AN EXAMPLE OF INDIVIDUALIZING LEARNING AND ASSESSMENT THROUGH COMPUTERIZED TESTING

Paul J. Fields and Edward Paul Johnson
Brigham Young University, United States
pjfields@byu.edu

With the dual goal of providing individualized learning and assessment, while simultaneously preserving academic integrity, we have implemented a computerized testing system to generate, administer and grade quizzes in an introductory statistics course for graduate students. A fundamental reason for individualization is to permit each student to learn at his or her own pace. At the same time, administering individualized instruction must not increase the time involvement of the instructor. The ability of the computer to randomly select questions from a test bank, to randomly generate data for the questions, and to randomly order the answer choices makes it possible for learning and assessment to occur in accord with each student's individual needs while maintaining fairness for the students and the instructor.

INTRODUCTION

It is prima facia evident that the ideal learning environment would provide each student with the greatest opportunity for the greatest academic growth. As is also prima facia evident, each student is a unique and distinctly different individual. Particularly at the graduate level, students have differing abilities and have different educational needs, even within the same course. Compared to undergraduate education, graduate education is characterized by increased specialization by the student and by increased independent study. Consequently, a student's educational experience could be optimized through individualized learning and assessment. We see technology as an important resource in accomplishing this goal.

DESCRIPTION

Maddux, Johnson and Willis (2001) claim that technology can make the delivery of education easier and faster to manage, and can expand and extend the learning process. To achieve such results, computerized testing has been used in numerous educational settings ranging from biology to linguistics to nursing (Lilley *et al*., 2004; Bloom and Trice, 1997; for example). Recent developments in computer-adaptive testing have further brought to the forefront the opportunities for technology to enhance education (van der Linden and Glas, 2000; Wainer 2000; Carlson 1994; for example).

With the intent to facilitate and enhance learning while maintaining academic integrity and fairness in assessment, we have implemented a process of individualized learning and assessment in an introductory statistics course for graduate students. Computer-generated quizzes are a key component of this approach.

Computerization provides the opportunity for quizzes to be created and taken by students at any time in accord with each student's individual rate of learning. It has been suggested that perceived academic ability can be more a reflection of a student's personal learning rate than of his or her innate intelligence. Accommodating differences in students' learning rates should lead to more students being able to achieve higher academic results.

However, to preclude students sharing test information each quiz must be different, but, to be fair to the students, each quiz must be equivalent in content and difficulty. In addition, to be fair to the instructor, using computerized quizzes must not increase the effort and time involvement of the instructor.

The computerized testing system we have implemented randomly selects questions from a test bank, randomly generates the data in each question and then computes the answers, and randomly orders the answers in the choices. Consequently, every test is different, but comparable in content and difficulty. The instructor can select the topics, number of questions and the level of difficulty of the questions. Any desired number of quizzes can be generated in virtually the same amount of time.

Questions can be selected by the instructor ranging from highly conceptual to highly computational. This assists the student in moving through the cognitive skill levels from knowledge to comprehension to application to analysis, as each student needs to achieve mastery.

With computerized quizzes, the students receive immediate feedback and, since the quizzes are done in a lab setting with a teaching assistant present, the student can receive on-the-spot assistance with the concepts behind the questions the student has answered incorrectly. After further study, the student can retake a non-identical, yet equivalent, quiz on the same material. The process can be repeated without limitation until the student has mastered the material to his or her satisfaction.

This approach can help graduate students to quickly progress to higher cognitive skill levels. It can also help students to deal with the time pressure and time constraints inherent in education. Above all else, time is scarcest of students scare resources obtaining an education.

DISCUSSION

We assert the vital importance of specific assessment of student's mastery of basic skills as a foundation for developing the skills necessary for competent scientific investigation. Graduate students need to go beyond recall of factual knowledge and basic understanding of statistical concepts. They also need to go beyond the ability to apply statistical tools and analyze problems. These are skills developed in an undergraduate education. Graduate students need to be able to synthesize information, evaluate their own and others professional work, and to create new knowledge. Consequently, we maintain that it is necessary for a graduate course to provide the opportunity for each student to move as quickly as he or she is able through mastering the course content at the lower levels of cognitive skills so he or she can spend the maximum time possible mastering the higher-level skills.

Using multiple-choice tests via computerized testing can facilitate the process. Consider the following advantages:

- Students are accustomed to multiple-choice tests, so switching from paper-based to computer-generated multiple choice testing is an easy step for students to take.
- Computerized quizzes – constructed from questioned tested for reliability and validity – provide equivalent assessment as "paper" quizzes (Summers *et al.*, 2005; Mason *et al.*, 2001; De Angelis, 2000; for example).
- Maintaining academic integrity in the assessment process is of the utmost importance. Randomization in formulating each test item is an even better method than secrecy and security techniques (Way, 1998, for example).
- Computerized quizzes offer the added advantage that students can easily makeup missed quizzes and do so without extra work for the instructor.

However, we see the most important feature of computerized quizzes as increased prescriptive ability based on student's responses. On a timely basis, the instructor can prescribe educational interventions that can direct the student to take appropriate remedial action. Again, this helps move the student past the lower levels of cognitive skill development and onto the higher levels with a minimum time delay due to real-time quiz processing.

An enhancement we are pursuing is for the computer system to keep track of each student's responses, identify patterns in how each student answers the quiz questions, and highlight areas of conceptual weakness for each student and for the class as a whole. This goes beyond simply noting which questions were missed and how many times they were missed. There are three objectives for this: First, to contribute information for selecting the questions presented to each student. Second, to offer prescriptive advice for the instructor to use in recommending remediation actions for each student. Third, to give the instructor a composite, comprehensive and timely view of where the entire class is in mastering the course content. This affords the instructor the greatest opportunity to make adjustments in the delivery of the course before the course is over.

An additional feature currently in development to customize the quizzes to the context of each student's own field of study, major discipline, or area of personal interest. The questions will also be individualized using the pronouns for each student's gender. This can be readily

accomplished since the database for the course contains the students' biographical information. Such further personalization should assist the students to internalize more quickly the course concepts without needing to "translate" the material from another context into their own.

CONCLUSION

Overall, the students have reacted very positively to the computerized quizzes. We have observed that the students are indeed able to spend more time developing higher-level cognitive skills. In addition, students express feeling less stress during assessment. We attribute this in part to the more comfortable setting for assessment since the questions are individualized for each student and designed to assist that student master the course material expeditiously. With reduced anxiety, a student should have a greater opportunity to perform fully at his or her true ability.

The most important factor for success using this approach, however, is the reliability of the technology. When the system is not close to 100% reliable, it is our experience that the added frustration for the students far outweighs the possible educational benefits and greatly increases the time commitment of the instructor. Although other researchers (Wise and Kingsbury, 2000; Harvey and Mogey, 1999; for example) have noted the importance of the administrative issues in maintaining a computerized testing system, it is clearly our observation that system reliability is the single most important factor to consider in designing and implementing computerized testing.

REFERENCES

Bloom, K. C. and Trice, L. B. (1997). The efficacy of individualized computerized testing in nursing education. *Computers in Nursing*, 15(2), 82-88.

Carlson, R. D. (1994). Computer-adaptive testing: A shift in the evaluation paradigm. *Journal of Educational Technology Systems*, 22(3), 213-224.

De Angelis, S. (2000). Equivalency of computer-based and paper-and-pencil testing. *Journal of Allied Health*, 29(3), 161-164.

Harvey, J. and Mogey N. (1999). Pragmatic issues when integrating technology in the assessment of students. In S. Brown, P. Race, and J. Bull (Eds.), *Computer-Assisted Assessment in Higher Education*. London: Kogan Page.

Lilley, M., Barker, T. and Britton, C. (2004). The development and evaluation of a software prototype for computer-adaptive testing, *Computers and Education*, 43(1-2), 109-123.

Maddux, C., Johnson, D. and Willis, J. (2001). *Educational Computing: Learning with Tomorrow's Technologies*, Boston, MA: Allyn and Bacon.

Mason, B. J., Patry, M. and Bernstein, D. J. (2001). An examination of the equivalence between non-adaptive computer-based and tradition testing. *Journal of Educational Computing Research*, 24(1), 29-39.

Summers, J. J., Waigandt, A. and Whittaker, T. A. (2005). A comparison of student achievement and satisfaction in an online versus a traditional face-to-face statistics class. *Innovative Higher Education,* 29(3), 233-250.

van der Linden, W. J. and Glas, C. A. W. (Eds.) (2000). *Computerized Adaptive Testing: Theory and Practice*. Dordrecht, The Netherlands: Kluwer Academic Publishing.

Wainer, H. (Ed.) (2000). *Computer-Adaptive Testing: A Primer*. Mahwah, NJ: Lawrence Erlbaum Associates.

Way, W. D. (1998). Protecting the integrity of computerized testing item pools. *Educational Measurement: Issues and Practice*, 17(4), 17-27.

Wise, S. L. and Kingsbury, G. G. (2000). Practical issues in developing and maintaining a computerized adaptive testing program. *Psicológica*, 21, 135-155.