Project Description

The University of Wisconsin Colleges (UWC)—13 two-year colleges in the University of Wisconsin System—with the University of Wisconsin-LaCrosse (UW-L) working in partnership with the Academic ADL Co-Lab in Madison, WI, seek the collaboration of the NSF through its CCLI/Educational Materials Development program to 1) create an exemplary repository of sharable content objects (SCOs) targeting trouble spots in a typical precalculus course, 2) create training materials that will help faculty assemble these SCOs into instructionally effective modules, and 3) evaluate and disseminate both this faculty development process and the resulting courseware.

Background

This project serves as a nexus for two significant national efforts: 1) the development and adoption of specifications and technology that support a "learning object" approach to authoring, delivering, and teaching with online mathematics content, and 2) the development of digital collections of instructional materials.

A great deal of effort has been put into the development of a theory and practice of "learning objects", building blocks of digital content that can be used in conjunction with each other and with other forms of instruction. The Advanced Distributed Learning initiative has gathered and published technical standards for such learning objects and vendors have created technology for creating, storing, managing, finding, and using such learning objects. This goes under the name "SCORM" which stands for *Sharable Content Object Reference Model*. (http://adlnet.org/).

The technological aspects of this project are based on the SCORM model. The Sharable Content Object Reference Model is a collection of specifications that enable some basic, but crucial, operations for online learning content: description of the content for cataloging and discovery, delivery of the content by any conformant learning platform, tracking of student interactions and capture of test scores by any conformant learning platform, and assembly of smaller content objects into larger modules that can be imported and delivered by any conformant learning platform. As a result of collaborative work done over the past several years by international specifications and standards organizations, SCORM is being rapidly adopted internationally as a learning content interchange standard. All major learning management and learning content management systems either already are conformant or will be within six to twelve months, and SCORM compliance is a requirement for most federal and many corporate e-learning procurements. SCORM is designed to support a world in which instructors can find and use high quality components when creating new content, allowing them to spend time on instructional and design aspects instead of on authoring everything from scratch.

There has already been a great deal of effort expended to create, evaluate, authenticate, and index digital learning resources in a wide variety of digital libraries. In some subject areas, the amount of digital content in digital libraries has reached the critical mass needed to afford students and teachers "anytime/anywhere" access to content appropriate to their specific context, for example, grade level, educational objective, prior knowledge, abilities, and assessment requirements.

In mathematics, we believe that sufficient content now exists to test a pedagogically-driven set of principles surrounding learning object theory. We have chosen the subject of precalculus mathematics because of its critical national importance. Precalculus is a foundational element for students entering mathematically-related fields and, at the same time, presents a major educational hurdle for many students in high school and college because poor performance in this subject discourages many students from entering SMET programs and professions altogether.

As the survey below (Rung, 1997) indicates, more than 30% of mathematics instruction in colleges in the United States is considered precalculus with almost a third of the precalculus instruction being done at two-year institutions.

Text table 4-4.
Estimated enrollment in undergraduate mathematics courses

Course level	Four-year institutions 1970	1980	1985	1990	1995	Two-year institutions 1970	1980	1985	1990	1995
					Enrollment (in thousands)					
All math courses	1,188	1,525	1,619	1,619	1,469	555	925	900	1,241	1,384
Remedial	101	242	251	261	222	191	441	482	724	800
Precalculus	538	602	593	592	613	134	180	188	245	295
Calculus	414	590	637	647	538	59	86	97	128	129
Advanced	135	91	138	119	96	0	0	0	0	0
Other	NA	NA	NA	NA	NA	171	218	133	144	160
					Percent					
All math courses	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Remedial	0.09	0.16	0.16	0.16	0.15	0.34	0.48	0.54	0.58	0.58
Precalculus	0.45	0.39	0.37	0.37	0.42	0.24	0.19	0.21	0.20	0.21
Calculus	0.35	0.39	0.39	0.40	0.37	0.11	0.09	0.11	0.10	0.09
Advanced	0.11	0.06	0.09	0.07	0.07	0.00	0.00	0.00	0.00	0.00
Other	NA	NA	NA	NA	NA	0.31	0.24	0.15	0.12	0.12

NA = not applicable

NOTE: Precalculus-level mathematics courses include algebra and trigonometry courses, as well as courses for nonscience majors, finite mathematics, non-calculus-based business mathematics, and mathematics for prospective elementary school teachers.

SOURCE: D.C. Rung, "A Survey of Four-Year and University Mathematics in Fall 1995: A Hiatus in Both Enrollment and Faculty Increases," *Notices of the AMS* 44, no. 8 (September 1997): 923- 31.

As precalculus is a foundational element for students entering mathematically related fields and is so widely taught in the US, it presents an educational hurdle for many students in high school and college. Poor performance in this subject discourages many students from entering SMET programs and professions altogether.

Our intent is not to add to the existing digital collections, although it might be necessary to do so in very focused and targeted areas that serve to complete parts of a pedagogical design. Rather we will identify digital content in our chosen subject utilizing the resources of the MathDL, Eisenhower National Clearinghouse (ENC), the Math Forum, SMETE, and MERLOT and others.

What is most significant and innovative about the proposed project is that we are attempting, from a research perspective, to determine whether the learning object approach will work in a formal, higher education context. Further, because the widespread use, reuse, and sharing of learning objects is dependent upon a standards agreement, it is important to pilot a program to critically examine the effectiveness of this approach. To these ends, we will convert precalculus educational materials in several existing digital libraries into SCORM format and put them into the hands of students and teachers. Our hope is to see an immediate positive impact that can be extended and scaled to other subjects, but our research conclusions will be based on data, not desires.

This has not yet been tried, but the technology and tools now exist to perform that experiment, and that is what we are proposing to do. The results of the proposed research will have far-reaching consequences, both in terms of improved access and learning.

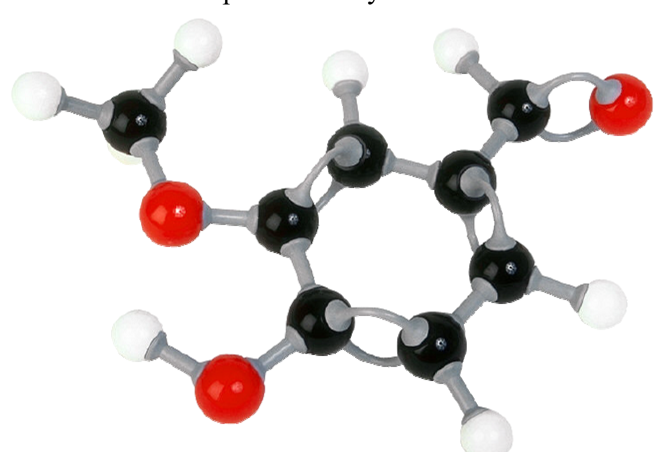
A Clarification of Terms

As a basis for conceptualizing our project, a clarification of terminology might be helpful. We are envisioning "SCOs" as building blocks and "modules" as faculty-created pieces made from multiple SCOs. At one level, these are the "educational objects" referred to in 1998 by then DUE Program Director Frank Wattenberg as the "interchangeable, complete, and self-contained unit[s] … designed to be used in various settings and in various ways." (Wattenberg, 1998) The keys to this reusability, says Wattenberg, are "the concepts of **educational objects** and **granularity**."

A number of metaphors have been used to try to capture the essential building block nature of SCOs. They have been compared to LEGO building blocks in that all LEGO blocks adhere to one absolute standard for pin size. Every LEGO piece, no matter what shape, color, size, age, or purpose can always be snapped together with any others piece because of their uniformly shaped pins. This allows children of all ages to create, deconstruct, and reconstruct LEGO structures easily and into almost any form they can imagine. If applied to the world of learning content, we can see that similar opportunities would result if we were able to have the same standards and the capabilities to reuse and assemble or disassemble SCOs drawn from any source at any time.

David Wiley (2001) compares SCOs to an atom: "An atom is a small 'thing' that can be combined and recombined with other atoms to form larger 'things.'" Wiley further points out that this may be even more applicable to SCOs than the LEGO metaphor as:

- Not every atom is combinable with every other atom.
- Atoms can only be assembled in certain structures prescribed by their own internal structure.
- Some training is required in order to assemble atoms.



We would add that atoms are almost infinitely reusable with different configurations of even the same atoms resulting in molecules with quite different properties.

For the purposes of this project, SCOs take on an added set of properties: In our discussion, a SCO is learning object that conforms to ADL current SCORM specifications and one that has the ability to report when a student has used it and, if appropriate, to report the scores of any assessments—formative or normative—for information that needs to be reported back. The SCO computes a score, and then transmits that score to a learning management system (LMS) so as to play a role in deciding the future direction of a student's learning. SCOs also are self-describing. Digital content without descriptive meta-data would be just a useless binary file. The information needed for digital content goes beyond title and author. It includes technical and pedagogic information as well as rights management information.

SCOs in and of themselves are not complete pedagogical tools. The learner must somehow engage with them in instructionally effective ways for teaching and learning objectives to be accomplished. Software that accomplishes this “engagement” task is commonly referred to as learning management system (LMS). For our purposes, this definition taken from the MASIE Center's e-Learning Consortium, (2002) will serve well. An LMS (Learning Management System) is software that

> “automates the administration of [educational] events. The LMS registers users, tracks courses in a catalog, records data from learners; and provides reports to management. An LMS is typically designed to handle courses by multiple publishers and providers. A learner's development plan … can be stored and personalized to the individual.” (MAISE Center, 2002)

The Need for Online Learning Content Standards

History shows that revolutionary changes do not take off without widespread adoption of common standards and specifications. For electricity, this was the standardization of voltage and plugs, for railroads, the standard gauge of the tracks, and for the Internet, the common specifications of TCP/IP, HTTP, and HTML. Common standards for online learning content are mandatory for similar success in the knowledge economy. Whether it is the creation of content libraries or learning management systems, accredited standards will reduce the risk when making large investments in learning technologies, because systems will be able to work together like never before. Accredited standards assure that the investment in time and intellectual capital can move from one system to the next. When content is trapped inside a proprietary format (such as a registration system, a courseware design, or a course sequencing model), the story is the same in each case: It is virtually impossible to reuse, transfer, or exercise interoperability between these proprietary models. This will not change until we build systems to an open accredited standard.

Moreover, as learning technologies have evolved over the last several decades, from the early mainframe-based programmed learning systems to the more recent Web-based systems, including online course dissemination and Learning management systems, the organized storage of eLearning materials has not. For, unlike the elaborate means that libraries have evolved for categorizing and describing printed texts, no such system exists for Web-based learning materials. **This has made the development, use, and organization of learning content chaotic, leaving many excellent materials underused.**

Further, as the creation of e-Learning content grows, interoperability standards are needed to allow for the sharing of that content. Not only are technical standards (like graphics-interchange formats) needed to share learning content, so is the standardization of formats for packaging, sequencing, and managing of SCOs needed, so they can be transferred between platforms and environments. Likewise, standard ways of describing educational materials are needed so that they can be easily searched and located. The rapid growth of the Internet has only accelerated this problem.

Today’s eLearning standards need to provide a strong new framework to serve as a bridge from abstract components to the practical world of implementation. Educators want to find content easily (wherever it might be on the Internet) and incorporate it into their courses just as easily! In a 2002 Macromedia survey of corporate and government eLearning developers, a convincing 93% said standards were either "very important" or important. This emphasizes how critical it is to understand the value of standards, and the challenges faced by developers in changing their models in support of standards. eLearning standards are of value in that they support investments in:

- ***Interoperability***, defined as interchangeability.
- ***Durability***, defined as having lasting value.
- ***Manageability***, defined by enabling value to be assessed.
- ***Re-usability***, defined as usage in different contextual situations.
- ***Accessibility***, defined as available to differing audiences regardless of physical, technical, and other differences.
- ***Portability***, defined as the capability of delivery on various systems, or even handheld devices (Heins and Himes, 2002).

These standards focus on the technical details of content meta-data (descriptors), content packaging and run-time communication to support tracking of student activities. ***All of the standards are predicated upon the notion of a reusable, sharable content object.***

Why SCORM?

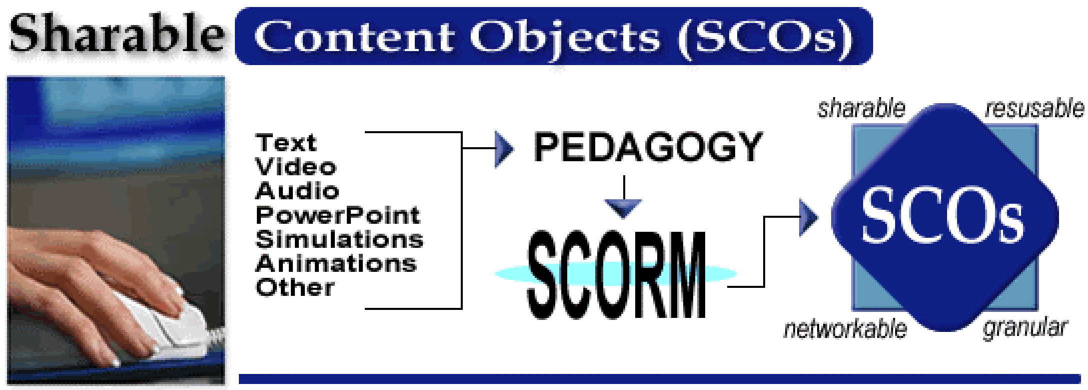
> "If the Web is to have a significant impact on the quality of SMET education, content developers must begin to build on each other's work. Much of the progress of modern software development is based on the concept of **reusability**." (Wattenberg, 1998)

In response to this need, the U.S. Department of Defense (DOD) has been working, for the past four years, to develop an open standard for use in a global, distributed network of interoperable and reusable learning content. As a major part of its initiative and to test, evaluate, and demonstrate ADL compliant tools and technologies, the DOD established three ADL Co-Labs: the DOD's original ADL Co-Lab in Alexandria, Virginia; the U.S. Military Joint Forces ADL Co-Lab in Orlando, Florida; and the ***Academic*** Advanced Distributed Learning (ADL) Co-Lab in Madison. The Academic ADL Co-Lab's functional responsibility is to research and develop advanced learning technologies *for the nation's universities and colleges*.

The three partnering ADL Co-Labs have worked together with industry collaboration on implementing and testing of SCORM. The use of this model allows for the creation, storage, and dissemination of billions of modular, reusable chunks of knowledge in the precise form required by an individual user, and accessible anytime and anywhere via a globally distributed network of repositories. It is important to note that SCORM provides only the specifications for the technical underpinnings of eLearning, such as meta-data tagging, content packaging, and communications with a learning or content management system. SCORM *does not* address content, instructional design, or pedagogy. ***The intent is not to promote uniform content, but to enable all compliant content to work better on a technical level.***

Impact on Educators

Rather than adhering to "traditional" course formats that are difficult to disassemble and reconfigure into re-purposable SCOs, instructors and curriculum designers must be trained to conceptualize online instruction in terms of reusable components (Bonk & Wisher, 2000). Instructors must learn to think about how SCOs can be combined into higher-level modules or courses depending upon the needs of the learner. In addition to building SCOs, instructors also need to learn how to use SCOs built by others. Even after prototype repositories of SCOs are constructed and work well from a technical standpoint, instructors will need to be trained in the



necessary workflow processes for using, reusing, and sharing SCOs. In addition, instructors will need methods for assessing the kinds of delivery mechanisms that are the most appropriate for the needs of the learner audience, the instructor, and the institution, and for designing courses with those needs in mind.

Why Use SCOs?

A key point of investigation in this proposal is critically assessing the use and application of reusable learning objects, to find out if it is worthwhile investing time, money, and intellectual effort in their further creation. Perhaps this can be better understood by examining a typical content creation and application scenario.

To help students learn the effects of scaling and translation on the *sine* and *cosine* functions, a professor of precalculus could choose:

- A story concerning surface waves in the Boston harbor
- A Java applet that allows students to quickly graph $A\sin(x+c)$ and $B\cos(x+d)$ on the same pair of axes
- An application that *plays* the sound corresponding to a periodic function using capabilities built into a typical Windows 2000 or Windows XP installation.
- Two "virtual laboratory" exercises that use the applets and are contextualized using the Boston harbor setting
- A third "virtual laboratory" exercise that is simply about physics and sound
- An on-line assessment that measures student understanding of translating and scaling *sine* and *cosine* functions. For example, it tests whether students understand the consequences of the identity $\sin(x+\pi/2)=\cos(x)$.

To make content more widely applicable, it is *chunked* into smaller objects that can be shared and re-used in different contexts, even different courses. The Advanced Distributed Learning initiative has called these *sharable content objects,* or SCOs. Some SCOs in this model include:

- the Java applet
- the application that plays periodic functions on a Windows machine
- the virtual laboratory exercise about physics and sound
- Assessment questions (individually or as a set)

Some pieces of content may have requirements or make use of technology that make them less accessible. As a unit, the accessibility of the module is limited to the *least* accessible of its components. For example, content:

- May have demanding English language requirements
- May require a particular platform
- May not meet or only partially meet Web Accessibility guidelines
- May require the use of a particular Web server or Course Management System

By disaggregating the components, we can access to the parts that are, by nature, accessible. For example, non-native English speakers may be able to use an applet with little loss of comprehension. Once components are disaggregated, it is possible for them to be used singly, to be improved singly, and to be mixed and matched. This disaggregation process makes content readily accessible and reusable. Further, each SCO uses standardized *meta-data* that repositories can use to catalog the content chunks. This standardization in description also offers cross-repository search capabilities (much like those available to libraries using the Library of Congress cataloging system).

The standards that define SCOs also include the means to report assessment results to a conformant delivery system. This means that faculty will be able to query the system to see if a student accomplished assignments and how he or she performed. In some cases, these can automatically populate a grade book, but the real point is pedagogic. SCOs provide *evidence* of achievement and competency, and that evidence can be used to adopt teaching and the content itself to the student's demonstrated level of understanding and achievement.

Finally, the standards that pertain to SCOs allow them to be *assembled* into larger units, by user-friendly authoring tools. These can ensure that the SCOs retain the meta-data, portability and tracking features of the individual components.

Relevance to NSF and National Goals

The creation of SCOs has the potential to disseminate high-quality learning materials nationally in a cost-effective manner. For example, faculty in Oshkosh or Billings or Baton Rouge can select high quality components and combine them in ways they feel are most educationally effective for their own students. This requires a shift in thinking (or at least in class preparation) on the part of faculty, but it is reasonable to expect resulting improvements in instruction and access. This is especially desirable in areas, such as precalculus, that are:

- on the critical path to STEM education.
- taught by faculty who, by and large, are *not* expert in creating innovative and effective new content.
- widely taught and otherwise requiring each faculty member to build all course components from scratch.

Project Plan

The project we are proposing will unfold in the following manner:

- Identification of appropriate digital resources for instructing precalculus available in existing collections.
- Evaluation of the most appropriate of these for conversion to SCOs.
- Placement of SCORM conformant authoring and assembly tools into the hands of teachers so that they can (a) become familiar with the process of creating SCOs and then assembling these into larger units of instruction (also SCOs) and (b) create additional SCOs to fill instructional gaps in the existing collections as needed.
- Creation of a repository of SCOs for precalculus that can be effectively searched using educational criteria and that supports the workflows needed for peer review, adding metadata, and allowing user-contributions.
- Review of the available collection (using existing peer review processes) and addition of appropriate meta-data so that the end result will be a quality assured collection of precalculus learning objects that can be searched by criteria including topic, grade level, relationships to state curriculum standards, federal accessibility guideline compliance, technological requirements, and pedagogical approach.
- Pilot studies in which students and teachers use the precalculus learning object repository.
- *During all phases*, collection of data regarding time spent on various processes, on ease of use, and, in the end, on measurable educational outcomes.
- Dissemination of results through appropriate channels.

Project Partners

The University of Wisconsin Colleges is the lead institution in the grant (www.uwc.edu). It is a freshman-sophomore institution in the University of Wisconsin System with a nearly 8,483 FTE student enrollment (2001 UW System Factbook). UWC's 13 campuses are distributed across the state in rural to urban settings. It currently offers an Associate's degree delivered both in a traditional campus setting and online. A great emphasis of UWC's 40-member mathematics department is on instruction in precalculus.

The University of Wisconsin-LaCrosse, a collaborating institution in this project, is a comprehensive four-year campus with an FTE enrollment of 7994 (2001 UW System Factbook) with a 23-member mathematics department. It generally offers seven sections of precalculus each semester.

The Academic Advanced Distributed Learning Co-Lab (www.academiccolab.org) is a partnership between the Department of Defense's Office of Readiness and Training, the University of Wisconsin System, and the Wisconsin Technical College System. Currently representing 39 accredited academic organizations and more than 500 post-secondary campuses in 30 states, the Academic ADL Co-Lab has the leadership role in researching and developing academic applications of sharable content objects in conjunction with the DOD's research into a *Sharable Content Object Reference Model*. Its goal is to promote the development of international standards in the creation and use of Internet-based learning through applied research, development, demonstration, implementation, and evaluation of ADL-compliant tools, technologies, and products for both academia and the workplace.

In operation since January 2000 at UW-Extension's Pyle Center on the campus of University of Wisconsin-Madison, the Academic ADL Co-Lab is one of three ADL Co-Labs, but the only one focused on secondary and post-secondary education. For this project, the Academic Co-Lab will work with selected existing mathematics content to disaggregate current courses into modular content or SCOs, which will then be made available through an online repository for faculty to assemble based upon the specific course or student needs.

The University of Wisconsin System is comprised of two doctoral universities, eleven comprehensive universities, thirteen two-year colleges, and UW-Extension, one of the nation's premier extension institutions. One of the larger Systems in the country, the University of Wisconsin System has an enrollment of about 150,000 students. The System Office of the President supports a rich technology infrastructure, including an education wide area network, a distributed learning "utility" which provides Web-based teaching and learning tools for all faculty in the System, a common automated library system, and common administrative systems. The chancellors and chief academic officers of all fifteen institutions work closely with the president and her staff to set out common goals and objectives to improve the high quality of education and research for which Wisconsin is widely known.

Project Goals:

Our project has the following over-arching goals:

- To meet critical educational needs (in this case, to improve precalculus education) by applying the technological and pedagogical notions embodied in the concept of a re-usable sharable content object.
- To improve the utility and accessibility of existing repositories of educational material addressing precalculus by applying standards and learning technology developed by major public and private efforts during the past five years (i.e. SCORM).
- Principally through the use of meta-data and learning objects, to make it easy to find, obtain, and use online precalculus learning material that meets the contextualized needs of a teacher or a student.
- To collect, analyze, and disseminate data on the cost, quality, scalability, practicality, and pedagogical effectiveness of the standards-based learning object assembly process for use in formal education.

The project will produce and assess both process **and** product. The process component examines faculty development and pedagogy; the product component will result in a set of tested training materials that can be shared nationwide.

The faculty development part of the project, will have the following broad objectives:

- To introduce faculty to the concept of the SCO.
- To create a learning community among post-secondary mathematics educators in Wisconsin.
- To provide professional development opportunities
    - in the effective evaluation of mathematical tools.
    - in the creation of SCO-based materials.

The specific objectives of the SCO workshop (described under "Training Workshop") are that the faculty, using the materials developed, will learn:

- The concept of a sharable content object (SCO)
- Instructional practices involving SCOs.
- How to discover appropriate SCOs.
- How to create modules and other SCORM content using SCOs.
- How to assist students in using SCORM content.
- How to use technology that tracks the usage and results from SCORM content.

The pedagogical component of this project will have as its primary goal:

- To assess the effect of this instructional mode on student learning.

The product component of the project will have as its objectives:

- Documentation of the process and identify a suite of tools for assembling the SCOs into instructional modules.
- Development of a set of workshop materials introducing faculty to the concept of SCOs and their use.

Project Participants

The principal investigator for the project will be Hal Schlais, Professor of Mathematics at the University of Wisconsin Colleges and Director of Learning Technology Development for the University of Wisconsin System. Co-PIs are Tom Peneski, Associate Professor and Chair of the UWC Mathematics Department, and Robert Hoar, Associate Professor of Mathematics at UW-L. Robby Robson, President and Senior Partner at Eduworks Corporation, (www.Eduworks.com) (See Biographical Sketches under Section E.) will serve as a senior member of the project team. Eduworks Corporation, a professional services company specializing in eLearning products and interoperability standards, will provide additional expertise and experience in learning technology, meta-data, SCORM, digital libraries, and applications to mathematics.

This project will involve 15 tenure-track professors, each with a history of having taught precalculus for several years. These faculty will come from the two participating institution, 10 from the UWC and 5 from UW-L all of whom have experience teaching the precalculus course. The later testing of faculty-developed products, in academic year (AY) 2003-04, will target a population of approximately 500 students in 30 sections of precalculus taught at the two institutions

The 15 professors, gathering collectively early in the spring semester of the 02/03 academic year, will identify five common, specific and fundamental topics, the teaching of which is expected to be enhanced pedagogically thorough the use of digital technology. Faculty subgroups of two or three, one for each topic, will then be formed to focus on locating available content to address the topic. Quality assurance in the objects retrieved will be stressed

Digital Content Assessment Workshop

> *Adjudicatory functions* are the most critical aspect of the national library. Educators must have a high level of confidence in the quality of the materials contained in the library. Mogk & Zia (2000)

Participating faculty will attend a one and a half day workshop at The Pyle Center in Madison Wisconsin conducted by MERLOT (www.merlot.org) staff. The goal of the workshop will be to provide the participating faculty with the well-tested framework for assessment of digital learning resources developed by the MERLOT project. It will be held in the spring of AY 02/03 possibly in conjunction with the spring meeting of the Wisconsin Section of the Mathematics Association of America.

Training Workshop

In June of 2003 the 15 faculty will attend a three-day workshop on SCO development to be held at the Pyle Center in Madison. The workshop will be followed with a three week, asynchronously delivered, online session during which faculty will develop and post content to the repository. They will be introduced to currently available, user-friendly SCO production software available through partnerships with the Academic ADL Co-Lab. The faculty will learn how to integrate these SCOs into learning management systems for later instructional delivery in the precalculus course.

The workshop will be structured to model the practices for the faculty to follow. It will be a combination of traditional classroom-style presentation, hands-on laboratory exploration and group learning, self-study using written materials, and online learning using SCORM-compliant content. This will allow time for assimilation and exploration. The online 3 week follow-up session will enhance faculty experience with asynchronous learning and will accommodate their diverse SCO development schedules.

The SCO workshop will be produced by Eduworks Corporation (www.Eduworks.com), a professional services company specializing in e-learning products and interoperability standards, will provide additional expertise and experience in learning technology, meta-data, SCORM, digital libraries, and applications to mathematics.

Additional Instructional Design Assistance.

It is expected that many of the SCOs that are located by the faculty teams will lack particular aspects (e.g. assessment components) and/or might benefit from instructional design modifications. These additional instructional design considerations will be addressed by two instructional design support staff housed at the Academic ADL Co-Lab.

Workshop Outline and Supporting Materials:

Schedule	Activities	Supporting Materials	Deliverables &/or Assessments
Day 1	Presentation on Learning Objects and Learning Technology	Slides and written material	Online quiz will be taken later
	Learn to use Trivantis Lectora	Laboratory set-up Sample "titles," including one on learning objects with associated assessment	Produce 4–6 page "title" Take assessment on learning objects
	Obtain WebMentor account	WebMentor	Register, log on, find one-page module, enter and exit module
Homework	Read printed and online materials about learning objects	Supporting material	Use of online learning material will be tracked by WebMentor
Day 2	Q&A about work so far		
	Meta-data searching	Presentation on meta-data and using it for search and discovery	
	Review of Learning Objects	Laboratory session: faculty search and review the learning catalog	Mini-reviews of learning objects
	Learning Object assembly techniques	Presentation and hands-on session on assembling SCOs into a module using Trivantis	Module composed of two SCOs from different sources
Homework	Review of learning object	Read MERLOT review guidelines and create review of learning object in repository	Review
Day 3	Q&A about work so far		
	Presentation on instructional practices	Presentation	
	Group discussions on instructional practices	Facilitated discussion	Group deliverable is list of suggestions
	Material for students	Faculty will be given written and online material explaining how to use the available technology	
	Develop course outline	Faculty develop course outline for course they will teaching, with slots for use of learning objects	Rough outline
	Access and use online student records	Laboratory experience with instructor account on Web Mentor	Perform specified administrative tasks
Homework	Further optional reading Complete course outline Review student materials	Online and print material. Access to learning object library	Completed course outline including use of learning objects
Three week, asynchronous, online follow-up	Final exam, Materials development	Laboratory exam: Faculty demonstrate ability to find and assemble learning objects and to use all aspects of Web Mentor	
	Q&A		
	Evaluation and feedback solicited online!		

Course Implementation and Control Group

Instruction of the precalculus courses utilizing these SCOs will be conducted during AY 2003-04. Approximately 17 sections will be taught in the fall semester, with another 10 in the spring. A formative assessment will allow for a restructuring the course content for the spring semester. Comparative evaluations will be made at the end of the spring semester of AY 03-04.

At least five of the sections of precalculus will be taught by instructors who did **NOT** attend the project workshops. This group will serve as a comparison/control group. To insure that they are aware of the materials available, they will participate in a half/day introduction to the project prior to the beginning of the fall semester 2003-04. This introduction will involve demonstrations of materials identified and developed, some ideas about how they might be use, and an invitation to use them in their respective classes. An assessment of SCO use, faculty perceptions and experience, and student achievement in those sections will be compared to that of other project participants.

Project Timeline

Spring Semester 02-03	**Jan**	**Feb**	**Mar**	**April**	**May**
CO-PIs' initial meeting/SCO workshop planning					
Eduworks develops SCO workshop materials					
Participant faculty identify "choke" points in PreCalc					
Professional development in digital content assessment/quality assurance workshops with MERLOT in conjunction with the spring meeting of the Wisconsin Section of the Mathematics Association of America.					
Participant teams assess digital materials for repurposing					
Academic ADL Co-Lab identifies tools					
Eduworks provides faculty development materials for evaluation					
Process Assessment, Data gathering					

Summer 03	**June**	**July**	**Aug**
Faculty workshops focusing on SCO			
Faculty teams: each working with the instructional design resources at the Academic ADL Co-lab and on their individual SCO, will develop a complete learning object to be placed into the course repository			
Group workshop preceding the fall 03-04 term to address pre-semester issues.			
Standards-based learning objects derived from existing content are ready			
Overview presentation to entire math departments at both participating institutions			
Process Assessment, Data gathering			

Fall Semester 03-04	Sept	Oct	Nov	Dec
Instruction of Fall Semester Pre-Calc courses				
Data gathering: Faculty assessment				
Data gathering: Student assessment				

Spring Semester 03-04	Jan	Feb	Mar	April	May
Additional Pre-calc Courses taught					
Data gathering: Faculty assessment					
Data gathering: Student assessment					
Research summaries written					
PI provides a documented process and identified suite of tools for assembling the objects into instructional modules					
Precalculus modules that have been tested and created will be available					

Evaluation

Assessment will address four areas: student learning, the pedagogical effectiveness of the SCOs, the faculty experience with SCO-enhanced instruction, and the pedagogical effectiveness of the training materials.

An outside evaluator, Dr. Shelly A. Potts, Associate Executive Director of the Division of Undergraduate Academic Services at Arizona State University, will be contracted to evaluate grant-funded activities. Dr. Potts has served as external evaluator on numerous NSF- and FIPSE-sponsored projects and serves as a consultant at FIPSE Project Directors' Meetings where she makes presentations and meets with project directors and evaluators.

The project's evaluation approach will be both formative and summative. Dr. Potts will provide periodic, written updates as well as participate in phone or online conferences with key project personnel throughout the funding period. By monitoring the project's implementation and providing timely and constructive feedback, project strengths will be maximized and shortcomings can be remedied in a timely fashion. Dr. Potts also will prepare and submit comprehensive reports each year and at the end of the grant period.

To maximize knowledge gain, credibility, and utility associated with the project's evaluation, the evaluation design will incorporate multiple and mixed measures as well as a combination of direct and indirect data collection methodologies. A variety of tools and methods will be developed and incorporated to allow the collection of quantitative and qualitative data on the project's success. These tools will include paper and on-line surveys (re: usage of materials; knowledge and skill development; satisfaction with training, instruction, and resource materials; appropriateness of workshops, instruction, and resource materials; and experiences with course development and instructional activities), interviews with project directors and/or staff, document and website review, and data extraction from institutional data warehouses (course completion, grades, and instructor evaluations). Analysis of project outcomes will involve pre/post as well as control group comparisons in the areas of: student achievement, course completion, and instructional evaluations; faculty confidence, acceptance, and use of material; and faculty and student satisfaction with instructional experiences.

Data sources will include project directors and staff, faculty (workshop participants and precalculus faculty who did not participate in workshops but who have knowledge of the methodology), students enrolled in precalculus courses ("treatment" and control sections), project documents and instructional materials, data warehouse/student information systems (course grades, completion, evaluations, etc.), and website(s).

Dr. Potts will also develop an assessment process (procedures and materials) that may be used during the dissemination period.

Dissemination

This project will develop and validate four related products for national use: 1) Quality assured SCOs derived from existing precalculus content in digital mathematics collections, 2) Workshop materials on SCOs, 3) A process faculty can use for creating classroom instruction using SCOs, and 4) Precalculus modules assembled by faculty involved in the project.

Workshop materials and materials on the courseware creation process will be made available to the public via a Web site. This material will be both expositive and interactive. Modules created by faculty participants will be made available, subject to any intellectual property rights restrictions on their components SCOs. By agreement with participating repositories, the SCOs derived from their content will be returned for re-population into the repositories. Thus, these SCOs will be available for national dissemination and will have been indexed by MERLOT.

All materials will be will be publicized through meetings of mathematical associations (e.g. AMS, MAA, and AMATYC), through national e-learning conferences and events (e.g., ED-Media, M/SET, Syllabus, Educause, and TechLearn), via the Web and through appropriate News Groups, and through traditional scholarly publications. Funding for a concerted dissemination of the workshops on a national scale is not part of this request and is intended as part of a future proposal.

Results from prior NSF support.

The PI and Co-PIs had no NSF support in the past 5 years.