2006-2423: EVALUATING SELF-ASSESSMENT AND A PLACEMENT EXAMINATION FOR A FIRST COURSE IN COMPUTER SCIENCE: HOW DO WOMEN AND MINORITY STUDENTS FARE?

Joseph Urban, Arizona State University

DR. JOSEPH E. URBAN Joseph E. Urban is a professor of computer science and serves the Ira A. Fulton School of Engineering as Inclusive Learning Communities Program Director at ASU. His research areas include software engineering, computer languages, data engineering, and distributed computing.

Mary Anderson-Rowland, Arizona State University

MARY R. ANDERSON-ROWLAND is an Associate Professor in Industrial Engineering. She was the Associate Dean of Student Affairs in the Fulton School of Engineering at ASU from 1993-2004. She was named the SHPE Educator of the Year 2005 and selected for the National Engineering Award in 2003, the highest honor given by the American Association of Engineering Societies. In 2002 the Society of Women Engineers named her the Distinguished Engineering Educator. She has received many other awards for her support of students. An ASEE Fellow, she is a frequent speaker on the career opportunities in engineering, especially for women and minority students.

Faye Navabi, Arizona State University

FAYE NAVABI is a lecturer in the Department of Computer Science in the Fulton School of Engineering at Arizona State University. She teaches CSE 110, Introduction to JAVA.

Debra Banks, Consultant

DEBRA L. BANKS, COOL Evaluator and former Director of Evaluation and Assessment for CRESMET (ASU), is now the Director of Outreach and Operations for Innovative Tailor Made Training and Technology (ITTT) in Berkeley, CA. She has been evaluating major school reform and technical programs for 14 years. She has served as a co-PI for several grants including COOL and the METS Project.

EVALUATING SELF-ASSESSMENT AND A PLACEMENT EXAMINATION FOR A FIRST COURSE IN COMPUTER SCIENCE: HOW DO WOMEN AND MINORITY STUDENTS FARE?

Abstract

The recruitment of women and minority students to computer science undergraduate degree programs has not kept pace with other science and engineering disciplines. The introductory computer science course is a contributing factor to the poor retention rates for students in general and worse yet for women and minority students. There is interest in revamping the introductory computer science course for improving student effectiveness and retention. In the meantime, the approach of centering the introductory computer science course on an industrial strength language, such as C++ and Java, is considered by some as a factor contributing to the retention problems. This paper discusses the role of a placement examination as the means for advisement on entry to the first course in computing. A self-assessment part of the placement examination that was coupled with correct responses can be used to aid in early identification for advisement and course support.

I. Introduction

Many students have difficulty with the first course in computer science, especially women and underrepresented minority students, as shown in research and with our own local data. Most engineering and computer science students are typically required to complete one of two introductory computer science courses, which is either a course in Java or a course in C^{++}. We noted in 2002 that a disproportionate percentage of women and minority students were withdrawing or receiving D's or E's (F's) in these introductory courses.[5]

Calculus I placement examinations have been shown to be effective for advising students into mathematics courses. We developed a placement examination for the introductory computer science course. The first administrations of the introductory computer science placement examination was to entering freshmen minority students enrolled in a Summer Bridge Academic Success Program and to entering freshmen women enrolled in a women's Summer Bridge Academic Success Program. These programs were held right before the fall semester began. In the Fall of 2002, the placement examination was taken in two sections of the introductory Java class taught by one of the co-authors. Students who scored very low on the examination were advised to take an introductory one hour course to enable them to be prepared to take the Java class. Students who scored in the middle range were advised to attend a group tutoring session held nearly every week to enable them to do well in the course.

The placement examination was refined for Fall 2003 and again in Fall 2004, achieving a correlation between the placement scores and student grades at a level of 0.041. Along with the twenty-six questions on computer skills making up the placement examination, five questions were asked as a self-assessment about the students' level of confidence in five areas of computer science. This paper examines the self-assessment scores of the summer bridge students relative to the placement examination scores and also the final grade obtained by the students who attended the Java class. In addition, the placement examination scores and the self-assessment scores of these two groups are compared to all of the women, all of the minorities, and all of the other students enrolled in two sections of the Java class.

The next section of the paper gives background information on the entry into the computer science curriculum and student support for the early part of the curriculum. The main part of the paper includes a section with a discussion of the placement examination and another section that covers the results of implementing the placement examination. The final section of the paper is a summary and describes a future direction.

II. Background

At this institution, Principles of Programming with Java is an introductory course to programming using the Java language. The course requires no previous background in programming. The course concentrates on programming concepts, problem solving, and program design. Major topics covered in the course are:

- introduction to problem solving, requirements & specifications, and algorithms;
- Java Primitive types (e.g., int, double, and char);
- classes, objects, methods, and parameters;
- Java control structures and more algorithms; and
- arrays, searching and sorting.

The students who take this course come from all colleges and from all levels; many come from high school. The students have several obstacles to overcome in their first programming course; learning about computer science, learning about program design, learning about programming, and in some cases, learning to be a student at a university.

There were three components of support for this first course that were developed as part of a comprehensive research program supported by the Arizona Proposition 301 research program.[2,6] The first component discussed in this section is a preparatory course prior to enrollment in Principles of Programming with Java. The second component discussed in this section is a set of workshops that have shown to be quite successful in supporting students during the Principles of Programming with Java course. The third component is discussed in the following section as a means for linking the preparatory and introductory courses.

A Computer Basics course was developed to assist students in computer science, as well as the other engineering undergraduate degree programs.[5] The course included topics for skills

development that would be beneficial during the formative years of a computer science or engineering undergraduate degree program.

In order to address the retention problem, the Computer Basics course was introduced to ease the transition into the introductory computer science course. This new course was originally designed as a one unit course that was offered in a semester setting. The initial course offering had a retention rate that was one of the highest of all retention measurements for women and minority students.

The topics in the first course offering of Computer Basics included an introduction to software engineering, algorithm development, and computer applications. During the Fall 2002 semester, a grant through the Arizona Proposition 301 research program allowed for several enhancements to the Computer Basics course as a two unit course. There was support for acquiring Pocket PCs with Internet access and robot kits.[7]

The second component of support for the Principles of Programming with Java course was the Academic Excellence Workshops, which was one of the most effective approaches of help provided for the students. The workshops were held twice a week for one hour and twenty minutes, but were extended as needed upon student request. The workshop facilitators have been graduate students in the Computer Science department.

The workshops were conducted with the following objectives:

- challenge students with non-trivial questions to stimulate their thinking;
- individualized instructions for the students attending the workshop;
- hands-on programming experience;
- personal student help on assignments;
- sample exams to help students evaluate themselves before the actual exams;
- brainstorming exercises;
- facilitate group discussion and teamwork; and
- review of hard to understand topics with lots of examples and self test questions.

Before each workshop session, the facilitator prepared programming questions as well as conceptual questions based on the material taught that week in class. Each workshop session was divided into two parts. In the first half, the students attending the workshop were asked to solve these questions during the workshop. The facilitator provided individual help to students in solving these questions and later on comprehensively discussing the answers to the questions showing different methods of achieving the same result and pointing out common mistakes. The students were given many useful tips on good programming practices and were encouraged to write efficient, understandable, and bug-free programs.

Frequently there were quizzes held in the workshop which helped students understand the concepts covered in the class, as well as clear any doubts. The second half of the workshop involved solving students' difficulties, as well as giving meaningful examples to answer their questions to help them understand the concept. The workshops also involved helping students individually on the homework questions and exercises in the book. On the week before each

class exam, a sample exam was held to help students evaluate themselves before the exam. This sample exam was followed by a comprehensive discussion of answers along with a review of course material for the exam. The sample exam helped students identify the topics that they were finding hard to understand so as to put extra effort to study those topics for the exam.

The following two student comments on the workshop were indicative of the success: "Sample exams are awesome, I recommend future students utilize the workshop" and "Tell other students to go to workshop as much as possible as it is helpful". Students found sample exams to be extremely helpful and wanted to have extended workshop hours during review for exams. Students felt that the group discussions held in workshop, as well as interaction with peers was very helpful.

The next section of this paper discusses the role of the placement examination as the third component that was developed in support of the introductory computing course.

III. The Placement Examination

The placement examination has evolved to five self assessment questions and twenty-six questions that covered the areas of logic, algorithms, mathematics, the web, e-mail, and tools. A score of nineteen or higher out of the twenty-six questions was a successful result for advising a student for entry into the Principles of Programming with Java course. A score of eighteen or less out of the twenty-six questions was not a successful result, which included a recommendation to complete the Computer Basics course before taking the Principles of Programming with Java course.

The use of self-assessment has been used successfully in science and engineering disciplines. Researchers at Purdue University developed the Computer Development Self-Appraisal Survey for assessing computer literacy and achievement.[3] The survey was applied at the beginning and end of an introductory computer course to engineering students. An introductory robotics course at Tufts University included an assessment of confidence levels as part of a broader analysis of gender differences.[4]

The Fall 2004 semester offering of the placement examination included for the first time a set of five self-assessment questions. The original purpose for including the self-assessment questions was for use during advising in conjunction with the outcome of the twenty-six questions. In addition the self-assessment questions were considered to be useful in identifying shortcomings and strengths of the students within a class. The self assessment questions were:

1) When it comes to using email, I am;
2) When it comes to searching the web, I am;
3) When it comes to building spreadsheets, I am;
4) When it comes to writing documents with a word processor, I am; and
5) When it comes to developing computer programs, I am.

There were five possible answers to the self-assessment questions: a) not at all confident; b) not very confident; c) average; d) confident; and e) very confident. There were values assigned to

the answers of the self-assessment questions with one for not at all confident through five for very confident. A summation of the self-assessment answers was compared to the number of correct of answers to the technical content questions. The group of students who did not successfully complete the placement exam had a self-assessment summation that was greater than the number of correct answers to the technical questions, except for a few students. The opposite was the case for most other students, i.e., the summation of the self-assessment answers was less than or equal to the number correct answers for those who successfully completed the examination. The next section is an analysis of the placement examination and self-assessment results for an offering of the Principles of Programming with Java course.

IV. Evaluation

The placement examination has been effective in recommending whether or not a student should begin with the Principles of Programming with Java course. During the 2004 summer session, there were twenty-nine students in the minority bridge program and eighteen students in the women's bridge program. At the start of the Fall 2004 semester, there were one hundred forty-nine students in two sections of the Principles of Programming with Java course that were taught by one of the co-authors.

Seventeen students in the minority bridge program successfully completed the placement examination, which gives a success rate of 58.6%. The remaining twelve students did not successfully complete the placement examination. Eleven of the twelve students who did not successfully complete the placement examination had a self-assessment score higher than the number correct. One student who successfully completed the placement examination had a self-assessment score higher than the number correct.

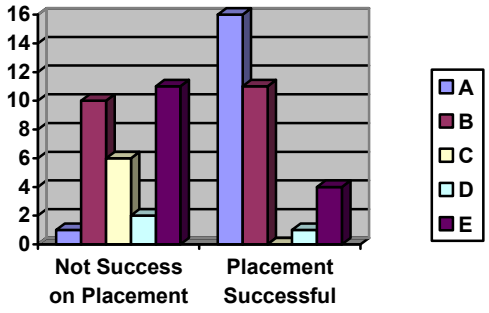
Eleven students in the women's bridge program successfully completed the placement examination, which gives a success rate of 61.1%. There were seven students in the women's bridge program who did not successfully complete the placement examination. Six of the seven students who did not successfully complete the placement examination had a self-assessment score higher than the number correct and the seventh student had a self-assessment score less than the number correct. Two students who successfully completed the placement examination had a self-assessment score higher than the number correct.

There were one hundred and nine students initially enrolled in the two sections of the Principles of Programming with Java course who successfully completed the placement examination, which gives a success rate of 73.1%. Thus, forty of the students did not successfully complete the placement examination. Thirty-eight of the forty students had a self-assessment score higher than the number correct and two of the students had a self-assessment score less than or equal to the number correct, which followed the pattern observed with the minority and women's bridge programs. The final grades for the thirty-eight students who had the self-assessment score higher than the number correct were as follows: one A, ten B, six C, two D, eleven E (or failing), and eight withdrew. Table 1 shows these results, under not success, without the students who withdrew from the course. Note that, out of the forty students who did not successfully complete the placement examination, there were nineteen Caucasian males, fifteen minority and female students, six students who did not report or were from a non-US country. There were forty-two

minority and female students in these two sections, which gives a success rate for them of 63.3% and is slightly higher than the same observations in the minority and women's bridge programs.

In the two sections of the Principles of Programming with Java course, there was a result that did not coincide with the two bridge program results. Thirty-four of the one hundred and nine students who successfully completed the placement examination had a self-assessment score higher than the number correct. Remember that only one minority bridge program and two women's bridge program students had the same situation of self-assessment score higher than the number correct. The final grades for the thirty-four students who had the self-assessment score higher than the number correct were as follows: sixteen A, eleven B, zero C, one D, four E (or failing), one audit, and one withdrew. These results appear in Table 1 as placement successful, with the exception of the audits and withdrawals. This group of students with success in the placement examination and higher self-assessment represent a source for contributing to the Academic Success Workshops.

Table 1. Grades and Placement Results When Self-Assessment Higher Than Number Correct



There were thirty-eight students who participated at varying levels in the Academic Success Workshops. There were fourteen students who withdrew from the course, which included eight of the students who did not successfully complete the placement examination, of which four students enrolled in and completed the Computer Basics course.

This inversion of the self-assessment scores and number of correct answers can serve as a notice to provide additional support for students who proceed to the Principles of Programming with Java course. The analysis shows that there was a measured lack of basic computing skills for many students that in many cases was coupled with a belief by a student that the situation was good for the student. The placement examination with self assessment questions has provided a basis to ease the transition to the introductory computer science course.

V. Summary and Future Research

The transition into computer science undergraduate degree programs can be difficult. The lack of a means to assist with the college transition only contributes to the problem. This paper described the impact of an introductory computer science placement examination with a self-assessment aspect. A unique approach to the analysis of the examination was found to be a predictor of course support that could be provided to the students.

Currently, the engineering administration has transitioned the Computer Basics course within the Computer Science and Engineering Department into a Success course, but not adopted the placement examination. There is a research effort to enhance the placement examination through a smart online version that provides tailored tutorial material.[1]

References

1. Tushar Chandra, Gitanjali Gunnam, and Joseph E. Urban, "Smart Online Placement Examination," *Proceedings of the IASTED International Conference on Web Technologies, Applications, and Services (WTAS 2004)*, July 4-6, 2005, Calgary, Alberta, Canada, pp. 204-208.
2. James S. Collofello, Joseph E. Urban, Mary R. Anderson-Rowland, Faye Navabi, and Doris Roman, "COOL (Computer Outreach Opportunities for Learning) Project," *Proceedings of the 2003 American Society for Engineering Education Annual Conference & Exposition*, Nashville, Tennessee, June 22-25, 2003.
3. William K. LeBold, Robert Montgomery, Dan Budny, Goranka Bjedov, and Sherman Ward, "Assessing Computer Literacy and Achievement Using Self-Concepts," *Proceedings of the 28th ASEE/IEEE Frontiers in Education Conference*, Tempe, Arizona, November 4-7, 1998.
4. Elissa Milto, Chris Rogers, and Merredith Portsmore, "Gender Differences in Confidence Levels, Group Interactions, and Feelings About Competition in an Introductory Robotics Course," *Proceedings of the 32nd ASEE/IEEE Frontiers in Education Conference*, Boston, Massachusetts, November 6-9, 2002, pp. F4C-7 – F4C-14.
5. Joseph E. Urban, Maria A. Reyes, and Mary Anderson-Rowland, "Minority Engineering Program Computer Basics With a Vision," *Proceedings of the 32nd ASEE/IEEE Frontiers in Education Conference*, Boston, Massachusetts, November 6-9, 2002, pp. S3C-1 – S3C-5.
6. James S. Collofello, Joseph E. Urban, Mary Anderson-Rowland, Faye Navabi, Debra L. Banks, and Doris Roman, "COOL (Computer Outreach Opportunities for Learning) Development and Assessment," *Proceedings of the 33rd ASEE/IEEE Frontiers in Education Conference*, Boulder, Colorado, November 5-8, 2003, pp. F2A-1 – F2A-6.
7. Joseph E. Urban, Mary R. Anderson-Rowland, and Debra L. Banks, "Experience With Autonomous Robots and Wireless Handheld Internet Devices in a Computer Basics Course," *Proceedings of the 2004 American Society for Engineering Education Annual Conference & Exposition*, Salt Lake City, Utah, June 20-23, 2004.