Management Simulators: A Tool for Fostering Experience-Based Learning of Agribusiness Management Concepts

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This article examines the role of a management simulator in teaching an agribusiness management course. The use of the simulator is described and the critical issue of the simulator's correspondence with management course content is discussed. A set of requirements for the realization of the maximum net benefits of using a simulator is presented for consideration. The conclusion is that the costs and benefits are neither global nor explicit and should be carefully and subjectively estimated before a decision is made on whether to incorporate a simulation game into an agribusiness management course.

Among general economists, the tentative conclusion about using computerized simulation games to teach economic principles is that "Games and simulation may be fun, but they may not be efficient." (Becker,[1] summarizing Siegfried and Fels.[2]) This conclusion is primarily based on comparisons of *Test of Understanding in College Economics* (TUCE) scores for experimental and control groups of students. Studies on the costs of computer assisted economic instruction have also been summarized,[3] and although changing computer technology has outdated much of this cost estimation, development and implementation costs remain substantial.

Despite the disappointing results of computer aided instruction (CAI) in general economics, the education literature is more positive about its use.[4] One explanation offered for this discrepancy is based on differing student's reactions to alternative teaching methods. Charkins et al.[5] hypothesized that some students benefit from CAI while others do not, with the result that on average a class does not demonstrate greater understanding. Other explanations have mentioned poor design

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of the computer materials, improper use of the materials, the difficulty of defining and testing for effectiveness, the use of TUCE scores as a measure of attainment, and the broad variety of techniques classified as CAI.[6]

Agricultural economists have documented the benefits and briefly discussed the costs of using simulation games to teach agricultural economics.[7–9] Other agricultural economists have described the use of simulation exercises and in general, seem satisfied with the results.[10–12] Thus, the disappointment with CAI in teaching economics principles does not imply that CAI will be ineffective in teaching other economic concepts, such as agribusiness management. This can occur because simulating managerial decision-making experiences is somewhat different from using the computer as a tutor to elicit a single predefined response to a situation. Computerized management simulators, which are used to expose students to situations where they must analyze and solve complex managerial problems that do not have a predetermined correct or best solution, correspond to Dreyfus and Dreyfus' (p. 586) notion of the use of CAI to establish expertise in which "...not only situational understandings spring to mind, but also associated appropriate actions."[13] The use of simulation exercises in this context is consistent with Becker's ideas (p.27); that learning can be achieved through computer simulations which are especially attractive for "...experiences that would be otherwise too costly, too risky, too time consuming, or not possible."[14]

This article has two objectives, the first of which is to discuss the use of a computerized simulation game in teaching agribusiness management. This technique is not new. In the early 1960s, Babb and Eisgruber wrote and used simulators for a grain elevator, a farm supply center, a farm marketing center and a supermarket.[15] These simulators have been widely used and continuously updated and documented.[16–19] Simulation has also been used to teach managerial economics in non-agricultural business curricula.[20,21]

The second objective of this article is to outline the implicit costs and benefits of using a simulation game in a teaching environment. The explicit costs, computing charges, are changing rapidly due to changing computer technology. The explicit benefits, better understanding by students created by mixing experience-based learning with abstract-conceptual learning, is difficult to measure accurately and the measurement problem is confounded by relatively small class sizes.

This article proceeds by describing a simulation game, then discusses the critical issues of the simulator's realism and compatibility between the simulator and the course content. Some not-always-obvious requiurements for using simulation will then be presented. Finally, a qualitative evaluation of using simulation games is given.

COURSE CONTENT AND SIMULATION GAMES

In prior agribusiness management experience, the author observed that agribusiness managers have multiple objectives, and that they carefully analyze and budget the consequences of major decisions in accordance with these objectives. Therefore, the instructional objectives in teaching agribusiness management are: (a) to teach students to analyze the impact of decisions in terms of their objectives and to plan for the results of decisions, and (b) to show students the connection between business decisions and the financial state of a business. Because these objectives are concerned with developing managerial decision-making and planning skills, managerial economics was selected as the disciplinary subject matter for the course. An experience-based learning situation was also desired to reinforce concepts covered under objectives (a) and (b) and to accomplish two additional objectives: (c) to provide controlled yet nearly realistic situations under which students must make business decisions, and (d) to provide students with situations where they can practice the analyses required to make good decisions. A computerized simulation game was selected as the best method to accomplish objectives (c) and (d).

The Farm Supply Center Management Simulation Game, developed at Purdue University, was selected as a device to reinforce theoretical concepts by simulating management problems which must be solved by the application of both managerial problem-solving techniques and economic concepts. The game simulates the decisions made by, and the financial operations of, a farm supply center that sells farm inputs to, and purchases farm output from, producers in the US Corn Belt. The rules and assumptions of the game are codified in both Fortran and Basic. The Basic version is newer and is designed for PCs,[17,18] but the older, Fortran version was used.[16] The Fortran version accommodates up to eight firms in each of up to eight markets, while the Basic version can be played by up to five firms in any number of markets. An administrator provides data that describe the market, oversees the processing of the data that result from the firms' decisions, and generally administers the game. When the input from each firm and the administrator's input are jointly processed, these programs compute sales volumes, profits (or losses), and the firms' financial positions. This information is then reported back to the participants in the form of income statements, balance sheets and other information.

Markets are composed of groups of competing firms. Each market is assumed to be independent of other markets, but within a market, the actions taken by one firm affect all other firms. The markets are nonspatial in that competitive actions affect all other firms equally rather than having a disproportionate impact on neighboring firms. The markets are assumed to be representative of Corn Belt agriculture with six major production activities: growing corn, soybeans, and oats, and feeding hogs, cattle, and layers. These six production activities are assumed to be uniformly spread over the entire market so that with everything equal, all firms are equally profitable.

Interfirm competition for the business generated by the production activity in the market takes the form of firm-level decision making which influences sales volume and hence the profitability of all firms in the market. The firm is assumed to be engaged in selling seven types of livestock feed and four types of fertilizer; merchandising three grains; providing an assortment of services such as delivering feed, spreading fertilizer, grinding and mixing feed, and storing grain; selling commercial supplements; and contracting hog and layer feeding. Each firm is managed by either an individual student or a group of students who collaborate to set prices for the firm's products and services; determine advertising expenditures, credit policy, and capital expenditures for trucks and grain storage facilities; hire and fire employees; order hog supplement and bulk fertilizer; and borrow and invest cash.

The Fortran version of the simulator had several features that needed to be revised before it could be used in the instructional regime described above.[22] First, though the source code is long and complex, the program was unable to model important real-world problems. For example, it was difficult to model annual inflation at the levels that existed in the 1970s. Should deflation characterize the last half of the 1980s, it would also be hard to model. The game was also unrealistic in that reference data were unavailable on historic price levels. At the outset, participants had only one year's history from which to make inferences about price movements in commodity and input markets. In reality, most of the rural population has a historical information base on commodity and input prices. The game also had an unrealistic model of product mix. In a real market, a relationship exists between the amount of fertilizer sold and the amount of grain available for purchase after harvest. No such linkage existed in the game. Finally, the game lost some realism as its product prices were substantially different from the prevailing prices for the products in actual markets.

A second problem arose when it was discovered that the game was incompatible with the economic theory taught in the course. The theory instructs students to set prices so as to maximize profits by equating marginal revenues and marginal costs. As the game generated data, these data were used to estimate demands and this information was used in pricing decisions. However, the demand model in the simulation game was for an oligopolistic firm. When students used simple linear estimated demands in an attempt to equate marginal revenues and marginal costs, they got either meaningless or profit minimizing solutions. Another problem with the oligopolistic specification was that it did not encourage students to actively search for profit maximizing prices. This price searching experience was deemed a valuable counterpart to the discussion of price searching as a pricing strategy.

To resolve these problems, revisions were made to the game. These revisions left the decision framework and the financial model of the firm intact but changed the economic model of the firm. First, the administrator's data were redefined so that an input-output model of input, commodity and service flows formed the basis of the simulation model. A highly simplified general representation of the input-output model of input, commodity and service flows is

Feed required = *f*(livestock numbers, feed required/head)
Fertilizer required = *g*(crop acreage, application rates)
Grain available = crop acreage × yield – grain fed to livestock
Services required = *h*(feed required, fert required, grain available)

where each input, commodity, and service is represented. According to this model, the quantity of each of the seven types of livestock feed required in the market depends on the number of livestock (cattle, hogs and layers) in the market and the amount of each type of feed fed to each type of livestock. The quantity of each of the four fertilizers required by the market will depend on the acres of each crop (corn, soybeans, and oats) planted and the application rate for each fertilizer to each crop. Thus, crop acreage ties fertilizer usage and crop production together. The quantity of corn and oats available to be merchandised in the market will be total production less the amount used in the market for livestock feed. All of the soybean production is assumed available for merchandising. Market structure coefficients are used to determine the market requirements for feed delivery, fertilizer application, feed grinding and mixing, and grain banking. The data on livestock numbers, crop acreages, feed requirements, and fertilizer application rates, as well as product costs and base price levels are supplied by the administrator.

Second, a new demand model was built. The input–output model results in (a) base activity levels which are generated from the coefficients supplied by the administrator, (b) these base activity levels are interrelated through an input–output structure and (c) these base activity levels are on a firm's demand and supply schedules. After the base activity levels have been determined, firm-level pricing decisions will cause actual activity levels to differ from the base levels as firms move along their demand functions. For example, if a firm sets a high fertilizer price relative to the other firms in its market, the firm's fertilizer volume will be below that dictated by the technical coefficients and relationships. As another example, relatively low prices offered for grain will result in the firm being able to buy less grain than the other firms in the market.

In general, the price-induced effects are due to (a) prices set by each individual center relative to the average of the prices set by all centers in the market, (b) the price set by each center relative to the average of the prices set by all centers for closely related products, and (c) a price aggregate set by the market administrator for the product under consideration. The demand functions governing these price-induced effects have constant elasticities over the entire range of activity, although some activities are constrained by inequalities. Hog feed sales, for example, are constrained by the amount of feed in inventory plus feed ordered. As another example, layer contracting is constrained by the maximum number of layers that the firm is willing to contract.

In addition to revising the game, a ten year historical simulation was done. This simulation used 1971–1980 USDA commodity and input prices and technical coefficients.[23,24] This simulated dataset was used to provide students with information to aid in price setting and planning. As the simulation and the course progressed, these data were also used to estimate demand relationships which were used for more advanced pricing and planning exercises.

IMPLICIT BENEFITS AND IMPLICIT COSTS

Figure 1 depicts an economic model of learning that illustrates the costs and benefits of using simulation. Although Kolb (p. 236) identified four different learning methods,[25] experience-based learning and abstract conceptualization are pertinent to combined lecture-gaming class presentations and are shown as output along the two axes. The fixed resources of class meeting time and the amount of outside study that can reasonably be expected from students for the credits given, generate a learning possibilities curve. This learning possibilities curve, P, shows that it is possible to use the fixed but mobile resources for experience-based learning by employing a simulation game with its decision framework, financial model of a firm, economic model of the market, and feedback requirements. On the other hand, resources can be used for observation-based presentations, i.e., lectures on various managerial economics topics, typically decision theory, demand theory, cost theory, and capital budgeting. The mobility of the resources generates the learning possibilities curve shown.

A family of total student learning curves, L_i, $i = 1,2,3,4$, is constructed with each member being convex to the origin. This shape reflects the interaction in a mix of learning experiences, as suggested by Kolb. The assumed objective in Figure 1 is the maximization of total student learning, subject to the learning possibilities curve. Within this model, the instructor plays the role of the manager in traditional production models. It is the instructor's responsibility to utilize resources such that

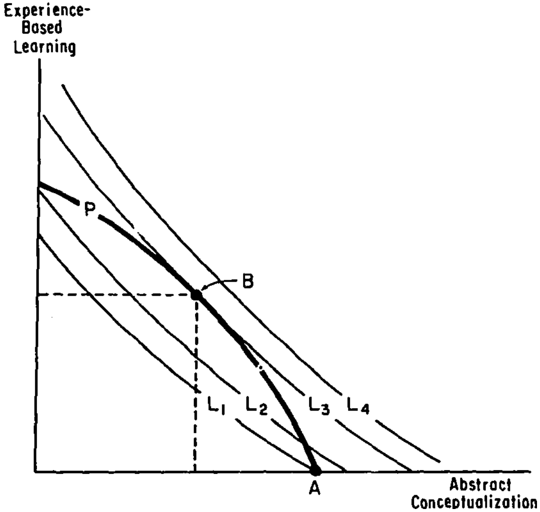

Figure 1. Diagrammatic Representation of Learning Production.

instruction occurs on the learning possibilities frontier. The instructor must also search for the constrained maximization of learning and properly interpret the marginal production conditions. It is also the instructor's responsibility to recognize that constrained maximization may occur at a corner solution so that exclusion of one of the instructional techniques would be advantageous.

The implicit benefits and costs of simulation gaming can now be identified in Figure 1. Assuming that a corner solution is not optimal, then the inclusion of a simulation game results in greater learning from the same bundle of fixed resources. These benefits are represented by the difference between L_1 and L_3 and arise because the instructional regime moves from specialized production at point A to diversified production at point B. Implicit costs, borne mostly by the instructor as additional instructional time, are incurred in managing the allocation of the instructional resources. These costs offset the benefits identified in Figure 1, and arise because several requirements must be met in order to include a simulator in a management class.

The first requirement, as already discussed, is that simulation games must be compatible with the theoretical constructs to be reinforced. An example of incompatibility is a demand specification that does not demonstrate profit maximization principles at the student's capability level. This compatibility is especially critical if the instructional objective is to induce students to transfer the theoretical constructs from the lectures to the simulation. If this compatibility does not exist, students who are performing according to instructional objectives are penalized. The problem of incompatibility between the lecture material and the simulation model can only be resolved by revising the simulation model or discontinuing its use.

A second requirement for simulation, is that the lecture material and the simulation exercise must be integrated. This integration requires extra instructional effort to structure lecture material so that it bears an apparent relationship to the decisions made for the simulation, and to present the game's decisions so that they bear an apparent relationship to the lecture material. To achieve some degree of integration, the managerial economics topics were redefined so as to create the greatest possible match-up with the decision making in the game. The topics discussed were decision making, demand behavior, implications of demand for pricing decisions, the implications of demand for inventory management, cost behavior, the implications of cost behavior for pricing decisions, the impact of marketing variables (advertising and credit policies) on sales, personnel management (breakeven overtime utilization), cash flows and cash management, capital expenditures analysis, and acquisitions analysis.

Working with more fragmented lectures is the third requirement for using simulation. Because the provision of experience-based learning was the reason for using the game, class time was used for team decision making, discussion, and feedback. These uses of class time resulted in fragmented lecture topics and it was found that the continuity of lectures was more difficult to maintain them if a lecture-only format was used.

A fourth requirement for simulation is that the simulation must be less abstract than the lectures it is to reinforce. Students are told to manage the assets of a hypothetical firm, but they may not be able to envision the firm and they certainly cannot see its assets. Should difficulties arise in envisioning the linkage between managing and the assets managed, the experiential basis for gaming is lost and the simulation degenerates into a meaningless exercise. A diagram of the physical layout of the imaginary firm, including detail on facility placement, property boundaries, location of roads and railroads, and the locations of trucks and the anhydrous ammonia equipment, proved useful in creating realism.

A fifth requirement for simulation is that the instructor's time required to process the decisions and provide quality feedback, exceeds the time required to prepare lectures to fill an equivalent amount of class time. This time requirement is compounded by the game being computer dependent so that the administrator must be a skilled computer user or have access to an assistant who is a skilled computer user. Additional revisions or refinements to the game also require the instructor's close supervision.

A sixth requirement is that the simulation game must be functioning smoothly for successful integration into a course. The simulation programs must be completely debugged before the simulation exercise begins because any change in the computer code is equivalent to a change in the rules, which is disconcerting for the participants. Also students need timely feedback on simulation exercises. A game which is not functioning smoothly cannot generate accurate feedback in a timely fashion and should be avoided.

Finally, a simulation requires quality feedback. Simulation games should provide feedback in a form that is consistent with the goals of the simulation. When a simulation is used for managerial skills development, the feedback should primarily relate to management's multiple objectives, and should allow for an examination of the tradeoffs between the objectives. Furthermore, feedback should be structured so that each participant's progress can easily be compared with that of the other participants. This cross comparison is the only means for students to objectively evaluate their mastery of the material. The feedback should also be structured so that it can be easily analyzed by the students. Ultimately, students should be able to isolate those areas where they are doing well relative to the competition and those areas where they are doing poorly. All of these requirements dictate that the feedback must be flexible enough to be presented in a form that is dictated by the progress of the game. It was found that graphs and charts were the best means of providing this feedback.

CONCLUSIONS

If this basic set of simulation requirements is provided, the use of simulation as an aid in teaching agribusiness management can provide the benefits shown in Figure 1. Blank,[9] and Boehlje and Eidman[7] provide objective measures of the impact of using simulation games and their results indicate that the benefits do exist. However, because each instructor uses simulation differently, has a unique set of computer skills, and faces different incentives, the universality of reported explicit costs and benefits is greatly exaggerated. Any instructor who is contemplating the adoption of a simulation game into a teaching program, must realize that each situation is unique and should subjectively evaluate each item in a comprehensive listing of likely cost and benefit categories, before the adoption decision is made.

In the situation described here, it was found that students' interest in the material is heightened by the competition in the simulation game. The students became keenly interested in their success and in their competitors' failures. A similar amount of interest is not generated in a pure lecture format. Furthermore, strategic planning can be taught through experience, and students get greater understanding from that experience than they do from strategic planning concepts taught through a lecture format. In course evaluations, students unanimously recommended greater use of the game.

This article has identified some implicit benefits and costs in the use of simulation games. The ultimate evaluation balances the potential costs against the potential benefits and asks, "Is it worth the trouble to incorporate simulation games into an agribusiness management class?" On one hand, if simulation games are properly executed, they can raise teaching effectiveness by creating situations that will be remembered by students. Experiences remembered are part of the educational process and are probably more useful for business management than memorized formulas. At the same time, simulation games require a great outlay of instructional effort. If this added effort is incurred by an instructor who is underemployed, then the game is worthwhile. On the other hand, if adoption of a game requires a curtailment of research endeavors, then the use of the game is probably not economically justified. In the evaluation of professional output, better-trained students do not measure up well, either by administrators,[26] or by our colleagues' yardsticks[27,28] against research publications. Thus, when using simulation games, the personal rewards of being a more effective teacher should be carefully weighed against the professional rewards of more published research.

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