New Technologies and Innovations in Agricultural Economics Instruction

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Applications of Computer Graphics to Instruction in Agricultural Economics

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Faculty in agricultural economics at the University of Kentucky have had considerable classroom experience employing computer graphics as an instructional tool in both undergraduate and graduate-level course work. The use of computer graphics as an instructional supplement has been of interest to agricultural economists for a number of years (Debertin, Pagoulatos and Bradford; Bay and Schoney; Debertin; Harris). In curriculum revision discussions (Beck et al.; Coffey; Dobson; Erven; Kropp; Manderscheid; Mather), the computer has frequently been mentioned both for its potential usefulness (Bentley; Hudson, et al.; Litzenberg; Osburn et al.) as well as problems (Wetzstein). This paper details some of our experiences and outlines both problems and opportunities, with emphasis on applications at the introductory level.

The GEN 101 Course

GEN 101 is an introductory, 3-credit course titled "The Economics of Food and Agriculture." It is part of the general studies program at the University of Kentucky and has no prerequisites. Since students may use the course to satisfy the university general studies requirement, it attracts considerable enrollment from outside the department of agricultural economics. Historically, most students were enrolled in the College of Agriculture, but enrollment from outside the College has been increasing and now constitutes nearly one-half of the students. Agricultural economics majors follow this course with a two-semester sequence in introductory micro and macro theory, but for non-majors this course may represent the only exposure to agricultural economics (or economics).

Course Content

Content of the course is similar to that of introductory courses offered in other agricultural economics departments, with an emphasis on applications of microeconomic theory to problems in agricultural economics. A high proportion of the students taking the course come from non-farm backgrounds. As a result, information on economic characteristics of U.S. and Kentucky agriculture is provided in the first three weeks. Eight weeks are devoted to micro theory using applications from agriculture. The remainder of the course consists of short introductory segments on topics such as agricultural policy, rural development, natural resource economics, marketing, trade and agricultural finance.

Sections of the course are taught by three different instructors using a common set of materials. Enrollment has been averaging 100 students per semester. Two rooms are used for instruction. Both are equipped with an IBM-compatible computer connected to a large-screen VGA projection monitor. Lecture materials, charts and graphs representing theoretical concepts are displayed with the projection equipment. A study guide containing the diagrams and lecture materials is also used. Figure 1 illustrates the room used for instruction.

The course uses over 1200 computer-generated charts, figures, diagrams and lecture text created with the aid of Harvard Graphics. Materials displayed on the computer are similar to those that an instructor might present on a chalkboard or with the aid of an overhead projector.

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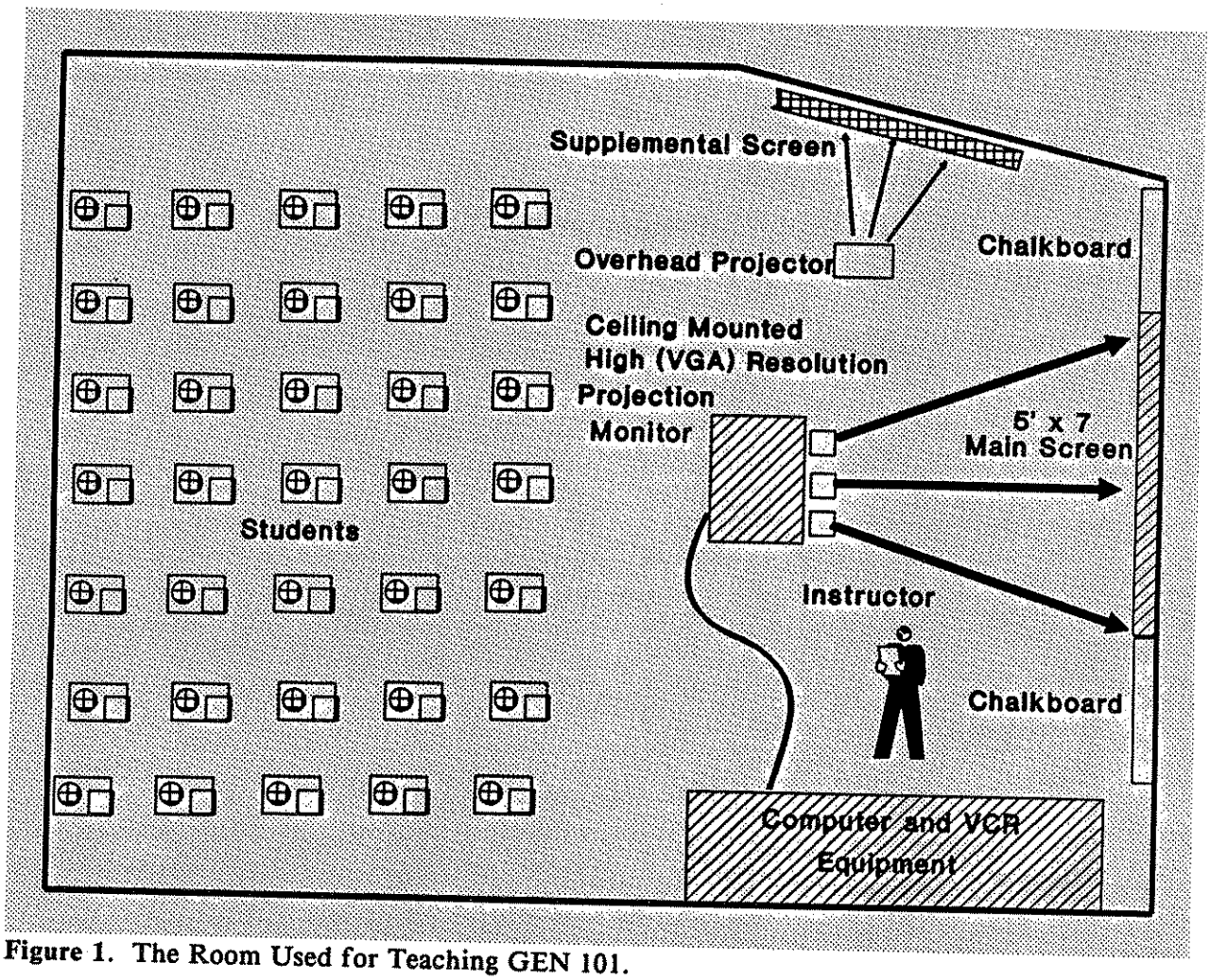

Figure 1. The Room Used for Teaching GEN 101.

The first section of the course uses charts based on data from the USDA and State Crop and Livestock Services. Data are presented using a variety of methods, including pie bar and line charts. For example, cash receipts from Kentucky agriculture might be presented using a pie chart; a bar chart might be used to depict changes in gross and net farm income, whereas yield trends for corn might be presented using a point chart with a trend (regression) line. Charts are updated regularly. The course also uses county-level state and U.S. maps to represent key economic concepts such as income levels or economic dependence of individual counties.

The section of the course that employs microeconomic theory also uses computer graphics in unique ways. Consider a simple diagram illustrating supply and demand curves and the equilibrium price and quantity. The computer draws the graph in the manner in which the instructor might draw the graph on a chalkboard, one step at a time. First, the vertical axis is drawn from top to bottom. Then, the horizontal axis is drawn from left to right. Axes are labeled from left to right. The demand curve is then drawn downward and to the right, and the supply curve upward to the right. Then a line representing the level of the equilibrium price is drawn from the intersection of the

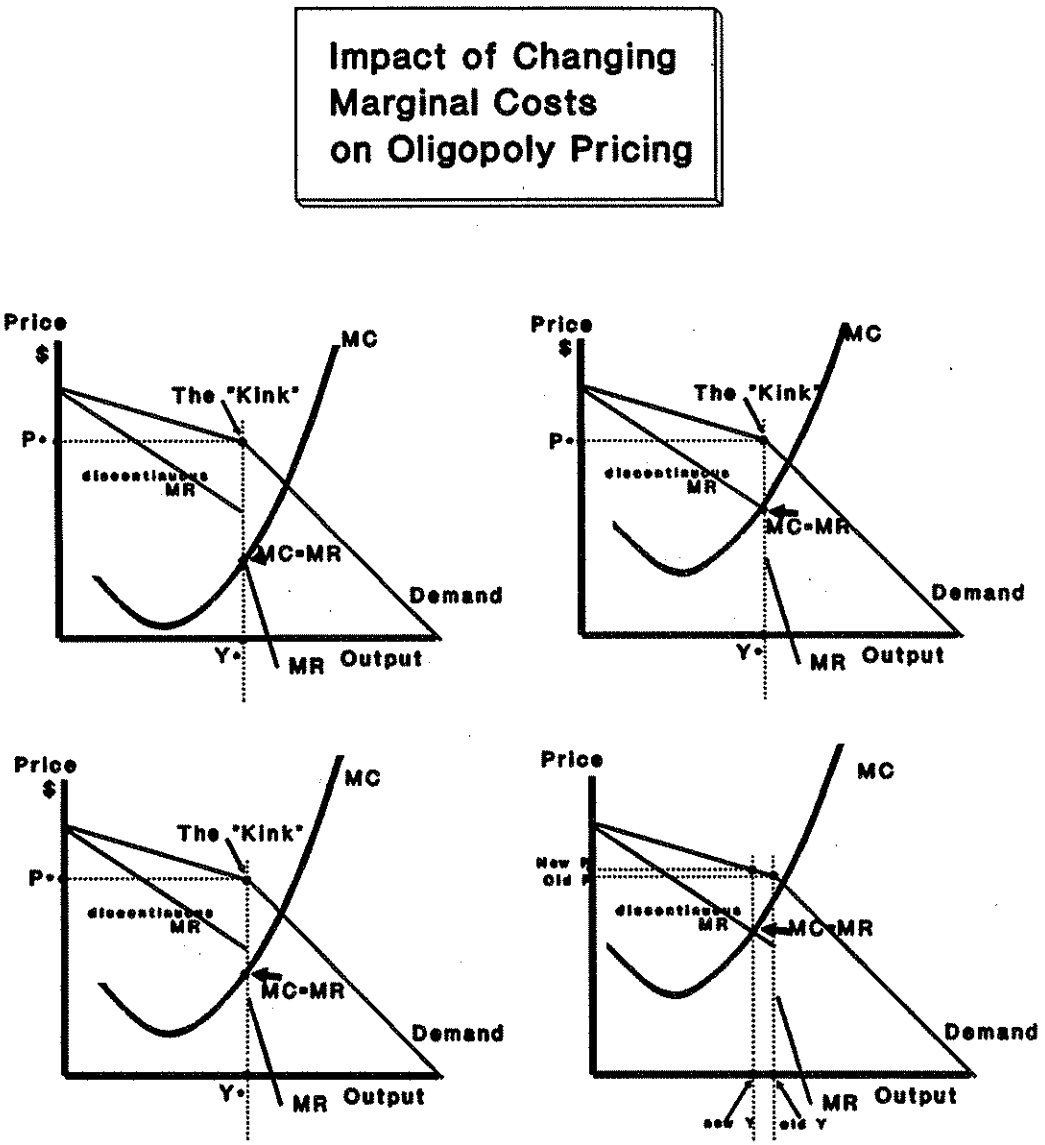

Figure 2. Sample Computer Slide Sequence from the Oligopoly Section.

supply and demand curves to the left axis. The equilibrium quantity is drawn from the intersection of the supply and demand curves downward to the horizontal (quantity) axis.

Figure 2 illustrates the section of the course that deals with pricing under oligopoly conditions. The sequence of computer-generated slides illustrates exactly when costs have risen enough to warrant an industry-wide price increase.

Other sections cover indifference curve analysis, elasticities, and production concepts including a detailed presentation of the factor-product model and shorter presentation of factor-factor and product-product models. Another section contains a "classic" presentation of the cost and revenue curves (Total Cost, Total Revenue, Average Cost, Marginal Cost and Marginal Revenue). Each of these diagrams are constructed in color and in sequence, one line at-a-time. Another section illustrates models of imperfect competition, including the monopoly,

oligopoly and monopolistic competition models. Each model is again constructed one line segment at a time.

The final section of the course consists of a series of computer-generated slides related to special topics dealing with marketing, development, agricultural policy, trade, comparative economic systems and word food needs. Most of this is text information, although charts and graphs are sometimes used, where once again the emphasis is on animated graphics sequences.

The computer-generated slides, although being "quasi" rather than "true" computer animation, provide similar benefits to true animation in that they mimic the manner and speed in which an instructor might draw, but in color and with greater clarity and accuracy. Additional discussion on the teaching technologies employed can be found in Debertin and Jones (1991).

The Study Guide

The study guide (Debertin, 1990, revised ed., 1992) is unique in that it also functions as the student's notebook. Included in the study guide are copies of each diagram and chart used in the course, as well as notes. Margin space is sufficient to permit the student to take supplemental notes. A standard beginning text is also available for students who wish to purchase it, and is placed on reserve in the college library. Specific reading assignments in the textbook are given for each section of the course.

An important component of the study guide is a series of glossaries, one for each of the 17 chapters or sections of the course. Glossaries not only define specific terms used in microeconomics (i.e., marginal cost and marginal revenue), but also terms frequently used by agricultural economists in discussing policy, resource, marketing and rural development issues.

A third element of the study guide is a series of worksheets consisting of discussion questions and problem sets. Students have the opportunity to plot data to illustrate marginal concepts.

A fourth element of the study guide, that has been added to the revised edition is a series of 3- to 5-page chapter summaries that provide information supplemental to the charts and diagrams. These chapter summaries closely follow the charts and lecture materials, but also make the study guide more "textbook-like."

Course Evaluation

Each semester, an extensive evaluation survey is conducted to elicit student reaction to the various teaching technologies employed in the course. Since the survey has been conducted for a number of years, it is possible to track over several semesters changes in students' responses to the various technologies (Figure 3).

The study guide and worksheets are ranked highly in terms of helping students learn the course material for GEN101. This result is consistent across instructors and (for instructors B and C) through time. It is noteworthy that the study guide is important to students even when used by instructors other than the author (instructor B). Results for instructor C also permit a comparison relative to subject matter covered. In particular, the midterm evaluation followed theoretical supply and demand concepts--often viewed as dry, abstract and more difficult by students--whereas the final evaluation also reflects more applied topics in agricultural economics. In this regard, the relative stability of the final evaluation result for the study guide over the two years contrasts sharply with the guide's greater importance in the 1992 midterm evaluation relative to that of 1991 for instructor C.

Other relatively high-scoring course components include the glossary, 4" x 6" index cards, instructor, hour exams and old exams. The index cards, onto which students were allowed to write notes and which they were permitted to bring to exams, are useful for a

number of reasons. They reduce the tempatation to merely memorize course material; they reduce exam anxiety among certain types of students; and the process of sifting through the study guide to distinguish "important" from "unimportant" material is an important learning tool.

The computer-generated slides tended to be more important in the case of instructor B. For instructor C, the ranking was lower in the 1991 final evaluation relative to the 1992 evaluation; this suggests the possible existence of a learning curve for instructors who adopt slides generated by others. The decline in the rankings between the middle and end of the term, although not statistically significant, suggests that the slides may be relatively more important for the abstract course material than for the applications section.

Students were also asked to provide suggestions for improving specific aspects of the course using a 5-point scale. For questions with words "more" or "less," a score of 3 is interpreted as meaning students are on average indifferent with respect to changes in the particular item. Thus, an instructor can use this information to work towards achieving a score that converges on 3. For some items this seems to be difficult (e.g., "use more worksheets" or "go over worksheets more" for instructor B), while for others the mean score is converging on 3 (e.g., "more class discussion is needed" or "the pace of the lecture is too fast" for instructor C). Students did not believe that they should be required to buy textbooks, and tended to agree that the study guide was adequate without a textbook. Also, worksheets were viewed as quite important as was the fact that they were graded (less so for instructor C than for instructors A and B). In general, the information obtained in the survey is valuable for making marginal adjustments in teaching methods and presentation. For example, in the case of instructor C, the course objectives were perceived to be clearer in 1992 than in 1991 (even though there was a within-year decline in the 1992 score).

To complement the relative ranking of course components on a 5-point scale, instructor B asked students to rank 10 components relative to one another (Table 3). The study guide was very important, surpassed only by worksheets in 1989, and it is becoming even more important over time, as the instructor has learned to use it more effectively. Interestingly, the same trend is not apparent for the lecture itself. The textbook and studying with classmates were least important in helping students master the course material.

As a final part of the course evaluation, students were asked to describe their reaction toward the computer-generated slides. For instructor B (the author of the slides) 47.7% of the class in 1989 indicated that "the computer-generated slides were superior to any other means I have seen instructors use to present lecture material." For instructor C, the proportion of those responding affirmatively to the same question rose from 26.2% in 1991 to 35.6% in 1992. While further data are needed, this tends to confirm the existence of a learning curve when instructors adopt slide material generated by others (without modification).

Other Applications of Computer Graphics to Instruction

Computer graphics has also been employed in teaching upper division and graduate-level courses in agricultural economics, though in these courses the computer graphics is employed only for segments or portions of the course. Instructional modules are developed that illustrate key elements of portions of each course. An example is the instructional module currently being used in AEC 620, a graduate-level course in agricultural production economics. This is a very recent update of work conducted fifteen years ago (Debertin, Pagoulatos and Bradford).

The module employed in AEC 620 uses both two- and three-dimensional graphics to illustrate not only the three-dimensional surfaces of various two-factor, one-product production functions as well as two-dimensional isoquant maps (Debertin, 1992). In addition, other important concepts can be illustrated, such as the

Please evaluate the following items with respect to how important they were in helping you learn the class material contained in GEN 101:

Very Important				Unimportant		
5	4	3	2	1	1.	The Study Guide and Lecture Notes
5	4	3	2	1	2.	The Textbook
5	4	3	2	1	3.	The Computer-Generated Lecture Slides
5	4	3	2	1	4.	The fact that the Computer-Generated Slides were in color
5	4	3	2	1	5.	The fact that lines on diagrams being discussed could "move" on-screen to see the effects of price changes and demand/supply shifts
5	4	3	2	1	6.	The Glossaries (Definitions of Terms) at the Start of Each chapter in the Study Guide
5	4	3	2	1	7.	The Worksheets
5	4	3	2	1	8.	Studying with Classmates
5	4	3	2	1	9.	The Hour Exams
5	4	3	2	1	10.	The Instructor
5	4	3	2	1	11.	Textbook assignments
5	4	3	2	1	12.	The Old Exam File
5	4	3	2	1	13.	The Extra Credit Computer Exercises

Strongly Agree				Strongly Disagree		
5	4	3	2	1	1.	The Instructor should use the chalkboard to illustrate ideas more often
5	4	3	2	1	2.	The instructor should use an overhead projector to illustrate ideas more often
5	4	3	2	1	3.	The instructor should make less use of the computer-generated slides
5	4	3	2	1	4.	Students should be required to purchase a textbook.
5	4	3	2	1	5.	The study guide is adequate without a textbook
5	4	3	2	1	6.	More class discussion is needed
5	4	3	2	1	7.	"Pop" quizzes should be required
5	4	3	2	1	8.	Worksheets should not be used
5	4	3	2	1	9.	More Worksheets should be used
5	4	3	2	1	10.	Worksheets should be used but students should not be required to turn them in.
5	4	3	2	1	11.	More time should be spent going over worksheets
5	4	3	2	1	12.	More time should be spent going over terms and definitions contained in the Study Guide
5	4	3	2	1	13.	More time should be spent going over quizzes and exams.
5	4	3	2	1	14.	The file of exams was a useful study aid.
5	4	3	2	1	15.	Some quiz and test questions should come from the textbook on reserve in the library
5	4	3	2	1	16.	More time should be spent going over extra-credit computer exercises

Circle number on the statement that most accurately describes your reaction to the computer-generated lecture presentations.

1. These computer-generated slides were superior to any other means I have seen instructors use to present lecture material.

2. The computer-generated slides were OK, but sometimes I wished that the instructor would use the chalkboard or a visual on an overhead projector.

3. I wish that the instructor would rely primarily on the chalkboard or an overhead projector for his presentations. The computer is ok to supplement the lectures on some material, but should not be used everyday.

4. The computer-generated slides were a bomb. Why can't we have ordinary lectures in GEN 101.

If none of these statements accurately describes your reaction, please write your own statement in the space below

Please rank from 1 to 9 the following in terms of value to you in learning the class material (1 = most important, 9 = least important):

___1. The study guide
___2. The lecture itself (the "live" instructor)
___3. The computer-generated slides
___4. Studying with my classmates
___5. The hour exams
___6. The worksheets
___7. The textbook on reserve in the library
___8. Old exams

What was the one thing you liked best about this course?

Figure 3. The Evaluation Survey Form.

Table 1. Absolute Mean Rankings of the Importance of GEN 101 Course Components, Various Terms[a]

	Instructor A	Instructor B			Instructor C[b]			
Course Component	1990	1989	1990	1991	1991M	1991F	1992M	1992F
Study guide	4.35	4.48	4.69	4.47	4.18	4.32	4.58	4.35
Textbook	1.68	2.07	1.21	1.50	1.82	1.82	1.71	1.54
Computer-generated slides	3.00	3.79	4.17	4.04	3.53	3.25	3.80	3.40
Slides in color	—[c]	3.43	3.37	3.63	—[d]	—[d]	—[d]	—[d]
Moving diagrams	3.10	3.89	3.81	4.18	3.50	3.32	3.67	3.31
Worksheets	4.55	4.73	4.58	4.34	4.38	4.61	4.16	4.54
Pop quizzes	—[e]	3.50	2.91	—[e]	2.76	2.82	3.07	2.88
Hour exams	3.97	3.93	4.08	3.84	3.12	3.64	4.02	3.77
Instructor	4.20	3.86	4.27	3.77	3.21	3.67	4.13	3.83
Textbook assignments	2.40	2.32	2.89	2.25	—[e]	—[e]	—[e]	—[e]
Glossary	—[f]	—[f]	4.72	4.72	—[d]	—[d]	—[d]	—[d]
Old exams	—[d]	—[d]	—[d]	—[d]	3.50	4.27	3.58	3.77
4×6 Index cards for exams	—[e]	—[e]	—[e]	—[e]	—[e]	—[e]	4.00	4.54

Data Source: Classroom surveys of students, various years.
a. 5-point Scale: 5=very important; 1=unimportant. Instructors A and C taught during Spring, Instructor B during Fall terms.
b. M=midterm, F=final evaluation.
c. Monochrome projector used.
d. Not asked.
e. Not used
f. Begun Fall, 1990

Table 2. Specific Student Suggestions for Improving GEN 101, Various Terms[a]

	Instructor A	Instructor B			Instructor C[b]			
Suggestion/Concern	1990	1989	1990	1991	1991M	1991F	1992M	1992F
Use chalkboard more	3.00	2.77	2.38	2.84	3.44	3.73	2.88	3.06
Use overheads more	3.30	2.61	2.33	2.54	--[c]	--[c]	--[c]	--[c]
Use computer slides less	2.63	2.05	1.77	1.95	2.91	3.00	2.20	2.65
Should purchase textbook	2.20	1.93	2.10	1.93	--[c]	--[c]	--[c]	--[c]
Study guide is adequate without a textbook	3.85	4.05	4.35	4.06	3.29	3.61	3.75	4.13
More class discussion needed	3.18	3.30	2.85	3.39	3.71	3.64	2.86	3.06
Should not have worksheets	1.20	1.52	1.52	1.57	--[c]	1.30	--[c]	1.71
Use more worksheets	3.45	2.98	3.06	2.61	3.53	3.86	3.11	3.29
Do not grade worksheets	1.53	1.62	1.63	1.59	2.03	1.66	2.19	2.06
Go over worksheets more	3.31	3.43	2.83	3.34	2.94	3.09	2.91	3.08
Go over exams/quizzes more	3.83	3.23	2.68	3.18	3.18	3.20	2.79	3.06
Cont. to provide old exams	4.64	4.09	3.85	4.23	--[c]	--[c]	--[c]	--[c]
Use questions from textbook	1.41	1.52	1.27	1.45	--[c]	--[c]	--[c]	--[c]
Pace of lecture is too fast	--[c]	--[c]	--[c]	--[c]	2.82	--[c]	3.05	2.98
Course objs. are very clear	--[c]	--[c]	--[c]	--[c]	3.15	3.59	4.00	3.67

Data Source: Classroom surveys of students, various years.
a. 5-point scale: 5=strongly agree with statement; 1=strongly disagree.
b. M=midterm, F=final evaluation.
c. Not asked.

Table 3. Relative Mean Rankings of Importance of Course Components in Learning GEN 101 Material[a]

Course Component	1989	1990	1991
Study guide	3.27	2.75	1.63
Lecture	4.18	2.77	3.63
Computer slides	4.09	5.53	3.95
Pop quizzes	5.11	6.60	--[b]
Hour exams	4.52	3.70	5.27
Worksheets	2.48	2.78	3.15
Textbook	7.86	7.45	7.93
Old exams	7.14	5.40	4.56
Studying w/ classmates	6.61	5.95	6.47

Data Source: Surveys of students, various years.
a. 9-point scale: 1 is most, 9 is least important.
Data for instructor B only.
b. Not used.

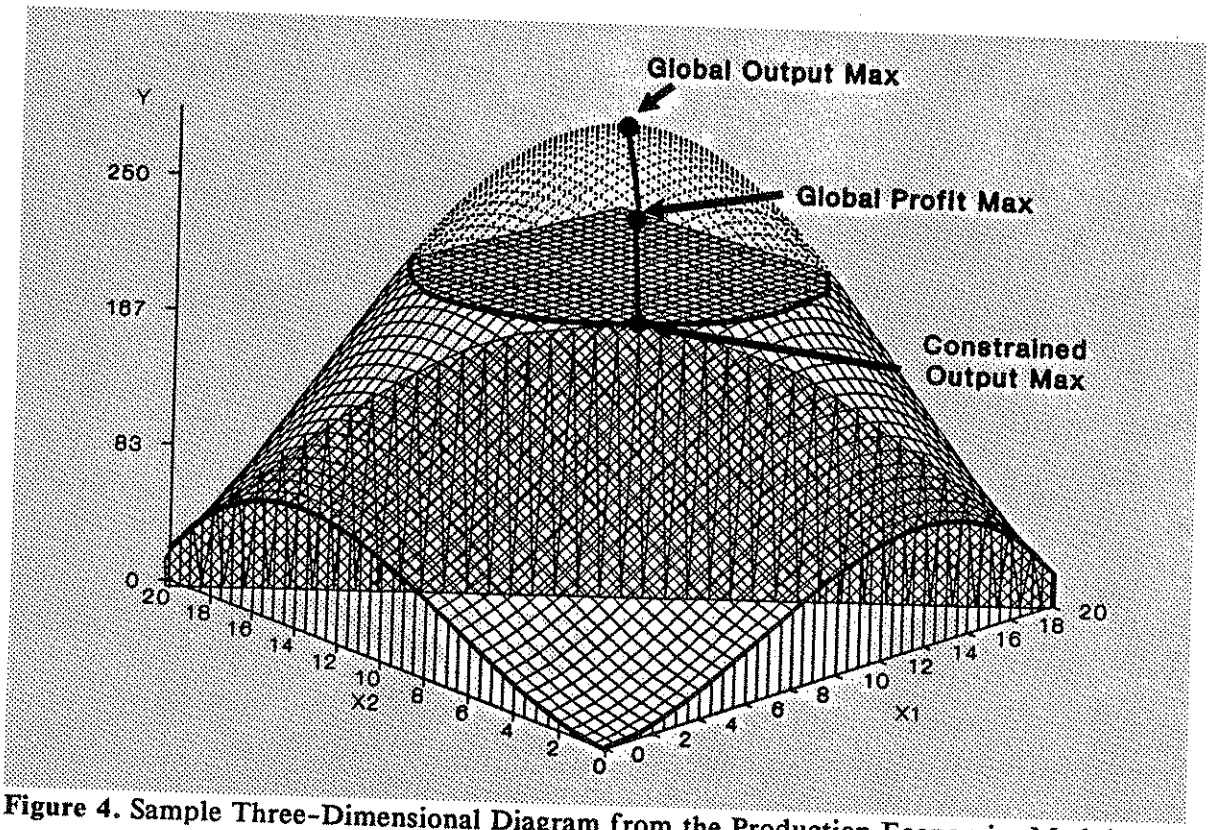

Figure 4. Sample Three-Dimensional Diagram from the Production Economics Module.

implications of a budget constraint on the three-dimensional production surface. The computer is used to draw three dimensional surfaces which have constraints imposed at various budget levels. The illustrations are then displayed in sequence. Figure 4 illustrates a sample drawing from the module.

The three-dimensional production surfaces and two- dimensional isoquant maps were constructed using PC-SAS, and then imported into Harvard Graphics from PC SAS as vector-based CGM files. This made it possible to edit the files generated with SAS using Harvard Graphics drawing and editing capabilities. For example, colors can be changed, lines highlighted and annotations made to illustrate key points. By using the quasi-animation features of Harvard Graphics, diagrams can again be created one step at-a-time. In addition, successively larger values for constraints can be used to create diagrams that illustrate changes that take place in the constrained optimization problem as the constraint level is increased.

Computer Cartography Applications

Another application used within an instructional setting is in computer cartography. In the department, faculty have used Harvard Geographics, Atlas Graph and the computer cartography component of PC SAS. Maps can be created on any of these systems and imported into Harvard Graphics screenshows. An example is a map depicting all counties in the U.S. and illustrating the USDA county dependence data indicating the major economic sector for each rural county--agriculture, energy, manufacturing, and others

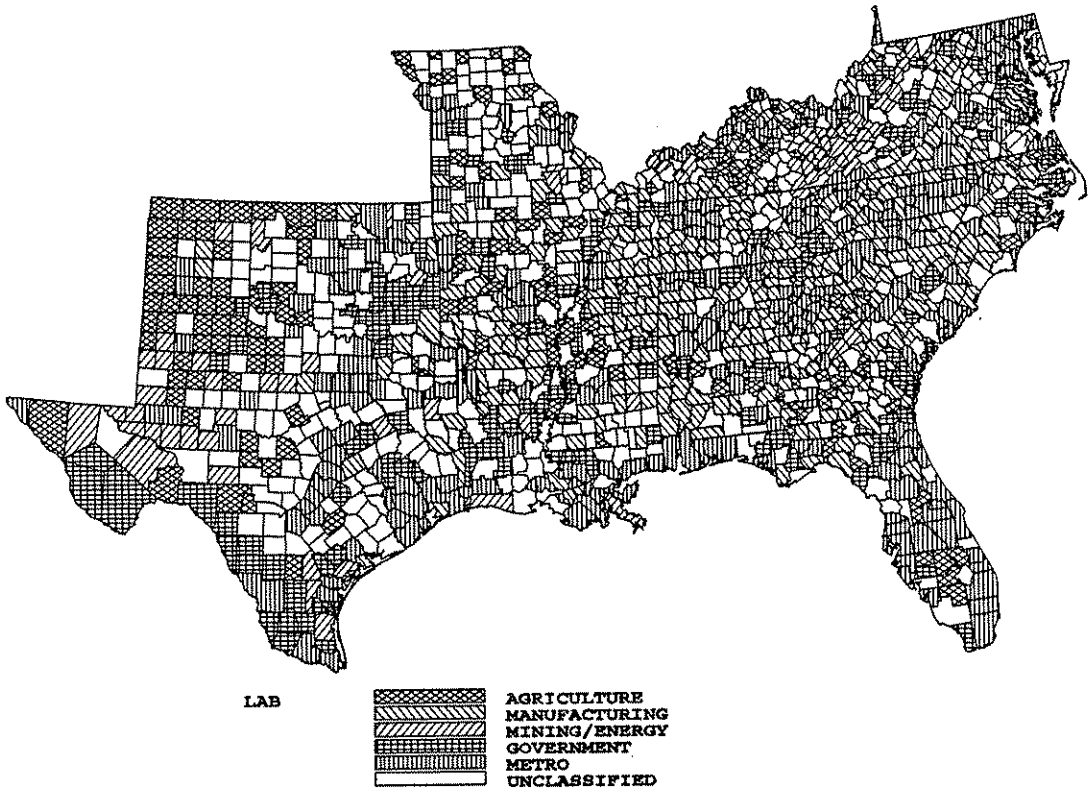

Figure 5. Sample Computer Cartography Map Illustrating U.S.D.A. County Dependence Data.

(Debertin and Goetz). These maps can also be displayed in sequence with Harvard Graphics.

Concluding Comments

Faculty in the University of Kentucky department of agricultural economics have successfully employed computer graphics in instruction. A key to the success has been the installation of high-resolution (VGA) computer projection equipment. The cost of equipping classrooms, upwards of $25,000 per room, is not inconsequential, particularly in an era of tight support and equipment budgets. However, the faculty in the department in large measure believe that the cost of equipping classrooms with the latest equipment has been money well spent. While the greatest use of the equipment has been in the introductory course, increasingly other instructors in other courses have been using the projection equipment as well, not only to display graphics, but for applications such as computer spreadsheets.

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