Relevance Of Prerequisites To Business Statistics: Some Preliminary Hypotheses And Tests

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Abstract

Statistics is an essential part of an undergraduate business degree program. Undergraduate institutions commonly require prerequisite courses to ensure that students are prepared to learn the material in the core courses. Presumably, successful completion of prerequisite courses should increase students' confidence and performance in the core courses. Students often express fear and anxiety over quantitative and mathematics courses, and frequently object to the math prerequisite for the business statistics course, complaining that it only results in prolonging their degree program. The objective of this paper is to examine empirically whether the math prerequisites for the business statistics course help the learning experience. This study suggests that these prerequisites do help students at a four-year state institution with an open enrollment policy. Grades are used as the measure of performance for both the prerequisite and the core statistics course.

1. INTRODUCTION

xperts in the fields of finance, economics, marketing, operations research, management, and forecasting are increasing their reliance on statistical analysis. Mathematical and statistical tools help managers and policy makers improve the likelihood of making sound decisions in the face of uncertainty. Little disagreement is found among academics and practitioners in the business world that a good understanding of basic statistical concepts is of fundamental importance for business school graduates. Regrettably, many business students resist the study of math and statistics and postpone taking such courses as long as possible. Instead of taking the statistics course during their sophomore years, some students delay until their junior or senior years, only to discover that they must first take one or more math courses as prerequisites to the statistics course. At that point they either petition to waive the prerequisites or postpone graduation until the required courses can be completed. Most business schools now require at least one statistics course for graduation. Despite its overwhelming significance in the business school curriculum, research on the value of requiring prerequisites for the statistics course appears to be meager. Although some research has been directed toward the broader question of course prerequisites, little has addressed the particular issue of the value of prerequisites to the business statistics course.

The objective of this research is to examine two questions. First, are prerequisites helpful to students taking the required statistics course in the school of business, and if so, is one prerequisite better than another? This involves evaluating prerequisites to determine which of them best serves the interest of the students in terms of their performance in the statistics course. Second, is there a quantifiable measure which can assess the strength of the relationship between the prerequisite and the statistics course? In other words, can the variability in the grades on the statistics course be predicted by the variability in the grades on the prerequisite? Answers to both these questions should have important policy implications.

2. REVIEW OF LITERATURE

The quality and content of education has been a major concern of professional economists, economics teachers, and policy makers in recent times. The American Economics Association (AEA) stated that one of its goals is "... to educate public opinion about economic questions and economic literature" (Hinshaw and Siegfried 1991, p. 373). With this objective in mind, over the first five decades of its existence, the AEA has been engaged in encouraging debate and discussion to emphasize the importance of learning economics. In 1955 AEA created the Committee on Economic Education with a view to "... improving the status of economic education within the profession, stimulating and encouraging professional work on economic education at all levels, from pre-college to college, ... and arranging economic education sessions at AEA meetings" (Salemi and Siegfried 1999, p. 355). Other business disciplines are also concerned about quality education for business professionals. A successful education in a business discipline requires a good understanding of statistics.

Success in college statistics courses depends on the quantitative skills of the students, which continue to decline in the United States. Opstal (2001) wrote,

... deficiencies in science and math education appear to cut across all schools. The Third International Science and Math Study (TIMSS) and its follow-up, TIMSS-R, indicate that U.S. students perform well below the international average in both science and math. Even more sobering, student achievement actually declines with years in the system. The relatively strong performance of U.S. 4th graders gradually erodes by 12th grade (p. 58).

Doyle (2001) cites a U.S. Department of Education report of 2000 showing that "more than one third of all high school seniors . . . don't have even a basic competency in mathematics" (p. 24).

The concern is that the students usually come to college with a poor quantitative background and are not ready for a statistics course. Many colleges now require one or more prerequisites to remedy the deficiency in math. At the college used for this study students with relatively low math skills may select one or more prerequisite courses from a list of courses offered by the business school and the math department. These courses can potentially delay the completion of the degree, particularly for students required to take a remedial math course before entering into the prerequisite. The students, fearful of quantitative courses, often find it discouraging to be required to take these prerequisites.

Most academics agree that business statistics should be application oriented. With increased access to sophisticated computers and software, the computational aspects of statistical procedures have become less important. However, if the statistical concepts are not well understood, students will be unable to understand a computer printout of even a simple statistical analysis. While they may not have to perform the underlying calculations, the key issue is whether the students understand the analysis well enough to interpret the results.

Perhaps the hardest part of teaching statistics is to provide students with the necessary skills to perform well both in a statistics class and in a real world situation. First, the necessary skills must be identified. Hansen (1986) noted that it is easier to talk about the coverage than to define the competencies to be learned. The latter requires definitions of student activities while the former labels students as passive recipients. If students are to do more than regurgitate definitions, duplicate proofs, or perform repetitive computations, then expectations must be specified. Second, it is critical to determine whether the prerequisites provide the needed skills to pass the statistics course. The question of effectiveness of the prerequisites in the learning experience is of interest to all parties. An administrator is concerned with institutional effectiveness. A professor, who wants students to be prepared with the skills to succeed in the statistics course, may be frustrated by having students enter the course without the requisite skills. Students become very frustrated in the course when they do not have the background to understand and learn the content. In addition, students often fail to see the relevance of statistics in the context of their own career. Because the purpose of teaching is to create a skill that students can apply in some real business situation, the assessment of success is often challenging. No one claims that the sole determinant of students' performance in statistics lies in taking the prerequisite. Colleges require prerequisites to improve subsequent student achievement. Cain (1987) identified four major constraints to such achievement: limited time in a one-semester course; typically large size and heterogeneous class; limited quantitative background of the vast majority of students; and limited skills of the teacher.

Perhaps the limited quantitative background is caused by mathematics anxiety in general and it in turn causes statistics anxiety in particular. Beasley, Long and Natali (2001) identified a sizeable body of research in this area dating back to 1957. They noted that mathematics anxiety affects performance in both math and science and even influences career choices. They wrote, "Furthermore, mathematics anxiety seems to occur with high prevalence" (p. 14). Onwuegbuzie (2000), reporting on statistics anxiety among graduate students, indicated that it is related to basic mathematics ability, the number of undergraduate mathematics courses completed, and the time that has elapsed since the last math course was taken. Lack of student enthusiasm for the statistics class may be due to the misconception that statistics is an unnecessary hurdle and that it does not really apply to their chosen field within the business school.

While identifying specific factors leading to poor performance in statistics is difficult, finding solutions is even harder. Another discipline that is likely affected by math anxiety is economics. In discussing their concern about learning economics, Salemi and Siegfried (1999) stated, "Americans know woefully little about our economy and about economic ideas" (p. 356). This may well relate to the lack of understanding of mathematic and statistical principals. Walstad and Larsen (1992) argue that surveys provide a sobering appraisal of economic literacy. Ideas for improvement range from assigning higher emphasis to redesigning courses. These studies suggest the need for a more serious approach to mathematics and statistics education.

3. METHODOLOGY AND DATA

The current research is based on information collected on students at a four-year state college, which began as a trade school, progressed to a junior college, and is now a four-year comprehensive public college with more than 4,000 students in the business school. Since the school began offering a bachelor's degree in business management, the push for rigor has constantly increased. One of the major concerns of the business school has been improving students' skills in statistics. Students in public schools in the state have consistently scored at or above the national average in mathematics (Davidson 2002). High-school students, on the other hand have to take only two math courses, perhaps not enough to deal with college math, and these courses can be completed by the end of the sophomore year, often leaving a considerable gap between high-school mathematics and college. Furthermore, due to an open admissions policy, any student can enroll in an undergraduate degree program. However, students must take placement tests on entering the school. Many fare poorly in the quantitative area. In the fall of 2001, approximately 19% of the student body was enrolled in remedial math courses due to their low scores on the placement tests.

In the fall of 1995, members of the faculty in the business management department within the school of business conducted a study to develop a prerequisite course for the statistics course. The idea was to impart quantitative skills to the students to enable them to complete the required statistics class successfully. A remedial course, then called foundations of business statistics, and later renamed quantitative business analysis, was implemented by the school of business in the fall of 1996. Two alternative prerequisite courses were identified from the math department, college algebra and introduction to calculus. To monitor success of the program a record of students' grades was maintained. The data for this study was collected from the spring of 1998 through the summer of 2002 from the office of institutional research on 1,474 students who registered for the introductory statistics course during that period. Data was also available on the grades earned in any of the prerequisites taken. Because 235, or approximately 16%, of the students audited the course or dropped out before completion, analysis was completed on the remaining 1,239 students. Grades for the statistics class were available for those students who took any of the three prerequisites. The possible prerequisites were quantitative business analysis, college algebra, and introduction to calculus. Students who scored sufficiently high on the placement test and those who transferred to the college with credit for an equivalent course from another school took no prerequisite class. Therefore, no grade for the prerequisite was available for those students. The quantitative business analysis course emphasizes the application of mathematical tools to business principles and is offered within the business school. The other two are offered by the mathematics department. Grades on these courses were also available.

4. FINDINGS AND DISCUSSION

The first question posed in the research was whether taking a prerequisite course was helpful to students in the subsequent statistics course, and if so, which of the three prerequisite courses is most effective? To answer this question, one-way ANOVA was applied. The mean grade was computed for that group of students who took one of the three prerequisite courses as well as for that group of students who took no prerequisite. This procedure allowed a test for the equality of mean grades among these four groups. Letter grades are on a 4.00 scale with 4.00 being an A. Both minus and plus grades are recorded. The use of grades as a measure of achievement introduces some bias as individual professors may grade differently. However, the use of letter grades is fairly standard in the United States, and a general understanding exists of the differences among various grades.

The mean score for the 216 students who took no prerequisite was 2.926. For the 715 students taking the quantitative business analysis prerequisite, the mean score was 2.497. For the 220 students taking the college algebra prerequisite, the mean score was 2.660. For the 88 students taking the introduction to calculus prerequisite, the mean score was 2.926. The ANOVA methodology shows a significant difference among these mean scores (F = 9.66, p-value = 0.000).

The second question for the study was, "Can the grade on the statistics course be predicted based on the grade on the prerequisite?" In order to test the relationship among the variables, simple regression analysis was employed. Although more sophisticated statistical procedures are available, simple regression analysis was considered adequate for the purpose. For the regression the grade in the business statistical applications course was the dependent variable and the grade in the prerequisite course was the independent variable. The estimated regression equation was $\hat{y} = 1.57 + 0.374X$. The explanatory variable, the grade in the prerequisite course did have the expected sign and was statistically significant (t = 11.85, p = 0.0000). The coefficient of determination was $R^2 = 0.125$.

As for the first question posed in the research, the findings support the idea that performance in the statistics course appears to be affected by the choice of prerequisites. A statistically significant difference was found among the means of the students taking each of the three prerequisites. Not surprisingly, 88 students (7.1%) who took calculus as a prerequisite had the highest average score on the statistics course. Because calculus is often considered by students to be a particularly difficult course, it seems likely that those selecting calculus as the prerequisite were those with more skill in mathematics, more confidence in their abilities, and less math anxiety than other students. At the same time, it should be noted that the mean letter grade in statistics for those with this prerequisite would be a B - (2.926 rounded to 3.0).

In addition, the 216 students (17.4%) who had no prerequisite listed, received the same grade (2.926) in the statistics class as those who took calculus. Business school advisors do not allow students into statistics without a prerequisite, so it seems likely that these particular students had taken an equivalent prerequisite at another school or had tested out of the prerequisite. Unfortunately, grades for those courses were not available. The 220 students (17.8%) who took college algebra as a prerequisite had a mean grade of 2.660, which would round to the 2.7 needed for a C+. The authors had hoped that the prerequisite specifically designed for business students would have proven the most effective in preparing students for success in the statistics course. However, the 715 students (57.7%) who took this prerequisite had the lowest mean grade of 2.494 (C). It should be noted that this does not necessarily mean that this prerequisite did not accomplish the goal. Students who elected to take this prerequisite rather than the higher-level mathematics courses may be among those with relatively low math skills who found this was the least threatening choice for them. This group could also represent those with a higher level of math anxiety. As a matter of fact, this course may have accomplished its objective, which was helping the least-prepared group of students to perform at an adequate level in the statistics course.

Other variables may create problems when grades are used as the criterion for success in either the statistics course or the prerequisite courses. Future research should use a pretest-posttest design. Students should take a test of basic mathematics skills before taking the prerequisite course. Then a similar test should be administered at the end of the prerequisite course. A final test at the end of the statistics course could be helpful in evaluating the actual skill levels of the students. This would allow an evaluation of the effectiveness of the prerequisite class both in providing

basic mathematics skills and in providing the specific skills necessary to successfully complete the statistics course. It would also eliminate the possible subjective nature of grades and the difference in grading among different faculty members.

For the second part of the research, the simple regression analysis did answer the question. The model was statistically significant even though questions may be raised regarding the specification problem. The authors are aware of this econometric problem. However the results do point to the relevance of the research, although further research would certainly address some of the other relevant questions, including how to better understand the prerequisite issue within a broader framework. The prerequisite grade variable loaded significantly into the model. A properly specified model would definitely increase the R-square. Nevertheless, the current model supports the supposition that the independent variable, grade in the prerequisite course, accounts for 12.5% of the variation in grades in the statistics course. Given the large number of variables that impact success in statistics, it seems that the prerequisite grade can help to predict success. To the authors, the R-square is reasonably high and calls for a more serious look at this question. It is safe to say that the schools now offering prerequisites to statistics should continue doing so, and those not offering them now should consider putting them in place.

When the underlying math skill is the important issue, one would expect a strong relationship between grades in any courses requiring mathematics skills and its prerequisite. While the grade in the prerequisite does have some predictive value, other variables need to be examined from the perspectives of economic and econometric theory. Future research should include analyses of variables that may be chosen from those identified by Cain (1987) and other variables such as memory retention, seriousness, and anxiety. This type of research needs to include the amount of time spent in a course, the size of the class, the background of the students such as SAT or other national test scores, high school GPA, ability of the teachers, and role of technology in learning. The time that has lapsed between the prerequisite and the statistics class could also have a major impact.

5. CONCLUSION

The findings of this paper provide some insight into the usefulness and the value of prerequisites for a subject such as business statistics. It appears that the importance of prerequisites is much more than hitherto believed. The significance of skill in statistics is not confined to the classroom but extends to the real world. Students are expected to apply their expertise with a view to making a difference in how informed decisions are made in real life. Further research should focus on how students can overcome their current knowledge deficiencies and quantitative anxieties. If students entered college with stronger math skills, fears could be replaced by enthusiasm, and challenges by opportunities. This would help them see the relevance of math and statistics to real life. Hopefully the decline in math skills of high school students can be reversed.

Secondary schools that co-operate with colleges could improve the quality of math education. These schools may have better leverage on students and may be more effective in eliminating the fear of math while the students are still young. Elementary and secondary school teachers can also give students a clear signal about the importance and relevance of math skills.

Future research should concentrate on specific skills that are needed as well as how those skills can be taught at a college level by integrating them in the course material. Emphasis should be placed on developing appropriate techniques with the potential to change the attitudes of the students towards mathematics in general and statistics in particular. As colleges examine their overall curriculum with regard to both content and delivery, new courses may be developed to inspire future students and make learning an interesting experience.

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