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The Effects of Instructional Strategies, College Division, and Gender on Students' Performance in Elementary Statistics and Probability at a University in South Texas

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ABSTRACT

Elementary Statistics and Probability courses have often served as gatekeepers to advancement toward a bachelor's degree for many undergraduate students in colleges and universities all over the United States. As Elementary Statistics and Probability courses are core requirements for graduation, it is very important that fail and drop rates for these courses be minimized. The ability to pass these classes has a direct influence on 4-year/6-year graduation rates as well as retention rates for undergraduate students. Different teaching methods are prescribed and new technologies are invented every day with the intent of helping students overcome difficulties. The present study was designed to explore the differences in final grades in Elementary Statistics and Probability courses regarding different instructional strategies, college division and gender. Test findings indicated that the performance of college students as measured by final grade in Elementary Statistics and Probability courses was significantly different among diverse instructional strategies. In addition, the performance of college students as measured by final grade in Elementary Statistics and Probability courses was not significantly different in each college division or gender for different instructional strategies. Students will be more likely to learn and retain mathematical knowledge when diverse approaches for teaching and learning mathematics are applied.

There are new computer-based technology assisted learning strategies in mathematics at post secondary levels. This study was designed to explore the effects of technology assisted learning strategies, college division, and gender on passing or failing Elementary Statistics and Probability courses. Elementary Statistics and Probability courses are core requirements for graduation and has been a stumbling block for many students in respect to graduating from college. Specifically, the study examined the fall 2013 pass/fail/drop rates in Elementary Statistics and Probability of students who were taught with different instructional strategies at a university in south Texas. The effects of college division and gender were also analyzed.

Literature Review

Juan, Steegmann, Huertas, Martinez, and Simosa (2011) claimed that instruction has transformed with the utilization of technology. Mainly in the areas of statistics and mathematics, many university departments worldwide have been working on producing, developing, applying, and assessing new engaging curricula that promote conceptual understanding instead of traditional focus. (Juan et al.). For instance, there is a solid statitistical indication that learners in restructured courses using computer-based mastery knowledge packages are outpacing leaners in old-style courses on the Collegiate Assessment of Academic Proficiency exam (Hagerty, Smith, & Goodwin, 2010).

In a study conducted by Schreyer-Bennethum and Albright (2011) on integrating interdisciplary application projects and technology in mathematics education, the goal was to increase students' acceptance and appreciation of mathematical themes. Schreyer-Bennethum and Albright discovered that by increasing the amount of teachers who use and incorporate technology and interdisciplinary projects, the performance of learners improved. Application projects could well become the norm within mathematic classes with time, support and continuous encouragement (Schreyer-Bennethum & Albright).

Teaching Elementary Statistics and Probability

The main concepts of statistics and probability courses involve sampling, measures of central tendency, dispersion, position, probability, comparing groups, and statistical inferences about the mean (Biehler, Ben-Zvi, Bakker, & Makar, 2013). Students can connect the main concepts of statistics with their everyday life (Biehler et al., 2013).

Biehler et al. (2013) discussed different types of technological tools for teaching statistics that support teaching and learning statistics. One such tool was a graphing calculator designed by Texas Instruments called TI-84. Graphing calculators are provided in statistics and probability courses to the students to give them the power to calculate anything and become familiar with the use of technology (Biehler et al.).

Chance, Ben-Zvi, Garfield, and Medina (2007) pointed out that prior to technological integration in the classroom; students had to be persistent in finding a solution to many statistical models. However, the content in statistics and probability has changed with the use of technology. Students are now required to become more acquainted with methodology and choose techniques based on their studies instead of just manipulating formulas (Chance et al.). As a consequence, statistics instructors no longer consider it necessary to use *z*- and *t*-tables because calculators or statistical software provide the answers (Chance et al.). Technology has enhanced statistical learning by visually applying statistical concepts (Chance et al.). Educators are encouraged to utilize technology as a tool to maximize learning not just to compute numbers without understanding the meaning (Chance et al.).

Chance et al. (2007, pp.15-16) provided positive reasons for the use of technology in teaching Elementary Statistics and Probability: 1) teachers could be more student-centered with the use of technology; 2) technology provides students with the opportunity to explore data and become engaged; 3) technology contributes to collaborative learning; 4) technology helps students to make connections with the meaning of numerical outputs; and 5) it is essential that educators provide students with a supportive learning environment. On the other hand, the primary challenge to integrating technology in Elementary Statistics and Probability courses are teachers' lack of knowledge and discomfort with new technology (Chance et al., 2007). In addition, teachers are not provided with the needed support to use technology (Chance et al., 2007). Educators must learn how to use the new technology and must have the necessary resources to effectively implement technology in the classroom (Ritchie, 1996). If teachers are not utilizing the new technology, students are denied the opportunity to interface with this technology, which may further deny them opportunities in the global market (Ritchie, 1996).

Cooperative Learning

Davidson (1990) considered cooperative learning a task for groups to discuss and possibly find a solution. In addition, students required face-to-face interaction, an environment that provides positive experiences by helping each other attain success (Davidson). According to Johnson, Johnson, & Smith (1991), it is essential for teachers to be aware that cooperative learning requires all students in a small group to participate, and if one of the team members completed the work first, he or she has to help his or her team members to complete the work.

Representatives from The National Council of Teacher of Mathematics and the National Research Council reported the need for a change in mathematics and sciences in general and specifically, in statistics (Cobb, 1992). Shaughnessy (1977) conducted a study in college statistics courses using cooperative learning. The findings showed that the utilization of "small groups" seemed to improve students understanding in statistics concepts and support learners to overcome misunderstandings in probability.

Traditional

Traditional lecture style in Elementary Statistics and Probability courses at the university in south Texas was teacher centered. For instance, the instructor explains mathematical concepts and presents procedures on how to solve mathematical problems. Further, the instructor assigns homework, quizzes, tests and a common final exam. However, instructors have Academic Freedom's right, which means they can teach the class the way they want.

CCA-FOCUS

College Completion America Fundamentals of Conceptual Understanding & Success (CCA-FOCUS) program started in 2008 as a summer bridge program (Loredo, 2012). The CCA-FOCUS program enrolled developmental mathematics students directly into an academic course, such as Elementary Statistics and Probability while providing remediation in content, content specific support learning, and academic support. Texas State University has successfully utilized the FOCUS program on its campus, and in the fall of 2011, 85 % of the students who had enrolled in their program successfully completed developmental mathematics and received credit for College Algebra (Loredo, 2012, p. 2).

ALEKS in Mathematics

Assessment and LEarning in Knowledge Spaces (ALEKS) has been used for Pre-Calculus students who were taking Calculus I and Calculus II (Hanna & Carpenter, 2006). Findings showed that 86% of learners who worked on ALEKS at least 23.5 hours throughout the semester earned a C, B, or A. The remaining 14% earned a D, F or dropped from the class (Hanna & Carpenter, 2006, p.6). Learners who did not use ALEKS did worse than those who used it, and there was a correlation between time spent in ALEKS and performance (Hanna & Carpenter, 2006).

Hu, Luellen, Okwumabua, Xu and Mo (2007) conducted a study at the University of Memphis to explore ALEKS' effectiveness closing racial disparities in an undergraduate behavioral statistics course. There were 548 undergraduate students (183African American and 365 White) who were taught statistics by the same instructor from the spring 1995 through the fall 2005 semesters. Of these, 137 students used ALEKS and 411 were in a traditional lecture. Findings showed that ALEKS increased one letter grade between groups of students in statistics at the University of Memphis (Hu et al.).

In introductory statistics courses Xu, Meyer, and Morgan (2008) examined the performance of graduate students enrolled. Findings from the *t*-test showed there was no significant difference in performance between students who had taken statistics during the fall of 2005 in a face-to-face setting and students who had taken statistics during the fall of 2006 using ALEKS in a blended course. In addition, findings from ANCOVA demonstrated that there was not a significant difference in performance in the blended class for gender, ethnicity, and age or class type. However, a significant difference was found for GRE-Quantitative scores (Xu, Meyer, & Morgan).

Methodology

The purpose of this study was to determine the effects of instructional strategies, college division, and gender on the performance of college students as measured by pass/fail/drop in Elementary Statistics and Probability courses. Instructional strategies include traditional lecture style, Assessment and LEarning in Knowledge Spaces (ALEKS) and College Completion America (CCA)-FOCUS in Elementary Statistics and Probability. In addition to the instructional strategies the independent variables included college division and gender. The dependent variable considered was success as measured by pass/fail/drop.

This study took place in a Hispanic serving university in south Texas with a total enrollment of 20,053 students during the fall of 2013. The gender make-up of the university was 45% male and 55% female. The race distribution was as follows: less than 1% American Indian or Alaskan Native, 1% Asian, 1% African American, 90% Hispanic, <1% Native Hawaiian or Other Pacific Islander, 3% White, <1% two or more races, 2% International and 3% race/ethnicity not reported. The students who took Elementary Statistics and Probability courses were generally undergraduates.

The sampling was based on the instructional strategies and was designed as follows: As the CCA-FOCUS had been implemented only once, a convenience sampling was used including all students who took those courses. The instructional strategies of ALEKS and traditional instruction had been implemented several times, and a randomization numbers' table was used to select samples of these two groups.

Archival information was gleaned from students' transcripts who took Elementary Statistics and Probability courses in the fall of 2013. The courses were taught by instructors who used instructional strategies, namely ALEKS, CCA-FOCUS, and traditional lecture style.

Results

Descriptive statistics are provided for Elementary Statistics and Probability undergraduate students' final grades regarding the variables in this study, including instructional strategies, college division, and gender for the fall of 2013 as exposed in Table 1. Of the students who took CCA-FOCUS, 34 (89%) completed the course successfully ("A", "B" or "C"), followed by Traditional with 45 (71%) students, and lastly ALEKS with 41(55%) students. Of the men, 38(62%) were successful while 82 (72.5%) of the women were successful. The majority of students came from the College of Health Sciences and Human Services followed by the College of Sciences and Mathematics. Table 2 shows the frequencies of instructional strategies, college division, and gender with respect to final grade.

Table 1

Frequency and Descriptive Statistics for Elementary Statistics and Probability (N=175)

Variable	N	Percent
Total	175	100
Final Grade		
A	42	24
B	41	23.4
C	37	21.1
D	14	8
F	16	9.1
DR	25	14.3
Instructional Strategy		
CCA-FOCUS	38	21.7
ALEKS	74	42.3
Traditional	63	36
College Division		
College of Arts and Humanities	14	8
College of Sciences and Mathematics	47	26.9
College of Business Administration	3	1.7
College of Education	3	1.7

College of Engineering and Computer Science	2	1.1
College of Social and Behavioral Sciences	13	7.4
College of Health Sciences and Human Services	93	53.1
Gender		
Male	62	35.4
Female	113	64.6

Table 2

Frequency and Descriptive Statistics for Elementary Statistics and Probability (N=175)

Final Grade	A	B	C	D	F	DR
Instructional Strategy						
CCA-FOCUS	17	10	7	2	1	1
ALEKS	11	18	12	5	13	15
Traditional	14	13	18	7	2	9
College Division						
College of Arts and Humanities	0	4	2	3	2	3
College of Sciences and Mathematics	13	11	8	1	8	6
College of Business Administration	0	0	1	0	1	1
College of Education	1	0	1	1	0	0
College of Engineering and Computer Science	0	0	0	1	1	0
College of Social and Behavioral Sciences	2	1	4	2	1	3
College of Health Sciences and Human Services	26	25	21	6	3	12
Gender						
Male	12	14	12	6	7	11
Female	30	27	25	8	9	14

Inferential Statistics

A Kruskal and Wallis H test (Leech, Barrett, & Morgan, 2015) was conducted to determine if there were differences in Elementary Statistics and Probability final grades among groups that differed in their level of instructional strategy: CCA-FOCUS (n=38), ALEKS (n=74), and traditional (n=63) on their final grades. Distributions of Elementary Statistics and Probability final grades were not similar for all groups as assessed by visual inspection of a boxplot. Elementary Statistics and Probability final grades were significantly different among the different levels of instructional strategies: χ^2 (2) =18.02, p = 0.000. Subsequently, pairwise comparisons were performed using Dunn's procedures with a Bonferroni correction for multiple comparisons. Adjusted p-values are presented. In this post hoc analysis, significant differences were revealed in Elementary Statistics and Probability final grades between the CCA-FOCUS (mean rank = 116.26) and traditional (87.10, p = 0.004), and CCA-FOCUS and ALEKS (mean rank = 74.25, p = 0.000) instructional strategies groups but not between ALEKS and traditional. Table 3 describes these findings. The means for students' final grades in Elementary Statistics and Probability for the different instructional strategies were as follows: CCA-FOCUS (*M*= 4.97), ALEKS (*M*= 3.51) and traditional lecture style (*M*= 4.05). In other words, the mean of college students' final grades in Elementary Statistics and Probability courses for CCA-FOCUS was higher than the mean for ALEKS, and the mean for ALEKS was lower than traditional lecture style. Findings showed that only the instructional strategy of CCA-FOCUS was significantly better than traditional lecture style and ALEKS in respect to final grades in Elementary Statistics and Probability (Table 4).

Table 3

Kruskal and Wallis H test for Elementary Statistics and Probability

Variable	N	Mean Rank	Mean
Instructional Strategy			
CCA-FOCUS	38	116.26	4.97
ALEKS	74	74.25	3.51
Traditional	63	87.1	4.05

Table 4

Pairwise Comparisons for Elementary Statistics and Probability

Variable	Test Statistic	*p*-value
Instructional Strategy Comparisons		
CCA-FOCUS vs ALEKS	29.16	0.004
CCA-FOCUS vs Traditional	42.013	0.000
ALEKS vs Traditional	-12.853	0.131

A Kruskal and Wallis H test (Leech, Barrett, & Morgan, 2015) was run to determine if there were differences in Elementary Statistics and Probability final grades between groups that differed in their level of college division: College of Arts and Humanities (n=14), College of Sciences and Mathematics (n=47), College of Business Administration (n=3), College of Education (n=3), College of Engineering and Computer Sciences (n=2), College of Social and Behavioral Sciences (n=13), and College of Health Sciences and Human Services (n=93) college division level groups. Distributions of Elementary Statistics and Probability final grades were not similar for all groups as assessed by visual inspection of a boxplot. The mean rank of Elementary Statistics and Probability final grades were significantly different between groups: χ^2 (6) =13.46, p = 0.04. Subsequently, pairwise comparisons were performed using Dunn's test. A Bonferroni correction for multiple comparisons was made with no significant difference at the $p < 0.007$ level among college divisions. Findings showed that the performance of college students as measured by final grade in Elementary Statistics and Probability courses for the three instructional strategies, namely ALEKS, CCA-FOCUS, and traditional lecture style, were significantly different for each college division. However, by dividing the alpha level of 0.05 by 7 college divisions, the new *p*-value became 0.007, and findings showed that the performance of college students as measured by final grade in Elementary Statistics and Probability courses for the three instructional strategies, namely ALEKS, CCA-FOCUS and traditional lecture style, were not significantly different for each college division.

An additional Kruskal and Wallis H test (Leech, Barrett, & Morgan, 2015) was run to determine if there were differences in Elementary Statistics and Probability final grades between groups that differed in their level of gender: male (n=62), and female (n=113) gender level groups. Distributions of Elementary Statistics and Probability final grades were similar for all groups as assessed by visual inspection of a boxplot. Elementary Statistics and Probability final grades increased from male (*Mdn* = 4.08) to female (*Mdn* = 4.50) gender groups, but the differences were not significantly different: χ^2 (1) =2.18, p = 0.14.

Conclusion

The purpose of the study was to analyze the effects of instructional strategies, college division and gender on student performance as measured by pass/fail/drop rates in Elementary Statistics and Probability courses. Specifically, the study examined the fall of 2013 pass/fail/drop rates in Elementary Statistics and Probability courses of students who were taught with different instructional strategies at a university in south Texas. The effects of college division and gender also were analyzed.

Students' final grades were significantly different among instructional strategies for students who were taught using CCA-FOCUS, ALEKS, and traditional lecture style in Elementary Statistics and Probability. In addition, pairwise comparison for Elementary Statisitics and Probability courses findings showed that students' final grades were significantly different in Elementary Statistics and Probability courses between CCA-FOCUS (mean rank = 116.26) and traditional (mean rank = 87.10, p = 0.004), and CCA-FOCUS and ALEKS (mean rank = 74.25, p = 0.000), but not between ALEKS and traditional.

The finding that students' mathematics final grades were higher using ALEKS than using traditional lecture style as an instructional strategy was supported by research that was conducted by Allen (2007), Hagerty, Smith, and Goodwin (2010), Hampikian, Gardner, Moll, and Schrader (2006), Hanna and Carpenter (2006), and Hasselbring (1988) because their findings reported gains in learning when ALEKS was used.

Xu, Meyer, and Morgan (2008) investigated the performance of learners who completed statistics classes. Findings from the *t*-test showed that there was no significant difference in performance between students who had taken the statistics course during the fall of 2005 in a face-to-face setting and students who had taken statistics during the fall of 2006 using ALEKS in a blended course. This research provided no significant differences between ALEKS and traditional lecture style as instructional strategies as well as the present study. However, this research was for graduate students, and the present study was for undergraduate students.

Students' final grades were significantly different with repect to college division in elementary and statistics courses. Although differences were found, χ^2 (6) =13.46, p = 0.04, after pairwise comparisons were made using a Bonferroni correction by dividing the significance level of 0.05 by the seven college divisions and the new significance level became 0.007, there were no significant differences between any pair of groups. Findings showed that the performance of college students as measured by final grade in Elementary Statistics and Probability courses for the three instructional strategies, ALEKS, CCA-FOCUS and traditional lecture style, were not significantly different for each college division. One reason for the lack of significant differences among college divisions in Elementary Statistics and Probability courses might be the small sample size because 26 of the 42 cells had very few or no observations as shown in Table 2.

The last comparison between performance of college students as measured by final grade in Elementary Statistics and Probability courses was not significantly different for females and males. The present study provided the same findings as the study conducted by Peters because we found that there was no significant difference in student achievement in Elementary Statistics and Probability courses in respect to gender. Penner and Paret (2008) studied gender differences in a sample of students as they advanced from kindergarten to fifth grade. Gender differences were discovered as early as kindergarten. Males were found to perform at the top and bottom of the distribution, but by grade three, males outperformed the females throughout the distribution.

Recommendations for Research

Findings showed that student performance in Elementary Statistics and Probability courses as measured by final grades using different instructional strategies were significantly different. CCA-FOCUS provided higher averages than ALEKS and traditional lecture style. Based on this finding, it will be worth it to advise more students who struggle with algebra to enroll in Elementary Statistics and Probability courses. Goodsell, Maher, and Tinto (1992) identified cooperative learning with students working in groups searching for a solution in order to deliver a product. CCA-FOCUS was based on cooperative learning, which supported small group activities that maximized learning by making students teach each other. However, it is necessary to understand why ALEKS was not significantly better than traditional lecture style for Elementary Statistics and Probability courses.

The following are recommendations for future research:

1. The sample was taken from one university during the fall of 2013; it is recommended that the study be run again using spring and summer semesters.
2. Similar studies need to be carried out in other universities with larger sample sizes to strengthen the literature in this area, and qualitative research might produce more detailed results and strengthen this study.
3. More investigation is needed in respect to college division impact on student achievement.
4. More research is needed regarding age groups.
5. More research is needed among different teaching delivery methods, such as face-to-face, hybrid, online, and massive open online learning courses.
6. More investigation is needed to understand the factors of each instructional strategy that increases and decreases student achievement.
7. More research is needed on students' knowledge of their freedom to take different mathematics courses.

Recommendations for Practice

According to the present study, CCA-FOCUS provided better student final grades in Elementary Statistics and Probability courses. However, instructors need to be able to facilitate the course using cooperative learning. Consequently, educational leaders need to provide the appropriate training to instructors in order to successfully implement cooperative learning in these courses. The following are the researcher recommendations for future practice:

1. Use of personalized learning is increasing in higher education, particularly in mathematics freshman courses. It is crucial that educational leaders provide mathematics' faculties with the training necessary to be up to date with technology. Students can take advantage of programs such as ALEKS in mathematics courses to enhance their learning.
2. It is necessary to learn the outcomes in students' performance of different universities that use ALEKS as an instructional strategy. There are universities that not only use ALEKS during lab, but also provide lecture.
3. It is necessary to provide faculty with teaching strategies such as CCA-FOCUS where cooperative learning is used. Students can take advantage of learning not only from their teacher but also from their classmates.
4. Educators need to continue improving instructional strategies by finding the best attributes of each and integrating them in one.
5. Every student is different. It is necessary to provide students with information on the different types of instruction offered before they are registered for classes.
6. College divisions should develop an alignment with mathematics courses so students can make a clear connection between mathematical concepts and their role in their future professional lives.

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