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THE EFFECTIVENESS OF CONCEPT MAPPING AS A TEACHING TOOL: EVIDENCE FROM COURSES IN APPLIED ECONOMICS

Applied economics courses are taught using a variety of teaching methodologies. For example, some instructors use the traditional lecture approach to present material, while others prefer to use student discussions as a vehicle for covering course material. Still other instructors encourage their students to learn economics using computer based teaching devices. The purpose of the research reported here is to compare two different teaching methodologies to determine if one form of presentation is superior to the other when used in two different undergraduate applied economics course. A secondary objective is to identify the significant factors that affect student performance on problem-solving examination questions.

Instructors experimenting with various methods of presentation may find themselves at a loss about how to measure the effectiveness of a new strategy. Usually the only viable alternative is an ad hoc analysis, in which the teacher solicits reactions from students. This paper presents a practical example of how a strategy can be tested in a systematic manner rather than relying on anecdotal evidence. A valuable aspect of this research is that the evaluation of the teaching method is placed in the context of many other factors which affect student performance. Thus, beyond the specific results pertaining to the particular teaching method, the general design and implementation of this research should be of interest to any instructor evaluating changes in teaching techniques.

The first form of instruction we used is the traditional lecture in which information is presented in a sequential manner, using overheads which contain an outline of the main points. The second form of instruction is lecturing with the use of instructor designed concept maps, a technique designed to spatially link concepts. Concept maps are a tool designed to help the student "learn how to learn" (Novak and

Gowin, 1984). Maps are constructed by linking concepts (main ideas) with connecting words (propositions) which identify the relationships between two concepts. For example, a concept such as "interest rate" would be linked to another concept such as "inflation" by the connecting phrase "is influenced by." Since concept maps explicitly convey the relationships between main ideas in a content area, we hypothesized that students taught economic principles using concept maps would be better able to solve applied economics problems than students who were taught the same principles in a sequential manner.

The literature on teaching methodologies in the field of economics does not include studies with a specific focus on concept mapping. Related work, however, includes Park and Kerr's (1990) study of the determinants of academic performance, and Bosshardt and Watts (1990) research on instructor effects in precollege economics courses. Other relevant literature includes Caudill and Gropper's (1991) examination of the impact of test structures, human capital and student performance on exams; and Dahlgran's (1990) comparisons of innovative and traditional instructional techniques in teaching agricultural economics. A unique contribution of our paper is it looks specifically at concept mapping in the context of economics.

The majority of research on concept mapping has been in the area of science education and has focused on the effects of students drawing maps as a learning strategy. To our knowledge, no controlled studies have been conducted on the effects of using a concept map designed by the teacher as a presentation strategy in class. Perhaps the most closely related study is Rewey et. al. (1989) in which knowledge maps, a tool similar to concept maps, were provided by the instructor to a portion of the class for use in studying for an exam. Those students with the maps showed a superior performance on a test of content recall.

Other studies on concept mapping have concentrated on the use of concept maps drawn by students. Most of these studies demonstrate students benefit from learning and

using concept maps. For example, Mitchell and Taylor (1991) show that subjects who draw concept maps to reflect a text passage demonstrate a greater level of comprehension than control subjects who study the same material without using concept maps. Jegede et. al.'s (1990) study suggests that subjects who learn concept mapping and practice its application perform better than subjects who study in their usual manner. Furthermore, their study indicates that subjects who use concept maps to study have significantly lower anxiety than subjects who use their usual study strategy. In contrast to the studies showing that concept maps are useful for students, Heinze-Fry and Novak (1990) found no significant difference between one group of subjects using concept mapping and another group not using the tool on a test of initial recall, retention and learning efficiency following self-paced instruction in a biology course.

Still other studies focus specifically on the effect of concept maps or other teaching techniques on the ability of students to solve problems. In her study of college students studying physical therapy, Beissner (1992) shows that subjects who draw concept maps as a study strategy score higher on problem-solving tests than subjects who use their usual strategy to study. Grieve (1992) compares three teaching formats to evaluate their effect on problem solving in a physiology class. The relative effects on problem-solving ability of cooperative groups versus independent practice were compared by Duren and Cherrington (1992).

To summarize, part of the literature focuses on various teaching methodologies in teaching economics, another part examines concept mapping as it applies to student practices, and yet another explores the impact of teaching techniques on problem-solving. Our study seeks to contribute a new perspective by examining whether concepts maps designed by the instructor and used in lecture can enhance the performance of students on problem-solving exercises.

METHODOLOGY

Our experiment took place during the 1992 fall semester in the Department of Agricultural Economics at Cornell University. The undergraduate program in this department focuses on Applied Economics and Business Management where the majority of the students are interested in business management and marketing. Students in two courses, 1) Price Analysis and 2) Information Systems and Decision Analysis, were asked to participate in a teaching methodology experiment. The enrollment in these courses consist of primarily seniors. A few graduate students, juniors and sophomores comprise the remainder of students. The fifty-five students in Information Systems and Decision Analysis and the eighty-one students in Price Analysis who agreed to participate in the study, were asked to provide information regarding their family background, academic achievement, parental education level, parental income level, demographic characteristics and previous coursework in economics. Students were given the Kolb Learning Style Inventory (LSI), a diagnostic tool, since the learning method a student uses can impact their course performance[1].

To test the relative effectiveness of the two methodologies, each instructor presented the same material in two different class sessions. One session used the traditional sequential lecture format. The second session used concept mapping. Students in each course were divided randomly into two groups, assigned to a specific class session, and asked not to attend the other session. Professor Willett, who had little experience with concept maps, presented the theory of industrial organization in Price Analysis. Professor Streeter used her maps to present information on decision making models in Information Systems and Decision Analysis. She has been a user of concept maps for six years, but had no previous experience presenting her own maps as an integral part of a classroom lecture. Each session was videotaped, viewed by the authors

[1]The LSI consists of twelve items designed to measure how students generally approach learning tasks. Based on these items learners are classified as divergers, convergers, assimilators, or accommodators.

and an instructional support expert to determine similarity of content and presentation style. For both instructors, it was concluded that the sessions were similar in quality and content, even though the lecture style differed for each session.

Immediately following each lecture, the students were given a short (15 minute) exam to determine their ability to apply information from the lecture to an economic problem. Material from the lectures was also included in a subsequent preliminary exam and the final exam in each course to test for longer-term effects of the teaching methodologies. Scores on those preliminary and final exam questions related to the lecture material were included in analyses. Each exam question required the students to use the concepts presented in class to solve a problem. To answer the exam questions correctly the student not only had to recall the concepts, but also needed to understand the interrelationships among ideas and apply them in a new context. The questions were asked at different intervals to provide perspective on whether problem-solving ability immediately after the lecture would differ from success at solving problems later in the term, when the students would have time to absorb and study the material presented. The results of the short term test represent the 'purest' effects of the teaching strategy. By contrast, the tests taken later in the term would allow for study techniques and conversations with faculty and/or other students to influence the outcome.

Each exam question was graded blindly, by the course instructor, using a ten (10) point scale. Another economist checked for grading inconsistencies, and none were found.

It was hypothesized that five categories of variables would influence student scores: method of presentation, endowed human capital, accumulated human capital, socioeconomic conditions, and student motivation. The presentation method could impact the student's score if one style has a comparative advantage in clarifying the use of concepts in problem solving. Endowed human capital might influence the innate problem-solving skills of the student, while human capital accumulated through

education might enhance the ability of the student to apply newly learned concepts to problem-solving situations. Socioeconomic variables were included to reflect the potential impact of a student's background on his/her test performance. Motivation could influence performance because a highly motivated student is likely to exert more effort in a testing situation. Proxy variables for each of the five categories, along with a priori expectations, are discussed below.

A binary variable (LEC) was used to capture the traditional lecture presented in a sequential format and the lecture using concept mapping. A zero was used to indicate the student attended the traditional lecture and one indicated the student attended the lecture using concept maps.

Endowed human capital is often measured with mathematics and verbal Scholastic Aptitude Test (SAT) scores. A positive relationship between SAT scores and the performance on the three exam questions is hypothesized to exist. Each individual's math and verbal SAT scores (SATM and SATV) were included in the analysis.

Endowed human capital was also measured by the Learning Style Inventory (LSI) (Kolb) to assess the way an individual learns and how he/she deals with ideas. The twelve-question inventory asks the student to rank the endings of the sentences according to how he/she would go about learning. Scores on the exam are used to classify students as divergers, convergers, assimilators, or accommodators. Each category provides information about an individual's involvement in learning, listening ability, creation of ideas and decision making methods. A diverger is one who finds practical uses for ideas and theories. This individual is best at evaluating concrete situations from many different points of view. The assimilator is best at understanding and organizing a wide range of information. This individual is less concerned about people and more interested in concepts. The converger prefers technical tasks rather than dealing with social issues and is solution-oriented when approaching problems. The accommodator prefers to learn from active experience, and enjoys carrying out the plans and becoming involved in new

experiences. Learning style was included in the analysis as a categorical variable with 1 = diverger, 2 = assimilator, 3 = converger, and 4 = accommodator. No hypotheses were made with respect to how this variable would affect exam performance, as there is no theory to support such *a priori* judgements.

Accumulated human capital was measured with five variables. Two of these measures captured the student's high school experience. We assumed the larger the high school graduating class, (HSS) the more access students had to special learning situations, including problem-solving opportunities. Hence, we hypothesied that these students were able to acquire more human capital and should perform better on the problem-solving exam questions. This variable includes seven categories where a 1 refers to a graduating class of less than 50 students and a 7 refers to a class of 1,000 students or more. We also hypothesized that type of high school (HST) may affect an individual's accumulated human capital and hence their performance on the three exam questions. This variable was specified such that 1 = public high school, 2 = private, non church-affiliated high school and 3 = private, church-affiliated high school. It was hypothesized that students who attended private schools received a higher quality education and hence would perform better on the questions than students who attended public schools.

The number of subjects in which an individual received advanced placement (AP) credit prior to college enrollment was also used as a proxy for accumulated human capital. We hypothesized that the more courses for which a student received credit, the higher the grade on any given exam question.

An individual's grade point average (GPA) in college was also used as a measure for accumulated human capital. We assumed the higher the grade point average the more knowledge a student has acquired from his/her undergraduate education. We hypothesized a positive relationship between a student's grade point average and his/her achievement on any given exam question.

The final measure of accumulated human capital dealt directly with the material covered in the course lecture. Students were asked if they had completed or were currently enrolled in related courses. We hypothesized that the number of related courses (COURSE) taken by students would be positively related to the performance on the problem-solving exam question.

Several socioeconomic factors were included in the analysis to determine if background influences the student's achievement on the problem-solving exam questions. The variables included were sex (SEX), race (RACE), education level of the mother (EDM), the family income level (INC), and if English was the student's native language (ENGS). Each variable will be discussed.

Student's sex was included as a categorical variable where 1 represented female and 2 represented male. The students were asked to categorize themselves as one of six races. These categories were: 1 = Caucasian, 2 = African American, 3 = Hispanic, 4 = Asian, 5 = Native American, and 6 = Other. No hypotheses were made regarding the relationship between the students' sex or race and the exam performance.

The education level of the mother was used as a proxy for the importance of education in the individuals' family. Since the mother typically is the predominant nurturer in the household, and due to high correlations between a mother's education level and father's education level, a variable for father's education level was omitted. Mother's education level is a categorical variable with eight responses where 1 represents less than high school education and 8 represents a doctoral degree. We hypothesized the higher the mother's education the better the performance on the problem-solving exam questions.

Family income was included in the analysis as a categorical variable. The eight categories ranged from income below $15,000 to income of $200,000 and over. Students were also allowed to indicate if they had no knowledge of their parent's income. No hypothesis was made with respect to household income and performance on the exams.

The final variable included to measure a student's socioeconomic background

identified if English was his/her native language. A response of 1 indicated that English was the native language. A response of 2 indicated that English was not the individual's native language. We hypothesized that a negative relationship would exist between the student's response to this question and their score on the exam questions.

The final factor included that might influence the exam performance is the student's motivation. We hypothesized that a student with higher motivation would perform better on the exam questions. The first motivation variable measures the highest degree the student plans to obtain(EDS). This categorical variable, ranges from 1 to 6, where 1 refers to a bachelor's degree, 2 refers to a master's degree, and 3 through 6 refer to higher educational degrees such as Ph.D., M.D., J.D., etc. A positive relationship was hypothesized. The second motivation variable measures the reason for a student taking the course (CREA). Eight responses were provided to the students and the student could identify an additional response.

Given the inclusion of variables to measure the lecture presentation, endowed human capital, accumulated human capital, socioeconomic conditions and student motivation the following relationship was specified:

$$(1) \quad GRADE_i = f(LEC_i, SATM_i, SATV_i, LSI_i, HSS_i, HST_i, AP_i, GPA_i, COURSE_i, SEX_i, RACE_i, EDM_i, INC_i, ENGS_i, EDS_i, CREA_i, m_i)$$

A similar equation was estimated for each of the exams given. The dependent variable (GRADE) measures the performance on each exam question. The grades on the exam question immediately following the lecture (SHORT), the preliminary exam question given two weeks after the lecture (PRELIM), and the final exam question given at the end of the semester (FINAL) are measured on a scale of zero to ten.

EMPIRICAL RESULTS

There were sixty-one usable responses from the eighty-one students in Price Analysis who agreed to participate in the study. Twenty responses were not usable

because these students did not give complete information. Thirty-two of these students attended the lecture in which the material was presented using concept maps. The remaining twenty-nine students attended the lecture in which the material was presented in a sequential manner.

There were thirty-seven usable responses from the fifty-five students in Information Systems and Decision Analysis who agreed to participate in the study. Eighteen responses were not usable because these students did not give complete information. Twenty of these students attended the lecture where the material was presented using concept maps. The remaining seventeen students attended the lecture where the material was presented in a sequential manner.

The relationship specified in equation (1) was regressed using each of the three dependent variables for each class. Because the dependent variables (SHORT, PRELIM, and FINAL) are restricted to a [0,10] interval, a censored regression technique is more appropriate than ordinary least squares for equation estimation. In this application, a two-limit tobit censored regression model was used (Maddala, p. 161) that has the following form:

$$(2) \qquad \text{RESPONSE}_i = \begin{cases} L_i, \text{ if } X_i\beta + \varepsilon_i \le L_i \\ X_i\beta + \varepsilon_i, \text{ if } L_i \le X_i\beta + \varepsilon_i \le U_i \\ U_i, \text{if } X_i\beta + \varepsilon_i \ge U_i \end{cases}$$

where L_i and U_i represent lower and upper limits of the dependent variable for observation i respectively, X_i is a matrix of independent variables, b is a vector of coefficients for the independent variables, and e_i is a vector of error terms. The software package LIMDEP was used to estimate the two-limit tobit equations (Greene). This package uses the Newton maximum-likelihood estimation method.

The results of the two-limit tobit regression models for Price Analysis and Information Systems and Decision are presented in Tables 1 and 2. A summary of the results, showing the sign and level of significance for each variable, are presented in

Table 3.

Several of the hypotheses stated above are supported by the data and the model, while others are not. The teaching methodology (LEC) was not statistically significant in determining a student's performance on any of the three exam questions in Price Analysis. However, the teaching methodology was statistically significant and positive in determining the preliminary exam grade in Information Systems. Thus, a student who attended the concept map lecture would have done better on the problem-solving preliminary exam in the Information Systems course. This result is not supported by the results of the equation in which the dependent variable is the final exam grade in Information Systems. Although not significant at the $\alpha = .05$ level, the empirical results suggest that the student who attended the traditional lecture would perform better on the final exam problem-solving question. Hence, the way material is presented did not affect an individual's ability to apply the economic concepts to a problem in Price Analysis and the results are inconclusive in the Information Systems course. The failure of concept maps to emerge as an important factor in student performance differs from previous research (Beissner, Rewey et. al., and Mitchell and Taylor). One possible explanation is that in our study concept maps were used in a single lecture rather than for the duration of a course. Furthermore, our results might differ because the students did not use the concept maps as an active study strategy. Rather, in this study the students viewed the concept maps in a presentation of the material.

Measures of endowed human capital - SAT scores (SATM, SATV) and the Learning Style Inventory (LSI) - did significantly affect a student's performance on the preliminary and final exam questions in both courses. However, the achievement on the short term exams was not influenced by these factors. The coefficients on SAT scores in the preliminary exam and final exam equations in Price Analysis were negative, suggesting that as an individual's SAT score increases, his/her score on the Price Analysis exams would decrease. The significant coefficients on SAT scores in the Information

Systems estimation are mixed. In the preliminary exam equation, the results suggest that as an individual's math SAT score increases, his/her score on the exam would increase. If an individual's verbal SAT score increases, his/her score on the preliminary exam would decrease. While some of these results are contrary to our hypothesis, they do support many people's concern about using the Scholastic Aptitude Test as a measure of an individual's academic potential.

The interpretation of the coefficients for the Learning Style Inventory are positive and significant in the preliminary exam and final exam equations for the Price Analysis course. According to these results, accommodators and convergers did better on the exams than divergers and assimilators. The coefficients are not significant in the equations for the Information Systems course.

Results for all of the equations suggest that some factors measuring accumulated human capital (HSS, HST, AP, GPA, COURSE) affect a student's performance on the exams. The size of an individual's high school graduating class (HSS) was statistically significant in predicting the performance on the short term exam in each course and the final exam in the Informaion Systems course. The type of high school (HST) did not affect a student's performance on any of the three exam questions in the Price Analysis course. Yet, it did significantly affect the student's performance on the preliminary and final exam questions in Information Systems. The number of courses for which a student received advanced placement credit (AP) was statistically significant and positive only in the Price Analysis preliminary exam equation. The grade point average (GPA) was consistently significant and positive in all three regressions in the Price Analysis course. Hence, the student with a higher grade point average is likely to do better on any of the three exam questions than a student with a low GPA. However, it was not statistically significant in the Information Systems course. While this result is not surprising, it does suggest that an individual's grade point average is a key measure in predicting a student's performance on problem-solving exam questions in Price Analysis. The number of

related courses was a better predictor of success in the Information Systems course than in the Price Analysis course.

The results of the six regression equations suggest that several socioeconomic conditions do not influence an individual's performance on an exam. Of the five socioeconomic factors (SEX, RACE, EDM, INC, ENGS) included in the regressions, sex (SEX) was the only significant socioeconomic variable in the short-term exam regression in the Price Analysis course. Females did significantly better than males on the short-term exam. This result suggests that females may respond better than males under short-term pressure situations or that females learn and listen better during class, while males rely on learning after lecture. In the preliminary exam regression of the Price Analysis course, the only socioeconomic variable that significantly affected a student's performance on the exam was the education of a student's mother (EDM). This factor was also significant in determining the final exam grade of the course. In the final exam regression, race (RACE) was another significant factor in determining the grade on the final exam question. This result suggests that students other than Caucasians performed better on the final exam question.

In Information Systems, race (RACE) was a statistically significant determinant of the grade on the short term and preliminary exam questions. English as a second language (EDS) was a significant determinant of the grade on the short term exam. No socioeconomic variables affected the score on the final exam question.

The motivation factors included in the regressions (EDS and CREA) were not significant determinants of the grade on any of the three exam questions in Price Analysis. The motivation variables were statistically significant in determining the score on the short term quiz and the preliminary exam in Information Systems. Results suggest that an increase in the desired education of the student (EDS) led to a decrease in the student's score. One might conclude that an individual's motivation may not influence their performance on exams. However, the measures we included for motivation -

desired education level and response for reasons to take the course - may not have captured a student's true motivation for study of Price Analysis and Information Systems.

SUMMARY AND IMPLICATIONS

This paper compared two different teaching methodologies to determine if one form of teaching is superior to the other when used in two different applied economics courses. For each class the same material was presented in two different class sessions. One session used the traditional lecture format where information was presented in a sequential manner. The second methodology used concept mapping, where concepts were linked spatially. Grades on problem-solving questions from three exams, a short-term exam, a preliminary exam and a final exam, were used to evaluate student's performance. Variables measuring endowed human capital, accumulated human capital, socioeconomic conditions and motivation factors were included in the analysis. Data were obtained from sixty-one students in a Price Analysis course and thirty-one students in an Information Systems and Decision Analysis course taught at Cornell University during the Fall 1992 semester.

This study provides useful results in two ways. First, it provides specific evidence on concept mapping techniques as compared to traditional presentation styles. Second, the study serves as a prototype for instructors interested in testing various classroom strategies in a systematic manner.

The specific results of the two-limit tobit regression models suggest that the teaching methodology was not a significant determinant of a student's performance on the three exam questions in Price Analysis. Results from the Information Systems course lead to conflicting conclusions. Hence, the way material is presented, either in a sequential format or through the use of concept maps, may not affect an individual's ability to apply the economic concepts to a problem. Together with the conclusions reached in previous work, the results of this study help define an appropriate role for

concept mapping. Concept maps seem most useful in a setting where students are involved in their construction and use. Those instructors interested in such techniques might focus their energies on more "hands-on" applications of concept mapping.

Several factors were identified as significant predictors of performance on problem-solving exam questions. Student performance on the short term exam questions was significantly affected by the size of his/her high school class, grade point average in college, sex, race, english as a native language and desired education level. An individual's performance on the preliminary exam questions was significantly influenced by his/her score on the SAT exam, learning method, type of high school, the number of courses for which he/she received advanced placement credit, undergraduate grade point average, number of related courses, race, mother's education, and reason for taking the course. An individual's performance on the final exam question was significantly influenced by his/her score on the SAT exam, learning method, high school type and size, undergraduate grade point average, number of related courses, race, and mother's education.

In conclusion, the results of the regressions suggest that a student's grade point average is a key indicator of his/her performance on problem-solving exam questions in Price Analysis. An individual's Scholastic Aptitude Test scores are negatively related to and significant determinants of his/her performance on Price Analysis problem-solving questions. High school type and size appear to be important factors in determining a student's performance on problem-solving questions in Information Systems. Student's who were not Caucasion did worse on the short term and prelim exam in Information Systems. Furthermore, our results are not definitive about the impact of the teaching methodology used by an instructor on the student's ability to apply economic concepts to a problem when that teaching methodology is used in an isolated lecture. These results may change if the teaching methodology was used throughout a course or the methodology was used by the student as a study strategy.

Table 1
Two-Limit Tobit Regression Results for the Teaching Methodology Equations for Price Analysis

Variable	Short-Term Exam (SHORT)		Preliminary Exam (PRELIM)		Final Exam (FINAL)	
	Tobit Coefficient	Asymptotic t-Value	Tobit Coefficient	Asymptotic t-Value	Tobit Coefficient	Asymptotic t-Value
CONSTANT	-0.703	-0.230	3.878	0.720	7.084	0.860
LEC	-0.559	-1.385	-0.0150	-0.021	-0.609	-0.576
ENDOWED HUMAN CAPITAL						
SATM	-0.000442	-0.150	-0.0107	-1.924	-0.0216	-2.330
SATV	0.00360	1.278	-0.00870	-1.560	-0.0143	-1.655
LSI	0.132	0.471	1.599	2.916	2.258	2.848
ACCUMULATED HUMAN CAPITAL						
HSS	0.358	2.162	0.126	0.417	-0.0626	-0.136
HST	0.596	1.517	0.159	0.227	0.876	0.746
AP	-0.321	-1.506	0.834	1.970	0.385	0.622
GPA	1.209	2.108	3.185	2.905	3.669	2.217
COURSE	0.0597	0.291	-0.0217	-0.059	-0.0544	-0.094
SOCIOECONOMIC CONDITIONS						
SEX	-1.298	-2.797	-0.237	-0.274	0.122	0.101
RACE	-0.111	-0.355	0.984	1.603	2.535	2.001
EDM	-0.165	-1.301	0.413	1.666	1.304	3.382
INC	-0.0803	-0.845	-0.0918	-0.536	-0.173	-0.687
ENGS	-0.516	-0.508	-0.620	-0.307	-1.739	-0.504
STUDENT MOTIVATION						
EDS	0.153	0.910	-0.240	-0.774	-0.282	-0.624
CREA	0.0905	0.873	0.0798	0.438	0.371	1.147
Sigma	1.398	10.774	2.270	7.684	2.819	6.122
Log likelihood	-105.329		-112.239		-114.556	
Observations	61		61		61	

Table 2
Two-Limit Tobit Regression Results for the Teaching Methodology Equations for Information Systems and Decision Analysis

Variable	Short-Term Exam (SHORT)		Preliminary Exam (PRELIM)		Final Exam (FINAL)	
	Tobit Coefficient	Asymptotic t-Value	Tobit Coefficient	Asymptotic t-Value	Tobit Coefficient	Asymptotic t-Value
CONSTANT	2.675	0.816	-2.670	-0.584	-18.793	-1.401
LEC	0.421	0.705	1.575	1.940	-3.696	-1.544
ENDOWED HUMAN CAPITAL						
SATM	-0.00424	-0.779	0.216	3.121	0.0102	0.565
SATV	0.00482	0.894	-0.0218	-3.165	-0.00920	-0.524
LSI	-0.544	-1.297	0.566	1.039	-0.622	-0.451
ACCUMULATED HUMAN CAPITAL						
HSS	1.179	3.693	0.528	0.128	2.015	1.724
HST	1.000	1.247	2.829	2.391	4.720	1.765
AP	-0.0604	-0.185	0.313	0.676	0.486	0.376
GPA	0.329	0.418	1.367	1.365	3.466	1.398
COURSE	0.220	0.328	1.378	1.706	5.327	2.110
SOCIOECONOMIC CONDITIONS						
SEX	-0.0894	-0.128	-1.433	-1.534	3.644	1.357
RACE	-1.547	-2.306	-2.135	-2.277	-0.820	-0.364
EDM	-0.212	-1.005	-0.359	-1.237	0.126	0.165
INC	-0.200	-1.431	0.00294	0.978	0.00127	0.180
ENGS	3.035	2.362	2.972	1.589	-0.285	-0.061
STUDENT MOTIVATION						
EDS	-0.804	-2.278	0.731	1.572	-1.550	-1.283
CREA	0.00143	0.00204	0.00576	2.114	0.00695	1.039
Sigma	1.443	8.117	1.953	8.010	4.275	5.348
Log likelihood	-63.241		-71.398		-63.533	
Observations	37		37		37	

Table 3
Summary of Results for the
Teaching Methodology Equations

Variable	Price Analysis			Information Systems and Decision Analysis		
	Short-Term (SHORT)	Preliminary (PRELIM)	Final (FINAL)	Short-Term (SHORT)	Preliminary (PRELIM)	Final (FINAL)
CONSTANT	-	+	+	+	-	-
LEC	-	-	-	+	+ *	-
ENDOWED HUMAN CAPITAL						
SATM	-	- *	- *	-	+ *	+
SATV	+	-	- *	+	- *	-
LSI	+	+ *	+ *	-	+	-
ACCUMULATED HUMAN CAPITAL						
HSS	+ *	+	-	+ *	-	+ *
HST	+	+	+	+	+ *	+ *
AP	-	+ *	+	-	+	+
GPA	+ *	+ *	+ *	+	+	+
COURSE	+	-	-	+	+ *	+ *
SOCIOECONOMIC CONDITIONS						
SEX	- *	-	+	-	-	+
RACE	-	+	+ *	- *	- *	-
EDM	-	+ *	+ *	-	-	+
INC	-	-	-	-	+	+
ENGS	-	-	-	+ *	+	-
STUDENT MOTIVATION						
EDS	+	-	-	- *	+	-
CREA	+	+	+	+	+ *	+

* Indicates significance at the $\alpha = .05$ level.

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