Running Head: Intelligent Tutoring Systems Help Elimination of Racial Disparities

Observational Findings from a Web-Based Intelligent Tutoring System: Elimination of Racial Disparities in an Undergraduate Behavioral Statistics Course

Xiangen Hu, Jason K. Luellen, Theresa M. Okwumabua, Yonghong Xu, and Lun Mo

The University of Memphis

Abstract

This paper presents the preliminary findings from an observational study conducted at a large urban university with the purpose of exploring the effectiveness of using an online intelligent tutoring system (ITS), ALEKS (Assessment and Learning in Knowledge Spaces), to close the racial score gaps in an undergraduate behavioral statistics course.

This study involved comparing the academic performance of students from online ALEKS-using sections of behavioral statistics to a retrospective comparison group comprised of students who took behavioral statistics under the traditional lecture format. The traditional one-letter-grade race-gap between white and black students in this course at this university was eliminated when the ITS was used.

Introduction

Much has been written about performance disparities between blacks, whites, and other ethnic minority groups on the mathematical section of standardized tests like the Scholastic Aptitude Test (SAT) as well as in math courses (e.g., Harris & Herrington, 2006; Orr, 2003). A common finding is that the scores of black students lag behind those of whites as well as other ethnic groups in the United States. Often, these disparities start as early as kindergarten and persist across grades, and in some cases, widen over time (www.jbhe.com/features/49_college_admissions-test.html).

There are a number of explanations that are being advanced to explain the continuing and growing racial disparities in math performance. One factor in explaining these differences relates to the fact that there may be real disparities in academic knowledge and skill between students from the various racial groups (Ferguson, 2002). Hence, to help raise achievement and close the gap, endeavors are needed to identify specific skill and knowledge deficits students might have and, then, respond in targeted ways.

Objectives

This paper presents the preliminary findings from an observational study conducted at a large urban university with the purpose of exploring the effectiveness of using an online intelligent tutoring system (ITS), ALEKS (Assessment and Learning in Knowledge Spaces), to close the racial score gaps in an undergraduate behavioral statistics course.

Theoretical Framework

Students majoring in psychology or social sciences find behavioral statistics one of the most challenging required undergraduate courses. The primary reason for difficulty with the course, especially for students who were out of school for a long time or who had a weaker mathematics background, is the prerequisite mathematics skills necessary to understand some of the basic concepts. Due to the variability of mathematics skills, lecture based traditional classroom instruction is very inefficient. Some students find it impossible to follow lectures and eventually fall behind.

While tradition lecture style instruction cannot help students who are behind, technology solutions have been explored. Hagerty and Smith (2005) found that a Web-based ITS, ALEKS, helped college students learn college algebra. Other studies (e.g., Fletcher, 1990) have shown that learners learn better with the help of technology . Examination of the ALEKS system helped us to select its Behavioral Statistics package (http://www.behsci.aleks.com) as a technological solution.

ALEKS Behavioral Statistics decomposes basic statistics (from frequency distributions to Analysis of Variance (ANOVA)) into smallest units called items. There are total of 19 mathematics readiness items and 109 statistics items. Each of the items is presented as a unique type of problem that students are required to solve, and items are grouped together into larger content areas that must be learned to demonstrate mastery in behavioral statistics. The collection of the 128 problem types forms a comprehensive course in behavioral statistics. The power of ALEKS is due to its sound theoretical foundation (Knowledge Space Theory) (Doignon and Falmagne, 1999, Falmagne, Cosyn, Doignon, and Thiery, 2006), which enables the fine tuning of the teaching to individual

students. Every interaction between ALEKS and a student results in a reappraisal of the student's knowledge state, signaling a student's critical weaknesses or lacunae, formulated in terms of the curriculum, and precisely gearing the teaching to them.

In addition to the features mentioned above, there are other advantages to using a Web-based ITS such as ALEKS. For example, ALEKS is available anytime, anywhere. This is especially helpful for students who need to spend more time to master concepts. For those students who have difficulty following traditional lectures due to a lack of basic mathematics knowledge, ALEKS allows them to spend time to catch up and get ready for advanced content. For students who have solid mathematics knowledge, ALEKS allows them to learn and master the entire curriculum faster, so they can spend more time on other courses. Furthermore, ALEKS is designed such that students need to master ALL prerequisite knowledge in order to learn advanced topics. It is in the design that ALEKS does not allow any students to be behind.

We believe that ALEKS provides a technological solution in teaching behavioral statistics that helps those students with lower levels of mathematics achievement work more efficiently toward mastery of statistical concepts.

Methods

Research Design

A nonequivalent control group design was used to compare the academic performance of students from online ALEKS-using sections of behavioral statistics to a retrospective comparison group comprised of students enrolled in behavioral statistics under the traditional lecture format.

Participants

The study included 548 undergraduate students (183 black and 365 white) from The University of Memphis who completed behavioral statistics under the same professor between the Spring 1995 and Fall 2005 terms. One hundred and thirty-seven students took the course in the online format, whereas 411 students took the course in the lecture format. Students receiving an incomplete or early withdraw are not considered here. Data from other professors in the department were excluded because no other professors had offered the course in both lecture and online formats and to eliminate the variability attributed to differences in professors. Of the 548 students who participated, 75 failed the course and were dropped from the analyses. We provide the rationale for doing so in the results section.

Measures

The analyses are based on a measure of grade performance. Several steps were taken in developing the grade performance measure. First, students' letter grades were retrieved from the university's database and transformed to numeric counterparts, where A was recoded as a 95, B was recoded as an 85, C was recoded as a 75, and D was recoded as a 65. For students who took the course more than once, their highest grade was used. Once this procedure was completed, any course outcome listed as a failure, incomplete, or early withdraw was removed from consideration. The remaining numeric grades were standardized by course section.

Procedures

The course delivered using the lecture format was led by an instructor and met three (3) days a week. The online sections of the course made use of ALEKS, an award-

winning, web-based ITS. ALEKS is grounded in knowledge space theory and supported by research in cognitive psychology and applied mathematics. Not only is ALEKS able to diagnose and adapt to a student's developing knowledge and skills, but it can provide precise feedback when students make mistakes and present new topics when the student is ready to learn. For this study, ALEKS was used to administer a self-paced distance-learning course, where students did not attend class and could interact with the system whenever and for as long as they desired.

Results

We first decided to eliminate the failing students from the study's main analyses. We were concerned that recoding the letter grade F as a number grade would be overly restrictive given the wide grade range for failures (0-59). As justification for the decision to remove the failing students from subsequent analyses, we offer the results of a full factorial analysis of variance (ANOVA) examining the relationships between cumulative grade point average (GPA) prior to enrolling in behavioral statistics and three factors, passing status (passed vs. failed), race (black vs. white) and course format (lecture vs. online ITS). The three-way interaction and all two-way interactions were nonsignificant. The main effects for passing status and race were significant. Thus, students that failed the course (n = 71, M = 2.41) had a significantly lower average prior GPA than did students that passed the course (n = 422, M = 2.88), and black students (n = 177, M = 2.58) had a significantly lower average prior GPA than did their white counterparts (n = 316, M = 2.94). Because the race by course format interaction was nonsignificant, we determined that the pattern of failing students was the same for online ITS and lecture sections. Therefore, eliminating the failing students does not in and of itself lead to

elimination of the racial disparities as might be expected if there were many more black failures, proportionately, than white failures.

In considering racial disparities and course format on students' performance in a behavioral statistics course, several models were examined. In the first model (Model 1), standardized grade equaled race, course format, and their interaction. Factorial analysis of variance (ANOVA) revealed a consistently disordinal race by course format interaction, F (1, 469) = 10.73, p = .001. Thus, the relationship between standardized grade and race varied significantly by course format. Simple main effects tests were conducted and evaluated using a Bonferroni-adjusted p-value of .025 to reveal the nature of the interaction. Considering the lecture format, black students (n = 118, M = -.49) had a significantly lower average standardized grade than did their white counterparts (n = 259, M = .20), F (1, 469) = 42.22, p < .001. This finding replicated the racial disparity often observed among black and white students in science and mathematics courses reported by many researchers(for details, see reports published in National Center for Educational Statistics, http://nces.ed.gov/). However, when the performance of students enrolled in the online ITS sections was considered, the racial disparity observed for black and white students enrolled in the lecture formatted sections did not hold. Rather, the standardized grade for black students (n = 35, M = .03) was similar to that of their white counterparts (n = 61, M = -.03), F (1, 469) = .09, p = .77. Furthermore, black students enrolled in the online ITS sections (n = 35, M = .03) had a significantly higher average standardized grade than did their black counterparts who participated in the lecture formatted sections (n = 118, M = -.49), F (1, 469) = 8.09, p = .005. White students who participated in the online ITS sections (n = 61, M = -.03) did not significantly differ on average standardized

grade from white students who participated in lecture sections (n = 259, M = .20), F (1, 469) = 2.76, p = .10.

Next, a number of potential covariates were considered including ACT, highest mathematics course taken prior to enrolling in behavioral statistics, and cumulative grade point average (GPA) prior to enrolling in behavioral statistics. We decided that the percentages of missing data were too high for ACT (44%) and highest mathematics course taken (33%). However, data on prior GPA were missing on only 69 (15%) cases. For Model 2, which adjusted for prior GPA, the consistently disordinal race by course format interaction persisted, F (1, 399) = 6.51, p = .01. Again, the four simple main effects tests were examined and evaluated using a Bonferroni-adjusted p-value of .025. The pattern of results was similar to that of the initial model, except that the difference in standardized grade performance for blacks who participated in online ITS sections (n = 35, M = .03) and blacks who participated in lecture sections (n = 104, M = -.45) was no longer significant after adjusting for prior GPA, F (1, 399) = 3.60, p = .06. The conclusions drawn from the other three simple main effects tests were the same as with Model 1: (1) Racial disparities in grade performance between black (n = 104, M = -.45) and white (n = 204, M = .21) lecture students were exhibited, F (1, 399) = 10.36, p = .001; (2) No difference was observed among the black (n = 35, M = .03) and white (n = 61, M = -.03) online ITS students, F (1, 399) = 1.06, p = .30; and (3) White students who participated in the online ITS sections (n = 61, M = -.03) did not significantly differ on average standardized grade from their white counterparts who participated in lecture sections (n = 204, M = .21), F (1, 399) = 3.02, p = .08.

Scientific Importance

These analyses demonstrate the potential value of an online ITS as a tool for eliminating racial disparities in college students' academic performance. Differences in the final grades for passing black and white students enrolled in a behavioral statistics course were eliminated in this study. Results were similar for both models tested in that disparities in the performance of black and white students were present for students who participated in lecture formatted behavioral statistics sections but were not present for students who participated in online ITS formatted sections that used ALEKS. This finding held regardless of whether the results were adjusted for prior GPA. Additional data is being collected and the investigators are currently reanalyzing the data to see if the findings persist under hierarchical linear modeling, where the effect of the clustering of students within course section is taken into account.

References

Doignon, J.-P. and Falmagne, J.-C. (1999). Knowledge Spaces. Springer, Berlin.

Falmagne, J.-C., Cosyn, E., Doignon, J.-P., and Thi´ery, N. (2006). The assessment of knowledge, in theory and in practice. In Ganter, B. and Kwuida, L., editors, ICFCA 2006, LNAI 3874, pages 61–79. Springer-Verlag, Berlin Heildelberg.

Ferguson, R. F. (2002). What doesn't meet the eye: Understanding and addressing racial disparities in high-achieving suburban schools. Cambridge, MA: Harvard University, John F. Kennedy School of Government. (ED 474 390)

Fletcher, D. (1990). Effectiveness and Cost of Interactive Videodisc Instruction in Defense Training and Education. IDA Report R2372.

Hagerty, G.W. and Smith, S. (2005) Using Web Based Interactive Software to Enhance College Algebra. Mathematics and Computer Education. Fall 2005. Vol. 39, Iss. 3; pgs. 183-194

Harris, D. N., & Herrington, C. D. (2006). Accountability, standards, and the growing achievement gap: Lessons from the past half century. *American Journal of Education, 112*, 209-238.

Orr, A. J. (2003). Black-white differences in achievement: The importance of wealth. *Sociology of Education, 76*(4), 281-304.