Effectiveness of Inductive and Deductive Teaching Methods in Learning Agricultural Economics: A Case Study[1]

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Abstract

The effects of inductive and deductive teaching method, students' cognitive and affective characteristics and learning style on students' performance are measured. Performance is measured by the scores on tests based on trade concepts and exercises in an introductory course in agricultural economics. Results suggest that inductive teaching increases students' performance and that learning is enhanced if inductive teaching is done prior to presenting general theories.

Introduction

Students have different intellectual capabilities and learning styles that favor or hinder knowledge accumulation. As a result, instructors are interested in ways to effectively cause students to better understand and learn. Instructors want to bring about a better understanding of the material he or she wants to communicate. The consequences of ineffective teaching are important. If college students do not have a good understanding of what they are taught, once they graduate and start working, they may be less efficient at the work place. Litzenberg et al (1983) investigated ways academic and professional programs can match the employers' needs by incorporating conceptual thinking and problem-solving capabilities that departs from traditional classroom approaches into curricula. From the students' perspective, time spent in ineffective learning environments is costly and frustrating. Felder and Silverman (1988) outline some of the negative consequences and suggest that the frustration can be partially responsible for students changing majors and/or dropping out of school.

Education produces its payoff to individuals or to society in the future. Some studies look at the salary returns (Broder and Deprey, 1988), or the social returns of education (Link and Rutledge, 1975). When students learn more, the overall future returns of education at both the private and social levels are higher. It is the responsibility of the educational institutions and instructors to seek more effective ways of teaching in order to meet individuals' and society's expectations from education. Improving teaching methods may help an institution meet its goal of achieving improved learning outcomes.

Teaching methods can either be inductive or deductive or some combination of the two. The inductive teaching method process goes from the specific to the general and may be based on specific experiments or experiential learning exercises. Deductive teaching methods progress from the general concept to the specific use or application. For example, to teach inductively, Bergstrom and Miller (1999) suggest that you send students to a market with the willing capacity to pay $25 for a bushel of apples. If they are able to buy apples for $20, they have experienced a consumer surplus of $5. Then we sum the individual surpluses experienced in the market to estimate the aggregate consumer surplus in the market, the more general concept (Bergstrom and Miller, 1999). To explain the same concept deductively, you might draw theoretical supply and demand curves and assert that above the equilibrium price, there are consumers willing to pay more than the equilibrium price for the good and the sum of the differences between the equilibrium price and the prices on the demand curve represent aggregate consumer surplus.

The choice of a teaching method may impact positively on the quality of knowledge accumulation. Quality, in this context, refers to matching of what a professor is trying to transfer to his or her students and what these students learn from the professor's class. Failures occur when students maintain preconceived and incorrect beliefs about the subject matter taught, or when misunderstandings or misconceptions are created by the instruction. A teaching method can be considered effective if it reduces the number of misunderstandings or misconceptions.

This case study is designed to evaluate two methods of teaching agricultural economics to undergraduate students at Oklahoma State University. At the national level, our results are an observation in a comprehensive analysis of instructional strategies and their effectiveness in teaching students economic concepts (Bonwell, 1999).

The objectives of this case study included:

1. To determine the relative effectiveness (as

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measured by students' test scores) of inductive and deductive teaching methods of teaching trade theory concepts in an introductory agricultural economics class (AG ECON 1114) at Oklahoma State University, along with consideration of the students' cognitive, affective, and learning style characteristics.

2. To determine whether the order in which students are exposed to the two teaching methods influences the effectiveness of the two methods.

Previous Work and Theoretical Background

Bloom et al. (1971) recommend that experiences in the laboratory or in the field be used in the learning process to better meet educational objectives. Although Thielens has found that lecturing occupies 80 percent of the class time in college classes (Thielens, 1987), both inductive and deductive methods have been used in several fields of studies: economics, language, sociology, training science, calculus, philosophy, literature, social education, education, chemistry, business, anthropology, management, biology, and physics (Yeany, 1995; Tanner, 1975; Strassenburg, 1977; Spindler and Spindler, 1990; Seliger, 1975; Newton, 1973; Neubert and Binko, 1991; and Klauer, 1996). Bartlett and King (1990) suggest there is a general reluctance among economists to teach economics as a laboratory science.

Numerous books and articles have been written to explain a wide range of ways economists can use alternative methods (other than chalk and talk) in various types of undergraduate courses (Becker and Watts, 1998; Bergstrom and Miller, 1999; Keenan and Maier, 1995; Porter and Riley, 1995; Holt, 1995; Ruffle, 2003; Giraud et al., 2002). In spite of the increased apparent interest in teaching Becker and Watts (p. 269, 2001) conclude that "the teaching methods in these courses have changed very little over the past five years and are still dominated by 'chalk and talk' classroom presentations."

Nixon-Ponder (1995) suggests that posing problems is a tool for developing and strengthening critical thinking skills. According to Nixon-Ponder, inductive questioning leads to dialog in the classroom. This process has five steps including describing the content, defining the problem, personalizing it, discussing it, and discussing alternatives.

Clarke (1989) has argued that teachers can use the inductive method to show how theories are formed in the social sciences. He has explained how students can practice inductive thinking, analyze information, or organize information gathering in a research project. Cova et al., (1993) described how the European School of Management developed a curriculum based on inductive pedagogy. Its five major foci are case study method, "memoir," company placements, lectures, and language learning.

Our theoretical foundation is a model of school learning proposed by Benjamin Bloom and presented by Keefe (1987) and by Anderson and Sosniak (1994). According to Keefe, the learning theory is based on three important elements: student characteristics, instruction, and learning outcomes. There are three sets of variables that account for the greatest degree of variance in student learning:

1. Cognitive entry behaviors, the extent to which the student has already learned the basic prerequisites to the learning to be undertaken;

2. Affective entry characteristics, the extent to which the student is or can be motivated to engage in the learning process; and

3. Quality of instruction, the extent to which the instruction to be provided is appropriate to the learner.

Student's learning style has been considered as an important factor in knowledge accumulation. Felder (1993) suggests four learning style dimensions: 1) active/reflective, 2) sensing/intuitive, 3) visual/verbal, and 4) sequential/global. Moreover, Felder (1993) asserts that instructors tend to impose their own learning style on the students or to teach the way they were taught. By so doing, they disregard students' own learning style preferences.

For the purpose of this study, Bloom's model has been modified to include learning style as defined by Felder (1993), Felder and Silverman (1988) and Soloman and Felder (2004). The modified Bloom learning model is schematically presented in Figure 1, where learning outcomes are represented as level

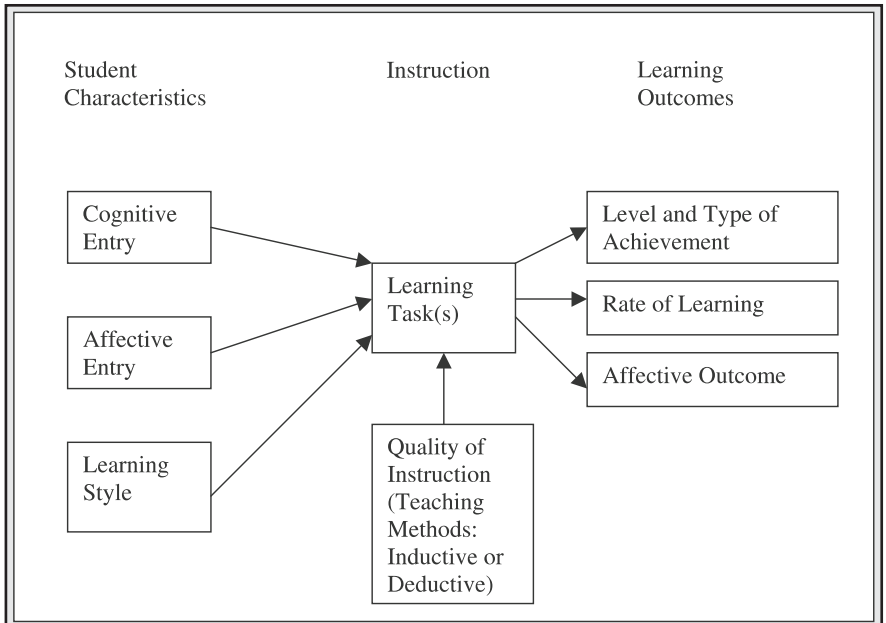

Figure 1. Modified Learning Model

and type of achievement, rate of learning, and affective outcomes.

The hypotheses are derived directly from Figure 1. We hypothesize that student's test performance in learning trade concepts and solving trade-based exercises is related to the teaching method (inductive or experiment, deductive or lecture, or a combination of the two), the student's cognitive and affective characteristics, and the student's learning style.

Definition of the concepts in the hypotheses

The modified model in Figure 1 describes learning primarily from an instructional standpoint and considers students' personal characteristics. In this study, the professor's teaching methods (inductive and deductive) represent the quality of instruction.

A student's personal characteristics are cognitive, affective, and include learning style. The cognitive characteristics are represented by the student's pretest score, his or her previous background in mathematics and economics, his or her GPA and ACT test scores, his or her major (Ag Econ or Animal Science or other). A student's affective characteristics are represented by his or her preconceived opinion about economics, which is measured by his or her response to the following statement: " economics is a boring subject" which was measured on a seven point scale (one is strongly disagree and 7 is strongly agree)

Students' learning styles are represented by four variables, one for each of four dimensions defined as 1) active/reflective 2) sensing/intuitive 3) visual/verbal 4) sequential/global. Each dimension is represented by a variable calculated from the response to 11 of the 44 questions in the index of learning style questionnaire (Soloman and Felder, 2004). Each question allows two answers: a or b. The first four questions are:

1. I understand something better after I
   (a) try it out.
   (b) think it through.
2. I would rather be considered
   (a) realistic.
   (b) innovative.
3. When I think about what I did yesterday, I am most likely to get
   (a) a picture.
   (b) words.
4. I tend to
   (a) understand details of a subject but may be fuzzy about its overall structure.
   (b) understand the overall structure but may be fuzzy about details.

Students are more active learners if they answer a to question 1, more reflective learners if they answer b. A value of 1 is assigned to indicate active and a value of 1 is assigned to indicate reflective. If a student answered a to the 11 questions designed to measure active or reflective, they would have a value of +11 as their active/reflective index. If they answered b to the 11 questions designed to measure active or reflective, they would have a value of 11 as their active/reflective index. Questions 2, 3, and 4 are the first questions for the sensing/intuitive, visual/verbal and sequential/global indices, respectively. The 44 item questionnaire yields one independent variable for each of the four dimensions of learning style that can range from -11 to +11. A positive number between 0 and 11 indicates more active, sensing, visual, or sequential. A negative number between 0 and -11 suggests reflective, intuitive, verbal or global. All of the above variables are hypothesized to explain a student's test scores and a student's subjective learning assessment about the two teaching methods.

Students' test score measures the level of achievement on concept-based questions and problem-solving questions that were parts of one pretest. The pretest/test questions were drawn from trade questions proposed by Bergstrom and Miller (1999) and from the authors' experience in teaching trade. The questions in the concept part of the test were multiple-choice questions that tested definitions and understanding of basic concepts. Concepts emphasized in the tests were opportunity cost, production possibilities curve, and comparative advantage. In the problem solving section, students were given production possibility curves for two regions and asked to determine the likely direction of trade if any and the comparative advantage that each country or region has.

Both the inductive and the deductive teaching methods focused on comparative advantage, free trade, gains from trade, free trade winners and losers, individual, national, and international production possibility curves. The deductive teaching method used lectures on the three-panel trade diagram, comparative advantage and production possibility frontiers. The inductive method used Exercise 11 in Bergstom and Miller (1999), where students had to make production and trade decisions in order to maximize output. In the exercise, students are assigned to either Richland or Poorland, two parts of a remote island. Richlanders enjoy higher productivity for both bread and fish production but students discover that Poorland has a comparative advantage and that people in both countries may be better off with trade (Bergstrom and Miller, 1999).

All questionnaires and examinations used to collect information on the independent and dependent variables are available from the authors.

Experimental Design

Figure 2 shows the experimental design. Prior to covering international trade in class, all students were given a pretest on trade and completed questionnaires describing their cognitive and affective characteristics. Trade topics were not covered prior

to the pretest. The pretest and all subsequent tests included sections that tested knowledge of concepts and the ability to solve problems. Tests following the pretest were similar to the pretest. In order to minimize the memorization effect, none of the tests were returned to the students.

To implement the deductive and inductive methods, students from the Agricultural Economics 1114 class were randomly assigned to two groups (A and B) with the same number of students in each group. Each group was subdivided into two subgroups to ease the implementation of the experiment, given that there were 182 students in the class. Figure 2 shows the different steps of the experiment. First, students were pre-tested and asked to fill out a general information questionnaire. Second, the students were assigned to groups A and B. Third, the inductive session was given to only group A during two consecutive days (one day for each of the two subgroups in A). Fourth, a test (test 1) was given to all the students in the class. At this point in the process, students in group A have participated in the experiments and students in group B have not and this test was essentially a repeat of a pretest for group B. Fifth, lectures of the deductive session took place and were addressed to the whole class. Sixth, another test (test 2) was given to the whole class, after the deductive lecture session. At this point, group A students have participated in the experiments and heard lectures while group B students have only heard the lectures. Seventh, students in group B were exposed to the inductive session in two consecutive days (one day for each of the two subgroups in B). After step seven, all students have heard the lectures and participated in the experiments. Group A did the experiments and then heard the lectures. Group B heard the lectures and then did the experiments. Eighth, a final test (test 3) was given to the whole class. Finally, ninth, an ex-post evaluation survey was conducted.

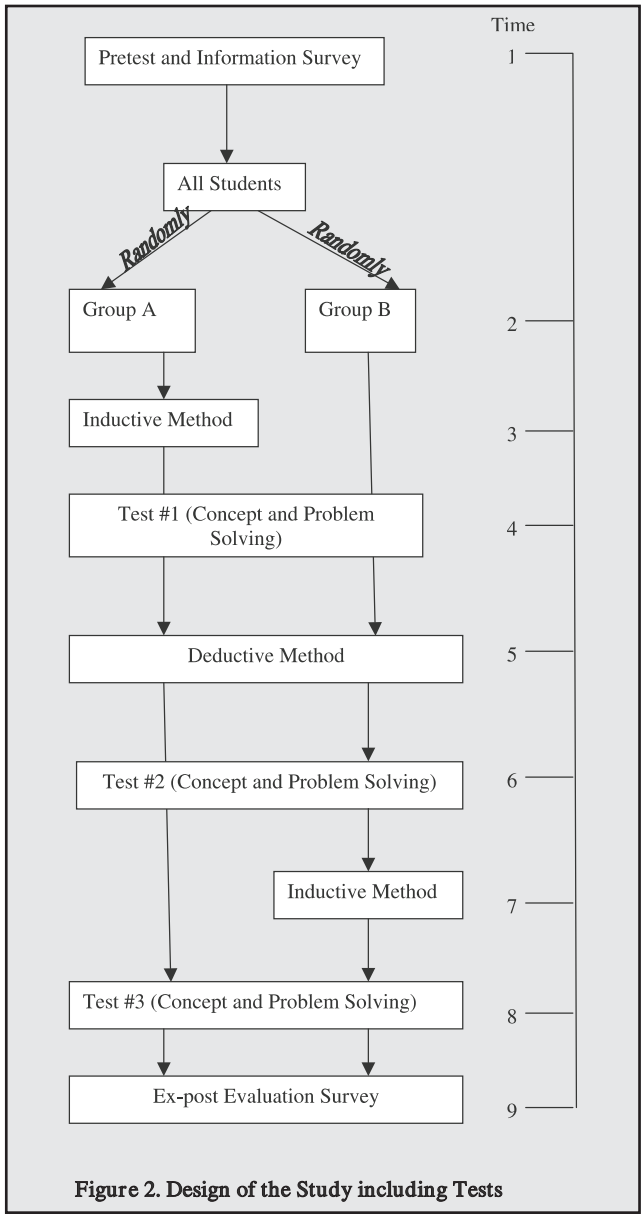

Figure 2. Design of the Study including Tests

Empirical Analysis

Regression analysis is used to determine the relative effectiveness of the two teaching methods and the influence of students' characteristics on test scores. Our hypothesis is: Test score = f (teaching method, concepts pretest score, exercises pretest score, calculus high school, calculus at OSU, economics background, major Agrucultural Economics, major Animal Science, opinion about economics, ACT, GPA, active/reflective, sensing/intuitive, visual/verbal, sequential/global).

Four different test scores are used as dependent variables. Concept and problem solving scores when one-half of the students have participated in the experiments only, (group A, Test #1), and the other one-half have had the lectures only, (group B, Test #2), are used to address Objective 1. Concept and problem solving scores from Test #3 in Figure 2 when one-half of the students participated in the experiments and then in the lecture (group A), and the other half have had the lecture and then the experiments (group B) are used to address Objective 2 (Figure 2).

The variables are defined as follows: teaching method is a dummy variable equal to one if students are in group A and equal to zero if they are in group B; concepts pretest score is students' pretest score for trade concepts; exercise pretest score is students' pretest score for trade exercises; calculus high school is a dummy variable equal to one if students had some calculus in high school and equal to zero if students had no calculus, algebra or trigonometry in high school; calculus at OSU is a dummy variable equal to one if students had some calculus at OSU and equal to zero if students had no calculus, algebra or trigonometry at OSU; economics background is previous background in economics and is equal to one for some background and is equal to zero for no background; major Agricultural Economics is a dummy variable equal to one if major is agricultural economics, and equal to zero otherwise; major Animal Science is a dummy variable equal to one if major is Animal

Science, and equal to zero otherwise; opinion about economics is the degree of agreement with the statement that economics is boring on a scale from one (disagree) to seven (agree); ACT is student's ACT score; and GPA is student's cumulative grade point average. Learning style is represented in four dimensions: active/reflective, sensing/intuitive, visual/ verbal, and sequential/global. Each of the dimensions ranges could be from 11 to 11 with the positive numbers indicating tendencies toward the first word in the description and negative numbers indicating a tendency toward the second as described previously.

Subjects and Data

Students from the Agricultural Economics 1114 class (Spring 2000) were the subjects of the study. Participation in the experiments was voluntary. Of the 182 students enrolled, 110 and 124 completed all of the requirements that allowed their data to be included in the individual equations that are estimated. Students in the class had diverse majors within the College of Agricultural Sciences and Natural Resources. The two largest majors represented were animal science (37 percent) and agricultural economics (25 percent). The average ACT score was 23.49, and the GPA average was 2.90. Learning styles were evaluated using the Solomon and Felder (2004) questionnaire and ranged from 11 to 11 for all of the dimensions except visual/verbal, which ranged from 11 to 7. Only 14 percent had calculus in college and 27 percent reported some background in economics. Test score means depend on the testing date and section ranged from 48 percent to 70 percent.

Results

Table 1 reports results for Objective 1. Separate equations for the concept and problem solving parts of the exams are reported. The dependent variables are the scores for those students who have either completed the inductive experiment or heard the deductive lectures.

Based on the experiment or lecture variable, there is evidence that the teaching method has an impact on the students' test score for learning trade concepts and completing trade exercises. The coefficients for "Experiment or lecture" in Table 1 show that students' concept and problem solving test scores are 25.07 and 10.59 points higher, respectively, for students exposed to the experiment compared to those who have experienced the lecture only. The other significant variable in both equations is ACT score. Students with higher ACT scores perform better on both the concept and problems solving portions of the tests. Both the concept pretest score and the problem solving pretest scores are significant in their respective equations. The coefficients for learning styles, major, opinion about economics, and mathematics background were not significant.

For Objective 1, we conclude that the experimental approach impacts students test scores and improves students understanding of concepts and their ability to solve problems related to those concepts.

For Objective 2, we test whether it is better to first teach with specific examples or to first teach the general principles. Results for Objective 2 are presented in Table 2. The results suggest that students who were exposed to the experiments first and then to the lectures performed significantly better on both the concept and problem solving portions of the tests. Students who were exposed to first to the experiments performed 5.26 points better on the concept portion of the test and 8.96 points better on the problem-solving portion of the test. The other significant variable in both equations is the students' ACT score. ACT score is positively and significantly related to performance both on trade concepts and problem solving portions of the tests. Students who did well on the problem-solving portion of the pretest also did significantly better on the post tests. Two additional variables are significant in the concept equation in Table 2. Those who are more inclined to agreed with the statement that "economics is boring" performed less well and those who tended to be global learners performed better. The other learning style variables, student's major, and grade point

Table 1. Impact of inductive and deductive teaching methods, cognitive ability, background, and learning style on concept and problem-solving test scores in introduction to agricultural economics

Independent Variables	Concept Score[1]		Problem-Solving Score[2]	
	Coefficient Estimate	Estimated Standard Error	Coefficient Estimate	Estimated Standard Error
Constant	1.94	11.00	3.74	11.96
Experiment or lecture	25.07**	2.44	10.59**	2.65
Concept pretest score	0.26**	0.08	0.06	0.09
Exercise pretest score	-0.004	0.08	0.36**	0.08
Calculus in high school	0.06	3.28	2.11	3.57
Calculus at OSU	3.28	3.68	-4.02	4.00
Economics background	-1.45	2.83	-2.49	3.08
Agricultural economics major	-1.00	3.48	-4.99	3.79
Animal science major	0.75	3.05	-0.009	3.31
Opinion about economics	-.079	2.85	0.47	3.10
ACT Score	1.48**	0.46	1.54**	0.50
GPA	-0.24	2.29	-2.84	2.49
Active/reflective learning index	0.20	0.27	0.05	0.30
Sensing/intuitive learning index	0.007	0.30	0.31	0.32
Visual/verbal learning index	-0.008	0.32	-0.02	0.35
Sequential/global learning index	-0.31	0.37	0.19	0.40

**Significant at 0.05. *Significant at 0.10. The Shapiro-Wilk normality test indicates that the residuals are normally distributed in both equations. From the misspecification test (joint conditional mean test), no functional form problem is detected. Furthermore, heteroskedasticity was not detected in either equation.

[1]The sample size is 110, r-square is 0.6050, the mean square error is 148.20, and the F-value is 9.70 with a p-value <.0001.

[2]The sample size is 110, r-square is 0.4294, the mean square error is 175.23, and the F-value is 4.77 with a p-value <.0001.

average did not explain variation in performance.

Overall, it appears that ACT scores are a good measure of cognitive ability. ACT scores is significant in every equation that we estimated. A one-point difference in ACT score, changes the expected test scores by from 1.5 to 1.9 points.

Table 2. . Impact of the order of inductive and deductive teaching methods, cognitive ability, background, and learning style on concept and problem-solving test scores in introduction to agricultural economics.

Independent Variables	Concept Score[1]		Exercise Score[2]	
	Coefficient Estimate	Estimated Standard Error	Coefficient Estimate	Estimated Standard Error
Constant	0.11	10.03	-4.88	11.15
Experiment/lecture (1) or lecture/experiment (0)	5.26**	2.38	8.96**	2.65
Concept pretest score	0.03	0.07	0.08	0.08
Exercise pretest score	0.09	0.07	0.18**	0.08
Calculus in high school	-0.31	3.21	5.82	3.57
Calculus at OSU	3.25	3.42	-3.98	3.81
Economics background	-4.25	2.77	-2.87	3.08
Agricultural economics major	2.56	3.31	2.73	3.68
Animal science major	-0.69	2.81	3.73	3.12
Opinion about economics	-5.93**	2.83	0.92	3.15
ACT Score	1.72**	0.42	1.87**	0.46
GPA	0.08	2.21	-0.65	2.46
Active/reflective learning index	-0.21	0.27	0.06	0.30
Sensing/intuitive learning index	0.17	0.28	0.07	0.31
Visual/verbal learning index	0.30	0.33	-0.25	0.36
Sequential/global learning index	-0.75**	0.32	-0.24	0.36

**Significant at 0.05. *Significant at 0.10. Estimated using OLS. The Shapiro-Wilk normality test indicates that the residuals are normally distributed in both equations. From the misspecification test (joint conditional mean test), no functional form problem is detected. Furthermore, heteroskedasticity was not detected in either equation.

[1]The sample size is 124, and the r-square is 0.4194. The mean square error is 156.57, and the F-value is 5.25 with a p-value <.0001.

[2]The sample size is 124 and the r-square is 0.4136. The mean square error is 193.62, and the F-value is 5.13 with a p-value <.0001.

Implications and Conclusions

Implications for those of us teaching economics are numerous. First, in this sample experiments were more effective than lectures. Second, these results suggest that doing the experiments prior to lecturing on material tends to be more effective than lecturing about a topic and then doing an experiment where students experience the concepts.

We conclude that learning is enhanced if teachers use methods that cause students to experience economic concepts before they begin to lecture over the general theory associated with that concept. We find learning is enhanced if students have a class experience that causes them to remember and understand the concept.

Our recommendation would be to use specific examples, experiments, and experiences often and, preferably, before trying to explain a general concept. For example, students can better understand diminishing marginal utility when a student is allowed to eat all of the chocolate cookies they want and the student stops eating at some point even though the cookies are free. Their comprehension of complementary goods is enhanced when they see that the student who has eaten all the cookies they want will eat even more cookies if they have a glass of milk. Relative prices, indifference curves, budget lines and substitutes are easier concepts for students to grasp if you bring a national brand of cookies to class, compare prices with a store label and determine at what price difference students begin to substitute one for the other. A useful visual exercise is to have a student prepare bundles of goods (combinations of different types of cookies) that will provide them with equal satisfaction and are bundles on the same indifference curve. Other people with different preferences would have different bundles on their indifference curves.

In addition, the common experience of an economic experiment provides the class with a common reference point that can be used in the lecture to illustrate a particular concept. The authors believe lectures are enhanced when the lecturer can refer to a common event that the students have observed or experienced.

Because many of our students in introduction to agricultural economics come from the animal and plant sciences, many are accustomed to inductive learning because they are accustomed to classes with experiments and laboratory exercises. Our results suggest that students do respond and learn if we can find ways to cause students to demonstrate and experience economic concepts.

While we hypothesized that learning styles would affect performance, it is somewhat comforting that we did not, with one exception, find that the learning style variables were significant. Apparently, the lectures we gave and the experiential learning exercises had a similar appeal to all learning styles.

Apparently, the number of books and articles being written about ways to teach economics that move away from lecture presentations and toward more active and experiential learning environments deserve review and, where appropriate, use in agricultural economics classrooms.

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