide. The NCE/AME hosted three Summer Institutes for module development in 1996, 1997 and 1998.
- Disseminated results via twenty-seven articles in national publications and twenty-one presentations at national and regional conferences.

The proposed "Continuous Process Improvement" certificate uses the instructional modules and the instructional architecture previously developed at the NCE/AME. A national shortage of qualified Manufacturing Engineering Technicians prompted the creation of the NCE/AME, with one of its expressed goals, the development and nationally dissemination of a competency-based, occupationally-verified, TAC/ABET accreditable associate degree in Manufacturing Engineering Technology (Society of Manufacturing Engineers, 1997). By June 2003, all sixty-two instructional modules designed for facilitator-led, hands-on collaborative learning will be available in an electronic or print-based format. These modules with varying equivalent college quarter credit hours, from one to three, were based on a module architecture that supports problem-based constructivist learning. A secondary deliverable of the grants was the conducting of two gap analyses for the suitability of materials produced in other NSF-ATE grants in the productions of modules. These materials were found incomplete, based on competency scope or on pedagogy, for replacement of proposed NCE/AME modules. The project team will review the results of the gap analysis and determine the applicability of those materials for use in support of the acquisition of the supportive declarative and structural knowledge necessary for the instructional activities in the modules. Additionally, web based searches will be conducted for applicable learning objects that could support the instructional materials. Table 2 provides summary information on the current and proposed instructional materials and delivery methods.

Table 2. *Linkage between Previous and Proposed Instructional Materials and Delivery*

Current Instructional Delivery	Proposed Instructional Delivery
• Instructional modules provide face-to-face small group competency-based activities facilitated by a subject matter expert.	• Instructional modules provide face-to-face small group competency-based activities led by a facilitator who can be classified as a competent practitioner.
• These activities support the acquisition of procedural knowledge, higher level thinking skills, oral presentations, and team building processes.	• Same as current.
• Students form natural study groups.	• Same as current.
• The end of the module transfer activity is based on current macro-context "Robotic Grippers Inc."	• The end of the module transfer activities can be customized to solve a specific company macro-context.
• All groups meets at the same time and same place	• Each group can meet at different times and different places
• Declarative and structural knowledge necessary to support the competency-based activities provided in the form of class lectures, homework assignments, and examinations.	• Declarative and structural knowledge necessary to support the competency-based activities provided over the web in the form of graphic organizers, worked examples, homework assignments, self-testing, and examinations.
• All students meet at the same time and place.	• All students can access the instructional materials at different times and places.
• A student's contact with a subject matter expert typically confined to the module instructor.	• All students will have opportunities to connect with subject matter experts outside of the course structure using "virtual conferences" and discussion forums.
• A student's contact with other students after the instructional unit finishes is by chance alone.	• Students can continue their contact with other students using discussion forums and e-mail.
• Nationwide there are only 14 TAC/ABET accredited Manufacturing Engineering Technology Associate degree programs thus limiting underrepresented student	• Proposed program can provide opportunities at any industry or college site that has access to the necessary

access.	equipment.
• Currently no TAC/ABET accredited Manufacturing Engineering Technology distance education program exists.	• The distributed-hybrid approach offers the possibility of an accredited Manufacturing Engineering Technology distance education program.

Project Overview

The NCE/AME will lead the development and testing of a distributed hybrid instructional delivery process as a method for increasing the number of students in Technology Accreditation Commission of the Accrediting Body for Engineering and Technology (TAC/ABET) accredited associate degree programs by providing greater student geographic access. The proposed distributed-hybrid instructional delivery method uses award winning face-to-face instructional materials while at the same time it provides the ability for small groups to function as part of a larger class even with temporal and geographical shifts. With this delivery system, each class consists of a network of multiple nodes (small groups), with each node consisting of four or more students that form a facilitated group that functions as part of the larger class. At least four nodes located at industry and two-year colleges, sites are proposed. These nodes and the module instructors connect to each other and to the "subject matter experts" by the use of WebCT course management software. The use of virtual conferences, discussion forums, chat and e-mail, provide the communication basis for a "community of practice" focusing on solving authentic problems. The instructional materials build on the modular curriculum funded by National Science Foundation grants. Organizational partners include several instructional departments at Sinclair Community College, Seminole Community College, Belmont Technical College, and the Social Science Research and Evaluation Corporation of Burlington, Massachusetts. The subject matter experts (SMEs) within this grant represent both industry and academic backgrounds and were the original SMEs for the modules.

The resulting materials developed in this project provide both instructive and constructive learning, require the learner to be active and interactive, and provides opportunities for the learner to work independently and as part of a team.

Goals and Objectives

The goal of this project is to develop, test, and evaluate the effectiveness of new web-based primary instructional materials, leading to a certificate in *Continuous Process Improvement* (CPI), that utilizes a unique distributed-hybrid delivery model. The project objectives are to:

- supplement twelve existing NCE/AME face-to-face instructional modules with web-based declarative and structural supporting materials, within a reusable learning object format, suitable for a distributed-hybrid method of delivery, and create and supplement one new module, *Problem Solving Models and Methods*;
- pilot test the materials and delivery method at a total of four or more industry and college sites with an average of four or more students per site per term;
- develop a web-based virtual "community of practice" over the length of the program that includes subject matter experts, participating students, and module instructors for the purpose of creating self-sustaining, student-led environments for sharing and growth;
- test the effectiveness by comparing student performance and retention in at least four modules; student, faculty, college, and industry satisfaction; and institutional and industry return on investment when compared to face-to-face or pure web based instruction;
- research and create a dissemination plan that addresses adoption barriers identified in the project.

Figure one below illustrates the functional relationships among eighteen modules, representing approximately thirty quarter hours of undergraduate courses, which provide sufficient skills to qualify for the awarding of a certificate in *Continuous Process Improvement*, and their level of instructional development. The five unshaded modules, *Process Control, Quality Foundations*, *Teamwork*, *Basic Statistical Variation,* and *Principles of Manufacturing Processes*, represent internally grant funded pilot distributed-hybrid modules developed but not fully tested or reviewed. The twelve lightly shaded modules require the development and testing of the web based support materials and represent the bulk of the instructional design effort for this grant proposal. The heavily shaded module, *Problem Solving Models and Methods*, is an entirely new module that requires the creation of both face to-face activities and web-based supporting materials.

The Quality Engineering Technology Department at Sinclair Community College, the only TAC/ABET certified Quality Engineering Technology AAS program in the United States, will award the short term certificate. The content of the certificate, which focuses on quality management and problem solving skills, can be applied fully towards a currently accredited associate degree in QET and is a subset of the entire Manufacturing Engineering Technology model curriculum. While this two-year project focuses on content found in the domains of statistics, management, manufacturing, industrial, and quality engineering, the same approach can be used for other programs with laboratory or hands-on components as demonstrated by two other hybrid examples: Crocker's hybrid hospitality management course, and a joint hybrid allied health Radiographic Technician program between Sinclair Community College and Hocking College in southeastern Ohio.

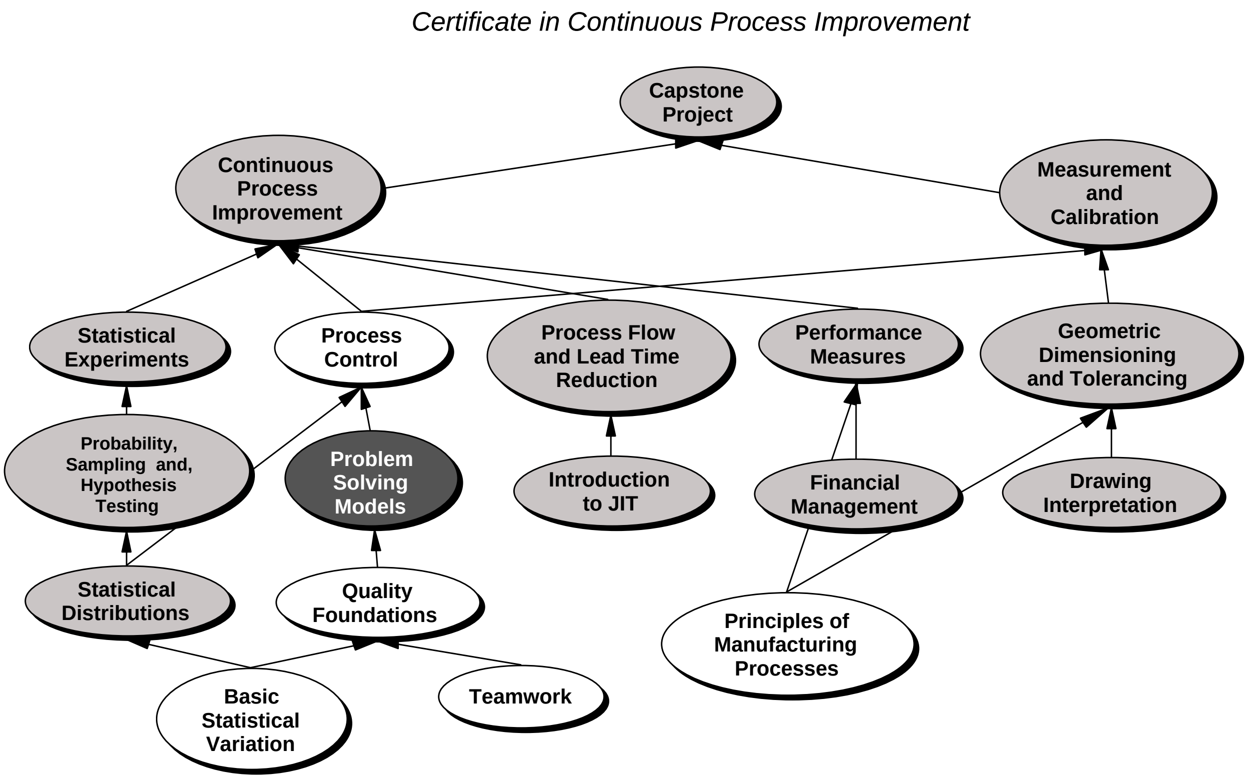

Figure 1. *Modules, with Prerequisites, for the Certificate in Continuous Process Improvement*

Crocker (2002) integrated hands-on learning methods with web based instruction in a hospitality management course by replacing those portions of the course that were traditionally delivered in face-to-face classroom instruction with web based instruction that included text, graphics, and streaming video. To demonstrate the functional skills Crocker required the students to intern at the hospitality center for the school or at certified inns or centers across the state.

Sinclair's Radiographic Technician AAS program is offered over the web using WebCT course management software to students at Hocking College. The students complete their laboratory requirements at a local hospital under the guidance of a local instructor hired by Sinclair to handle the supervision and evaluation of the students' clinical skills. The successful students ultimately complete their associate degree from Sinclair, without ever coming to Sinclair 's campus. Both of these examples address the critical need of incorporating authentic experiences, with the necessary equipment, as part of the student's learning experience.

How will this proposal address the issue of laboratory requirements within the CPI certificate? The most challenging module within the CPI certificate, in regards to laboratory equipment requirements, is the *Measurement and Calibration* module. The laboratory activities for this module focus on the use of hand instruments (micrometers, dial or vernier calipers, gage blocks, and the steel rule), and on the use of surface plate mounted measurement instruments (height gages, gage blocks, mu-checkers). Typically, a company site will have the hand instruments and most of the more elaborate measuring instruments while a college site lacking the basic instruments can visit a local company or borrow instruments from Sinclair's loaner supply.

Project Plan

Problem/Need Statement

The demand for skilled graduates, articulated in the Society of Manufacturing Engineers' *Manufacturing Education Plan,* and based on a wide-ranging study by manufacturing professionals in six key industry sectors identified gaps between industry needs and the capabilities of recent college graduates. The most frequently mentioned gaps included: (1) communication skills and teamwork, (2) business and project management skills, (3) materials and manufacturing processes, (4) lean manufacturing and continuous improvement, (5) quality principles, statistics and probability, (6) ergonomics and human factors, and (7) continuous, lifelong learning (Society of Manufacturing Engineers, 1997). While the national need is documented, currently only fourteen two-year colleges, down from eighteen four years ago, offer a TAC/ABET accredited associate degree program in Manufacturing Engineering Technology and only eleven two-year schools offer a NAIT accredited associate degree in Manufacturing Technology (Technology Accreditation Commission, 2000). This proposal provides an innovative delivery solution for increasing the number of trained graduates.

Convincing community colleges and technical institutes to add or maintain an additional degree program that will draw a small number of students is difficult given the current institutional barriers. These institutional barriers to the development of an accredited program include: (1) the costs of allocating and maintaining the required laboratories, (2) cost of equipment procurement, (3) finding qualified instructors, (4) the cost to develop instructional materials, and (5) recruiting a sufficient number of qualified students. A popular alternative delivery approach, pure web based instruction is unlikely to meet the TAC/ABET or NAIT accreditation requirements for manufacturing technology programs, given their heavy laboratory emphasis. Many community colleges wish to meet the educational and training needs of their manufacturing community but are unable to sustain manufacturing related courses beyond a common curriculum core. The proposed distributed-hybrid method allows a TAC/ABET or NAIT accredited college partner to offer additional courses at distance sites much the same as current Instructional Television Fixed Service (ITFS) content delivery methods. This allows the students to continue their degree program and as the enrollment increases the partner college can choose to offer more classes on site or at their local industry. Thus, the distributed-hybrid instructional delivery system directly address the barriers of finding qualified faculty, students, and minimizing the development cost for new instructional materials by scaffolding on existing accredited programs. Indirectly, the instructional system provides a solution to the problems of equipment purchase and upkeep by using equipment at the industry sites. Why would industry be interested in this certificate? This certificate provides skill sets that address three-fourths of the gaps identified in the previously cited SME study, and these needs related to process improvement continue to be demonstrated by the explosion in training and application of "six sigma" methodologies. An example of the demand for these skills is illustrated by the results of a web search at net-temps.com conducted on August 7, 2002 using the keyword "process improvement." This search produced 3,925 current job openings.

Supporting Research

Module Pedagogy and Instructional Strategies

The project uses a module architecture developed by the NCE/AME which reinforces our beliefs about effective learning and consists of four major elements, the "big picture," "authentic learning tasks," "closure and generalization," and the "transfer activity". (NCE/AME, 2000, p.

21). Table three provides supportive research for the instructional architecture and figure two illustrates the model.

Table 3. *Supporting Research for the Module Architecture*

Module Features	Supporting Research
The "big picture" defines the contexts for all activities within the instructional unit.	Pask (1976) supports the need for a holistic, "whole to part" delivery of instructional materials.
An "authentic learning task" (ALTs) consists of a discrete event or experience through which students acquire one or more competencies.	Herrington and Oliver (2000) support the creation of authentic learning environments and contexts with an authentic activity. VanMerriënboer (1997) supports the use of transfer activities, claims that the "appropriate design of whole-task practice is critical to reaching the goals...of problem solving and transfer of the non-recurrent aspect of complex cognitive skills as an overall learning outcome".
The "transfer activity" allows the students to reinforce and extend competencies learned in the ALTs to a new authentic ill-structured problem.	Lynch (2002) cites the need for learners to apply their problem solving skills "to the real world environment in which they live/work". Mayer (1998) hypothesizes that asking learners to solve ill-structured problems reinforces the need for developing metaskills; that is, strategies for how to use their knowledge in problem solving.
The each learning task is designed to provide closure and generalization.	

The metaskills and communications skills are reinforced in each module by the application of core competencies that focus on how students think, how they communicate, how they interact with others, and how they use knowledge. Each learning activity provides closure and at the same time the facilitator guides the discussion back to the overall "big picture" in order to provide a broader view of the applicability of the skill set. The competencies supported by the module architecture are by their construction aimed at developing higher level thinking skills. The modules provide the activities for attaining and assessing the procedural knowledge and the higher level thinking skills, but by original design intent did not provide the supporting materials necessary for achieving the sub competencies necessary for successful completion of the competency illustrated in figure two. It is one of the objectives of this grant to produce web based learning objects which provide instructional granules, such as text, video, audio, graphical organizers, worked examples, self-assessment exercises, and other assessment opportunities that will support the sub competencies required for successfully completing the ALTs and transfer activities in the selected modules.

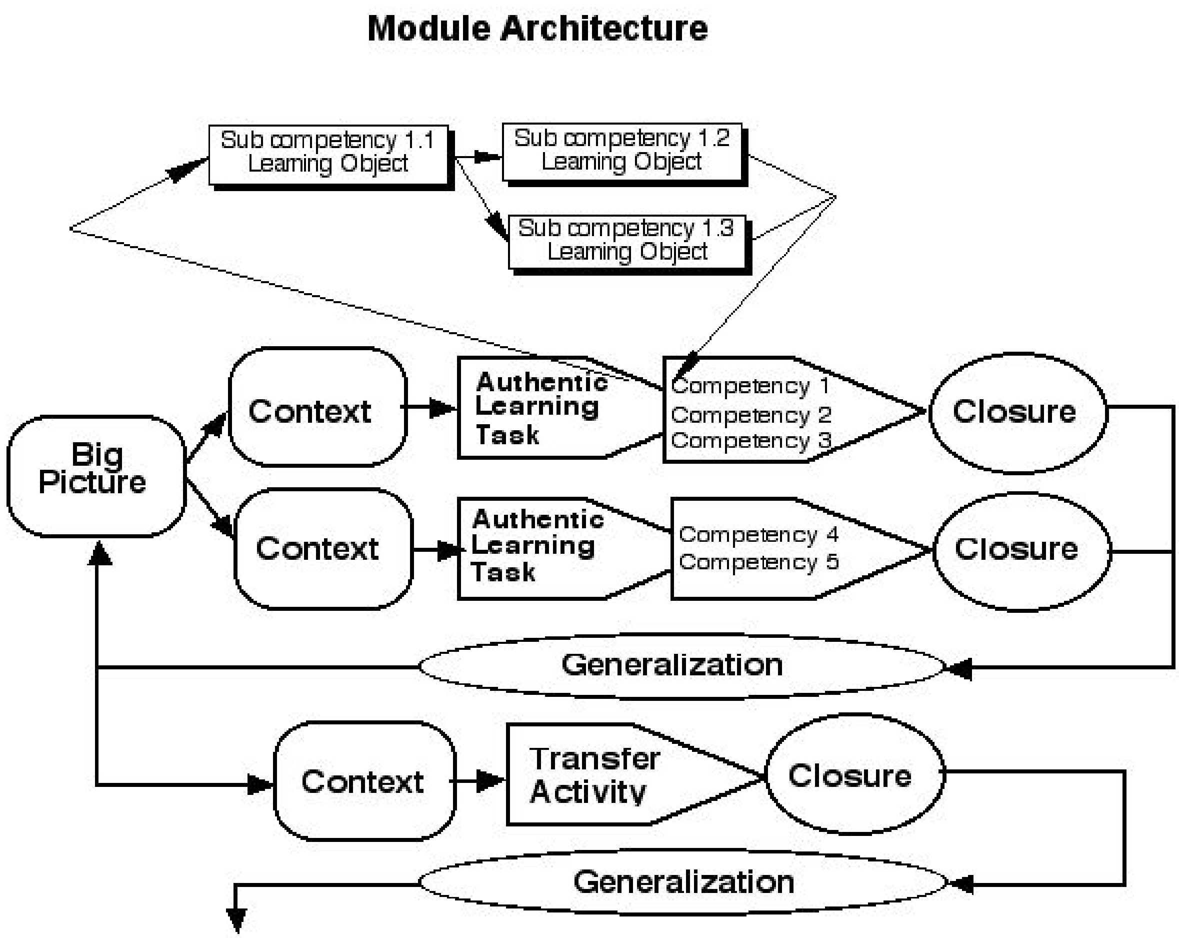

Figure 2. *NCE/AME Module Architecture*

Ertmer and Newby, supported by Spiro, etc., suggest that the requirements of the task to be learned define the instructional approach. For declarative and structural knowledge typically found in supportive sub competencies, a low to medium level of cognitive processing is necessary. A low degree of cognitive processing includes knowing the facts or steps, knowing what, and typically uses the behaviorist approach to learning, for example the triad of practice/reinforcement/feedback for learning and memory instruction. Typically in medium levels of cognitive processing, knowing why, “schematic organization, analogical reasoning and algorithmic problem solving" methods are appropriate. Examples of activities, that require higher level thinking skills, include case problems, simulations, situated learning, cognitive apprenticeships, and other constructivist approaches to instruction focus on knowing how, and knowing knowing (Ertmer & Newby, 1993, p 67-68; Spiro, Feltovich, Jacobson, & Coulson, 1991, p 24). Table four provides a summary table that indicates the relationship between the cognitive level of knowledge and suggested instructional strategies. This approach to selecting the instructional strategy based on the knowledge taxonomy is the approach endorsed by the team.

Table 4.*Relationship between Learning Taxonomy and Instructional Strategies*

<table>
<tr><th>Bloom</th><th>Anderson/Jonassen</th><th>Reigeluth</th><th>Suggested Instructional Strategies</th></tr>
<tr><td>Knowledge</td><td>Declarative knowledge</td><td>Memorizing information</td><td rowspan="2">• Direct Instruction**
• Gagne's Nine Events of Instruction
• Inductive Thinking**</td></tr>
<tr><td>Comprehension</td><td>Structural knowledge</td><td>Understanding relationships</td></tr>
<tr><td>Application</td><td>Procedural knowledge</td><td>Applying skills</td><td rowspan="2">• Simulation Models
• Experiential Learning*
• Inquiry Learning
• Problem Based Learning*</td></tr>
<tr><td>Analysis
Synthesis
Evaluation</td><td>Metacognitive knowledge</td><td>Applying generic skills</td></tr>
</table>

*Typical approaches used in the development of the ALTs and transfer activities.
**Approaches advocated for the new instructional materials to be developed in this project.

Instructional Delivery

The possible delivery continuum of solutions runs from fully temporally and geographically diverse distance education, taught at multiple institutions, to traditional face-to-face classroom/ laboratory delivery. In order to select the "best" solution, the project development team proposed six possible delivery solutions for evaluation based on specified criteria found in table five. A mandatory criterion is the ability to meet TAC/ABET accreditation requirements. The team tried to gain specific answers to all of the listed criteria for each of the delivery modes. It was determined that the numbers were not available, because of the uniqueness of the proposed delivery method and thus became important evaluation measures within the proposed grant.

Table 5.*Possible Instructional Delivery Solutions and Criteria for Selection*

Possible Delivery Solutions	Criteria for Selection
Option 1: Face-to-face instruction, with adoption of program based on full institutional commitment. Option 2: Hybrid face-to-face and web based distance education, based on single site delivery. Option 3: Distributed hybrid face-to-face and web based distance education, single institution offers. Option 4: Distributed hybrid face-to-face and web based distance education, multiple institutions offer. Option 5: Pure web based distance education, single institution. Option 6: Pure web based distance education, multiple institutions.	• Will the proposed method meet accreditation requirements? (TAC/ABET) - Mandatory Requirement • Does the delivery method support the most effective instructional strategies? • What is the level and quality of the interactivity and responses? • What is the delivery units' instructional retention rate? • Does the method satisfy student and employer needs? • What is the difficulty of hiring qualified facilitators? Faculty? • What portion of the instructional unit must be delivered at an institution versus a remote site (including ones home or workplace)? • What portion of the instructional time is fixed? • What is the complexity of the delivery technology? • What is the overall ease of adoption of the materials? • What is the dollar cost to the participant per Carnegie unit? • What is the fixed dollar cost to the institution per Carnegie unit based on a five-year depreciation cycle?

The use of hybrid instruction (Option 2) versus pure e-learning (Option 5) has exploded across college campuses as documented by Young (2002). Additionally, Grobler (2002) advocates the use of blended instruction (Option 2) that includes face-to-face, with e-learning as the only way to guarantee effective student learning. The authoring team found eight NSF-DUE awards over the past seven years have supported research efforts studying the use of distance education and various media to deliver or to support student learning in technology or supportive courses. Table six categorizes these grants into two categorizes (1) creating web-based resource centers, (2) and developing and delivering web based distance education courses (Options 5 and 6).

Table 6. *Recent DUE Distance Learning Grants*

Grant Category	DUE Grants
Creating web-based resource centers	• Chang's (1999) creation of a web based resource center. • Washington State's project investigating online learning environment (Crouch, Brown, Jenkins, Hallgren, & Hudelson, 2000). • Owens and Pelton's (1995) project to create a distance learning program for undergraduate engineering adult learners in industry. • Bringsjord and Noel's (2000) "Super-Teaching" project.
Developing and delivering web based distance education courses and investigating potential pedagogues on the web	• Kurose's (1999) efforts to create and deliver a fully web based computer science degree. • South Dakota project to deliver electronics education to upper level high school students (Miller, Gulliver, Termes, & Bailie, 2001). • Maui Community College's efforts to deliver an electronics curriculum using teleclasses and simulated multi-media laboratory experiments (Converse, Pezzoli, George, & d'Argy, 1995). • MATEC project using web based simulations to deliver sixteen instrumentation and control experiments (Meyer, 2001).

While these studies address distance education in science, mathematics, engineering, and technology, none of them focus on the manufacturing engineering technology or on distributed-hybrid (DH) delivery methods. Until this past year no research studies had been published related to the proposed delivery mode until the faculty at the University of Tennessee concluded that twenty-six MBA students participating in a hybrid delivery system performed at a significantly higher level than students participating in just a resident program, $p < 0.01$ (Dean, Stahl, Sylwester, & Peat, 2001). The hybrid delivery system (Option 2) consists of resident instruction and the use of the World Wide Web and/or synchronous cyber classes. Based on the literature review, the level of student interaction, and cost considerations, the project team proposes that an appropriate distance delivery modality for the NCE/AME modules be a DH model (Options 3 or 4).

Community of Practice

Dewey and Vygotsky proposed a social-constructivist view that “the theory of individual learning that pervades schools is flawed" therefore, there exists a “need for a supporting community to provide the framework for individuals to construct their own knowledge” (Bielaczyc & Collins, 1999). Tu and Corry (2002) classified possible communities as, communities of interest, communities of purpose, communities of passion, and communities of practice. "Communities of practice focus on a common set of activities and are composed of people who share common or related professional responsibilities and activities that can often catalyze breakthrough thinking" (Tu & Corry, 2002 p. 210). Communities of practice can also be distinguished by their emphasis on both vertical learning (i.e. novice - expert) and horizontal learning (i.e. novice - novice), and on both individual and community learning. The community of practice first proposed by Lave and Wenger was based on a social theory of learning, which included the key elements of the theories of social practice and of identities (Lave & Wenger, 1991; Wenger, 1998). Legitimate participation defines ways of belonging to a community of practice, these ways can include community membership, both locally and within related communities, and the members trajectory: peripheral, inbound, insider, outbound or boundary. Does Wenger provide any guidance concerning the organization of a community of practice?

Wenger suggests that a learning architecture that supports a community of practice must maintain three infrastructures or components of learning design. These include (1) providing places of engagement, (2) providing materials and experiences with which to build their own image of the world, and (3) providing ways for the learner to have an effect on the world. The first component, engagement, requires mutual activities that include students and other involved people, challenges and responsibilities that call on the participants' knowledge and at the same time encourage them to explore new possibilities and finally, enough continuity for participants to develop shared practices and long term commitment. The second component, educational imagination, requires that "students must be able to explore who they are, who they are not, who they could be" (Wenger, 1998 p 272). This can include the practice of orienting their positions as part of a whole, reflecting on their situations with new eyes and finally exploration by not accepting things the way they are without experimenting and exploring possibilities. The last element, educational alignment, requires participants to have a first-hand experience of what it takes to accomplish something on a larger scale.

Model for Creating the Distributed-Hybrid Community of Practice

Project objective three is to develop a web-based virtual "community of practice" over the length of the program that includes subject matter experts, participating students, module instructors, and facilitators for the purpose of creating self-sustaining, student-led environments for sharing and growth. In order to achieve this objective the proposed model class creates a network of nodes and participants. Each node consists of at least four students and a facilitator that meet face-to-face to complete the instructional activities developed within each module, as part of the web based modular class. The supporting structure includes the multiple networks of nodes, a web/course management system that supports the delivery of the necessary declarative and structural knowledge, and the technology that supports horizontal and vertical communications. Figure three illustrates the organizational system model for a four-node distributed-hybrid trial.

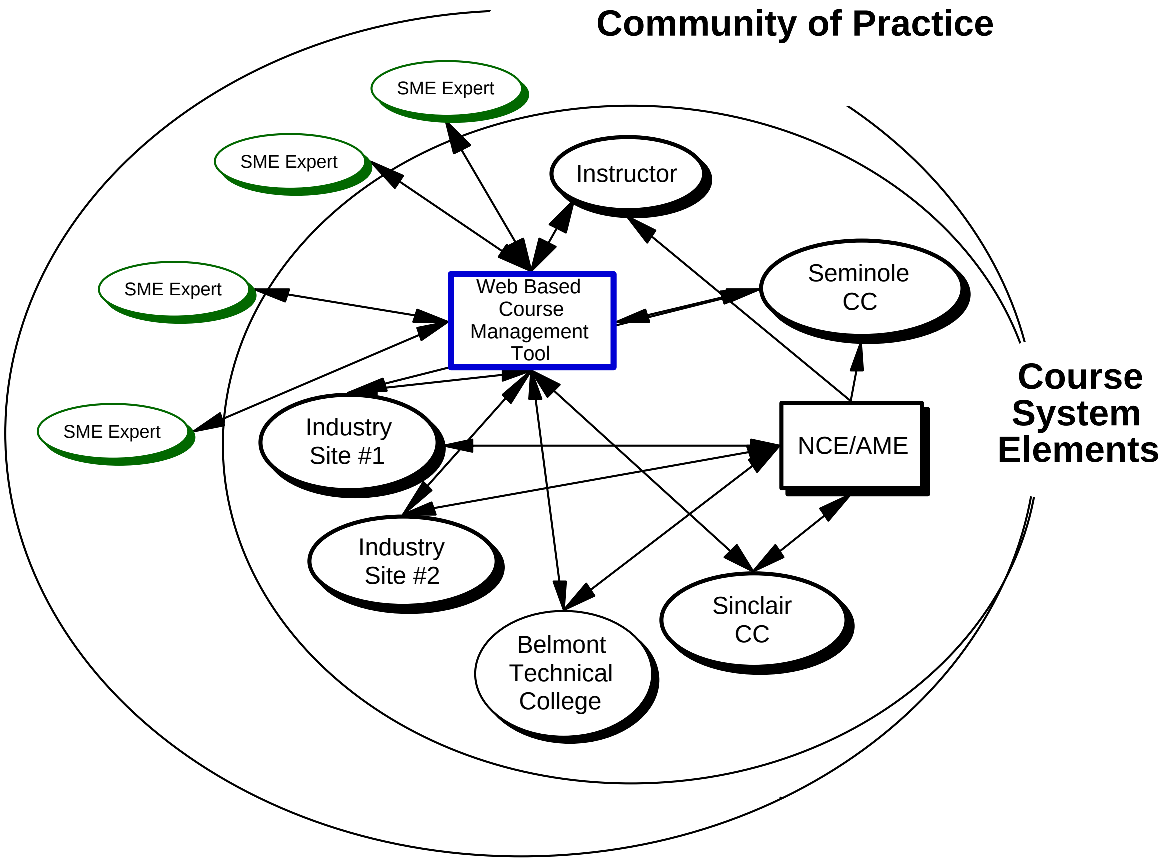

Figure 3. *Four-Node Distributed-Hybrid Model of a Community of Practice*

The use of the face-to face instructional modules developed by the NCE/AME and the use of a distributed-hybrid (DH) instructional delivery method provide the basis for meeting Wenger's instructional design elements. The face-to-face facilitation of the activity-based materials at the nodes satisfies the requirement of places of engagement. The activity-based materials based on Kolb's learning cycle providing materials and experiences with which to build their own image of the world (Stice, 1987). The third element, the use of a transfer activities will allow the learners to apply what they have learned to a new context, such as their workplaces, and provides a mechanism for the learner to have an effect on the world. The use of a DH modality provides the supportive structure for student learning at multiple levels including; face-to-face facilitation at each node of four to six students, node-to-node and learner-to-expert interactions occur using a discussion forum. The proposed modality should include the use of virtual conferences and companion discussion forums, to provide greater support for interactions between experts and the overall community. The desire to have a student led, self-sustaining community is more problematic, and will require creating a community, through training and facilitation, with the skills to transition from being faculty led to being student led. A community of practice requires both horizontal and vertical two-way communications between students, facilitators, the instructor, outside subject matter experts, and inside the "company" subject matter experts. The interactions include both face-to-face and by electronic means, including instant messenger, telephone, e-mail, chat, discussion forums, and virtual conferences.

Urgency for Solving the Problem

The Society of Manufacturing Engineers has documented the need for qualified technicians and manufacturing practitioners, at the same time the number of TAC/ABET accredited programs has dropped from eighteen to fourteen. Given the current economic conditions it is safe to predict that the number of manufacturing and manufacturing related programs will continue to decline, reducing student access to these programs, unless some new intervention is proposed. Pure web instruction can not always be used to deliver laboratory content, current solutions require either moving the laboratories to the students or moving the students for extended time to the laboratories. These choices are costly logistic nightmares or prohibitive in cost and time for the typical two-year college student. The proposed delivery methodology must be tested in order to measure the impact on student retention, satisfaction, and overall cost to colleges and industry. The *CPI Certificate* provides a coherent body of knowledge to test the proposed delivery methodology.

Certificate Description, Sequencing, and Impact

The grant intends to develop web based materials and assessment instruments, that support the declarative and structural knowledge requirements necessary to support the face-to-face activities developed previously by the NCE/AME. The module activities and web supplements, in the form of learning objects, developed under this grant provide sufficient skills to qualify for the awarding of a certificate in *Continuous Process Improvement*, a subset of an overall associate degree. Appendix A provides a list of the entire NCE/AME model curriculum, the modules found in the CPI certificate, and schedule for section offerings. Table seven provides the planned sequence of module pilot testing offerings by quarter. Based on job opportunities and SME documented industry needs students that finish the CPI certificate will have demonstrated achievement of a marketable set of manufacturing and quality management skills.

Table 7. *Distributed-Hybrid Pilot Testing Sequence and Credit Hours by Academic Quarter*

Winter 2004 (5 credit hrs.)	Spring 2004 (6.5 credit hrs.)	Summer 2004 (6 credit hrs.)
• Teamwork • Basic Statistical Variation • Quality Foundations • Principles of Mfg. Processes	• Problem Solving Models • Statistical Distributions • Process Control • Introduction to JIT • Process Flow and Lead Time Reduction	• Drawing and Interpretation • Geometric Dimensioning and Tolerancing
Fall 2004 (9 credit hrs.)*	**Winter 2005 (6 credit hrs.)**	**Spring 2005 (3 credit hrs.)**
• Probability, Sampling and Hypothesis Testing • Statistical Experiments • Financial Management • Performance Measures	• Measurement and Calibration • Continuous Process Improvement	• Capstone

*Second cohort group starts

Most of the modules within this grant will be offered as part of courses, i.e. the combination of the Teamwork, Basic Statistical Variation and Quality Foundations modules are currently offered as a single course at Sinclair Community College. While other modules will be offered as stand- alone courses, i.e. Continuous Process Improvement and Principles of Manufacturing Processes. By June of 2003 an approved certificate as outline in Appendix B will be available for implementation.

The impact of the documented project is potentially national in scope, and could change the way college level educational content is delivered by adding another point on the continuum between pure face-to-face and pure web-based. A concept review by Drs. Simonson from Nova

Southeastern University, and Branch from the University of Georgia attested to the uniqueness and value of the research on the distributed-hybrid delivery method. This approach ends the isolation of the distance education student by providing a combination of group face-to-face and individual asynchronous learning opportunities. The effectiveness of the delivery system is accomplished by providing the students with high quality instructional materials and activities.

The following table eight provides estimates of the module enrollees based on the schedule. This number should be sufficient to acquire meaningful data as outlined in the evaluation section. What is unclear is the rate in which the delivery method will be adopted. The numbers will be impacted by the success of the dissemination efforts and favorable results from the evaluation.

Table 8.*Projected Impact of Project*

Academic Year	Year 1	Year 2	Year 3	Year 4	Year 5
Number of Module Enrollees	304*	532* 1,400	112* 2,800	8,000	16,000

*As part of the project

Project Timeline

Table nine provides a timeline for each of the objectives and major supporting activities for completion of the grant proposal that supports the distributed-hybrid module offering sequence developed in table seven.

Table 9. *Project Objectives, Activities, and Timeline**

Project Activity	2003-04				2004-05			
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
Objective 1 Supplement twelve existing NCE/AME face-to-face instructional modules with web-based declarative and structural supporting materials, within a reusable learning object format, suitable for a distributed-hybrid method of delivery.								
Supporting Activities: • Create and evaluate learning object web template for effectiveness (by Fall 03) • Review gap analysis materials and research potential sources (by two quarters before module testing) • Review and modify web materials based on SME and web pedagogy feedback to fit learning object format (QF, Teamwork, BSV and Manufacturing Processes) (by Winter 04) • Create, review, and test web-based supportive materials for								

twelve existing modules (by Winter 05)
- Create and test Facilitator guide on how to be an effective facilitator - web based (Create by Winter 04, Test by Spring 04)
- Create a Learning Object development kit for faculty use (Create by Fall, Test by Fall 04)
- Create and test guide on how to create effective macrocontexts (i.e. robotic gripper) (Create by Winter 04 test by Summer 04)

Objective 1a
Create and supplement one new module, *Problem Solving Models and Methods.*

Supporting Activities:
- Module competencies developed
- Module development team assembled
- External reviewer reviews materials
- Module pilot test using DH method (ready by Summer 04)

Objective 2
Pilot test the materials and delivery method at a total of four or more industry and college sites with an average of four or more students per site per term.

Supporting Activities:
- Secure sites and facilitators
- Recruit students (by Winter 04)
- Test through Spring 05

Objective 3
Develop a web-based virtual "community of practice" over the length of the program that includes subject matter experts, participating students, and module instructors for the purpose of creating self-sustaining, student-led environments for sharing and growth.

Supporting Activities:
- Set up ongoing WebCT or external discussion forum (by Winter 04 through Spring 05)
- Secure SME's for virtual conferences with students - schedule two per term related to current module topics with follow-up discussion board (by Winter 04)
- Create and test training materials for developing student-led discussion forums (Create by Spring 04, test by Fall 04)

Objective 4
Test the effectiveness by comparing student performance and retention in at least four modules; student, faculty, college, and industry satisfaction; and institutional and industry return on investment when compared to face-to-face or pure web based instruction.

Supporting Activities:
- Select courses/modules that are both face-to-face and pure web based (by Winter 04)
- Generate a report that answers fundamental effectiveness questions (by June 05)
- Create a model that defines the needed face-to-face time versus

pure web-based considering subject domain, activity levels, level of interaction, etc. (by June 05)								
Objective 5 Research and create a dissemination plan that addresses adoption barriers identified in the project.								
• Based on feedback from the evaluation section develop a plan for the dissemination of the instructional materials that addresses the different stakeholders - – four year colleges with technology programs – community colleges with manufacturing engineering technology programs – with manufacturing related programs – with no technology programs – industry and industrial associations (by Spring 05). • A broader dissemination of the findings related to the delivery method will be disseminated at a national level								

* Light gray shading represents the planning and development phase, dark gray represents the testing or implementation phase.

Experience and Roles of Senior Personnel

The primary deliverables in this grant focus on the development of web based instructional materials and the delivery of those materials to community college and industry students. The senior personnel provide extensive experience in web and instructional design and are capable of implementing this project.

Jim Houdeshell, Project Director is Professor of Quality Engineering Technology at Sinclair Community College and a Co-Principal Investigator at the NCE/AME on all the NSF center grants since the beginning of the center in 1995. He has extensive experience in all phases of the National Center, including creating and applying the instructional design model, managing the center, and co-authoring five of the modules offered as part of the *Continuous Process Improvement* certificate. Before working on the grant, he served as an academic Department Chairperson and as President of the Faculty. Professor Houdeshell has spent time overseas as an instructional designer as part of a USAID project in India and as an exchange guest lecturer at the Western Melbourne Institute of TAFE. His dissertation topic, "Scaffolding Transfer Activities Using Concept Maps to Enhance Student Learning and Adaptive Problem Solving," focuses on the effect of problem structuredness on cognitive transfer. Prior to working at

Sinclair, Professor Houdeshell worked on the product development team that designed and built the first commercial driver airbag system.

Kate Brown, Principal Investigator currently an e-learning consultant was formerly employed by Siemens ICN Corporation as a Principal Technical Trainer (e-Learning Development) as project manager for the German/American Collaboration project. This project connected Siemens American technical training with training at the home office in Munich and transferred content into XML-based content for delivery to multiple countries in multiple languages--both synchronous and asynchronous. Ms. Brown also managed multiple instructional design projects and worked as a course developer for Web Based Training. Before working at Siemens, Ms. Brown was a founding member of the Florida Virtual High School where she taught business education online, developed online content, and mentored teachers. In addition, she was responsible for the school's web presence and statistical reporting, strategic planning and marketing. Ms. Brown's dissertation topic is on the differing perceptions of instructional technology between subject matter experts and instructional designers.

Paul Giguere, Principal Investigator, is a Senior Technology Associate at Education Development Center, Inc. (EDC) in Newton, Massachusetts. Mr. Giguere is responsible for investigating and implementing distance learning systems, theories, and practices with regard to web-based learning and its appropriateness for the delivery of training and professional development through projects primarily based in the Center for Health and Human Development Programs (HHD) at EDC. Mr. Giguere develops and teaches on-line classes at University of Massachusetts at Lowell on such topics as computer science theories and the ethical issues involving technology in society. Mr. Giguere's dissertation research area is in synchronous web communications and interactivity.

Sherry McAndrew, Principal Investigator, is a Web Course Facilitator/ Instructional Designer at Sinclair Community College. Ms. McAndrew assists faculty with the development and delivery of distance learning courses on the internet. Before working at Sinclair, Ms. McAndrew worked for Reynolds and Reynolds as a Senior Web-Based Training Developer where she implemented Cisco-based reusuable learning object strategy using a three-level hierarchy of Authorware learning objects. Ms. McAndrew has nearly fifteen years additional experience in both industry as a technical trainer and systems analysis, and as a community college computer science faculty.

Gilah Rittenhouse, Principal Investigator is a Co-Principal Investigator for the NSF "Completing the Curriculum Grant," and Manager of Instructional Publications at the NCE/AME. Ms. Rittenhouse is responsible for supervising, evaluating, and coaching the five staff members responsible for coordinating the module development process. This staff has developed instructional modules covering seventy separate subjects for a two-year degree program in manufacturing engineering technology and other industrial customers including the Dayton Tool and Machining Association. Before joining the NCE/AME. Ms. Rittenhouse held positions in educational administration and teaching.

Managing the Project

A project where the senior personnel and partners are geographically dispersed in three cities - Dayton, Boston, and Orlando - requires the use of different approaches to managing the process. Hinds and Bailey (2001) argued that technology alone is unlikely to solve the problems of team virtuality, and suggested to structure team coordination so as to limit team interdependence and to provide face-to-face interaction for the team at critical development points. With these suggestions in mind, each PI leads a subset of the overall activities in support of the objectives at their "node" in order to minimize interactivity. If the task requires more than one PI to be involved, then the task will be handed off from one PI to the next, or a virtual conference will be scheduled. The PI team is scheduled to meet face-to-face at least two times a year, once at the NCE/AME and at an appropriate national conference i.e. AECT, and at least monthly temporal using web conferencing software. The overall team feels that with this management method, and based on an excellent historical record at the NCE/AME of meeting deadlines and budgets, the goals and objectives of this grant can be successfully met on time and on budget.

Each of the Principal Investigators brings specific areas of expertise and is assigned specific areas within the project to act as lead investigator. Table ten provides additional detail on the assignment of activities to the PI's.

Table 10.*Project Responsibilities for Principal Investigators*

Project Member	Project Title	Project Responsibilities Manages or Co-Manages these Activities
Jim Houdeshell	PD	• Manages PI Team. • Review gap analysis materials and research potential. • Create and test guide on how to create effective macrocontexts (i.e. robotic gripper). • Secure SME's for virtual conferences with students - schedule two per term related to current module topics with follow-up discussion board. • Select courses/modules that are both face-to-face and pure web based. • Based of feedback from the evaluation section a plan will be developed for the dissemination of the instructional materials that addresses the different stakeholders - community colleges with manufacturing engineering technology programs, with and without manufacturing related programs. • A broader dissemination of the findings related to the delivery method will be disseminated at a national level.
Kate Brown	PI	• Review current web template for effectiveness. • Secure industry sites and facilitators, recruit students. • Based of feedback from the evaluation section a plan will be developed for the dissemination of the instructional materials that addresses the different stakeholders - industry and industry associations. • A broader dissemination of the findings related to the delivery method will be disseminated at a national level.
Paul Giguere	PI	• Create and test facilitator guide on how to be an effective facilitator - web based. • Create and test training materials for developing student-led discussion forums. • Generate a report that answers fundamental effectiveness questions. • Create a model that defines the needed face-to-face time versus pure web-based considering subject domain, activity levels, level of interaction, etc. • Based on feedback from the evaluation section a plan will be developed for the dissemination of the instructional materials that addresses the different stakeholders - four year colleges with technology programs. • A broader dissemination of the findings related to the delivery method will be disseminated at a national level.

Sherry McAndrew	PI	• Review current web template for effectiveness. • Provide technical leadership in the creation of the Learning Object development kit for faculty use. • Set up ongoing WebCT or external discussion forum. • Manage loading of materials onto WebCT course management software. • A broader dissemination of the findings related to the delivery method will be disseminated at a national level.
Gilah Rittenhouse	PI	• Review gap analysis materials and research potential sources. • Review and modify web materials based on for SME and web pedagogy (QF, Teamwork, BSV and Manufacturing Processes). • Create, review, and test web-based supportive materials for thirteen existing modules. • Create and test Facilitator guide on how to be an effective facilitator - web based. • Create a Learning Object development kit for faculty use. • Create and test guide on how to create effective macrocontexts (i.e. robotic gripper). • Create and supplement *Problem Solving Models and Methods* Module. • A broader dissemination of the findings related to the delivery method will be disseminated at a national level.

Partners

This project has three partners, Seminole Community College of Orlando, Florida, Belmont Technical College in St. Clairsville, Ohio, and the Social Science Research and Evaluation Corporation of Burlington, Massachusetts. Additional industry test sites are being developed as part of the project, with the expected industry nodes to come on-line the fall of 2004.

Seminole Community College is a full-service education provider offering two-year college credit degrees (AA, AS); specialized career certificates; continuing professional education; customized workplace training; adult education; community, leisure and youth programs. SCC located in the metropolitan Orlando area in Seminole County, Florida. SCC provides learning opportunities at two campuses, an instructional center, businesses, high schools and numerous outreach centers throughout the county. The Florida High Tech Corridor cuts through Seminole County, fostering the explosion of high-tech industrial growth, which has added high-tech manufacturers such as Veritas, Siemens ICN and InterVoice Brite.

Belmont Technical College is a two-year public college with an enrollment of over 2,000 students per year serving Belmont County in eastern Ohio. The college offers associate degree programs and certificates in business, engineering, industrial skills, health and public service technologies, with a strong college emphasis on information technologies.

Seminole is a large community college, in a rapidly expanding area, that has been involved with NSF in the content area of information technology and minimal manufacturing related courses. Belmont is a medium to small technical college that is serving a section of Ohio that is suffering unfavorable economic conditions and job growth. These colleges represent two potential user classes for the application of DH delivery method and the manufacturing related curriculum and will provide valuable facilitation and adoption feedback. Both Seminole and Belmont are providing support for the physical location (node) and the module facilitators for the testing of the DH delivered module, and will assist in the recruiting of students for the project and provide feedback related to the success of the method and the development of a dissemination plan aimed at two-year colleges.

Founded in 1984, Social Science Research and Evaluation, Inc. (SSRE) is a nonprofit firm specializing in the delivery of program evaluation and basic and applied social science research services to government, industry, and private organizations. SSRE staff possess extensive experience in basic and applied research in several areas, including substance abuse, basic alcohol and drug abuse research, education and educational programming, health care, highway safety, and criminal justice. SSRE's founders, Dr. Robert Apsler and Dr. Wayne Harding, each have over 25 years experience conducting basic and applied social science research, organizing results into publishable material, and presenting findings to professional and lay audiences. They have expertise in utilizing a variety of both traditional data collection techniques (such as written questionnaires, telephone surveys, interviews, focus groups, and records review) and more progressive methods (such as web-based and e-mail surveys). Drs. Apsler and Harding are faculty members at Harvard Medical School. SSRE also brings experience in the assessment and evaluation of web based programs, measuring cost effectiveness, and are nationally recognized. SSRE has taken the lead in developing the evaluation plan, supporting instruments, and administering the appropriate instruments to collect the data. SSRE will also perform the statistical analysis and assist in the dissemination of the results.

Other individual partners include the seventeen Subject Matter Experts from academia and industry that created the original module activities and the content reviewers that will verify the content accuracy of the final materials.

This project supports Sinclair's mission in multiple areas by providing a technical content certificate through an alternative delivery mode to increase student access, by preparing today's workforce to meet the needs of rapidly changing global economy, and by developing and implementing new ideas that lead to regional and national partnerships. The institutional support for this project includes in-kind contributions necessary to support the project activities.

Evaluation Plan

Social Science Research and Evaluation, Inc. (SSRE) of Burlington, Massachusetts will serve as the grant evaluation partner under the direction of co-principal investigator, Paul Giguere, a Senior Technology Associate at Education Development Center, Inc. (EDC) in Newton, Massachusetts. Dr. Wayne Harding will serve as the lead evaluator and will be supported by Scott Formica, research assistant. SSRE has collaborated successfully with Mr. Giguere on several other projects (Harding, Formica, & Giguere, 2001; Formica, Harding, & Giguere, 2002; Giguere, Formica, & Harding, 2002). For this project, SSRE will use a collaborative model of evaluation (Kelly, 1990; Wandersman, et. al., 2002). Consistent with this model, which capitalizes on the participation from stakeholders, NCE/AME staff will be actively involved in key aspects of the evaluation. SSRE has used this model in other studies and has found that it increases investment in the evaluation, reduces cost, helps assure that the evaluation is relevant to the project's needs, and can enhance participants' evaluation knowledge and skills (Harding, 1995).

The evaluation will address both process and outcomes. The primary goals of the evaluation will be to: (1) test the effectiveness of the distributed-hybrid approach on at least four modules by assessing student performance and attrition as compared to a comparison group of students who participate in traditional face-to-face instruction on the modules, (2) compare the cost effectiveness for distributed-hybrid and face-to-face versions of the modules, and (3) assess the development and utilization of the web-based virtual "community of practice" to determine the extent to which a self-sustaining, student-led environment for sharing and growth is created.

Overall Design for the Process Evaluation

Five broad questions will guide the process evaluation: (1) What were the goals and objectives of the project, and what activities were planned to accomplish them; (2) How was the project actually carried out; (3) Was it implemented as planned; (4) If not, what changes were made in the project design and for what reasons; (5) What problems, if any, were encountered when carrying out the project and how were they addressed? Data to assess these questions, most of which will come from written records and interviews with implementation staff, will be collected and summarized by NCE/AME staff under the direction of SSRE. By the second month of the project, SSRE will prepare a detailed plan that will guide the process evaluation.

Overall Design for the Outcome Evaluation

Participants in this project will be recruited from students enrolled in the Industrial and Quality Engineering Technology programs at Sinclair Community College and from students at Seminole Community College in Orlando, Florida and at other potential node sites. All participants will meet the same academic admission requirements as the current face-to-face classes. Students at Sinclair Community College will have the option of taking the module in a traditional face-to-face class, or taking it using the distributed-hybrid approach. Students from Seminole Community College and other potential sites will by necessity be placed into the distributed-hybrid condition.

Modules will be delivered multiple times during an academic year. For at least four of the modules, each of the individual implementations will be evaluated, and data will also be aggregated within each of the different modules delivered in one academic year, yielding a sample of approximately 30 students per condition for each module. Modules repeated during the second year of the project will be evaluated and treated as replications.

For each module evaluated, we will administer pretest questionnaires before it begins and posttest questionnaires at its close. We will also conduct interviews with school administrators, module instructors, and site administrators for each of the modules. These instruments are discussed in more detail below.

Pretest Questionnaires

Instructors will administer pretest and posttest questionnaires to all students in the face-to-face comparison condition, and site administrators will administer them to all students in the distributed-hybrid condition. The pretest will contain multiple-choice questions to assess changes in knowledge. Additional close-ended items will measure attitudes, and collect data on background variables (e.g., age, ethnicity, gender, experience with web-based instruction, previous training related to continuous process improvement) that may be associated with outcomes.

Posttest Questionnaires

The post-test will contain items corresponding to knowledge and attitude items in the pretest. The post-test will also include items designed to measure students' satisfaction with the different elements of the modules, including its content, organization/format, materials used, and overall satisfaction with the module as a whole. Because closed, scale items do not provide qualitative data that may explain the meaning of the responses (e.g., why a respondent was dissatisfied with the materials), we will provide respondents with opportunities to add comments on each satisfaction item. We will also include at least two open-ended items at the end of the posttest questionnaires that ask participants what they liked and disliked about the training.

Interviews with School Administrators, Module Instructors, and Node Site Administrators

For each module evaluated, SSRE will conduct telephone interviews with school administrators, module instructors, and node site administrators. Major topics to be discussed will include: (1) ease of adoption of the distributed-hybrid versus the face-to-face approach; (2) barriers to implementation; (3) concerns specific to the distributed-hybrid approach; and, (4) their assessment of the impact of the two approaches and attrition rates for both.

Cost Effectiveness Analysis

SSRE will compare the costs for implementation of the face-to-face version of the modules and the distributed-hybrid version of the modules. Computations will exclude development costs, and focus on such maintenance costs as instructors' salaries, node site administrator salaries, website maintenance, meeting space, and course materials. Using a cost-effectiveness framework (Apsler and Harding, 1991), costs of the two approaches will be compared per student, instructional hours, and student performance.

Evaluation of the Web-based Virtual "Community of Practice"

SSRE will assess the extent to which use of the web in the distributed-hybrid approach creates a self-sustaining, student-led environment for sharing and growth. SSRE will document the characteristics of the community of practice (e.g., number of students who participate and the extent and frequency of participation over time). Also, two months after the relevant modules end, SSRE will conduct a web-based survey with students who did not participate in the community of practice. The main focus of this survey will be to determine barriers to participation, reasons for non-participation, and likelihood of future participation in the community of practice and in other modules offered using the distributed-hybrid approach.

Procedures to Protect Participant Confidentiality and Ensure Validity

The main threat to validity is students' concerns that their responses may be disclosed to instructors, site administrators, or others. Therefore, each instrument will describe precautions taken to protect their confidentiality. For example, each will state that the evaluation is being carried out by an off-site evaluator, that computerized data will not contain identifying information, and that reports on research will not identify individuals.

Data Analysis

While details of the analyses cannot be specified until the instruments are finalized and will depend on the distribution and metric of the variables. We expect the main statistical procedures will be an analysis of variance (ANOVA) using the students' posttest scores as the dependent variable with the pretest as a covariate. Several secondary analyses will also be conducted as permitted by sample size. For example, differences in scores over time will be examined as a function of other covariates (e.g., gender, highest level of education, experience with web-based instruction).

Reporting of Results

Brief but comprehensive summary reports will be completed within one month after the completion of each module. They will include the number and percentage of responses for all close items on the pretest and posttest, results of statistical tests on pretest to posttest scales constructed to measures changes in knowledge and attitudes, a summary of the number of students making different types of comments, and a listing of key findings for the module. Where appropriate, results will be presented graphically to facilitate understanding of the data. SSRE will also make oral presentations at the end of the first year and towards the end of the second year of the project. Evaluation reports will also be distributed to all project staff, which will underscore the projects' commitment to improving the modules, and increase staff willingness to cooperate in ongoing data collection. A more comprehensive evaluation report covering all of the evaluated modules will be delivered at the close of the project.

Dissemination Plan

The project development team realizing the difficulties of disseminating for adoption the products and methodologies to other two and four year colleges and universities. In order to aid in the dissemination the product development team will apply a dissemination plan that addresses Rogers' four elements affecting the adoption of innovations (Rogers, 1995). Accomplishing the first element, dissemination of information, will be through the submittal of paper presentations and journal articles to the American Society of Engineering Education (ASEE) at their annual national conference, to the Association for Educational Communication and Technology (AECT) annual conference, and to the *League for Innovation* annual conference. Journal article submittals include the *Quarterly Review of Distance Education*, and the *Journal of Engineering Education.* The other elements will be addressed by Faculty members that have tried the methods will be available via site visits, workshops, and virtual conferences to describe how to they used the materials.

The product development team recognizes a potential commercial market for the materials at adopting schools or industries. Textbook publishers typically provide supporting PowerPoint presentations and software free to instructors who have adopted their textbooks, but now have switched to providing web materials tied to their textbooks within a course management environment based on a per student licensing fee. An example fee for the supporting materials for a college statistics course found on WebCT was $15/student.

The dissemination of the course materials will be facilitated using the National Center for Manufacturing Education resource center web site. Specific dissemination strategies for each potential group of stakeholders will be developed as part of the deliverables from objective five. The project development team is optimistic since already several engineering and technology faculty members at Virginia State University, an institution serving underrepresented student populations, have expressed interest in applying the content and methodology at their university. This overall combination of presentations and journal articles in conjunction with the ability for organizations to acquire the entire course package will aid the dissemination and adoption of the instructional package and the distributed-hybrid delivery methodology.