Learner-Centered Education Program
Arizona Board of Regents
Attachment A
INSTITUTIONAL SUPPORT FORM

Proposal Title: Personal Response Devices in General Chemistry Discussions

Institution: University of Arizona Dept./Unit: Chemistry

Multi-Campus/University Projects
(check other campuses or universities participating)
___ ASU Main ___ UA
___ ASU East ___ UA South
___ ASU West ___ NAU

List other participating agencies:

Briefly describe the program and the development plan.

Introduce personal response systems ("clickers", Classroom Performance System – CPS) in the General Chemistry Lecture discussion sections by developing a question bank specifically designed for discussion sections on the major topics of freshman chemistry with the aim of increasing student participation, as well as providing the instructor with immediate feedback about the students' understanding. Funds are requested for time during the summer to construct these question banks.

Funding Category

Indicate a primary (P) and, if applicable, secondary (S) funding category:

Professional Development	_____	Program or Course Development/Modification	__P___
LCE Research	_____	Improved Assessment of Learning Outcomes	__S___

Authorizations

Project Director

Signature: _____

Mailing Address: Chemistry Dept., U of Arizona, P.O. Box 210041, Tucson AZ 85721-0041

Name: Dr. Wayne E. Wesolowski Title: Lecturer

Phone: 520-626-8866 Fax: 520-621-8407 Email: weso@email.arizona.edu

Department Chair / Unit Director / College Dean / Provost (may not be PD)

Name: _____ Dr. Mark Smith _____Title___ Professor, Department Head

_____

Signature

Official Authorized to Enter into Contractual Obligations

Signature _____

Name: _____ Title: _____

Phone: _____ Fax: _____ Email: _____

Abstract

Improving graduation rates begins during the very first semester in introductory courses like Fundamentals of Chemistry (CHEM 103A). Early course difficulties and failures upset four year schedules, force changes in majors and begin a declining spiral in confidence. The Chemistry Department at the University of Arizona proposes to extend a personal response device system (CPS-Classroom Performance System, also known as "clickers") already being tested in large lecture classes and apply it to selected smaller discussion group sections to increase success on lecture exams, reduce initial course drop rates, increase attendance at discussion groups and ultimately increase graduation rates. Success will be measured by comparison of self-evaluations, scores on common final exams, final grades, attendance records and diagnostic tests administered early in the course. Ultimately, course completion and graduation rates will be the final measure of success.

Background

In recent years, the Chemistry Department has increased its focus on the 100 and 200 level classes, with great emphasis on the redevelopment of the undergraduate laboratory classes. The Chemical Education Committee, under the leadership of Regents' Prof. John Enemark and Prof. Vicente Talanquer, has overseen this transformation. The Department demonstrates its commitment to undergraduate lectures and laboratories by hiring Lecturers who are excited and enthusiastic about teaching fundamental classes. In addition, and budget permitting, graduate students are assigned to these course development projects in lieu of teaching a laboratory.

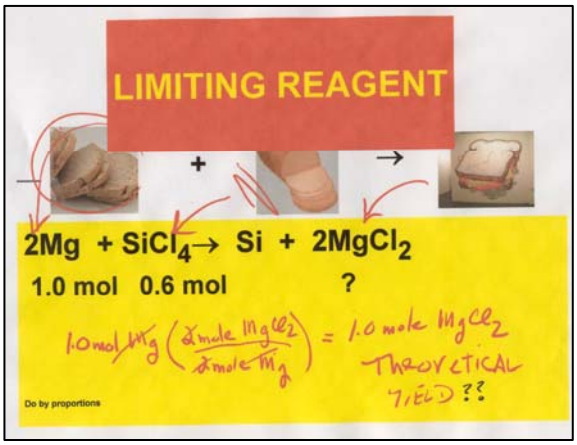
Recent projects include the reconfiguration of the General Chemistry 104a/b laboratory courses incorporating a discovery-based component, giving the students more decision power, the linking of the Chem 104 lab sections to specific lectures, the introduction of on-line homework assignments in the Chem 103 lectures, and the implementation of a common final for all Chem 103 lectures. All undergraduate students taking chemistry classes, currently more than 8,000 per semester, will benefit from these projects. Our current student body is nearly 50% female and nearly 35% minority students, with majors ranging from engineering and agriculture (~ 45 %) to chemistry (< 5%), MCB and pre-med (~50 %).

Identification of Need

The process of incorporating a new concept into memory requires engaging the learner. Studies suggest that engagement within any style of teaching – the classic lecturer-learner, small groups, learner-centered--can all be successfully driven by asking questions and allowing the individual learner to respond—the Socratic method.

In reality, though, the Chem 103 lectures are taught in a large lecture hall (Koffler 204) with 300 students in each section. This set-up clearly challenges the instructor to devise new methods to engage all students in a class. The Chemistry Department at the University of Arizona uses a variety of approaches to encourage the learner to ask questions and draw conclusions about chemistry. Two recent technological approaches are:

- *Tablet Laptops*



In Spring 2004 Dr. Wayne Wesolowski was the first lecturer in the Chemistry Department to adopt a tablet style laptop which is an electronic blackboard. The teacher can write on any slide, projecting the entire image to the audience. Rather than presenting line after line of facts, situations are presented, questioned and then the class is invited by questions to think about the issues. Projecting a large yellow box means – "you write a solution" – then the lecturer gathers ideas writing the conclusion in the yellow box. "What do you think? Why?" Since the teacher can't write any faster than the

students, this approach gives them a chance to organize concepts and think about issues. Combined with all the dynamics of PowerPoint the tablet laptop reinvigorates the long recognized exercise of writing ideas on a board.

Among 300 Chem 103A students surveyed in Spring 2004 over 86% picked the new tablet laptop as their personal "best learning tool."

In Fall 2004 tablet laptops were joined with a new technology:

- *Personal Response Devices*

The nagging question still persists: of those three hundred or more faces in a classroom how many are really engaged in the lesson? Technology has yet another tool to connect the learner to the teacher. The popular television program, "Who Wants to Be a Millionaire?" uses personal response devices to "survey the audience" at the contestant's request. By pressing buttons on a TV remote-like device each student can be engaged and answer questions. An instant survey is performed by a receiver and reported back to the audience.

In cooperation with McGraw-Hill Publishing, and at no cost to our students, Drs. Wayne Wesolowski and John Pollard began a pilot project in Fall 2004 to test a CPS (Classroom Performance System [www.einstruction.com]) in large sections (300 students) of introductory chemistry. The software is embedded in the tablet-style PowerPoint driving the lecture. This is clearly a learner centered tool; as each student responds, their number lights up on a large screen. When 254 students were questioned, there were 254 individual answers. Everyone is engaged.

Dr. Wayne Wesolowski's class

student response devices

To date the experiment has shown that the equipment physically works in our largest classroom, the students are enthusiastic and some interesting data has been gathered. It has been used to review material, conduct surveys and repeat material given on diagnostic exams. CPS is very new to Chemistry- - there were no presentation on personal response devices at the 18th ACS Biennial Chemical Education Conference in 2004. The UA Chemistry Department wants to be a leader.

The mechanics of distributing almost three hundred devices and setting up receivers for each class in only a 10 minute change period has taken up too much lecture time. We will hopefully solve this with a permanent installation and the individual purchase of responder units by the students in the future.

The bigger problem is that only a limited number of very general questions are available from the text publisher. There are no large question "CPS banks." At this time each question for CPS must be prepared and entered into a special template. Very few visual questions (e.g."Which drawing represents a weak acid?") are available. Developing and preparing questions especially for our specific Chemistry classes is a time-consuming process. In the large group setting many students still do not respond correctly and realistically only 2-5 questions can be asked in a fifty minute period.

Our proposal is to focus further on the individual student,and to develop a model whereby the CPS is adapted to our smaller chemistry discussion problem-solving groups. Traditionally these smaller groups are led by faculty or the course lecturer, not TA's. For budget reasons these "discussion" groups still approach 100 students. They are classically taught at the blackboard, with traditional class participation. The use of CPS in this environment has not yet been explored, but should be highly beneficial. No new material is introduced in these sessions, they are primarily designed to help the students solve problems, to make more connections with previously acquired knowledge, and to give the instructors a better chance to gauge the understanding of the students. CPS responses are private so the embarrassment and powerful negative peer pressure of an incorrect response would be removed. In discussion, questions are now uniformly answered by the best students with the most courage. Even small group activities, which are often utilized in discussion sections, have a dominating student. We think CPS can engage everyone and be more effectively used in discussions.

During Summer 2005 we propose to accomplish the following:

1. Using the specific learning outcomes for Chem 103A developed by the UA Chemistry Education Committee, create sets of CPS modules focused on each of the major areas in CHEM 103A: Basics, Components of Matter, Stoichiometry, Thermochemistry, Atomic Structure, Molecular Structure, Intermolecular Forces, Gases and Kinetic Behavior.
2. Each module will use more than one learning style and/or approach appropriate to the material – calculations, visual representations (weak acids, molecules), audio, proportions vs. conversion factors, everyday chemical applications, etc. These will not be multiple choice computations.
3. Each module will include individual and group activities, e.g. a problem could be done individually, tabulated by the CPS but not released. Then a small group could work together on the same problem and a consensus result reported via CPS—individual vs. group activities compared. The instructor immediately receives tabulated results and can appropriately respond. CPS can use a free form spontaneous question format.
4. Each module will contain a survey tool to decide when to move to new material and how to identify students needing additional help (diagnostic surveying). That decision now is made with a show of hands or instructor intuition.
5. The sections will be taught by faculty, not TA's, improving the quality of student- faculty interaction via CPS.
6. The modules will be tested on selected groups during the second summer session
7. To share the information obtained:
   - The CPS modules will be made available to all the members of The 100 Group – lecturers in 100 level classes
   - A report on CPS in Chemistry has been accepted for the 2nd Innovations in College Biology Teaching Seminar, UofA Fall 2005
   - A presentation will be prepared for the 19th Biennial ACS Chemistry Education Conference at Purdue University in July 2006 and for publication in the Journal of Chemical Education.

Technical Needs

McGraw-Hill has provided initial software and hardware needed for this project at no cost to the students or University. Additional minor software and miscellaneous electronic supplies are needed for distribution to other faculty and adaptation to other classrooms in Chemistry buildings. No consultant will be required.

Work Plan/timeline

- Fall 2004/Spring 2005: continued introduction of the CPS system in Chem 103 a/b lectures in a limited fashion by Drs. Wesolowski and Pollard.

- Summer 2005: development of question banks for specific topics covered in Chem 103 a; limited testing of the question banks in the discussion sections during the summer sessions. Graduate students employed by the Chemistry Department as teaching assistants, will assist in the creation and testing of these questions. A wide variety of questions have to be developed to avoid repetitions and student "memory", i.e. we have to avoid students expecting certain questions.
- Fall 2005/Spring 2006: full implementation of CPS in the Chem 103 a discussion sections, with assessment at the end of each semester.

Performance Measures

Formative Evaluation, which will be on-going throughout the implementation of the project. The information provided will be used to improve the project. Feedback will be collected from the faculty teaching other Chem 103 lectures and the students. The students' feedback will be collected as an evaluation which can be done in class using CPS itself, asking the students' opinion immediately.

Summative Evaluation, which will be executed at the end of the project/semester, providing information concerning the usefulness of the project. The following questions will be asked:

- Did the students' overall performance increase as a result of the project?
- Did the students' content-knowledge increase as a result of the project?
- Were the students' retention rates in the courses increased as a result of the project?
- A key feature in our evaluation process will be the students' performance on the new *Common Final* which has been created for Fall 2004.
- Since Fall 2003, the Chemistry Department has given a chemistry readiness diagnostic exam to several sections of CHEM 103A. The exam explores both confidence level and ability in more than twenty areas of chemistry and mathematics.
- Both the common final and diagnostic exams provide a database to compare the learning of students using CPS discussions vs. those who do not.
- Registration data is available to compare completion rates with and without CPS.
- Sustainability can be maintained if, as expected, the students will purchase the response devices packaged with their book. The current cost is less than $23/ year.
- The active support of the faculty is essential. If success is demonstrated and the packaged modules are available without extra work, the odds of adoption by other faculty greatly improve.

Key Personnel

- *Wayne Wesolowski*, (Ph.D. in Chemistry, 1971), Lecturer (Professor of Chemistry (ret) Benedictine University) has taught undergraduates for more than thirty years. He was a Technical Education Consultant for the AMOCO Corp (1982-2002) and has received ten grants for chemical education including NSF and the State of Illinois. Currently he is a section chair for the ACS General Chemistry Examinations Committee and is leading the CPS experiment at the UA. weso@email.arizona.edu, 520-626-8866
- *John Enemark*, (PhD. In Chemistry 1964) former Chairman of the Chemistry Education Committee, developed a research-like introductory Honors Chemistry course used at Arizona and the University of Sydney, Australia. He received the Faculty of Science Innovation in Teaching Award (1987) and the El Paso Natural Gas Faculty Achievement Award, (1994).jenemark@u.arizona.edu, 520-626-2245.
- *Mark Smith*, (Ph.D. in Chemistry, 1982), Department Head and Professor in Chemistry, is an expert in gas phase chemistry, has been intimately involved in the restructuring of the Chem 104 labs, and teaches general and physical chemistry. chemhead@u.arizona.edu, 520-621-6354.
- *Anne Padias*, (Ph.D. in Chemistry, 1975), Director of Academic Services and Organic Chemistry Laboratory Supervisor, has extensive experience in synthetic polymer chemistry and regularly teaches the Organic Chemistry Lecture. She assisted in the design of the CourseWeb server, and in the

implementation of the WebCT lab quiz server for the organic chemistry laboratories. anne@u.arizona.edu, 520-621-9978.

- *John Pollard*, (Ph.D. in Chemistry, 1996), is a Lecturer of Chemistry at the University of Arizona. He has extensive experience in web-development and the creation of web-based animations. jpollard@email.arizona.edu , 520-621-8843