Selecting Prerequisite Courses for Student Admission into Undergraduate IS Programs: *A New Approach*

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Abstract

The purpose of this study was to compare the effectiveness of the correlation and effect approaches in selecting appropriate IS major prerequisites from a list of nine upper-division business core courses. Since the literature to date has focused solely on correlation, the two approaches had never previously been compared. In forming a methodology to compare the two approaches, the researchers developed two innovations: (1) an Adjusted grade point, which allowed for the control of the professor effect regardless of the statistical approach, and (2) a system of Index values, which aided in the accurate comparison of the results of the two types of statistical tests (stepwise multiple linear regressions versus independent sample means tests) utilized in this study. Conclusions that may be drawn from the study are that: (a) the design and implementation of Adjusted grade points was effective in controlling for the professor effect, (b) the design and implementation of the Index values proved to be a valid means of comparing the results of the two types of statistical tests, (c) the correlation approach is not the ideal method for choosing prerequisites, (d) the use of the effect method, and Adjusted grade points, implicated three upper-division core courses as necessary prerequisite courses for the IS major, (e) when the results of the correlation and effect methods for the IS major are compared, a different set of prerequisite classes are indicated for each approach, and (f) when the results for the IS major are compared to other majors in the college, similar results occur.

Keywords: Higher education, undergraduate, course prerequisites, program admission criteria, business administration, information systems, accounting, , finance, management, marketing, , real estate.

1. INTRODUCTION

A challenge commonly encountered in administering an academic major such as Information Systems (IS) is the selection of appropriate admission requirements. Conceptually, such requirements could be chosen on the basis of either their correlation with, or their effect upon, performance later in the major (or both).[1]

To illustrate the distinction between a *correlation* and an *effect*, consider a situation in which completion of Course 1 is being considered as a possible admission requirement for a major that includes Course 2. In this context, these two terms would be defined as follows:

- A **correlation** is a statistical relationship between performance in Course 1 and performance in Course 2. Such a relationship can be examined using traditional techniques such as correlation and regression.
- An **effect** is a statistically significant difference in the Course 2 performance between students who have and students who have not previously completed Course 1. Such a difference can be tested using an independent samples means test.

Which of these two approaches is the best for selecting admission requirements? Unfortunately, since the literature to date has focused on correlation, it appears that the question has never come up. Why is there a general lack of research on the effect approach? Upon reflection, the reason becomes clear: there is a shortage of data to implement it. The difficulty is that students are (understandably) motivated to complete their various major requirements in what appears to be a logical order, because to do otherwise could harm their performance in requirements for which they are not adequately prepared. Also, a desire to do what is best for their students would generally prevent faculty members and administrators from interfering with normal course sequences solely for the purpose of generating enough observations to fill out proper research designs.

The shortage of data to implement the effect approach is unfortunate because, in certain situations, use of the

correlation approach in selecting admission requirements could actually hurt students. For example, suppose that an IS Department Chairman wanted to choose two of eight existing upper-division business core courses as requirements for entry into the IS Major. If he used the *correlation* approach to select the courses (i.e., a stepwise multiple linear regression using some performance measure such as course grades), then he would choose the two courses that entered the equation first, say Course 4 and Course 6. If, on the other hand, he used the *effect* approach (i.e., a series of independent samples means tests), he would compare the IS performance of students who have had versus have not had each of the core courses to determine which core courses have the most significant effects on later performance. Assume that Courses 6 and 8 were selected.

What is wrong with requiring Courses 4 and 6 (determined by *correlation*) instead of Courses 6 and 8 (determined by *effect*)? The problem is that students must be obtaining important information in Course 8 (i.e., either material learned and/or a set of skills developed) that is needed for success in the IS program as a whole, but since they would focus on satisfying the admission requirement for Course 4, they would not obtain that information until later – perhaps too late to do them any good.

Due to a number of factors (e.g., the shortage of classes with empty seats and the difficulty of closely monitoring the sequence in which students take their classes), data needed for application of the combined approach do exist at California State University, Northridge. The data consist of course grades for nine upper-division business core courses and the five primary courses in the Information Systems (IS) major. The data contain a substantial amount of variety in the order that students have taken the core courses relative to the IS courses (i.e., before, concurrently with, and after). Data from five other business majors (Accounting, Finance, Management, Marketing, and Real Estate) were also examined for purpose of comparison.

The objective of this study is to compare the effectiveness of the *correlation* and *effect* approaches in selecting appropriate IS major prerequisites. The paper will proceed as follows:

- First, the literature relating to the selection of appropriate admission requirements will be reviewed. As mentioned earlier, such studies have focused on the correlation approach.
- Second, the methodology used in this study, including (a) a description of the data records included, (b) specification of the five extracted and two computed fields used (i.e., RAW grade point and an ADJUSTED grade point field that controls for differences in professor grading policy), (c) the two sets of stepwise multiple linear regressions and two sets of independent samples means tests (for raw versus adjusted grade points) to be performed, and (d) the index values and average index measures developed in this study to allow comparison of the results of the four analyses, will be outlined.
- Third, the results of the study will be presented. The section includes: (a) a detailed description of the results obtained for a major consisting of five IS courses as well as (b) a summary of the results obtained for courses in five other business majors.
- Finally, a summary of the study as well as conclusions that can be drawn will be presented.

2. REVIEW OF THE LITERATURE

The *correlation* approach (i.e., regression) has been used in countless studies to examine the relationship between earlier and later academic work. Many of these studies (e.g., Jex, 1966; Williams, 1973; Boutelle, 1975; Crooks, 1980; Chase, 1981; Eskew and Faley, 1988; Chase and Jacobs, 1989; and Georgakakos, 1990) have used pre-college performance (e.g., high school rank, high school grades, and entrance exams) to predict performance in college work (e.g., college grades and grade point averages).

The studies of particular interest here are the ones that have used earlier college level work (i.e., individual course grades, grade point averages) to predict later success in a college program. Eleven such studies will now be described. Each description identifies the predictor variables, outlines the methodology, and summarizes the overall results.

Bellico (1972) examined eighteen independent variables as possible predictors of success in an economics program. Based on a sample of 92 B.A. degree candidates, the study concluded that freshman/ sophomore GPA was the best predictor of GPA in junior and senior advanced economics courses. The next best predictor was community college attendance.

Wasik (1974) studied the relationship of prior statistics, algebra knowledge, and other miscellaneous background variables with the performance of 43 students in a statistics course. The best predictors were found to be knowledge of algebra, performance on a pre-statistics test, the academic department, type of degree, years out of school, prior statistics class, prior calculus class, and four self-concept measures.

Lowell and Gillmore (1981) compared the academic performance of 67 transfer and 229 nontransfer students. Records were reviewed to identify how the lower division GPA (which was based on 90 quarter credits) could be used to predict GPA for the upper-division junior and senior level business curriculum. The investigators discovered that nontransfer students graduated from the School of Business Administration with a significantly higher upper-division GPA and concluded that separate admission requirements should be established for the two groups.

Burdick and Schwartz (1982) found a positive relationship between several predictor variables (GPA, grade in introductory managerial accounting, community college attendance, and bookkeeping/

accounting experience) and the performance in the first intermediate accounting course. Their study used logistic regression on a sample of 230 students.

Hicks and Richardson (1984) assessed the correlation of a diagnostic examination, average grade in principles of accounting, and overall freshman/sophomore GPA with student performance in the first intermediate accounting course. Using correlation analysis, simple linear regression, and multiple linear regression in a study of 312 students, they found that all three variables helped to predict student success.

Doran, Bouillon, and Smith (1991) conducted a study to identify criteria for admission to an accounting program based on exam data from Accounting Principles I and II data (i.e., two 75-minute in-class multiple choice exams and one 120-minute multiple choice exam). There were 552 Principles I students and 434 Principles II students. A significant amount of demographic data collected from the students (i.e., gender, academic performance and aptitude, college major, high school bookkeeping, credit hours, work hours, and study hours) was also examined. The results showed that the single most important predictor of later accounting principles performance was the score on the first course exam.

Norton and Reding (1992) used a sample of 367 students to measure the relationship of three predictor variables (i.e., ACT score, GPA in tools courses, and an admission qualifying examination) with the average grade achieved in two sets of accounting courses (i.e., three courses versus seven courses). The results showed that it is easier to predict average performance for the seven courses than for the smaller set of three.

Bassin and Sellner (1992) created a model to predict success in a Bachelor of Science in Business Administration program (BSBA). The model combined traditional pre-college measures (i.e., SAT scores and high school ranks) with college course grades for 343 nontransfer students in selected BSBA and Arts and Science courses. The model accounted for 75.1% of the variation in lower-division business core course performance.

Danko, Duke and Franz (1992) developed a two-stage predictive model for predicting student success in intermediate accounting. The first stage used regression analysis for 892 cases to determine that two variables, GPA to date and the score on an internally generated diagnostic examination, were most highly correlated with the Intermediate I course grade. The second stage used discriminant analysis to determine that first the GPA, and then the diagnostic examination, should be used to limit enrollment.

Pharr, Bailey, and Dangerfield (1993) examined the relationships between ACT/SAT scores, sophomore GPA, and GPA in lower level business courses (i.e., financial and managerial accounting, micro- and macro-economics, and basic statistics) and performance in upper level business and university courses. Using linear regression and a sample of 483 students, it was found that these predictor variables had a significant effect on performance, with ACT/SAT a much weaker predictor.

Borde (1998) examined the influence that GPA as well as various student characteristics (i.e., gender, academic origin, extracurricular activities, and employment) have upon overall course grade earned in an introductory marketing course, based on a questionnaire completed by 349 students. The results indicated that GPA is clearly the most important predictor of introductory marketing course performance.

3. METHOD

The methodology used in this study will now be described. The description is presented in four parts: (1) the data records included, (2) the five extracted and two computed data fields used, (3) the statistical analyses performed, and (4) the index values and the index averages computed.

Data Records Included

The data used in this study were selected from a large database of grade information for the 10-year period from Spring, 1990 through Winter, 2000. From this database, records were extracted for all of the IS students who had completed the following combination of courses:

- **ALL** of the nine upper-division business core courses [i.e., Managerial Accounting (*Mgrl Acct*), Business Law II (*Bus Law*), Economic Price Theory (*Price Theory*), Money, Income, and International Economics (*Money & Intl*), Financial Management (*Fin Mgmt*), Management and Organizational Behavior (*Mgmt & OB*), Information Systems (*IS*), Marketing Management (*Mktg*), and Decision Support Models & Methods (*Dec Supp*)], AND
- **AT LEAST ONE** of the five IS major courses [i.e., Systems Analysis & Design (*SA&D*), Database Management (*DB*), Data Communications & Networking (*Comm*), Systems Development Project (*Project*), and Accounting Information Systems (*AIS*)].

As mentioned earlier, similar data for students from five other business majors (Accounting, Finance, Management, Marketing, and Real Estate) were also extracted from the database for purposes of analysis and comparison.

Data Fields Used

Each extracted grade record included five types of information: (a) the term number (**TERMNUM**), (b) the course number (**COURSENUM**), (c) a code identifying the professor who taught the particular section of the course (**PROFESSORID**), (d) the student's ID number (**STUDENTID**), and (e) the letter grade ($\mathbf{LETTERGRADE_{TCPS}}$) assigned to student **S** by professor **P** for course **C** taken in term **T**. Two calculated variables were also added to each record: $\mathbf{RAW_{TCPS}}$ and $\mathbf{ADJUSTED_{TCS}}$.

The first calculated variable, $\mathbf{RAW_{TCPS}}$, represents the typical conversion of a letter grade to a number from 0 to 4 (i.e., A = 4.0, A- = 3.7, B+ = 3.3, ..., F = 0.0). The second calculated variable, $\mathbf{ADJUSTED_{TCS}}$ (which is also on a 0 to 4 scale), adjusts $\mathbf{RAW_{TCPS}}$ to control for differences among the grading policies of the various professors teaching a particular course. The next two sections describe the two-step procedure employed to calculate the $\mathbf{ADJUSTED_{TCS}}$ variable first in somewhat general, and then in more specific, terms.

a. $\mathbf{ADJUSTED_{TCS}}$ in General Terms. In Step #1 of the procedure, the performance of student **S** in term **T** is positioned among all students who have ever taken course **C** from professor **P** by converting $\mathbf{RAW_{TCPS}}$ to $\mathbf{STANDARD_{TCPS}}$. $\mathbf{STANDARD_{TCPS}}$ is a value between - ∞ and + ∞ on a standardized normal distribution (i.e., a normal distribution with a mean of 0 and a standard deviation of 1). Then in Step #2, the performance of student **S** is compared against the performance of all students who have taken course **C** from any professor by converting $\mathbf{STANDARD_{TCPS}}$ to $\mathbf{ADJUSTED_{TCS}}$. $\mathbf{ADJUSTED_{TCS}}$, like $\mathbf{RAW_{TCPS}}$, is a grade point that is measured on a 0 to 4 scale.

b. $\mathbf{ADJUSTED_{TCS}}$ in More Specific Terms. A specific example should help to illustrate the procedure. The example will show how a student's original raw grade point of 3.0 ("B") in his Systems Analysis course first gets converted to a standardized normal value of .65625, and then to an adjusted grade point of 3.24 among all students who have taken Systems Analysis. The formulas and computations are as follows:

Step #1. The standardized normal grade ($\mathbf{STANDARD_{TCPS}}$) positions the performance of student **S** in term **T** among all students who have taken course **C** from professor **P**. The general equation is:

$$\mathbf{STANDARD_{TCPS}} = (\mathbf{RAW_{TCPS}} - X_{CP}) / S_{CP} \qquad \textit{(Eq. 1)}$$

where:

$STANDARD_{TCPS}$ = Grade points received by student **S** from professor **P** in course **C** during term **T**, converted to a value on a standardized normal distribution (i.e., $\mu=0$, $\sigma=1$).

RAW_{TCPS} = Grade points received by student **S** from professor **P** in course **C** during term **T**, stated on a 0 to 4 scale (i.e., A = 4.0, A- = 3.7, B+ = 3.3, … , F = 0.0).

X_{CP} = Mean grade point for all students who have taken course **C** from professor **P**.

S_{CP} = Standard deviation of the grade point for all students who have taken course **C** from professor **P**.

The student who received a raw grade point of 3.0 in his Systems Analysis course would thus have a standardized normal grade of .65625 ((3.0 – 2.37) /.96), under the assumption that his professor had a long-run mean and standard deviation for the Systems Analysis course of 2.37 and .96, respectively. As mentioned earlier, standardized normal grades are normally distributed with a mean of 0 and a standard deviation of 1. Since .65625 is greater than 0, this student is assumed to be above average for all of the students who have taken Systems Analysis from this professor.

Step #2. The adjusted grade point ($\mathbf{ADJUSTED_{TCS}}$) compares the performance of student **S** against the performance of all students who have taken course **C** from any professor by converting $\mathbf{STANDARD_{TCPS}}$ to a grade point on a 0 to 4 scale. The general equation is:

$$\mathbf{ADJUSTED_{TCS}} = X_C + S_C \cdot \mathbf{STANDARD_{TCPS}} \qquad \textit{(Eq. 2)}$$

where:

$ADJUSTED_{TCS}$ = Performance of student **S** in term **T** compared against all students who have taken course **C**, stated as a value on a 0 to 4 scale.

$STANDARD_{TCPS}$ (As defined in Equation 1.)

X_C = Mean grade point for all students who have taken course **C** from any professor.

S_C = Standard deviation of the grade point for all students who have taken course **C** from any professor.

To continue the example, the student's adjusted grade point for his Systems Analysis course would be 3.24, (2.64 + .91 (.65625)), assuming that the long-run mean and standard deviation for the Systems Analysis course (without regard to professor) was 2.64 and .91, respectively. In this case, the student's adjusted grade point of 3.24 is higher than his raw grade point of 3.0. This is due to the fact that his Systems Analysis professor is a somewhat "tougher" grader (i.e., mean of 2.37) than Systems Analysis professors at large (i.e., mean of 2.64).

Statistical Analyses Performed

A series of four statistical analyses will be conducted: two sets of stepwise multiple linear regressions and two sets of independent samples means tests.

Regressions. The two sets of regressions were based on the $\mathbf{RAW_{TCPS}}$ and $\mathbf{ADJUSTED_{TCS}}$ grade points described earlier. The null hypothesis (H_0) and model used in each regression set are shown below in Table 1.[2]

Table 1
Null Hypotheses and Models Used in Regressions

	RAW	**ADJUSTED**
H_0:	Students' raw grade points in upper-division business core courses are not related to their raw grade point in a particular course in their major.	Students' adjusted grade points in upper-division business core courses are not related to their adjusted grade point in a particular course in their major.
Models:	$\mathbf{RAW_{TMPS}} = \beta_0 + \Sigma(\beta_U \mathbf{RAW_{TUPS}}) + \varepsilon$ *(Eq. 3)*	$\mathbf{ADJUSTED_{TMS}} = \beta_0 + \Sigma(\beta_U \mathbf{ADJUSTED_{TUS}}) + \varepsilon$ *(Eq. 4)*
	where:	*where:*
	RAW_{TMPS} = Grade points received by student **S** from professor **P** in major course **M** during term **T**.	$ADJUSTED_{TMS}$ = Grade points received by student **S** in term **T** compared against all students who have taken major course **M**.
	RAW_{TUPS} = Grade points received by student **S** from professor **P** in upper-division business course **U** during term **T**.	$ADJUSTED_{TUS}$ = Grade points received by student **S** in term **T** compared against all students who have taken upper-division business course **U**.
	β_0 = Intercept term	
	β_U = Coefficient for upper-division business course **U**.	
	ε = Error term	

Independent Samples Means Tests. The two sets of independent samples means tests will also be based on the $\mathbf{RAW_{TCPS}}$ and $\mathbf{ADJUSTED_{TCS}}$ grade points variables. The hypothesis and model used in each set are presented in Table 2.

Table 2
Hypotheses and Models Used in Independent Samples Means Tests

	RAW	**ADJUSTED**
H_0:	The mean raw grade point for students who take a particular upper-division business core course **U** before a particular major course is less than the mean raw grade point for students who take the core course either concurrently or after the major course.	The mean adjusted grade point for students who take a particular upper-division business core course **U** before a particular major course is less than the mean adjusted grade point for students who take the core course either concurrently or after the major course.
Models:	$\frac{\Sigma_B \mathbf{RAW_{TMPS}}}{n_B} \leq \frac{\Sigma_A \mathbf{RAW_{TMPS}}}{n_A}$ *(Eq. 5)*	$\frac{\Sigma_B \mathbf{ADJUSTED_{TMS}}}{n_B} \leq \frac{\Sigma_A \mathbf{ADJUSTED_{TMS}}}{n_A}$ *(Eq. 6)*
	where:	*where:*
	RAW_{TMPS} = Grade points received by student **S** from professor **P** in major course **M** during term **T**.	$ADJUSTED_{TMS}$ = Grade points received by student **S** in term **T** compared against all students who have taken major course **M**.
	n_B = The number of students who take a particular upper-division business core course **U** before a particular major course **M**.	
	n_A = The number of students who take a particular upper-division business core course **U** either concurrently or after a particular major course **M**.	

Index Values and Index Averages Computed

In order to compare the results of the four statistical analyses just described, an average index value was developed to measure each upper-division business core course **U**'s correlation with, or overall effect upon, the major courses taken as a group. The two-step procedure used to calculate this average index value is now described.

Step 1. The first step is to compute an index for each core course/major course combination. The exact procedure used will differ slightly for the regression versus independent means test results, as shown below:

Index for Regression Results. An index value will be computed for each core/major course combination in both the **RAW** and **ADJUSTED** regression sets. Each value, denoted $\mathbf{INDEX_{UM}}$, will be computed using the formula:

$$\mathbf{INDEX_{UM}} = 100 \cdot ((n + 1) - \mathbf{STEP_{UM}}) / n \qquad \textit{(Eq. 7)}$$

where:

$INDEX_{UM}$ = A measure of the importance of performance in upper-division core course **U** in the prediction of performance in major course **M**.

n = The number of upper-division core courses used as independent variables in the stepwise multiple linear regression.

$STEP_{UM}$ = The step at which upper-division core course **U** enters the equation used to predict major course **M**.

For example, if one of four core courses entered the regression equation for a particular option course at step 2, then the $\mathbf{INDEX_{UM}}$ for that core course would be 75, calculated as 100((4+1)-2)/4.

Index for Independent Samples Means Tests Results. An index value will also be computed for each core/major course combination in both the **RAW** and **ADJUSTED** independent samples means tests. Each value, $\mathbf{INDEX_{UM}}$, will be computed as:

$$\mathbf{INDEX_{UM}} = 100 \cdot (1.1 - 20 \cdot \alpha_{UM}) \qquad \textit{(Eq. 8)}$$

where:

$INDEX_{UM}$ = A measure of the strength of the effect of upper-division core course **U** on major course **M**.

α_{UM} = The significance level, if any, for the independent means t-test (i.e., .05, .025, .01, or .005) comparing performance in major course **M** when taken before versus after upper-division core course **U**.

For example, if an independent samples means test comparing performance in Systems Analysis taken both before and after Financial Management found a significant difference at α=.01, then the $\mathbf{INDEX_{UM}}$ for the Financial Management/Systems Analysis combination would be 90, calculated as 100(1.1 – 20(.01)).

Step 2. The second step is to compute an average index for each upper-division core course based on the individual index values computed in Step 1. The procedure used will be the same for both the regression and the independent samples means test indexes, as shown below:

$$\mathbf{AVG\_INDEX_U} = \frac{\Sigma \mathbf{INDEX_{UM}}}{n} \qquad \textit{(Eq. 9)}$$

where:

AVG_INDEX_U = The mean of $\mathbf{INDEX_{UM}}$ for all courses in major **M**.

$INDEX_{UM}$ = A measure computed for either regressions or independent means tests, as shown in Step 1.

n = The number of courses in the major **M** of interest.

The average index for a particular core course is the mean of the indexes for each of the major courses.

4. RESULTS

In interpreting the results presented in this section, it will be assumed that the goal will be to select three of the nine upper-division business core courses to be prerequisites for the major of interest. This number was chosen because it is both (a) large enough to allow a calculation of an average grade to be used as a screening device prior to entry into the major and (b) small enough to be completed in the first Semester of the Junior year so the remaining three Semesters could be used for completion of the courses in the major as well as the other core courses.

The results of this study will be presented in five parts: (1) the data records and data fields used, (2) the findings of the stepwise regressions done for the IS major, (3) the

findings of the independent samples means tests performed for the IS major, (4) comparisons of the four sets of average indexes calculated for the IS major, and (5) a comparison of the IS results to the results from five other business majors.

Data Records and Data Fields Used

The data extracted from the aforementioned grade database included approximately the following numbers of records from each of the six majors examined in this study: Information Systems, 408; Accounting, 827; Finance, 1534; Management, 739; Marketing, 665, and Real Estate, 704. As described earlier, each extracted record included five original fields (**TERMNUM**, **COURSENUM**, **PROFESSORID**, **STUDENTID**, and **LETTERGRADE$_{TCPS}$**); and two calculated fields (**RAW$_{TCPS}$** and **ADJUSTED$_{TCP}$**) were added for purposes of this study.[3]

Stepwise Multiple Linear Regressions

The results of using the regression model given in Equation 3 to regress the raw grade points for each of the five IS major courses (i.e., **RAW$_{TMPS}$**) on the raw grade points for the set of nine upper-division core courses (i.e., **RAW$_{TUPS}$**) are summarized in Table 3a.

Table 3a
Results of Stepwise Regressions for Each of Five IS Major Courses
on Nine Upper-Division Core Courses
[RAW_{TMPS} on RAW_{TUPS} *(Eq. 3)*]

MAJOR COURSES	n	UPPER DIVISION CORE COURSES									ADJ. R-SQ'D	SIG. LEVEL
		Mgrl Acct	Bus Law	Price Theory	Money & Intl	Fin Mgmt	Mgmt & OB	IS	Mktg	Dec Supp		
SA&D	442	4	3				1	2			0.199	0.000
DB	444	1		4	2	5		3			0.351	0.000
Comm	355	3	4		1			2	6	5	0.406	0.000
Project	380	2			4	3					0.134	0.000
AIS	418	5	2		4			1		3	0.374	0.000

The various columns of Table 3a contain the following information:

- **Major Courses**: The five primary required courses in the IS option.
- **n**: The number of observations included in each of the five stepwise multiple linear regressions performed.
- **Upper Division Core Courses**: The step at which each of the nine core courses entered the equation (at $\alpha \leq .05$). Note that only one core course, Managerial Accounting (Mgrl Acct), entered into the equation for all of the five courses in the IS major.
- **Adjusted R-Squared**: The overall adjusted r-squared values for the each of the five final equations.
- **Significance Level**: The overall significance level for each equation.

As shown previously in Equations 7 and 9, formulas for an index value (**INDEX$_{UM}$**) and then an average index (**AVG_INDEX$_{U}$**) were developed in this paper to allow for synthesis of complex stepwise regression results into a single average index for each core course that measures the importance of that course to the major of interest. The results of applying these formulas to the numbers given in Table 3a are presented in Table 3b.

Table 3b
Index Values and Average Indexes
for Stepwise Regressions of Five IS Major Courses
on Nine Upper-Division Core Courses
[$INDEX_{UM}$ ***(Eq. 7)*** **and** AVG_INDEX_{U} ***(Eq. 9)*****]**

MAJOR COURSES	n	UPPER DIVISION CORE COURSES									ADJ. R-SQ'D	SIG. LEVEL
		Mgrl Acct	Bus Law	Price Theory	Money & Intl	Fin Mgmt	Mgmt & OB	IS	Mktg	Dec Supp		
SA&D	442	67	78				100	89			0.199	0.000
DB	444	100		67	89	56		78			0.351	0.000
Comm	355	78	67		100			89	44	56	0.406	0.000
Project	380	89			67	78					0.134	0.000
AIS	418	56	89		67			100		78	0.374	0.000
Average Index		78	47	13	64	27	20	71	9	27		

Table 3b can be interpreted as follows:

- **Index Values** (The integers shown in the body of the table): A measure of the importance of a particular core course to the prediction of a specific IS major course. As described earlier, the index is on a scale from 0 to 100.
- **Average Indexes** (The integers shown at the bottom of the table): The mean of the index values for one particular core course and all of the IS major courses.

The higher this number, the greater the likelihood that a core course is a good predictor of success for all of the IS major courses. As indicated by the shaded cells on the bottom row, the core courses that appear to be the best predictors of success in the IS major courses are (1) Managerial Accounting (Mgrl Acct), (2) Information Systems (IS), and (3) Money,

- Income, and International Economics (Money & Intl).

Table 4 shows the final results of performing the same set of analyses done in Tables 3a and 3b on the second set of grade point data used in this study, adjusted grade points.

Table 4
Index Values and Average Indexes
for Stepwise Regressions of Five IS Major Courses on Nine Upper-Division Core Courses
[$ADJUSTED_{TMPS}$ on $ADJUSTED_{TUPS}$ (*Eq. 4*), $INDEX_{UM}$ *(Eq. 7),* and AVG_INDEX_{U} *(Eq. 9)*]

MAJOR COURSES	n	UPPER DIVISION CORE COURSES									ADJ. R-SQ'D	SIG. LEVEL
		Mgrl Acct	Bus Law	Price Theory	Money & Intl	Fin Mgmt	Mgmt & OB	IS	Mktg	Dec Supp		
SA&D	442	67	89				100	78			0.197	0.000
DB	444	100		78	67		56	89			0.356	0.000
Comm	355	78	67		100			89		56	0.420	0.000
Project	380	89			56	67		100	78		0.122	0.000
AIS	418	89	78		44		56	100		67	0.420	0.000
Average Index		84	47	16	53	13	42	91	16	24		

The results contained in Table 4 can be interpreted as follows:

- **Index Values:** After controlling for differences in professor grading policy through the use of adjusted grades, the predictive ability of the IS core course improves from being a predictor for four to all five of the IS Major courses. (Compare the IS column in Tables 3b with the IS column in Table 4.)
- **Average Indexes:** Although the same three courses emerge as the top three predictors, the order of importance has changed: the IS core course has moved from the second position (71) to the first position (91). (Compare the three shaded cells in the bottom rows of Table 3b and 4.)

Independent Samples Means Tests

The results of testing the null hypothesis given in Equation 5 (i.e., the mean raw grade point is lower for students who take the core course before the option course than for those who take it after the option course) for each of the 45 combinations of five IS major courses and nine upper-division core courses are presented in Table 5a.

Table 5a
Results of 45 Independent Samples Means Tests
Comparing Raw Grade Points
of Students who Take a Particular Upper-Division Core Course
Before versus After a Particular IS Major Course
[Mean of RAW_{TMPS} *(Eq. 5)*]

MAJOR COURSES	n	UPPER DIVISION CORE COURSES *											
		Mgrl Acct			Price Theory			Money & Intl			IS		
		Mean After	Mean Before	Sig. Level	Mean After	Mean Before	Sig. Level	Mean After	Mean Before	Sig. Level	Mean After	Mean Before	Sig. Level
SA&D	442							2.32 (45)	2.65 (397)	0.025			
DB	444	2.71 (171)	2.88 (273)	0.025	2.60 (50)	2.84 (394)	0.05	2.55 (31)	2.82 (413)	0.05	2.04 (8)	2.83 (436)	0.025
Comm	355				2.04 (24)	2.66 (331)	0.005	1.93 (12)	2.64 (343)	0.01			
Project	380												
AIS	418				1.81 (45)	2.41 (374)	0.005	1.82 (23)	2.38 (396)	0.025	1.71 (9)	2.36 (410)	0.025

* Only the four courses with significant results are shown.

Table 5a contains the following information:

- **Major Courses**: The five primary required courses in the IS option.
- **n**: The total number of students who have taken all nine of the upper-division core courses as well as the

particular IS major course listed in the **Major Course** column.

- **Upper Division Core Courses-Mean After**: The mean raw grade point in the IS major course for students who take the particular upper-division core course either concurrently with or after the particular IS major course. (The number of student grades used to compute the mean is shown in parenthesis.)
- **Upper Division Core Courses-Mean Before:** The mean raw grade point in the IS major course for students who take the particular upper-division core course before the particular IS major course.
- **Significance Level:** The significance level of the independent means test (based on a table of *t* values). Only statistically significant results ($\alpha \leq .05$) are shown. If a result is reported, then completion of the particular upper-division core course did have an *effect* (as defined earlier in the paper) on performance in the particular IS major course.

To aid in interpreting the large number of results given in Table 5b, the next step was to use Equations 8 and 9 to compute index values (**$INDEX_{UM}$**) and average indexes (**AVG_INDEX_{UM}**) for each of the core courses. The results are shown in Table 5b.

Table 5b
Index Values and Average Indexes
for Independent Samples Means Tests
[Mean of RAW_{TMPS} *(Eq. 5)*, $INDEX_{UM}$ *(Eq. 8),* and AVG_INDEX_{U} *(Eq. 9)*]

MAJOR COURSES	n	UPPER DIVISION CORE COURSES *											
		Mgrl Acct			Price Theory			Money & Intl			IS		
		Mean After	Mean Before	Index	Mean After	Mean Before	Index	Mean After	Mean Before	Index	Mean After	Mean Before	Index
SA&D	442							2.32 (45)	2.65 (397)	60			
DB	444	2.71 (171)	2.88 (273)	60	2.60 (50)	2.84 (394)	10	2.55 (31)	2.82 (413)	10	2.04 (8)	2.83 (436)	60
Comm	355				2.04 (24)	2.66 (331)	100	1.93 (12)	2.64 (343)	90			
Project	380												
AIS	418				1.81 (45)	2.41 (374)	100	1.82 (23)	2.38 (396)	60	1.71 (9)	2.36 (410)	60
Average Index				12			42			44			24

* Only the four courses with significant results are shown.

Table 5b is the same as Table 5a, except for (a) the substitution of index values in the significance levels columns and (b) the addition of an average index row. These new numbers can be interpreted as follows:

- **Index Values**: These values (computed using Equation 8) measure the strength of the effect of a given core course on a particular IS major course. Similar to the regression index values, these values are also on a scale of 0 to 100.
- **Average Indexes:** These means (computed using Equation 9) indicate that the following courses appear to have content that is important for student success in the IS Major courses: (1) Money, Income, and International Economics, (2) Economic Price Theory, and (3) Information Systems.

Table 6 shows the final results of performing the same set of analyses done in Tables 5a and 5b using adjusted grade points.

Table 6
Index Values and Average Indexes
for Independent Samples Means Tests
[Mean of $ADJUSTED_{TMPS}$ *(Eq. 6)*, $INDEX_{UM}$ *(Eq. 8),* and AVG_INDEX_{U} *(Eq. 9)*]

MAJOR COURSES	n	UPPER DIVISION CORE COURSES *								
		Price Theory			Money & Intl			IS		
		Mean After	Mean Before	Index	Mean After	Mean Before	Index	Mean After	Mean Before	Index
SA&D	442				2.35 (45)	2.67 (397)	60			
DB	444	2.61 (50)	2.84 (394)	10				2.10 (8)	2.83 (436)	60
Comm	355	2.03 (24)	2.65 (331)	90	1.91 (12)	2.63 (343)	90			
Project	380									
AIS	418	1.91 (45)	2.45 (374)	90	1.89 (23)	2.42 (396)	60	1.84 (9)	2.40 (410)	10
Avgerage Index				38			42			14

* Only the three courses with significant results are shown.

In examining the results contained in Table 6, please note the following:

- **Index Values:** The number of significant results using adjusted grade points (8) is lower than the number of results when raw grade points are used in the analysis (10). Also, of the eight course combinations that remained significant, the significance level either stayed the same or decreased.
- **Average Indexes:** The order of the three core courses that appear to have content that is important for success in the IS Major courses (i.e., Money, Income, and International Economics, Price Theory, and Information Systems) did not change. All three values did, however, decrease.

Comparison 1: Average Indexes for IS Major

To facilitate a comparison of the correlation and effect approaches (using both raw and adjusted grades), the average indexes computed as a result of the four sets of statistical tests just described (i.e., in Tables 3b, 4, 5b, and 6) are presented in Table 7.

Table 7
Average Indexes for IS Major

MAJOR	AVERAGE INDEX	UPPER DIVISION CORE COURSES *								
		Mgrl Acct	Bus Law	Price Theory	Money & Intl	Fin Mgmt	Mgmt & OB	IS	Mktg	Dec Supp
MIS	REGR-R	78	47	13	64	27	20	71	9	27
	REGR-A	84	47	16	53	13	42	91	16	24
	TTEST-R	12		42	44			24		
	TTEST-A			***38***	***42***			***14***		

* The shaded values represent the top three core courses, which would be chosen as prerequisites in the IS major.

Three pairwise comparisons of the rows in Table 7 are of particular interest:

- **REGR-R versus REGR-A:** When differences in professor grading policy were controlled for through the use of adjusted grade points, the order of the core courses changed (i.e., the Managerial Accounting and Information Systems courses traded their first and second places). Although this change did not alter the course set selected, there was the potential for it to do so (e.g., if only one course, instead of three, was to be used as a prerequisite). Such a change in results between the two methods shows the importance of controlling for professor grading policy.
- **TTEST-R versus TTEST-A:** Similarly, a comparison of the two sets of independent means tests shows a decrease in the average indexes for each of the three core courses when adjusted grade points are used. Here too, adjustment of the grade points appears to have been important.
- **REGR-A versus TTEST-A:** This is the most important comparison: it examines the results of the *correlation* approach with the results of the *effect* approach using grades points that have been adjusted to remove the effect of individual professors' grading policies. As can be seen from rows 2 and 4 of Table 7, these results are quite different. In the *correlation* approach, (1) Information Systems, (2) Money, Income, & International Economics, and (3) Managerial Accounting would be selected as the prerequisites. In the *effect* approach, the choices would have been (1) Money, Income, & International Economics, (2) Economic Price Theory, and (3) Information Systems. This is a big shift. The course that was #2 in the *correlation* approach (Managerial Accounting) didn't show up at all in the top 3 in the *effect* approach. Also, a course that tied for #7 in *correlation* (Economic Price Theory) ended up as #2 in the *effect* approach.

Therefore, the resulting set of prerequisite courses from REGR-A and TTEST-A would indeed be different.

Comparison 2: Average Indexes for IS Major Compared with Other Majors

To see whether the findings for the IS Major hold true for other majors, all of the regressions, independent means tests, and index average computations (just described for IS) were also completed for the five other majors in the College that had a large number of students: Accounting, Finance, Management, Marketing, and Real Estate. The final results and average indexes for each discipline, are shown in Table 8.

Table 8
Average Indexes for IS and Five Other Majors

MAJOR	AVERAGE INDEX	UPPER DIVISION CORE COURSES								
		Mgrl Acct	Bus Law	Price Theory	Money & Intl	Fin Mgmt	Mgmt & OB	IS	Mktg	Dec Supp
MIS	REGR-R	78	47	13	64	27	20	71	9	27
	REGR-A	84	47	16	53	13	42	91	16	24
	TTEST-R	12		42	44			24		
	TTEST-A			***38***	***42***			***14***		
ACCT	REGR-R	76	41	23	30	61	23	60	17	44
	REGR-A	78	31	26	29	70	22	56	19	42
	TTEST-R	10	10	1				6		
	TTEST-A	***1***	***10***	***1***				***6***		
FIN	REGR-R	93		56	70	48	11	67	30	81
	REGR-A	100		70	41	33	19	74	26	81
	TTEST-R		33	100	67	100	3	37		87
	TTEST-A		***33***	***100***	***67***	***100***	***7***	***3***		***87***
MGT	REGR-R		72		89		50	89	33	
	REGR-A	28	67		89		89	89	50	
	TTEST-R	50		45				55		5
	TTEST-A			***30***	***5***			***45***		
MKT	REGR-R	28	42	17	19	19	81	81	53	56
	REGR-A	50	39	17	11		58	86	81	50
	TTEST-R	15	28	75	55	23	3	48	63	80
	TTEST-A	***23***	***25***	***90***	***63***	***25***	***3***	***55***	***65***	***98***
RE	REGR-R	100	53	22	64	8	56	78	11	58
	REGR-A	100	61	11	56	11	8	81	44	61
	TTEST-R	70	50	90	68	3	70	53		90
	TTEST-A	***43***	***50***	***80***	***68***	***5***	***63***	***45***		***90***

* The shaded values represent the top three core courses, which would be chosen as prerequisites.

The same three pairwise comparisons done for the IS major in Table 3 reveal the following when applied to the five other majors listed in Table 8.

- **REGR-R versus REGR-A:** Use of adjusted grades instead of raw grades in regression had a more dramatic effect in these five majors than it had in IS. In IS it only changed the order of the three selected classes, in four of the other five majors, it changed one of the set of three courses to a completely different course.
- **TTEST-R versus TTEST-A:** Similarly, using adjusted grades in the independent means tests also changed the results for the other majors. In IS, the selected courses did not change, but all the indexes did decrease. For two of the five majors one of the three courses changed. The average indexes were not, however, necessarily lower for the adjusted grade points than they were for the raw grade points.
- **REGR-A versus TTEST-A**: The results here were dramatic and consistent with those found in the IS case. A different set of courses was selected using the correlation approach than would be chosen by using the effect approach for ALL of the five majors. In two of the majors (i.e., Accounting and Management), the lists of core course prerequisites would differ by one course; in the other three majors (i.e., Finance, Marketing, and Real Estate), the lists would differ by TWO courses.

Since the results are similar for all six majors, it appears that the results for the IS major are sound and the approach utilized in this study is valid.

5. SUMMARY AND CONCLUSIONS

The purpose of the current study was to compare the usefulness of the *correlation* and *effect* approaches for the task of selecting appropriate IS major prerequisites. Although numerous studies using the correlation approach were found in the literature, none were found to have used the effect approach for this purpose.

During the process of developing the methodology for the current study, the investigators developed and implemented two innovations: (1) a method of controlling for the professor effect (through the use of adjusted grade point) and (2) a way of comparing the four sets of statistical tests to be conducted (through the use of index values and average indexes).

After extracting the data from the database, calculating the raw and adjusted grade point variables, running the regressions, conducting the t-tests, computing the average indexes, and doing the various comparisons in this study, a number of conclusions were reached:

1. The use of adjusted grade points seems to be a helpful way of controlling for professor grading policy.
2. The use of both index values and average indexes is of substantial help in comparing the results of regression and independent means tests.
3. Despite its extensive use in the literature, the *correlation* approach does not appear to be the ideal one for selecting prerequisite courses for admission into an academic major.
4. The *effect* method seems to be superior to the *correlation* method because it results in the selection of prerequisite courses that a student either needs for (a) the specific material covered in those courses, and/or (b) the actual experience of taking those courses, to be successful in the IS major.
5. The results of this study (based on the *effect* approach) indicate that the required prerequisites for the IS major should be: (1) Money, Income, & International Economics, (2) Economic Price Theory, and (3) Information Systems.
6. When the results of the two approaches (*correlation* versus *effect*) for the IS major are compared to the results of five other majors (Accounting, Finance, Management, Marketing, and Real Estate), the approach used in this study appears to be a sound one.
7. Although the effect method may not be easily utilized at other institutions to determine whether existing prerequisite courses are valid, the investigators believe this method would be highly useful in determining a set of new prerequisites for any given major.
8. The investigators would recommend that any future prerequisite studies which utilize the effect method should attempt to control for the following: (a) student ability level (such as the use of a student's lower-division GPA or transfer GPA), and (b) demographic variables in the after versus before groups (e.g., gender, ethnicity, marital status, and age).

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[1] The term *major*, as used in this paper, refers to an academic major, option, or program.

[2] Note that the course subscript **C** used up until this point in this paper has been modified beginning with its use in Table 1. It has now been split into two separate subscripts: **M** to designate courses in the *major* and **U** to designate *upper*-division core courses. These new subscripts are used in the variables $\mathbf{RAW_{TMPS}}$, $\mathbf{RAW_{TUPS}}$, $\mathbf{ADJUSTED_{TMS}}$, and $\mathbf{ADJUSTED_{TUS}}$.

[3] The formulas used to compute $\mathbf{ADJUSTED_{TCP}}$ are given in Equations 1 and 2.