Customized internet assessment for students and educators

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The average age of students at Lake Michigan College (LMC) is twenty-eight years old. In the current study, the application of customized internet assessment for Chemistry 101, Introductory College Chemistry, from 2001 to 2005 is compared with traditional assessment from 1996 to 2000. The authors describe the ways in which computerized assessment empowers a student, makes teaching efficient and helps the instructor to monitor progress and intervene when necessary. Customized assessment does not require any computer programming knowledge on the instructor's part, nor computer classes for the student.

Introduction

Angelo and Cross (1993) in *Classroom Assessment Techniques: A Handbook for College* addressed questions about learning by students and effectiveness of teaching. When a community college teacher is faced with a wide range of responsibilities—including research supervision, committee participation, college-wide meetings and a full teaching load—these two questions are critical. The authors have tried to address the questions with the help of advances in software technology.

A typical community college student is a twenty-eight year old, employed female. At Lake Michigan College, which serves 5300 students each year, more than 60% of students in the last decade have been minorities and/or female; more than 25 % receive financial aid. Unlike students at a large research university, the average community college student does not use instant messaging, bulletin boards, community websites, streaming videos, and sometimes not

Definitions

BlackBoard Web-based product that enables universities, schools, and corporations to host classes on the World Wide Web.

ESO Expected Student Outcome

mole International System unit of substance amount: the amount of a substance equal to the amount containing the same number of elementary units as the number of atoms in 12 grams of Carbon12. Symbol is mol.

moodle.org A free, open-source PHP web application for producing modular internet-based courses that support a modern social constructionist pedagogy

PHP stands for *php: hypertext preprocessor*, a server-side, HTML embedded scripting language used to create dynamic Web content. The abbreviation confuses many people because the first word of the acronym is the acronym. This type of acronym is called a recursive acronym. (http://us3.php.net/manual/en/faq.general.php)

POGIL Peer-oriented guided inquiry learning

stoichiometry is the branch of chemistry concerned with the relative proportions in which atoms or molecules react together to form chemical compounds.

Web CT (Web Course Tools) is WBT (Web-based training) authoring, delivery, and management. The authoring environment is entirely web-based.

even e-mail. Many community college instructors teaching science courses belong to the Baby-boomer generation and do not know HTML programming.

In the past, Wagner (2001) described the use of "Customized Internet Assessments." He discussed problems of interactive online assessment, a technology that enables instructors to create their own online assessment with complete control over the content and structure of questions. However, within the last five years, the programs moodle.org, Web CT, and Blackboard have become available and an educator without any HTML programming training can use such assessments. While meeting only ninety hours in a term for a college chemistry course, we have added twenty hours of testing using internet assessment. The resulting savings in testing time is devoted to teaching and other learning activities like peer-oriented guided inquiry learning (POGIL) as described by Spencer (1999). Cognitive and classroom research provided Spencer with a basis for developing new pedagogies.

The staples of instruction in the past have been based on a behaviorist model, but new pedagogy shifts to a constructivist model. Active involvement of the student in the classroom and laboratory creates a significant change in the traditional roles of both student and

instructor. What worked in the past may not work today. Students come to a community college with different learning styles. The learning environment and classroom activities play important roles in student comprehension of chemistry, but such teaching methods demand additional time.

In 2001, the authors introduced computerized testing for assessment in Chemistry 101, Introductory College Chemistry, using the Blackboard software. The impact of the change on classroom performance is analyzed and compared with traditional classroom assessment. Applications of technological resources with many unique features have made it possible to monitor student learning through computerized assessment. Weekly chapter quiz and chapter test assessment is done through the Lake Michigan College (LMC) Assessment Center. Computerized grading keeps an electronic record for each student. Students can check the result of the quiz or chapter test as soon as they click a "submit" button on the computer screen and can check their semester grades at any time using "Student Tools."

Methods and techniques

For customized internet assessment, the authors found Blackboard software superior to other available resources such as moodle.org and WebCT. Complete control of examination questions; automatic grading; inclusion of equations, symbols, and tables; and easy access to grades by students and instructors were primary considerations in the server selection.

Assessment of any discipline includes knowledge of methods, procedures, and analysis skills. What is not measured is not valued. Traditional forms of assessment do not provide an instant and continuous picture of the learner. When a new and difficult concept is taught, the teacher would like to know if the learner has grasped the concept. As each semester progresses, continuous assessment is more effective than middle and end-of-the-semester testing. Such confirmation of concepts learning and skill development by students forms the backbone of effective teaching. Obviously, the goal of the teaching is to ensure that the students are learning the necessary basic concepts before moving on to more challenging ideas. By checking the progress of student comprehension of chemical concepts during the semester, the teacher can intervene to change or modify teaching methodology.

The instant feedback from computerized assessment makes it easy for students to realize mistakes and weaknesses. The time between a chapter quiz of ten points and a chapter test of one hundred points is enough to go back and solve the problem. For the instructor, homework assignment posting is easier to administer. Blackboard allows students to prepare and practice for quizzes and tests using on-line tools. When students want

to check homework answers, they can e-mail communication alerts to the instructor to post the key or solution on the server site. The next step for the student is to consult with the instructor in case of doubts or disagreements.

The deployment of a quiz is easy. Questions can be written, scanned, and posted on the site, or they can be selected from a question pool. Even after the assessment quiz or test is deployed, it can be modified. If the instructor wants it to be password protected to allow proctoring or wishes it to be completed in a certain time limit, those limits are allowed. The number of choices in a multiple choice question can be increased or decreased easily.

Such on-line assessment allows the instructor to measure a student's understanding before moving to the next chapter. Many assessment properties and presentation options are easy to learn and use. The test is automatically graded. Each quiz or test can include one or more of the following types of questions: multiple choice, true-false, multiple answers, matching, fill-in-the-blanks, or short answer with a specific word in the answer.

With computerized assessment, the focus is on empowerment of the students. What is the best time for quiz or test taking from the student's point of view is determined by the individual student himself or herself. To address student learning needs and to meet the Expected Student Outcomes (ESO) established by the instructor, the assessment techniques are simple and effective.

Before teaching the students about balancing chemical equations, the authors wanted to make sure that each student had mastered the nomenclature. If necessary, formulae, charts, and other information can be provided before asking students to balance equations. Computer-based performance assessments reveal a variety of problems instantly. For example, finding that students lacked the skills to balance equations called for intervention and extra help from tutors before starting the concept of mole. Customized Internet Assessment provides the missing component needed to teach further, from nomenclature to balancing equations to mole calculations. It reveals insight into a student's level of conceptual knowledge and helps the instructor to determine if more instruction is needed.

With computer-based learning, students are graded on their ability to solve problems. In chemistry, each student receives a score based on individual performance. The procedure allows for immediate feedback to both the student and the instructor. The immediate feedback is used as background for the next step in teaching and learning. Analysis of the results includes better performance on the on-line quizzes and tests than in-class examinations of previous years. A dramatic increase in attendance, as well as retention of students, is another positive outcome. At the mid-term, a complete

analysis called "half-term" report is prepared. Each student signs up for a conference and receives the report in person.

Assessment preparation for on-line deployment

How many questions should be on a quiz or a test? What must be the time limit, and the number of attempts that are sufficient to ensure concept learning? Science knowledge demands understanding natural laws and underlying principles. When designing a multiple choice or objective test, one must consider all approaches to problem solving—working backward, dividing a problem into parts, working systematically, solving problems by analogy, and using procedural and conceptual knowledge. Table 1 shows each major concept chosen for the assignment. A series of questions was designed to reinforce the relevant ideas behind each concept.

It is important to subdivide the problems related to stoichiometry

Table 1. Chemistry 101 concepts about which questions were asked

Assignment		Concept	
1.	Element/atom	Ch 3	Define terms
2.	Significant fig	Ch 2	Rules and application
3.	Metric/US system	Ch 2	Conversions
4.	Density	Ch 2	Mass, volume, density calculation
5.	Atomic #/mass #	Ch 4	Subatomic particles
6.	Isotopes	Ch 4	Isotopic distribution
7.	Periodic table	Ch 4	Properties and terms
8.	Reaction/equations	Ch 6	Balancing, classification
9.	Mass relation/equation	Ch 8	Calculation
10.	Nomenclature	Ch 5	Formula and name
11.	Chemical formula	Ch 7	Empirical and molecular formula
12.	valence shell electron pair repulsion (VSEPR)	Ch 10	Shape of a molecule
13.	Mole	Ch 7	Calculations
14.	Limiting reactant	Ch 8	Identification and calculation
15.	Gas laws	Ch 9	Calculations
16.	Solutions/molarity	Ch 11	Calculations
17.	Acid, base and ph	Ch 12	Calculations
18.	Electron configuration	Ch 4	Description
19.	Energy/specific heat, etc.	Ch 9	Calculate sp ht or final temp.
20.	Octet rule	Ch 10	Apply to molecules
21.	Lewis dot structure	Ch 10	Demonstrate skill
22.	Resonance/polarity	Ch 10	Define and describe

about mass, moles, volumes, and balancing equations. Instead of a complex lengthy problem with more credit, the authors divided the concepts into separate problems with fewer points. For example, one problem asked the students to balance the equation; another problem asked them to calculate moles of the product from given moles of reactants; the third problem demanded the skill of mass calculation of either the reactant or the product. After these skill requirements were demonstrated in a quiz, the test included limiting reactant problems, coupled with chemical reaction concepts.

Research in stoichiometry chemistry by Saouma BouJaoude and Hala Barakat (2003) has established the relationships between students' learning approaches and their success. Stoichiometry is the most basic, central, and difficult concept in chemistry due to its quantitative and qualitative nature. The chemical reactions and mole calculations intimidate many students because of their limited problem solving and qualitative thinking skills. Their inadequate mastery of stoichiometric calculations demands new approaches to prepare them in chemistry. Attempting to understand student problem solving strategies in chemistry in general and more specifically in stoichiometry led the authors to use customized assessment for monitoring continuous progress and determining the need for intervention.

The problems were written with an increasing, cumulative degree of complexity, requiring a few steps to a greater number of steps, demanding more conceptual understanding and mastery of mathematical manipulative skills. The multiple choice questions provide the students appropriate and valuable feedback throughout every week of the semester.

After the development of goals and objectives for the ESO, the quiz questions are formulated to match the desired outcomes. Each question is based on increasing intellectual challenges. Using recommendations not only from adjunct instructors but also performance of past students, the questions are modified or the corresponding points are increased or decreased. The Blackboard software allows essay, fill-in multiple blank, matching, multiple answers, multiple choices, short answer, true-false, or any combination of these. To measure the effectiveness of what was taught, the custom-developed assessment tools of quizzes and tests are flexible to meet individual needs. The only drawback is the investment of time needed for development. But once developed, they save time. Any academic discipline can use this model to create assessment instruments with either a professional development grant or departmental released time.

Table 2 illustrates five typical questions developed and posted for on-line assessment.

The feedback feature allows display of a response to either a correct

or incorrect answer. It even allows partial credit. The answers can be numbered using either Arabic numerals, Roman numerals, or letters, and as many as twenty possible answers are available for a single multiple choice question. For each test, questions are devised to test students' order of thinking, analytical, and problem solving skill as discussed by Cross (1988). Through close observation of students and their performance in the process of learning, the instructors collected feedback and analyzed the data related to student learning.

Over the years, from experience and from student feedback, the authors have corrected and/or modified the assessment questions. Classroom assessment helps individual college teachers obtain useful information on what, how much, and how well their students are learning. Faculty can then use the information to refocus their teaching to help students make their learning more efficient and more effective. Throughout, the authors focused on the dual goals of teaching fundamental chemical principles and the developing skill in applying scientific method to problem solving.

The computer administered assessment described is not only customized and flexible, but it also promotes learning in the true sense. The Assessment Center of LMC conducts testing every day, with extra testing time on Wednesday night till 9 P.M. The data col-

Table2. Typical Chemistry 101questions

1.	Circle the chemical compound having ionic bond: a. NaCl b. Carbon dioxide
2.	Circle the chemical compound having a polar covalent bond: a. Br-Br b. H-Br
3.	How many grams of water will be produced when 1 mole of C_3H_8 will be allowed to react with excess oxygen gas according to $C_3H_8 + O_2 \rightarrow CO_2 + H_2O$? a. 4 b. 40 c. 360 d. 720 e. None of the above
4.	A solid has the density of 0.374 g/ml. Its length, width and height are 10 cm, 50 mm, and 0.1 meter respectively. The approximate mass of the solid should be: (Circle One) a. More than 200 grams b. Less than 200 grams
5.	What is the mass of a liquid that has a density of 0.60 g/ml and volume of 3.0 ml? Show your calculations.

lected in Graph 1 reveals the day and time when students take the quizzes and tests.

Table 3 compares the class averages of traditional in-class exams given between 1996 and 2000 with computer-based exams given between 2001 and 2005. The first group performed little better in the first four of the seven class exams. Entry #2 is an exception due to an influx of students from the cancelled class at another university in a neighboring town. The important numbers to consider are in the last three years, once the system was well established.

One must take into consideration the variability of the data due to changes in class composition as well as other minor variations. The numbers are most useful looked at from the perspective of trends and qualitative comparison. The variable of different classroom composition makes exact com-

Graph 1. Distribution of student test-taking

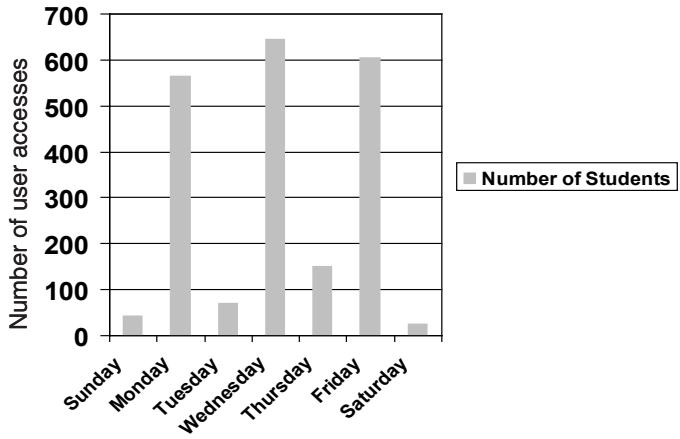

Table 3. Chemistry class performance averages: traditional and computer-based electronic assessment

Entry #	1996-2000 Traditional in-class testing (%)	2001-2005 Computer-based online testing (%)
1	67	71
2	78	67
3	72	70
4	67	65
5	65	69
6	67	78
7	69	74

parisons difficult. For example, Table 4 illustrates traditional and computer-based electronic assessment tested students according to gender, ethnicity, age, and enrollment goal objectives. The analysis of class composition differences acknowledges that their impact on the assessment data cannot be completely ignored. The only change in the textbook for the class occurred through revisions from the first to fourth edition by Barot (2004).

Several design features are critical to the ultimate success of the computer-assisted assessment tool. The learning system must provide immediate and adequate feedback. For the student, immediate feedback is essential to stimulate learning. For the instructor, feedback facilitates changes in instructional methodology or re-explanation of critical concepts or a review session of the chapter before moving on. Currently, results regarding teaching effectiveness for many college instructors are normally available only after the completion of an in-class examination at the end of the semester. What may work for one class section may not be an effective strategy for a different class. The system must engage the students in an active learning mode as the term progresses. It is well known that an active learning environment, with intervention, is superior to a passive learning environment. Another design goal is to

Table 4. Class composition differences in traditional and computer-based electronic assessment

Class composition factor		1996-2000 Traditional in-class testing	2001-2005 Computer-based on-line testing
Gender	Male	32	38
	Female	68	61
Ethnicity	White	78	72
	Black	12	16
	Others	10	12
Age	Less than 20	32	34
	More than 20	68	66
College goal or objective	Associate degree	40	40
	Transfer	20	19
	Undecided	40	41

ensure that learning is effective in variable environments. During the semester, all problems related to a certain concept are grouped together to identify them collectively before testing. Only the students are able to improve proficiency with a concept. A final design feature is to ensure a high degree of flexibility within the system, using minor modifications. No two persons learn the same way and more than one method of instruction is needed. These design requirements are easily met with the technology available today.

By combining the internet capabilities of the Blackboard program with the availability of computers in the assessment center, instructors can serve students better. The system is composed of a simple Blackboard site. Almost instantaneous results are provided to students when they "submit" answers from a series of questions. Results are also provided instantly to the instructor. Table 5 shows a typical record keeping chart from the Blackboard site. As illustrated, the chapter 5 testing is just posted and only student #10 has completed it. His overall score at mid semester is 82% or a B grade.

Data about each student or the entire class is easy to gather and analyze. Every week, analysis answers the important questions of how many students took a quiz or chapter test, how well each student is doing in the class for a given week, and who took the quiz or test just before the deadline. The analysis leads to interpretation and modification in teaching as well as learning and allows instructors to intervene and assist a failing student. Overall, the assessment

Table 5: Student records on a Blackboard site

Student No.	Ch 1 Exam Pts Poss. 100	Ch 2 Exam Pts Poss. 100	Ch 3 Exam Pts Poss. 100	Ch 4 Exam Pts Poss. 100	Ch 5 Pts Poss. 100 (in progress)	Total Out of total 500
1	80	70	50	80	--	280
2	80	70	30	60	--	240
3	70	90	--	80	--	240
4	70	80	50	60	--	260
5	50	90	100	90	--	330
6	40	70	100	90	--	300
7	90	90	70	70	--	320
8	90	80	80	--	--	250
9	70	80	80	80	--	310
10	80	80	90	70	90	410
11	50	80	70	60	--	260

promotes an appraisal of learning which is not only flexible but is also effective in meeting ESO, as pre-determined by the individual instructor.

Technical implications and issues

If students are given a choice to take a quiz or test from any place other than the college assessment center, a number of technical issues must be addressed, including browser selection, the speed of internet connections, the minimum modem requirements, and plug-in requirements. For example, clicking back, forward, home, or refresh can cause interruption. LMC is offering on-line assessment of Organic Chemistry from student homes and workplaces this year. Undoubtedly, technical problems will surface as the year progresses.

Conclusion

By creating online assessment with complete control over the content and structure of questions, the authors have found that students with diverse backgrounds, traditional and non-traditional, national and international, are aided in many ways, including more class time, more hands-on activities, more review sessions, and better grades. Teaching of science classes at the college level can be more effective if instructors use technological tools for assessment, feedback, grading, and recordkeeping. With software developments such as moodle.org, Blackboard, and Web CT, it is possible for an educator to use the technology without any computer programming skill. Students do not need any computer classes before using the assessment tool and technique. The majority of scientists use technological tools to measure, collect, and classify data during scientific investigation. Educators agree that science is mastered if enough time is available in the classroom to learn the basic scientific principles by hands-on learning activities. But that requires time. During the years 1996-2000, the authors spent three hours a week preparing a chapter quiz or a chapter test, proctoring, and grading them, compared to just a couple of minutes in a week using computer technology. On-line assessment helps college teachers save valuable time.

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