US-China Education Review A 10 (2012) 875-884
Earlier title: US-China Education Review, ISSN 1548-6613

Predicting Students' Performance in Elements of Statistics

Kuiyuan Li, Josaphat Uvah, Raid Amin
University of West Florida, Pensacola, USA

In this paper, we assess students' performance in Elements of Statistics, one of the popular courses in general education, using data from UWF (University of West Florida) for fall 2008, fall 2009, and fall 2010 semesters. We analyze associations between students' performance in the course and several performance related factors including: college and high school GPA (grade point averages), prerequisite algebra courses, and scores on standardized examinations. Our analyses show that the college GPA is the single most reliable predictor of performance in Elements of Statistics, and that a more stable prediction is obtained when the college GPA is used in conjunction with math and English scores on a standardized test, such as the SAT (Scholastic Assessment Test) or ACT (American College Testing). Aside from interpreting our results, we offer suggestions regarding curriculum development and placement criteria for Elements of Statistics.

Keywords: introductory statistics, assessment, college readiness

Introduction

Applied research studies in education, business, arts, agriculture, engineering, and the sciences often involve collecting and organizing data which are analyzed to draw conclusions. Thus, many departments across universities in the United States encourage or require their students to take Elements of Statistics, a college level introductory course in statistics. In order to be awarded a baccalaureate degree in the State of Florida, for example, the general education and Gordon Rule requirements in the area of mathematics dictate that students show proficiency in two courses at or above the level of College Algebra. Typically, college students in Florida use Elements of Statistics as one of the two courses to meet those requirements. The relevance of this study lies in the centrality of Elements of Statistics in lower division mathematics.

In this paper, we assess students' performance in Elements of Statistics and compare the same with their academic performances prior to enrolling in the course with the main goal of identifying reliable predictors for success in the course. We analyze data for all students who enrolled in Elements of Statistics in the fall 2008, fall 2009, and fall 2010 semesters at UWF (University of West Florida). Aside from identifying the content areas of Elements of Statistics in which students at UWF have done poorly in recent time, we analyze performance-related variables including: college GPA (grade point averages) and high school GPA; grades in requisite courses, such as Intermediate Algebra and College Algebra; and scores on standardized tests often used for placement into Elements of Statistics, including the SAT (Scholastic Assessment Test) (verbal, math, and combined) and the ACT (American College Testing) scores (English, math, reading, science, and

Kuiyuan Li, Ph.D., professor, department chairman, Department of Mathematics and Statistics, University of West Florida.
Josaphat Uvah, Ph.D., professor, Department of Mathematics and Statistics, University of West Florida.
Raid Amin, Ph.D., professor, director, Department of Mathematics and Statistics, University of West Florida.

combined). Among other things, we perform correlation analyses between the variables and elements of statistics, and perform multiple regression analyses to determine predictors of performance. The results of our study could enhance further development of the Elements of Statistics curriculum at universities and colleges, especially institutions whose admission criteria are similar to those of our institution in a regional comprehensive setting. Aside from equipping advisors with information to make viable placement decisions for the beginning level statistics, our methods may also be of interest to educators who wish to assess other courses in the general education curriculum.

Further Rationale for the Study

Li, Uvah, Amin, and Okafor (2010) have defined college readiness as a proficiency level attained by high school students in order to begin college-level studies without remediation. Although college entry requirements vary from institution to institution in the United States, it is common to use the students' success rates in key courses at the college freshman level as a yardstick for measuring proficiency in various areas of study. We may, therefore, associate students' performance in College Algebra and in Elements of Statistics with their college readiness for mathematics. In order to improve students' achievement in gateway mathematics courses, colleges and universities utilize two main strategies, namely: (1) engaging in curriculum review and redesign to take advantage of new teaching strategies as well as instructional technologies to improve students' performance; and (2) determining students' readiness for popular courses in order to make appropriate placement decisions. Several studies have attributed enhanced rates of students' success to the first strategy. For instance, see the researches of Amin and Li (2010), Barnes, Cerrito, and Levi (2004), Hauk and Segalla (2005), O'Callaghan (1998), Smith and Ferguson (2005), and Stephens and Konvalina (1999). However, other studies, such as Li, Uvah, Amin, and Hemasinha (2009) have shown that similar initiatives may produce only modest improvements. At UWF, we have embarked on annual assessments of general education courses with the goal of enhancing students' performance during the past few years. Since the list of topics for Elements of Statistics is state mandated in Florida, our review and adjustments have consisted of apportioning more time to identified topics of concern on the one hand, and changing the method of delivery on the other hand. For instance, in 2008, we introduced a blended learning approach consisting of face-to-face lectures and a Web-based homework in all sections of Elements of Statistics while delivering a few sections of the course fully online. As we reported in an earlier assessment study of Li et al. (2009), there was significant improvement in students' performance when we moved from the traditional face-to-face lecture and homework to the blended mode of face-to-face lecture and Web-based homework. However, students in the fully online sections performed worse than those in the traditional and blended modes.

Three of the many variables that are often used to determine college readiness stand out as being universally adopted, namely: (1) graduating from high school (which depends heavily on state standards); (2) receiving passing grades in identified high school courses (typically, courses required by colleges as providing requisite skills); and (3) demonstrating basic literacy skills (For instance, see the researches of Allen and Sconing (2005), Conley (2007), Greene and Forster (2003), Greene and Winters (2005), and the Nation's Report Card by Shettle et al. (2007)). Several traits are known to account for students' poor performance during their initial year in college. Not only is the nature of college courses fundamentally different from that of their high school experience, the expectations of college instructors concerning what students must do in order to succeed may also differ. As noted by Conley (2007), in some instances, high school teachers select course materials based on their skills and personal interests, with little consideration for what students need in order to succeed in college. In their Policy Research Brief, ENLACE Florida (2010) also made a strong case for the sweeping reform of Florida's high school curriculum requiring higher mathematics standards for high school graduation. In spite of such stricter requirements for high school graduation across the United States, only two-thirds of the nation's college freshmen are said to be prepared for college-level mathematics (ENLACE Florida, 2009). In fact, studies show that remediation is generally high among students from low income families, especially Hispanics and African Americans. As Long, Iatarola, and Conger (2009) have posited, female students are also more likely than their male counterparts to require remediation for college-level mathematics. These and similar considerations dictate that colleges should exercise diligence in placing students into college-level courses. It is, therefore, crucial to identify characteristics that indicate good promise for success in Elements of Statistics and other general education courses.

Students' Performance in Elements of Statistics

Course Content

For several years now, we identified "quantitative reasoning" and "problem-solving" as the appropriate domains for assessing general education and Gordon Rule mathematics. As a result, we formulated the course objectives as SLOs (student learning outcomes) for Elements of Statistics in the context of those domains. The following SLOs were used over the duration of the current study.

Upon successful completion of the course, the student will demonstrate the abilities to:

(1) calculate frequencies and measures of centrality, dispersion, and location for data sets;

(2) apply probability rules and calculate probabilities for discrete and normal random variables;

(3) solve problems involving application of discrete and continuous random variables;

(4) estimate statistics parameters;

(5) perform statistical hypotheses testing.

In the sequel, we refer to these learning outcomes by their respective numbers as above.

Assessment Data Collection

The Coordinator of Lower Division Courses oversees the general education curriculum in the department. Through this coordinator, the department maintains uniformity in the teaching and learning of the applicable courses so as to achieve and maintain the desired quality. In particular, all sections of Elements of Statistics have the same syllabus with scheduled weekly topics and homework assignments. Hourly tests of similar strength are made and given to all sections of the course within a specified week. In addition, a uniform, comprehensive final examination is given at the end of the semester. During the period under study, course instructors formulated hourly test questions in consultation with the coordinator. However, the coordinator independently selected 20 problems, each with possibly multiple questions, for the uniform final examination, with the goal of pointedly addressing each SLO in order to assess student learning. Uniformity was further enhanced by assigning each course instructor to grade some problems on the final exam for all sections. Using the data from the comprehensive final examination exclusively, the department assesses students' abilities in "quantitative reasoning" and "problem-solving". Table 1 shows the problem distribution among the SLOs.

Students' Performance in Content Areas

For each assessment period, the department identified problems on the final exam in which more than 35%

of students' responses were incorrect. Table 2 details those areas with high percentages of incorrect responses for the various semesters.

Table 1

Problem Distribution on SLOs

SLOs	Fall 2008	Fall 2009	Fall 2010
SLO 1	1, 2, 3, 4, 11, 12	1, 2, 3, 4, 7	1, 2, 3, 4, 5
SLO 2	4, 5, 6, 7	7, 8, 9, 10, 11	6, 7, 8, 9, 11, 12
SLO 3	7, 8, 9, 10	5, 6, 12	5, 6, 12, 19
SLO 4	11, 12, 13, 14, 15, 18	13, 14, 1 5, 16, 17	9, 10, 13, 15, 16
SLO 5	2, 16, 17, 18, 19, 20	18, 19, 20	14, 17, 18, 19, 20

Table 2

Areas With High Percentage of Incorrect Responses

	Quantitative reasoning domain	Problem-solving domain
Fall 2008	Finding a percentile; Computing the value of range; Finding the area under normal curve at a specified value; Determining the decision rule for rejecting the null hypothesis.	Solving problems with binomial probability; Computing the variance; Finding probability for a given data set.
Fall 2009	Computing the value of *t*-test statistics and determining the decision rule; Computing the confidence intervals; Making decisions for rejecting null hypothesis.	Finding the variance for a given data set; Computing probabilities, and use the binomial tables to find the probabilities; Computing the values of *z*-test statistic and *p*-values.
Fall 2010	Determining a decision rule; Finding the expected value for a given data set; Determining a decision rule for rejecting the null hypothesis.	Computing probability; Finding the value of *z*-test statistics and the *p*-value of *z*-test statistics; Computing binomial probability.

The Population for the Study

For the purpose of this study, we classified the 1,405 students who enrolled in the Elements of Statistics course during the fall 2008, fall 2009, or fall 2010 semesters, according to their related experiences prior to taking the course. In this population, 621 students took College Algebra, 691 had SAT scores, 1,024 had ACT scores, and 289 students had grades in Intermediate Algebra (which is the prerequisite for both College Algebra and Elements of Statistics). Some students enrolled in Elements of Statistics based on their high ACT and/or SAT scores without taking the prerequisite algebra. It should be noted that some students belonged to several subgroups; for instance, 263 students had ACT and SAT scores. We collected pertinent data for the 1,405 students in order to assess their readiness for Elements of Statistics. While we stress that the number of students included in any of the statistical analyses depended on the variables we studied, our use of a sizeable pool permitted reasonable numbers per variable.

The SAS (statistical analysis system) was used for all statistical analyses on the data to determine the relationships, where such existed, between students' performance in the Elements of Statistics and each of the following factors: high school GPA, college GPA, Intermediate Algebra grade, College Algebra grade, SAT scores, and ACT scores.

Performance-Related Factors

Our study identified the performance-related factors that potentially affect students' performance in

Elements of Statistics, viz.: Intermediate Algebra grades, College Algebra grades, high school GPA, college GPA, as well as scores on the ACT mathematics, ACT English, ACT science, ACT reading, SAT mathematics, and SAT verbal. We also identified combined ACT and SAT scores, respectively, as additional factors. Table 3 is a summary of the data for the performance-related factors that were covered in this study. Aside from examining the relationships by analyzing frequency distributions of students' grades and pair-wise correlations, we performed multiple regression analysis on several determined models of interest. In the sequel, we use 0.05 as the significance level.

Table 3

Summary Statistics of Students Enrolled

Variable	*N*	Mean	Std. Dev.
sta	1,405	2.4498932	1.3807726
hs	1,405	2.9656655	1.5159686
cgpa	1,405	2.8013025	0.7700777
mat	289	2.7397810	1.0492216
mac	621	2.7593368	1.1541674
acteng	1,024	22.2568359	4.4473077
actmath	1,024	21.5996094	3.8015071
actread	1,024	23.5117188	5.1147019
actsc	1,024	21.5644531	4.6797484
actcomb	1,024	22.1699219	4.4423574
satverb	691	517.6487663	79.5791163
satmath	691	506.2173913	75.1604707
satcomb	691	1021.64	140.4653348

Notes. sta: Elements of Statistics; hs: high school GPA; cgpa: college GPA; mat: Intermediate Algebra grades; mac: College Algebra grades; acteng: ACT English; actmath: ACT mathematics; actread: ACT Reading; actsc: ACT Science; actcomb: ACT scores; satverb: SAT verbal; satmath: SAT mathematics; satcomb: SAT scores.

Success Rates in Elements of Statistics

In order to determine the success rate for the group under study, we adopted the notion that "success" is the attainment of passing grades of A, B, or C. Thus, grades D, W, or F were considered to be "failure". Here, the W-grade refers to the grade given when a student withdraws early without completing the course. Table 4 shows the frequency distribution of the grades of students who enrolled in Elements of Statistics during the period of interest. As Table 4 shows, the success rate in Elements of Statistics was 78%.

Table 4

Frequency Distribution of Grades

Grade	Frequency	Percent (%)	Cumulative frequency	Cumulative percent (%)
A	406	28.90	406	28.90
B	358	25.48	764	54.38
C	331	23.56	1,095	77.94
D	74	5.27	1,169	83.20
F	120	8.54	1,289	91.74
W	116	8.26	1,405	100.00

In order to further compare success rates for the group, we identified the students who took Elements of Statistics and Intermediate Algebra. We performed Fisher's Exact Test (N = 289) to examine any association between the students' grades in these two courses. Since the *p*-value for this test was 0.08, we concluded that there was no significant association between the grades in these two courses. The Fisher's Exact Test on students' grades in Elements of Statistics and College Algebra ($N = 621$) showed a significant association, with a *p*-value less than 0.0001. Although the descriptive statistics and Fisher's Exact Test provided information on students' performance in Elements of Statistics on the one hand, and their performance in College Algebra and Intermediate Algebra on the other hand, it was of interest to examine other pertinent experiences that many students had prior to taking the Elements of Statistics in order to draw predictive conclusions.

Correlation Between Factors and Elements of Statistics

The students' letter grades in Elements of Statistics, College Algebra, and Intermediate Algebra (i.e., A, B, C, D, and F) were converted to equivalent numerical grade-point scores (4, 3, 2, 1, and 0), respectively, in a manner consistent with that used for computing GPAs at UWF. Since the W-grade (the grade for early withdrawal without course completion) does not attract similar points, we eliminated all students with W-grade in the rest of the study. Further, we placed all high school GPAs on the same 4.0 scale. In order to test the relationship between each performance-related factor and Elements of Statistics, we performed the Pearson Correlation Test. Table 5 shows the Pearson Correlation Coefficients for the factors, with factor sample size *N* and the *p*-value for testing the hypothesis of a zero correlation coefficient.

Table 5

Pearson Correlation Coefficients

	hs	cgpa	mat	mac	acteng	actmath	actread	actsc	actcomb	satverb	satmath	satcom
sta	0.08816	0.68663	0.41493	0.41825	0.17765	0.26802	0.12217	0.15131	0.17731	0.10890	0.19252	0.19226
p-value	0.0017	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002	<0.0001	<0.0001	0.0061	<0.0001	<0.0001
N	1,269	1,269	242	507	929	929	929	929	929	632	633	634

Notes. hs: high school GPA; cgpa: college GPA; mat: Intermediate Algebra grades; mac: College Algebra grades; acteng: ACT English; actmath: ACT mathematics; actread: ACT Reading; actsc: ACT Science; actcomb: ACT scores; satverb: SAT verbal; satmath: SAT mathematics; satcomb: SAT scores; sta: Elements of Statistics.

Our analyses show that:

(1) There was a significant correlation between performance in Elements of Statistics and each of the factors named above;

(2) With each *p*-value less than 0.0001, the highest pair-wise correlations with Elements of Statistics grades were, in rank order: college GPA (0.687), College Algebra grades (0.418), and Intermediate Algebra grade (0.415).

Although the findings from the Pearson Correlation Tests and the grade distributions were informative, especially for the purpose of students' placement in Elements of Statistics, we performed deeper and more elaborate statistical analyses in order to draw other generalized conclusions.

Multiple Regression Models

Following methods similar to those in Myers (1990) and Montgomery, Peck, and Vining (2006), we used multiple regression analysis to identify several models with the potential to be useful for predicting success in Elements of Statistics. We applied PROC RSQUARE (a SAS procedure) to rank-order all possible regression models using three criteria: the adjusted coefficient of determination (R^2), the MSE (Mean Square Error), and Mallow's Cp statistic. Based on these criteria, we selected a subset of regression models that exhibited a combination of desirable characteristics, namely, a high R^2 value, a low MSE value, and a low Cp value. The high R^2 value in concert with a low MSE value was to assure that we have a good fit. In addition, a low Cp value was an indication of striking a good balance between: (1) "over-fitting" and possible multicollinearity (from use of too many regressor variables); and (2) "under-fitting" with the possibility of excessive bias (from too few regressor variables). By design, the three regression criteria enhanced our ability to select regression models that provided a good "fit" for the data at hand. They did not, however, provide a basis for identifying good prediction models. In the context of our current study, these good "fit" regression models simply amplified the characteristic features of the group under study exclusively. We then utilized SAS on the subset comprising the selected models to obtain the PRESS (prediction-oriented sum of squared errors) statistic. It should be noted that a low PRESS value indicates stability of a model for prediction. In the framework of this study, those models with low PRESS values represent suitable models for predicting (future) students' performance in Elements of Statistics. Another consideration was our wish to use the largest sample sizes possible in our analyses so as to take advantage of higher levels of statistical power. Consequently, we partitioned and separately analyzed the performance of students who took Elements of Statistics in fall 2008, fall 2009, and fall 2010, and had the following data:

(1) Grades in Intermediate Algebra and scores on the ACT;

(2) Grades in College Algebra and scores on the ACT;

(3) Grades in Intermediate Algebra and scores on the SAT;

(4) Grades in College Algebra and scores on the SAT.

Table 6

Multiple Regression Model With STA as Response Variable

Model	Adjusted R^2 (%)	MSE	Mallow's Cp	PRESS	Sample size
cgpa	45	0.75	12.4	198	256
cgpa, actmath, actcomb	48	0.72	4.49	156	212
cgpa, actmath, actread, actsc	48	0.71	4.98	155	212
cgpa, mat, actmath, actcomb	47	0.72	6.37	150	203
cgpa, acteng, actread, actsc, actcomb	48	0.70	3.17	157	212

Notes. cgpa: college GPA; actmath: ACT mathematics; actcomb: ACT scores; actread: ACT Reading; actsc: ACT Science; mat: Intermediate Algebra grades; acteng: ACT English; Regressor variables: hs, cgpa, mat, actmath, actsc, acteng, actread, actcomb.

Table 7

Multiple Regression Model With STA as Response Variable

Model	Adjusted R^2	MSE	Mallow's Cp	PRESS	Sample Size
cgpa	41%	0.83	10.86	197	256
cgpa, satverb	43%	0.79	5.40	134	170
cgpa, satmath, satcomb	44%	0.77	2.33	128	170
cgpa, satverb, satmath	45%	0.77	2.33	128	170
cgpa, hs, satmath, satcomb	44%	0.77	4.00	129	170
cgpa, mat, satmath, satcomb	44%	0.78	4.32	127	159

Notes. cgpa: college GPA; satverb: SAT verbal; satmath: SAT mathematics; satcomb: SAT scores; hs: high school GPA; mat: Intermediate Algebra grades; Regressor variables: cgpa, hs, mat, satverb, satmath, satcomb.

As described above, the three criteria along with the PRESS statistic resulted in our choice of multiple regression models. Although we analyzed several of such models, we exhibit a sample of two summaries of our analyses in Tables 6 and 7, showing the results for the above portioned subgroups, respectively. A more elaborate report can be accessed in a related technical report of Li, Uvah, and Amin (2012). As it can be seen in Tables 6 and 7, college GPA (cgpa) consistently showed good promise and, when combined with one of the standardized test scores, the PRESS statistic dropped rather drastically, an indication of stability of the model.

Our analyses clearly indicate that:

(1) College GPA (cgpa) was the best single predictor of students' performance in Elements of Statistics;

(2) The stability of prediction models was best when college GPA was used in combination with either ACT or SAT scores. While many regression models had adjusted R^2 values in the neighborhood of 45%, we note that the best prediction model was detected if the PRESS value was also low;

(3) College Algebra grades were more important than Intermediate Algebra grades for predicting performance in Elements of Statistics. However, where the students had college GPAs as well as either ACT or SAT scores, neither of the two courses was needed to predict performance in Elements of Statistics;

(4) Surprisingly, high school GPA was seen to be of less importance as a performance-related factor for Elements of Statistics, a deviation from the earlier study on College Readiness for College Algebra (Li et al., 2010);

(5) Overall, using college GPA with either of the standardized tests (SAT or ACT) gave the best prediction model of performance in Elements of Statistics.

Conclusions

Summary and Interpretation of Results

In many fields of college study, Elements of Statistics is one of the courses that students take to satisfy their general education and other requirements. The present study emanates from several years of assessments of students' performance in the course. Having gone through a major transition from the traditional face-to-face instruction and homework, to the blended format of face-to-face lecture and Web-based homework at UWF, we compared the teaching and learning of Elements of Statistics in the two modes of teaching (Li et al., 2009). Since there are several methods for placing students into Elements of Statistics, the thrust of this paper is to determine factors that best predict students' performance in the course. Among other things, our analyses showed that:

(1) There was a significant correlation between students' performance in Elements of Statistics and each of the factors considered in this study. The highest correlation values were obtained between performance in Elements of Statistics and college GPA, followed by College Algebra and Intermediate Algebra grades in that order;

(2) The correlations between performance in Elements of Statistics and the standardized test scores (SAT and ACT) were much weaker than those of college GPA, and grades in College Algebra or Intermediate Algebra. These findings are in agreement with some studies such as those of Geiser and Santelices (2007) who indicated good predictors of college performance that exclude scores on the standardized tests;

(3) College cumulative GPA was the best predictor of students' performance in Elements of Statistics. The stability of prediction was strongest when college GPA was used in conjunction with either the ACT or SAT scores. Under these conditions, the prerequisite algebra courses appeared to make little or no difference on the predictor models;

(4) High school GPA was not seen to be a viable performance-related variable for the prediction of

performance in Elements of Statistics. This contrasts other studies such as Li et al. (2010) who found high school GPA played a major role in the prediction of performance in College Algebra.

That college GPA when combined with standardized test scores provided the most stable prediction for students' performance in Elements of Statistics made sense because of the nature of statistics. The word problems that dominate statistics tests require the students to be proficient in comprehension (as in reading) and symbolic manipulation. Our study concerning college readiness for College Algebra also showed that college GPA was a better predictor of students' performance than scores on standardized tests.

Suggestions and Recommendations

Based on our study and assessments, the suggestions and recommendations are as follows:

(1) In order to improve the teaching and learning of Elements of Statistics, it is beneficial to: (a) determine several appropriate criteria for placing students into the course; (b) provide a variety of platforms for teaching and learning the subject; (c) assess students' performance in the course on a continuing basis, to determine areas of strengths and weaknesses; and (d) adjust the curriculum by apportioning more time to areas where students are weak. These and similar systematic measures are likely to produce good results by design over time;

(2) Cumulative college records, where such exists, may be the best predictor of students' performance in Elements of Statistics. These should be used in conjunction with standardized test scores in mathematics and English;

(3) We do not recommend that Elements of Statistics be taken in the student's first semester in college. Ideally, the presence of a college record to be used together with other characteristics will help to position students for heightened success in the course;

(4) Colleges should devise alternative means to deal with areas in which students persistently show weakness. For instance, beyond the regular class lecture, students can be subjected to guided hands-on workshops whereby they collect data in their everyday environment and apply what they are learning in small groups (with discussion) in a nonthreatening atmosphere. The applied nature of statistics lends itself to hands-on learning that may motivate students to better learn the concepts because they want to apply these to issues of their interest;

(5) An early warning system that identifies students who are experiencing problems with the aim of employing interventions strategies may enhance students' performance overall, hence improve the success rate in the course;

(6) It may be of further interest to also investigate correlations between performance in Elements of Statistics and various sub-levels of the standardized test scores.

References

Allen, J., & Sconing, J. (2005). *Using ACT assessment scores to set benchmarks for college readiness* (ACT Report Series No. 3, pp.1-24). Iowa City, I. A.: ACT, Inc..

Amin, R., & Li, K. (2010). Should the graduate math courses be offered online? *Electronic Journal of Mathematics and Technology, 4*(1).

Barnes, G., Cerrito, P., & Levi, I. (2004). An assessment of general education mathematics courses via examination of student expectations and performance. *Journal of General Education, 53*(1), 20-36.

Conley, D. T. (2007). The challenge of college readiness. *Education Leadership,* 1-5. Eugene, O. R.: Educational Policy Improvement Center.

ENLACE Florida. (2009). *Opening the gates to success in Florida higher education* (Vol. 3, Issue 5, pp. 1-10).

ENLACE Florida. (2010). Why algebra II. *Policy Research Brief, IV*(2), 1-6.

Geiser, S., & Santelices, M. V. (2007). *Validity of high-school grades in predicting student success beyond the freshman year: High-school record vs. standardized tests as indicators of four-year college outcomes*. Berkeley: Center for Studies in Higher Education, University of California.

Greene, J. P., & Forster, G. (2003). Public high school graduation and college readiness rates in the United States. *Education Working Paper, 3*, 1-23.

Greene, J. P., & Winters, M. A. (2005). Public high school graduation and college-readiness rates: 1991-2002. *Education Working Paper, 8*, 1-27.

Hauk, S., & Segalla, A. (2005). Student perceptions of the web-based homework program Webwork in moderate enrollment college algebra classes. *Journal of Computers in Mathematics and Science Teaching, 24*(3), 229-253.

Li, K., Uvah, J., & Amin, R (2012). *Predicting students' performance in elements of statistics* (Technical Report No. Stat-LI-070912-1). Retrieved from http://uwf.edu/mathstat/technical

Li, K., Uvah, J., Amin, R., & Hemasinha, R. (2009). A study of non-traditional instruction on qualitative reasoning and problem solving in general studies mathematics courses. *Journal of Mathematical Sciences and Mathematical Education, 4*(1), 37-49.

Li, K., Uvah, J., Amin, R., & Okafor, A. (2010) A study of college readiness for college algebra. *Journal of Mathematical Sciences & Mathematics Education, 5*(1), 52-66.

Long, M. C., Iatarola, P., & Conger, D. (2009). Explaining gaps in readiness for college-level math: The role of high school courses. *Education Finance and Policy, 4*(1), 1-33.

Montgomery, D. C., Peck, E. A., & Vining, G. G. (2006). *Introduction to linear regression analysis* (4th ed.) John and Wiley.

Myers, R. H. (1990). *Classical and modern regression with applications* (2nd ed.) Belmont, California: Duxbury Press.

O'Callaghan, B. (1998). Computer-intensive algebra and students' conceptual knowledge of functions. *Journal for Research in Math Education, 29*(1), 21-40.

Shettle, C., Roey, S., Mordica, J., Perkins, R., Nord, C., Teodorovic, J., …, Kastberg, D. (2007). *The nation's report card: America's high school graduates* (Report No. NCES 2007-467). Washington, D. C.: U.S. Department of Education, National Center for Education Statistics.

Smith, G., & Ferguson, D. (2005). Student attrition in mathematics e-learning. *Australasian Journal of Educational Technology, 21*(3), 323-334.

Stephens, L., & Konvalina, J. (1999). The use of computer algebra software in teaching intermediate and college algebra. *Journal of Math Education in Science and Technology, 30*(4), 483-488.