NSF – Transforming Undergraduate Education in Science (TUES) Grant Project

TITLE: Increasing adoption of active learning in STEM disciplines by integrating a faculty development program and a technology-facilitated learning environment

Project Summary, Project Description, and References Cited

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Project Summary: ***Increasing adoption of active learning in STEM disciplines by integrating a faculty development program and a technology-facilitated learning environment***

Intellectual Merit. The influence of science, technology, engineering, and mathematics (STEM) on today's society makes these areas of education more important than ever before. STEM education is responsible for producing future scientists and engineers, technologically proficient workers capable of dealing with the demands of science-based high-tech jobs, and scientifically literate voters and citizens who understand the world around them (National Science Teachers Association 2008). To facilitate student comprehension, interest, and inclusivity in the STEM disciplines, teachers at all levels must use appropriate pedagogical techniques. Both active learning and the incorporation of technology into teaching have been identified as effective for learning in the STEM disciplines, but barriers to these approaches have prevented their broad adoption in undergraduate institutions. Barriers identified by faculty are a lack of time, of institutional support, and of training in active learning pedagogy and technology, as well as the prevalence of traditional classrooms that were designed for passive lectures. The goal of this project is to increase the adoption of technology-enhanced active learning in classes taught by STEM faculty.

Project Design. This project will implement a faculty development program that integrates training in active learning pedagogy within a technology-facilitated student-centered learning environment. We will develop focal point faculty (Catalysts) who will serve as nuclei for the incorporation of active learning pedagogies in each of six STEM departments at Northern Michigan University (NMU), a laptop university in Michigan's Upper Peninsula. Catalysts will help recruit additional faculty into a learning community that is trained to effectively use a new student-centered, technology-rich studio classroom. We will also evaluate the effectiveness of the studio classroom and its component technologies as tools for active learning.

Specific Objectives:

- Facilitate the implementation of technologically-enhanced active learning by developing a cohort of six STEM faculty catalysts who will redesign at least one of their own courses and serve as models for other faculty.
- Establish a student-centered technology-rich studio classroom designed to support active learning pedagogy.
- Assess the effectiveness of technologies used in active learning pedagogy in order to provide 'best practices' recommendations to institutions.

Outcomes. Expected outcomes include high usage of the studio classroom, increased incorporation of active learning into all STEM disciplines on campus, assessment of specific educational technologies for active learning, and an evaluation of the impact of program components on the adoption of active learning in STEM. In addition, lessons learned from this project will be transferable to other institutions seeking to increase adoption of active learning into STEM courses.

Broader Impacts. Creating a replicable program for facilitating adoption of active learning techniques will enhance the likelihood of transformational change in STEM education. This project will build upon existing active classroom methodology and, by sharing the assessment of its technological innovations, will further the development of this area of education. This project intentionally includes individuals who have not participated in STEM reform programs so that they will interact with STEM education reformers outside the university. In addition, this project will contribute to the general knowledge about STEM education through the participation of the project personnel in educational conferences and other venues. The proposed project also has a likelihood of broadening participation in the sciences through active learning pedagogies that have been documented to be particularly effective with women and minorities who continue to demonstrate low participation nationally. The reform of STEM education to include greater emphasis on student-centered pedagogy will likely increase its accessibility for these demographic groups at NMU and elsewhere. NMU is located in the Upper Peninsula of Michigan and supports a highly rural population. Bringing these dynamic educational techniques to the region makes STEM education more accessible to our remote population and increases the likelihood of the area's youth pursuing careers in STEM fields. This project will also have broader impacts at NMU by allowing us to develop the new active learning studio classroom as a prototype for further campus development.

Project Description: ***Increasing adoption of active learning in STEM disciplines by integrating a faculty development program and a technology-facilitated learning environment***

Goals and Objectives

The goal of this project is to increase the adoption of technology-enhanced active learning in classes taught by science, technology, engineering, and mathematics (STEM) faculty. The project objectives are to:

- Facilitate the implementation of technologically-enhanced active learning by developing a cohort of six STEM faculty catalysts who will redesign at least one of their own courses and serve as models for other faculty.
- Establish a student-centered technology-rich studio classroom designed to support active learning pedagogy.
- Assess the effectiveness of technologies used in active learning pedagogy in order to provide recommendations to institutions for best practices.

The project team will implement this replicable program at Northern Michigan University (NMU), a mid-sized public university that has a strong commitment to integrating technology into its students' learning experiences.

Background

Today's scientific advances profoundly impact all aspects of modern life, making it more important than ever that people develop a literacy in scientific issues. Yet higher education institutions tend to teach students in a manner that emphasizes short-term memorization over complex reasoning skills and problem-solving (National Research Council 1997, 2003; George et al. 2001). In addition, despite genuinely exciting new scientific discoveries, the U.S. has experienced a decreasing percentage of students who wish to pursue research careers (Cech 2003). Thus, STEM disciplines continue to face the ongoing challenge of recruiting, educating, and retaining students. The incorporation of student-centered, active learning techniques in STEM courses has resulted in improved student understanding (Kvam 1999; Crouch & Mazur, 2001; Handelsman et al. 2004), and improved student retention in the general student population and in underrepresented minorities (George et al. 2001; Cortright et al. 2003; Lorenzo et al. 2006).

The role of technology in higher education has increased in the past 15 years and is a core part of developing scientifically literate citizens (AAAS 2009). For example, the emergence of the World Wide Web has put multiple comparative sources of information at students' fingertips, facilitating learning based on seeking, sieving, and synthesizing; digital media enables customization of educational products; electronic interfaces encourage dialoging among classmates (Dede 2004). One of the present challenges in higher education is integrating technology with student-centered, active learning in ways that enhance different learning styles.

Within the last ten years, the Student Centered Active Learning Environment for Undergraduate Programs (SCALE-UP) project at North Carolina State University, along with related efforts such as Massachusetts Institute of Technology's (MIT) Technology Enhanced Active Learning (TEAL) initiative, have integrated technology into redesigned, student-centered classrooms to create more powerful and engaging learning landscapes (Beichner 2000, Bookman & Malone 2006, Yehudit et al. 2003, Carle et al. 2009). Student attitude and retention, problem-solving skills, and conceptual learning improved in SCALE-UP and TEAL courses compared to traditionally taught courses (Beichner et al. 2007, Yehudit et al. 2003). Student responses indicated that they valued the elements of visualization, web-based assignments, and conceptual questions using personal response systems (Yehudit et al. 2003, Yehudit & Belcher 2005). Moreover, although all students experienced greater net gains in their conceptual understanding of course material, the lowest-achieving students experienced the greatest net gain. These programs show that technology can facilitate deep conceptual understanding. For learning technology programs to succeed, instructors must not only participate, but fully buy-in and take active roles in implementation. Exposure and experience are key elements to increasing their self-efficacy and beliefs about the value of technology in the learning process (Dani & Koenig 2008).

Despite the call to adopt active-learning strategies (National Research Council 1997, 2003; George et al. 2001), traditional lecture methods continue to dominate higher education classrooms (Bonwell & Eison 1991, Handelsman et al. 2004). A successful transition to an active learning culture requires overcoming barriers on multiple fronts (institutions, financial resources, students, faculty, environment). Changing how we teach is difficult at the college and university level because it necessarily entails risk-taking and ambiguity, and the effort required for change to occur conflicts with limited resources and time (Cohen 1988, Sunal et al. 1997). The most effective faculty professional development programs that result in improved college teaching require follow up and monitoring, which are often not done following single-day faculty development workshops (Sunal et al. 1997). Among the barriers blocking successful implementation of student-centered active learning pedagogy are a lack of an organized implementation strategy and the limitations of the traditional classroom environment (Garvin 1992; Lippincott 2009, Hunley & Schaller 2009). This project targets both barriers.

The Locale

Northern Michigan University (NMU), located in Michigan's Upper Peninsula, is a four-year, public, coeducational, comprehensive university which offers 180 degree programs to nearly 9,500 undergraduate and graduate students. In addition, it fulfills a community college role by offering certificates and associate degrees in the arts, sciences, business, and technology. More than 80 percent of NMU's 300-plus faculty members have doctorates or the highest degree in their fields. Its STEM departments are Biology, Chemistry, Engineering Technology, Geography, Mathematics, and Physics.

Instructional Technology at NMU

NMU considers information technologies to be a critical signature of its educational experience. All faculty and full time students receive leased laptop computers through a Teaching, Learning, and Communication (TLC) notebook initiative. NMU was one of the first “laptop universities” in the nation. TLC laptops are used heavily by students and faculty alike. The campus and surrounding community is blanketed with extensive Wi-Fi coverage and a new WiMAX network; this is currently one of the largest such networks in the world. In 1998, an NMU longitudinal survey reported that under 40% of responding faculty had incorporated the Internet into their courses. Ten years later, over 90% of respondents reported having some level of Web enhancement in their courses (Poindexter, NMU, personal communication). Part of that increase was likely due to the introduction of NMU’s web-based course management system; in less than 10 years, use of that system has nearly doubled from 400- 500 courses per semester during its early years to over 900 courses per semester currently. NMU students have the ability to participate in collaborative online discussions at any hour, find answers to intellectual inquiries through online resources, and connect with students and professionals in their fields worldwide.

Technology in the Classroom

The ongoing effort to incorporate technology into NMU classrooms is evident in the last ten years' on-campus changes. In addition to wireless Internet access, a typical NMU classroom configuration includes an instructor laptop docking station, an LCD projector, a DVD/VHS player, and speakers. These tools make it possible for faculty to integrate media and computer-based content into their lectures. They are also utilized for student presentations. However, this technology focuses on the same place that lectures halls and classrooms always have: the front of the room, and hence, the professor. With the proliferation of laptops and wireless Internet connections, all NMU students in traditional classrooms have the ability to participate in active learning exercises such as trying a computer programming technique (Barak et al. 2006) or going on "WebQuests" (searching online for information needed to solve a problem posed by the instructor) (Dodge, 2007). However, students seated in traditional classroom rows are not well positioned to participate in collaborative active learning exercises, significantly limiting the effectiveness of a classroom's technologies. Not surprisingly, NMU professors appear, based on peer evaluation, to continue to structure their classroom time primarily into lectures and shunt student-centered work into laboratories.

Commitment to Educational Reform

NMU's mission includes challenging students to think independently and critically and to develop lifelong learning habits (NMU Road Map to 2015). Strong evidence shows that students are better prepared to meet those challenges when they actively engage in learning activities rather than passively receive lectures (Beichner et al. 2007, Yehudit et al. 2003, Handelsman et al. 2004). However, student-centered active learning has not yet established roots throughout NMU's STEM curriculum. Individual efforts have been made to use active learning in STEM courses at NMU. For example, four Biology faculty members participated in the NSF-supported Faculty Institutes for Reforming Science Teaching (FIRST) II program, where they worked to incorporate active learning into science courses and assess its effect. The Chemistry Department instituted a peer learning component into their introductory course. Other efforts to encourage active learning have come from NMU's Teaching and Learning Advisory Council (TLAC), which has periodically offered seminars on active learning topics. Similarly, technology such as personal response devices (clickers) has been used specifically for active learning on campus. However, results have been mixed and some professors have ceased using the equipment due to logistical issues. Overall, these efforts have not had the infrastructure, resources, and ongoing support needed to facilitate widespread adoption of active learning pedagogy.

The Current Issue

NMU is similar to many institutions in that there is an interest in active learning among STEM faculty members, but the pedagogy has not yet been widely adopted. This project will create a framework to change that. Our university is a model setting for implementing a plan to broaden and sustain the incorporation of technology-enhanced active learning in STEM courses. NMU has an existing commitment to technology, a mission focused on student thinking and learning, and tech-savvy faculty members dedicated to continuously improving instruction. Using these attributes, we plan to foster increased incorporation of technology-enhanced active learning activities into STEM courses through a program that addresses two barriers to faculty members adopting active teaching pedagogy:

- Lack of time and resources needed to become familiar and comfortable with active learning pedagogy and the technology that supports it while maintaining other responsibilities.
- Classroom environments that are designed for instructor-centered teaching rather than student-centered learning.

We will overcome these barriers by integrating training and support, technology, and classroom environment in a clearly defined strategy for infusing active learning throughout the STEM curriculum. Additionally, we will prepare documentation on the program's effectiveness in the adoption of student-centered active learning in a technology-rich classroom studio.

Proposed Project

We propose an integrated strategy designed to facilitate adoption of active learning pedagogy by STEM faculty by making the process better supported, more attractive, and more comfortable. This program will meet the following objectives:

1. **Facilitate the implementation of technologically-enhanced active learning by developing a cohort of six STEM faculty catalysts who will redesign at least one of their own courses and serve as models for other faculty.**

In conversations with STEM faculty, the project team found that, though traditional teacher-centered education techniques are dominant in current NMU courses, many professors have an interest in active learning. Among major barriers to implementing it are unfamiliarity with specific active teaching methods, frustration with classrooms ill-designed for student-to-student interaction, and lack of time needed to re-develop courses to utilize active learning or to use appropriate technology.

The project PIs recruited six faculty members who expressed strong interest in technologically-enhanced active learning to serve as "Catalysts." Faculty in Biology, Chemistry, Engineering Technology, Geography, Mathematics and Physics have joined the project in this Senior Personnel role. Along with the project PIs, these individuals will take a leadership role in bringing active learning into NMU STEM courses. They will incorporate and assess the effect of active learning in their own courses and develop examples and approaches to technology-enhanced active learning that they will share with colleagues.
The project will provide Catalysts with:

- Training, which will include:
  - *On-campus pedagogy workshops conducted by guest speakers.* In early April of Year 1 and Year 2, the Ebert-May educational research group from Michigan State University will conduct pedagogy workshops at NMU. They will develop the workshops to model backward design to guide participants' creation of learner-centered classrooms and curricula. Participants will develop learning objectives, assessments, and inquiry-based instructional design for their courses that cover active learning, inquiry-based learning, educational assessment, and student centered pedagogy. Catalysts will attend these workshops along with other interested faculty members.
  - *Educational technology orientation/training.* Beginning with the Fall 2010 semester, NMU Instructional Design, Technology and Media (IDTM) staff will conduct at least two technology workshops each semester to orient faculty to technology available in the active learning classroom and related technological resources available for teaching STEM content.
  - *Off-campus conferences.* Catalysts will attend at least one off-campus conference on active learning pedagogy and/or assessment. They may identify an appropriate discipline-specific conference or choose from general events such as the Lilly

    - Conference Series, National Science Teachers Association/Society for College Science Teachers annual or regional conferences.
    - *Catalyst-led workshops.* Catalysts, supported by IDTM, will lead at least four workshops for faculty who have become interested in active learning.
- Development time needed to integrate technology-enhanced active learning techniques into their courses; this time commitment is supported by the Department Heads in each of the STEM departments (see attached letters).
- Resources, which will include:
    - Articles and other publications about active learning to supplement what faculty learn from formal training opportunities
    - Discipline-specific online resources. There are many exercises readily accessible for STEM disciplines [e.g., biology (Ebert-May & Hodder 2008), physics (Physics Education Research site 2009), chemistry (Bullard & Felder 2007, Felder 1992,1994), mathematics (Rosenthal 1995, Bookman & Malone 2006)]. Re-using (or modifying) these existing exercises can help decrease the time required for instructors to incorporate active learning into their courses.
    - An "Active Learning at NMU" community. Aside from formal training sessions, the project team and Catalysts will host casual gatherings each semester during the project term where those practicing or interested in learning more about active learning can have informal conversations. The MERLOT Voices community will provide online tools with which community members can ask questions, brainstorm, and share updates between gatherings. To contribute to the sustainability of the project goal, these tools will continue to be supported by IDTM after the end of the project period.
- Opportunities to interact with the STEM education community at conferences.

Catalysts will help expand and sustain use of active learning within and outside of NMU STEM courses by:

- Meeting as a group at least twice each semester to share experiences and ideas.
- Sharing activities that they develop with their NMU colleagues and the STEM faculty community in general. Materials will be shared under a creative commons license through web sites such as SCALE-UP, MERLOT (Multimedia Educational Resources for Learning and On-line Teaching), and NSDL (National Science Digital Library). Pedagogical instruments and other relevant project documentation will be shared through a customized portal, or Institutional Teaching Commons, within the MERLOT web site. Access to these resources will facilitate adoption of active learning pedagogy by additional faculty members.
- Communicating online in a customized social networking community within the MERLOT Voices web site. In addition to communicating with each other, this site will help Catalysts connect with other interested faculty at NMU and other institutions.
- Helping to establish and expand a learning community at NMU for technology-enhanced active learning practitioners. In addition to leading workshops for colleagues and presenting and departmental meetings, Catalysts will provide informal support through casual gatherings and online discussions.
- Presenting their experiences at regional, national, and/or international conferences in their respective disciplines.

Expected outcomes:

The six STEM active learning Catalysts will have received active learning training by the time that the technology-rich studio classroom is available for use in Fall 2011. They will incorporate what they learn in training into the courses they teach in the studio classroom. They will then share their knowledge and experiences in workshops for additional faculty.

Within the project period, each Catalyst will contribute to the project as a whole by:

- Teaching at least one class in the studio classroom
- Expressing the desire to teach all of their classes in the studio classroom
- Posted at least one active learning activity to the NMU Active Learning Teaching Commons portal on the MERLOT web site
- Delivering at least one presentation to their own department
- Recruiting at least one person in their own department to investigate active learning pedagogy
- Preparing and submitting at least one presentation for an extramural venue

By the conclusion of the project, at least 10 additional faculty members will have received active learning training and begun to incorporate it into their courses. In addition, resources will have been identified that assisted Catalysts and other faculty with incorporating active learning into courses.

Assessment:

Training: All participating faculty members (Catalysts and non-Catalysts) will evaluate each on-campus training session (pedagogical and technological) immediately after completing it and then again after they have employed its techniques in teaching a course. Catalysts will provide similar feedback on any off-campus training they attend. All faculty members who attend training will be surveyed about the number and kinds of active learning activities and technologies that they incorporated into any courses and particularly into courses taught in the studio classroom. Faculty will also be asked to provide feedback on resource materials in order to help refine the process used to identify and provide resources.

Reformed Teaching: In addition, the Reformed Teaching Observation Protocol (RTOP) will be used to assess the level of reform demonstrated by the Catalysts across the course of the project (Sawada et al. 2002, Lawson et al. 2002). Faculty will also be required to complete a daily log of active-learning-related activities and technology used in the studio classroom. Accomplishment of Catalyst contributions expected outcomes (see above) will also be tallied.

On-campus dissemination: Assessment will include pre- and post-project surveys of members of each Catalyst's department to gauge changes in the levels of interest and commitment to a) active learning generally and b) technology-enhanced active learning specifically.

2. **Establish a student-centered technology-rich studio classroom designed to support active learning pedagogy.**

The project will provide faculty with an environment conducive to deploying technology-enhanced active learning strategies. An existing traditional classroom will be renovated into a studio-style classroom that accommodates a high level of student-instructor and student-student interaction (e.g., experiential learning, peer learning, think-pair-share, brainstorming, games, debates, case studies). The re-designed classroom will follow the principles of SCALE-UP (Beichner 2000) to facilitate interactions between teams of students. Seven round tables will each seat nine students, giving the room a capacity of 63 students. Instead of a lectern at the front of the room, a station will be located centrally for the instructor, who will spend a good part of the class period moving about the room to facilitate the student groups' activities. Each student table will have a large wall-mounted whiteboard for use in brainstorming, diagramming, working equations, and other activities. The room will accommodate multiple levels of collaboration: each table can be divided into three teams of three students for some activities, the nine students at each table can work together on other exercises, and the entire class can come together for larger discussions and presentations.

As mentioned previously, NMU is a "laptop university." As part of tuition, all full time students lease standardized laptop computers, and campus is fully covered by a wireless Internet signal. Technology incorporated into the studio classroom will build upon this existing infrastructure. Adjacent to its whiteboard, each student table will have a 42 inch widescreen LCD monitor. All nine students at a table will be able to hook their laptops into a video switcher. Through a touch-screen interface, the students will be able to select which laptop is displayed on the "big screen" LCD monitor. Each table's LCD monitor will have a SMART™ flat panel overlay, which will transform it into an interactive display. This will enable students to mark up items on the monitors and to electronically capture notations. In addition, each table will also have a multimedia visual presenter/recorder camera that can be used to share and record microscope slides, documents, or activities that involve models or other manipulatives. Microphones at each table will enable students to be heard clearly when sharing information with the entire class. Students will use web-based personal response software (essentially virtual "clickers" that run on their laptops) to answer informal quiz questions, respond to brief surveys, and share summarized results of activities.

Complementing the LCD monitors for each table, the room will have two ceiling mounted LCD projectors with larger screens visible to the entire class. Two screens are needed because students seated at round tables face in different directions. All students will have a clear view of one of the two screens without the need to twist around in their chairs. By default, those screens will display the instructor's laptop image, enabling the instructor to display information from introductory "mini lectures" or questions for students to answer using personal response software. The instructor will have the capability to display the image from any table's LCD monitor on the projection screens, enabling groups to share their work with the rest of the class. In a studio classroom, instructors still need to present information and give brief demonstrations. To accommodate those needs, the instructor station will also have an electronic notation tablet and a multimedia visual presentation/recorder camera.

The design of the NMU active learning studio classroom builds upon other high-tech SCALE-UP classrooms, including the Active Learning Classroom (ALC) pilot project at the University of Minnesota (University of Minnesota, 2005) and the TEAL classroom at MIT (Massachusetts Institute of Technology, 2005). By taking advantage of NMU's "laptop for every student" culture, our model is able to expand upon these projects. For instance, many such classrooms only enable three laptops to be connected at each table or have laptops permanently located in the classroom. The NMU room will allow all nine students at each table to hook their own laptops into the environment. Other innovations in the NMU classroom include the use of multiple SMART™ flat panel overlays and the incorporation of multimedia visual presenter cameras. All technology in the studio classroom will be A) directly used by students in active learning, or B) providing control and infrastructure necessary for functionality. We have chosen the most economical and utilitarian technology, forgoing any componentry that may be considered "bells and whistles." For example, an audio-visual consultant the project team spoke with initially recommended very expensive projection screens with motorized retraction. The project team rejected that recommendation and selected basic, but equally functional, pull down screens.

Expected outcomes: Work on the technology-rich studio classroom will begin during the Winter 2011 semester and it will be ready for use in Fall semester 2011. Use of and demand for the classroom are expected to increase throughout the project. More specifically:

- During the Fall 2011 semester, at least two of the six active learning Catalysts and at least one of the PIs will offer a revised course in which the studio classroom's design and technology fosters active learning pedagogy.
- By the end of the Winter 2012 semester, all six of the Catalysts and PIs will have taught such a course.
- Over the first five semesters during which data are collected, instructor requests to be scheduled into the studio classroom will increase by at least 10%.

In addition, the project team expects a high level of student enthusiasm for learning in the studio classroom, which will help influence demand. Finally, the project team expects to collect information and discover issues (e.g., technology use levels, integration issues) that will be valuable in the design of future technology-rich studio classrooms.

Assessment: Successful attainment of this goal will be based on whether the studio classroom is completed on schedule and on budget. Team members will document the causes of any delays or cost adjustments so that those issues can be taken into consideration in planning for future, similar projects. Once installed, all equipment will be thoroughly tested to ensure that the room as a whole functions as designed. Though the studio classroom has been designed by knowledgeable professionals, the many variables in its unique technology configuration leave open the possibility that testing could uncover an issue such as an equipment incompatibility. Any design modifications will be documented and explained. Completion of the facility and its technical functionality will be measured by user comments, maintenance requests, and requests for alternatives. The P.I.s will coordinate with the Registrar's Office to monitor requests for scheduling in the classroom. We will also conduct a budgetary analysis of the costs of constructing and operating the room. This assessment information will be valuable input to the design of future technology-rich studio classrooms, both at NMU and other institutions.

3. Assess the overall and individual impacts of technological tools in an active learning studio classroom on the reform of STEM education.

As outlined previously, this project builds on established research that illustrates the value of active learning, studio classrooms, and incorporating technology into both. This project focuses largely on supporting and evaluating faculty adoption of technology-enabled active learning and on providing an appropriate active learning environment. However, it is also important to evaluate the impact that the learning environment has on students. Goal #3 represents a preliminary assessment that may generate the opportunity for future projects (e.g., Type II TUES grants).

The financial cost of outfitting technology-enabled studio classrooms is significant. Evaluating the overall impact of the technology in the studio classroom will help determine the educational return on this type of investment. This is a timely question for NMU where Jamrich Hall, a primary learning space, is due for renovation. Other institutions planning or considering learning space renovations will also value this information. Campus planners who are responsible for the broader incorporation of high-tech studio classrooms during building renovation (or construction) need such data.

On a finer scale, the project will evaluate the impacts of individual technological tools. Knowing the pedagogical impact of specific tools will help determine whether their benefits justify the cost of including them in future studio classrooms. In the shorter term, results from this evaluation will help faculty who use the studio classroom determine modifications to their teaching plans from semester-to-semester.

Expected outcomes:
The project team will produce a compendium of recommendations and best practices for selecting and implementing technologies into active learning studio classrooms. This document will include information on overall impact of the technology on use and effectiveness in active learning pedagogy, as well as data on how specific technology tools have impacted student engagement and learning. This document will provide valuable information locally, as NMU considers options for renovating Jamrich Hall. It will also be of use to educators and campus planners at other institutions seeking to update their teaching and learning infrastructure. The project team will gather data on courses taught in the studio classroom over five semesters.

Assessment:
- Interest (increased, decreased, flat) in using a technology-rich learning environment will be assessed by tracking the number of STEM faculty that request this classroom space and the percentage of schedulable hours when the classroom is in use over the course of the project.
- Faculty users of the classroom will track which technologies are used and how much class time is dedicated to using different elements.
- Instructors will provide feedback on all aspects of the room. Questionnaires will focus especially on non-standard features implemented by NMU.
- Students will be surveyed to measure their attitudes about STEM courses offered in the active learning classroom using the Student Assessment of Learning Gains online instrument (Seymour et al. 2000). Specific questions will be added (within the confines of the validated instrument) to address learning gains associated with technology and its combination with active learning activities. This instrument will also allow us to assess specific patterns related to student demography (gender, race, educational background, etc.) while maintaining anonymity.
- Successful completion and dissemination of the compendium of technology recommendations.

Timetable for Project Activities

Year	Winter Semester	Summer Semester	Fall Semester
2011	• Funding starts • Technology purchasing • Active Learning Pedagogy Workshop I (Apr) • Learning community forms (May)	• Renovation of Active Learning Studio • Technology Workshops I (Aug) • Learning Community continues (all year)	• First courses taught in studio • Assessment & formative evaluation of project (ongoing) • Annual report produced (Dec)
2012	• Second set of courses taught in studio • Learning Community continues (all year) • Assessment & formative evaluation continues • Annual report sub. (Jan) • Active Learning Pedagogy	• Third set of courses taught in studio • Assessment & formative evaluation continues • Technology Workshops II (Aug)	• Fourth set of courses taught in studio • Assessment & formative evaluation continues • Annual report produced

Year	Winter Semester	Summer Semester	Fall Semester
	Workshop II (Apr)		
2013	• Fifth set of courses taught in studio • Learning Community continues (all year) • Assessment & formative evaluation continues • Annual report submitted (Jan)	• End of data collection for assessment (May 1) • Summative evaluation of project • Production of final report • Submit of final report (Aug) • Aug 31 end of grant period	

Outside Project Evaluation

Dr. Diane Ebert-May (Michigan State University) has agreed to serve as an outside evaluator for this project. Dr. Ebert-May will provide advice and feedback for the project, particularly in the area of assessment, by visiting NMU three times (beginning, middle, end) during the grant period and will also be available for remote consultation with the PIs. She will assist with expansion and definition of the assessment plan to include specific metrics and assist in ensuring that collected data are linked to our objectives. Formative assessment will be compiled on the project at the end of each teaching semester with summative assessment/evaluation at the conclusion of the project. Dr. Ebert-May's lab will also provide RTOP evaluation. Dr. Ebert-May is a Ph.D .scientist who has maintained an extensive research program on biology education. She is currently the PI of FIRST IV, a professional development program for biology postdoctoral scholars that evolved from the original Faculty Institutes for the Reform of Science Teaching project 1998. She is recognized as an expert in the field of active learning/inquiry-based learning in STEM disciplines.

Broader Impacts

This project has strong potential for broader impacts through several pathways.

1. *Contribution to STEM education by improving an area of recognized need* – Adoption of active, inquiry-based pedagogy by faculty in the sciences is presenting a substantial challenge to the goal of reforming STEM education at the post-secondary level. There is now a considerable body of literature documenting the positive effects of these techniques for students. Because both academic institutions and funding agencies recognize the potential of active learning techniques to enhance the likelihood of transformational change in STEM education, it is important to create a replicable framework for facilitating its adoption.

2. *Participation in the evolution of technology facilitated active learning* – This project will build upon existing active classroom methodology (e.g., SCALE-UP, MIT's TEAL classroom, and the University of Minnesota's ALC initiative) and further the implementation and assessment of technological innovations. This information will be shared as part of the dissemination of results for this project and will contribute to the development of this area of education.

3. *Build the STEM education community* – This project intentionally includes individuals, both Catalysts and other faculty, who have not participated in STEM reform programs before. We will provide the tools and resources that these faculty need to network among themselves as well as with individuals involved in STEM education outside the University. In addition, this project will contribute to the general knowledge about STEM education through participation in educational conferences and other venues by the PIs and others.

4. *Broadening participation in science and engineering* – The proposed project also has a likelihood of broadening participation in STEM through the advocacy of active learning pedagogies. These techniques have been documented to be particularly effective with women and minorities who continue to show low participation nationally (Lorenzo et al. 2006). Similarly, there is an increasing cohort of young students with substantial comfort with technology who will likely find our technologically-facilitated approaches effective (see Mayo 2009). The NMU undergraduate population is currently approximately 53% female, and women represented 56% of freshman (2008 data). The largest minority group on campus is Native American, a result of our close proximity to tribal lands, and students who identified themselves as Native American made up 2.4% of NMU's total student population and 3% of freshmen in 2008. Within the STEM disciplines at NMU, only 42% of students enrolled in 2008 were female and 1.8% of students identified themselves as Native American. The reform of STEM education to include greater emphasis on student-centered pedagogy should increase accessibility of scientific content for these demographic groups both at NMU and elsewhere.

5. *Provide enhanced STEM education for rural population* – NMU is located in the Upper Peninsula (U.P.) of Michigan which contains roughly 1/3 of the state's land mass but only 3% of its population. As a regional university, NMU supports a highly rural population: only 28% of U.P. residents live in the 12 towns larger than 4000 residents; 55% of NMU students in fall 2008 were from the U.P. The area is physically remote and climatically rugged given its location in the upper Great Lakes region. Bringing innovative educational techniques to this region has the potential to make STEM education more accessible to our rural population and increase participation in STEM fields. The Upper Peninsula is one of the most economically depressed regions in the state. The State of Michigan has identified increased undergraduate education and, in particular, an emphasis on STEM disciplines, especially those related to "green" industries, to be of primary importance for the recovery of this economically-challenged state.

6. *Enhance infrastructure for science and engineering education* – This project will also have broader impacts at NMU by allowing us to develop the new active learning studio classroom. This project is intended to be a pilot on campus. It is our hope that this project will lead to the development of additional active learning instructional spaces during upcoming renovations of our primary teaching facility, Jamrich Hall. Inclusion of similarly designed studio classrooms would support these active-learning techniques across disciplines (including beyond STEM) and would aid sustainability of this project into the future.

7. *Provide opportunities for undergraduate researchers* – This project will provide opportunities for undergraduate students to be involved in educational scholarship by serving as project research assistants, important experiences for developing future scholars.

8. *Impact on future K-12 educators* – All majors in the NMU School of Education incorporate STEM courses in their requirements. Students in the NMU College of Education seeking certification for teaching K-12 that enroll in courses offered by project personnel will participate in active learning experiences. This project will serve to model active learning techniques for these students that may be incorporated into their future pedagogy.

Dissemination of Project Results
We plan to disseminate our work and its results in a series of widening intersecting circles of influence.

- The working stages of this project will be presented on-campus through formal reports at department meetings, seminars, informal "hallway" reports, and the semester meetings of people teaching in the studio classroom (open to any interested party).
- More finalized results will be reported at seminars and workshops on campus, and at regional, national, and/or international discipline-specific conferences.
- Pedagogical instruments, studio classroom information, and other relevant project documentation will be shared through a customized portal, or Institutional Teaching Commons, within the MERLOT (Multimedia Educational Resources for Learning and On-line Teaching) web site (www.merlot.org).
- Project documentation will also be provided through digital libraries such as OER Commons (Open Educational Resources, www.oercommons.org), SCALE-UP (Student-Centered Active Learning Environment for Undergraduate Programs, scaleup.ncsu.edu), NSDL (National Science Digital Library, nsdl.org).
- Senior personnel will present at a TUES conference and/or other conferences (e.g., EDUCAUSE, MERLOT).
- Principal Investigators will participate in the National STEM Educational Digital Learning Project.
- Project participants will submit at least one manuscript for publication to an appropriate journal. These may be discipline specific (e.g., Advances in Physiological Education, J of Engineering Education, Cell Biology Education), or more general (e.g., J of College Science Teaching, J of Research in Science Teaching).

Facilities and Resources
Northern Michigan University currently occupies 360 acres that includes 50 academic facilities. 2009-10 student enrollment was 9,428. NMU employs 538 faculty members (332 full time) including 63 full-time in STEM disciplines.

For this project, NMU has agreed to allocate 1,450 square feet of space for the active learning studio classroom in the Learning Resources Center. The studio space is located in close proximity to the Center for Instructional Technology in Education and the Instructional Media Services office as well as the Computer Help Desk and Microcomputer Repair Center. The space is centrally located on campus and is positioned close to the primary building (New Science Facility) that houses most STEM departments. The NMU administration has agreed to provide funds to renovate and furnish the studio classroom space; estimated costs for this renovation are $47,000 (see attached letter of support). Electronics technicians from NMU's Learning Resources Division (LRD) will install the technology in the active learning classroom. They will also be available to assist with technical troubleshooting, repairs and ongoing support.

NMU's Instructional Design, Technology, and Media (IDTM) unit, directed by Matthew Smock, supports teaching and learning in online and classroom-based environments by providing resources, tools, and services that enable faculty to innovatively use technology to deliver and enhance pedagogically sound courses. IDTM will assist faculty members with becoming comfortable with the technology in the studio classroom and assist Catalysts with designing workshops for faculty. In addition to Mr. Smock, an instructional technologist and two classroom technology support specialists are available to provide support. Student employees are also available to help with basic technology questions and troubleshooting. IDTM's Center for Instructional Technology in Education (CITE) is a resource center where faculty can go to learn about, experiment with, and get advice and assistance with a variety of instructional technology tools.

NMU is a member of the Multimedia Educational Resource for Learning and Online Teaching (MERLOT) and EDUCAUSE consortiums, as well as of EDUCAUSE's sub-group, the EDUCAUSE Learning Initiative (ELI). These resources will be utilized for support in developing online learning activities, as well as in disseminating results of the project.

Departmental Resources**:** All involved departments (listed below) have equipment and resources for teaching within their disciplines including, but not limited to, specialized software (e.g., ecological modeling) and portable scientific apparati (e.g., microscopes, physiological transducers, spectrophotometers, field sampling equipment) that will be available for use in our project. A brief description of each participating STEM department at NMU follows:

Biology: Fourteen faculty members. Six majors/emphases offered: General Biology, Ecology, Microbiology, Physiology, Secondary Education Biology, Zoology.

Chemistry: Ten faculty members. Four majors offered: Biochemistry, ACS Chemistry, Forensic Biochemistry, Chemistry Secondary Education.

Engineering Technology: Six faculty members. Five baccalaureate majors: Electronics Engineering Technology, Industrial Technology, Industrial Technology Education, Mechanical Engineering Technology, Technology & Applied Sciences. Associates degrees and certificate programs are also offered.

Geography: Ten faculty members. Eight majors: Earth Science, Environmental Conservation, Geographic Information Science, Human Geography, Physical Geography, Planning, Secondary Education Earth Science, Secondary Education Geography.

Math & Computer Science: Sixteen faculty members. Five majors: Applied Mathematics, Computer Science, Mathematics, Network Computer, Secondary Education Mathematics.

Physics: Five faculty members. Two majors: Physics, Physics Secondary Education.

Experience and Capability of the Principal Investigators

Jackie Bird, Jill Leonard and J.D. Phillips are active scientists (see Biographical Sketches) and engage undergraduate and graduate students in research. Leonard and Bird are tenured faculty in the NMU Biology Department and Phillips in the Mathematics and Computer Science Department; they teach a variety of courses including introductory and upper-level offerings. In addition, Leonard and Bird were part of the NMU FIRST II team that participated (2002-2006) in the NSF-funded FIRST (Faculty Institutes for the Reform of Science Teaching: NSF 0817224, 0618501, 0088847, 9752713) project, which began in 1998 led by Diane Ebert-May (Michigan State University) and Janet Hodder (University of Oregon) initially and continues as FIRST IV led by Ebert-May and Terry Derting (Murray State University) (see letter from D. Ebert-May). As part of their participation in the program, Leonard and Bird received training in active learning techniques, inquiry-based learning pedagogy, formative and summative assessment, and conducting educational research. Phillips has been active in the STEM community as a Project Kaleidoscope fellow since 1999. He also led an NSF-funded REU at Wabash College for many years—guiding scores of undergraduates through research projects that have led to publications, conference talks, and two national awards. He has participated in national conferences for REU leaders, and has published his experiences as an REU leader. The P.I.'s have presented to the STEM education community in the form of conference presentations and they have also attended numerous professional development courses on active learning and outcomes assessment. Leonard and Bird obtained NMU internal grant funding to support the incorporation of personal response devices (“clickers”) in biology courses. The P.I.s have been using a variety of active learning and inquiry-based learning techniques in their courses for more than seven years. In addition, Leonard has received federal funding (NSF International postdoctoral fellowship and several National Park Service grants), which has given her experience effectively managing large grants. She has published on information generated from these grants. Bird has received federal funding (USDA through The Ohio State University College of Veterinary Medicine and two National Park Service grants) and published results from the funded studies. Phillips has received funding from IREX and numerous European grant agencies. He chaired the Department of Mathematics and Computer Sciences at Wabash College through a period of great growth; by the time he left the College in 2009, fully 8% of the College’s students were math majors, one of the highest percentages in the nation. He has published on building a strong STEM department.

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