COMPUTER-BASED CASE STUDIES IN MANAGEMENT EDUCATION AND RESEARCH

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Abstract

There is growing interest in combining system dynamics models with conventional case studies in order to create learning environments for management education. Such computer-based case studies promise improvement in strategic thinking skills and better integration of modeling in the policy and strategy area. Moreover, these models-with-cases are tangible products with which to conduct research in computer-based learning. This paper surveys the opportunities for using computer-based case studies in management education and for conducting novel research on management learning.

The paper first examines how models-with-cases fit in the established areas of strategic management and business policy. Which issues, in the broad range covered by strategic management, do models-with-cases address? Next, two current examples of computer-based case studies are presented (People Express Airlines and the Intecom PBXs) to show explicitly how cases and models are combined and used. Finally, the paper explores research questions that arise in conjunction with such work: 1) how to teach effective inquiry skills, 2) how to teach conceptualization skills, 3) how to enhance the ability to apply learned theories to new situations, and 4) adapting measurement methods to evaluating the educational effectiveness of computer-based cases in teaching these mental skills.

Introduction: Where do models fit in?

To understand where system dynamics models, especially models-with-cases, fit into management education, consider first how business policy and strategy are traditionally taught. Case studies are the cornerstone : The objective is to inculcate skills to "think strategically", to "view the business as a whole" or "adopt the perspective of the general manager". A typical case study is 20-30 pages in length, and contains around 10,000 words of text, several diagrams and several pages of numerical information (often financial reports and market data). Usually case writers provide a brief history of the company, a description of its products or services and information on competitors. Then, depending on the case writer's purpose, the case may describe operating details of manufacturing, marketing, and distribution, or delve into human resource policy, systems of administration and control, organizational structure, company traditions and values, management style, leadership or personalities. Case teachers use this descriptive and numerical information to trigger classroom discussion about the business, its administration and its strategic options. But how and what do students learn?

Case teachers do not teach answers to cases. They offer frameworks that guide class discussion and help learners organize case information and form opinions. For example, Porter's (1980 and 1985) competitive analysis framework is now widely used to guide discussion about business unit competitive strategy (see the process in action in Porter 1988). Whether the subject is supercomputers, water meters, airlines or fashion watches, the framework prompts critical thinking and debate about questions like: is this an attractive industry to be in, what stops competitors from entering, what motivates customers to buy, are suppliers or distributors in a position to siphon-away the firm's profits? It encourages close and critical examination of the value-added activities upon which a company builds and sustains a unique competitive edge. The framework provides the case teacher with a checklist of thought-provoking questions, and graphics with which to collect and select participants' comments.

At the end of a 3 hour case class, learners see several chalk boards-worth of writing, based mostly on their own comments, with a visual layout controlled by the case teacher (Ghemawat 1986). What has been the pedagogical value of the process? First, learners feel involved—their opinions and comments have received attention. Second, the instructor has imposed discipline on the discussion through the use of the framework, but not a heavy discipline. The framework provides broad brush questions and will accept a range of comments. With repeated use, and a lecture on competitive analysis, learners begin to adopt the framework. Third, the class as a whole has a shared focus for debate—the information displayed on the board. (The same learning benefits occur when strategic frameworks are used to organize management team discussion of live business problems, as in Morecroft 1988b).

Business policy and strategy courses cover topics in several dimensions. The strategies in question range from strategies for the business unit/single business firm to corporate strategy (strategy for a complex multi-divisional, multi-business firm). The considerations can range from the competitive and economic forces that shape strategic options and choices, to administrative and organizational constraints.

Different frameworks develop different dimensions of strategic thinking. For example, McKinsey's "7 S" framework (a simple diagram showing 7 labelled and interlinked bubbles, Hax and Majluf 1984, pp. 94-96) helps trigger thinking about constraints on strategy—the so called "fit" between strategy and structure: can the existing organization's people, administrative systems, shared values, skills, and organization chart, execute the strategy? Portfolio frameworks like the famous growth-share matrix of the Boston Consulting Group (Hax and Majluf 1984, Chapter 7) can guide discussion about corporate portfolio management—which businesses should a multi-business firm be in, how should corporate investment funds be allocated, what criteria should the corporate management use to evaluate and compare business unit performance, how should one segment the business for strategic planning purposes?

Computer-based case studies retain a strong process flavor—they stimulate and guide discussion, without stifling it. By direct analogy with Porter's framework, the model, along with the systems thinking concepts that accompany it, shapes the case discussion. (Later sections will describe the elements of systems thinking.) The Intecom case described later uses STELLA maps (Richmond *et al.* 1987) combined with "chalk talk" to fill the need for shaping. In addition models-with-cases allow "what-ifs" and role-playing in a closed feedback system, which add important new process dimensions that cannot be replicated in the conventional case method. Learners are drawn into the case by taking the role of key decision-makers, exercising choice and judgement, and seeing the consequences. The People Express case described below shows what is possible with decision-making simulation and the simple what-ifs. (See Graham and Senge 1988 for additional discussion of how models extend the case study method.)

System dynamics models are particularly suited to understanding the coordination of operating policies—how to design a set of interlocking policies and programs that support rather than frustrate strategic objectives. This strength of dynamic modelling positions models-with-cases clearly at the level of business unit strategy rather than corporate strategy and portfolio management. In addition, at the business unit level, models can illuminate the so-called administrative issues (goal formation, incentives, time allocation, priority setting, information deficiencies, behavior and motivation) rather than market and micro-economic issues (as covered by Porter's framework). Models-with-cases, then provide an important link between strategy formation and implementation at the operations management level. There is no claim, then, that models-with-cases have across-the-board applicability to all strategic issues, but instead make unique and much needed contributions to developing strategic thinking skills for operating policy design.

Case 1: People Express Airlines

The Rise and Fall of People Express. One of the most popular Harvard Business School cases in recent years focuses on People Express (PE) Airlines (Whitestone 1983). PE went from startup in 1981 to the fifth-largest US airline in less than five years. Behind its meteoric rise were deep discount prices that made an airline ticket comparable to a bus ticket on many east coast routes, a host of innovative "new management" policies, such as universal employee ownership and job rotation, and a charismatic founder, Don Burr. But, the spectacular success of People Express' startup was not sustained. In the first six months of 1986 the firm lost $132 million, and, in September 1986, the firm was purchased by Texas Air. Business school professors have used the People Express case to examine a broad range of issues in growth management, industry deregulation, human resources, and executive hubris.

A Strategy Model. The PE simulation model builds on the generic "market growth" structure of interactions between developing demand and satisfying demand (Forrester 1968 and Senge 1986). The model includes a human resources sector with multiple experience levels, and effects on productivity of stock ownership and profit-sharing, morale, and turnover. The model assumes a two-tier market with established air travelers and "new" air travelers attracted by lower fares, with "market diffusion" driven by advertising and word of mouth. Potential customers respond to availability of routes and scheduled flights, fares, service quality, and "service scope" (the range of services offered). The model includes competitor price response based on PE's market share (Sterman 1988).

The Lessons. For the past two years, the System Dynamics Group at MIT has used PE as a computer-based case to show how a firm can develop a set of policies that make sense individually but fail in concert. At the heart of People Express' demise were inherent contradictions between its innovative human resource policies and its aggressive growth policies. Don Burr wanted to demonstrate "a new way to run an airline," to show that a non-hierarchical structure, democratic principles, trust, and shared economic risks and rewards would produce a vastly more productive workforce. He also was intent on becoming a major player in the airline business in a few years, to which end he expanded fleet capacity 100% per year, marketed aggressively, and maintained exceedingly low fares. The result was inadequate time to develop management skills, falling service quality, declining morale, and high turnover.

A Game and Workshop. For learning purposes, the model has been converted into a decision-making simulation (called the "People Express Management Flight Simulator"), which allows learners to decide each quarter year how many planes to buy, how many service personnel to hire, and how much to spend on marketing. The learner can also set price and service scope. For a day-long session, learners receive in advance the Harvard Business School case writeup (Whitestone 1983), a fifteen-page briefing book that summarizes the assumptions of the gaming model and gives instructions on how to use the game (Sterman 1988). The morning focuses on interleaving game play by teams of 2-3 learners per computer with instructor-lead discussions.

The afternoon concludes the workshop with the instructor showing simulation experiments and generalizing lessons (both on the business results on strategy and human resources and on general systems thinking principles) illustrated by the case. The People Express Flight Simulator was used in Fall 1988 by all 200 incoming masters' students at the MIT Sloan School of Management in a day-long orientation, and is being used regularly in courses on operations management in service industries, behavioral decision-making, and system dynamics.

Case 2: Intecom and the PBX Market

Background. In the early 1980s the AT&T operating companies (such as New England Telephone and New York Telephone) were converting their highly profitable base of electromechanical telephone switching systems (known as PBXs) to new electronic PBXs, in an increasingly competitive market. A key issue facing senior managers was how to retain a high share of the installed base of PBX systems while migrating customers from old to new technology systems. The strategy for managing the migration required executives to think about pricing, the size of the sales force, motivation and compensation, and the actions of competitors. In the event, some of the operating companies lost 60 percent of their market share during the migration while others lost only 20 percent!

The Model and Case. A management team from one operating company commissioned a system dynamics project to help the team think more closely about the migration strategy. It is this model (Morecroft 1984) which is combined with the Intecom case (Ghemawat 1985) in order to replicate for students the insights gained from the project. The Intecom case deals with the entry of Intecom, a new company affiliated with Exxon, into the top-end of the US PBX market. Most of the case is devoted to describing switching products, PBX technology, customers, channels of distribution, installation, service and manufacturing. There is also information on competitors and deregulation. The appendices contain industry level data on the installed base, line shipments, market shares, manufacturing costs and corporate financial performance.

The Process. The case provides a wealth of background information on the industry, thereby mimicking the experience base of the AT&T management team. Students are asked to read the case in advance and think about the following questions: what is a relevant measure of market share in the PBX market, how do you set reasonable sales objectives for a migration strategy, what pricing options would you consider for old and new systems?

The case discussion lasts for 3 hours and is organized around 3 STELLA maps (Richmond *et al.* 1987) of increasing complexity that represent visually the migration strategy. The maps are displayed on a Macintosh computer linked to a large-screen projection system. The first map shows a base of electromechanical PBXs (represented as a single stock) being depleted by migration rates which flow into a base of electronic PBXs shared between competitors and the operating company (represented as two stocks). The case teacher can use this very simple model to clarify the near monopoly starting position of the operating companies, to trigger discussion of the changing regulatory environment and to think about market share definitions (share of base or share of sales?). He can also introduce simulation by posing the question and simulating the answer to—how will the base change if migration proceeds at a constant (specified) rate for the operating company and for competitors?

The case teacher then sets-aside the computer and reverts to conventional chalk talk in order to make the class think carefully about the customers—who are they, why should they migrate, what factors influence their decisions, what are their motives and incentives? Here the behavioral underpinnings of system dynamics (Morecroft 1985 and 1988b, pp. 24-33; Sterman 1987a, b, and c) provide a checklist of leading questions to structure the discussion and record people's comments. The second STELLA map incorporates the main features of the chalk talk and shows explicitly how sales effort, prices and customer behavior influence migration.

Class discussion next turns to the sales force. What is it like to be a systems salesman, how might you spend your time, how do you set priorities, what motivates you, how do you decide to allocate your time?—a series of questions that makes the class probe the vital issue of what determines sales effort. The final step is to talk about the competition. A crucial point here is to have the class recognize that the competitors (as a group) are growing companies that feed on their own success. The structured discussion lasts about two hours and leads into the third STELLA map which incorporates sales effort, prices, sales time allocation, customer behavior and growing competitors.

The students are now divided into teams of five, and sent away for half an hour to devise their own migration strategy. The "levers" they have at their disposal are price (for both old and new systems) and sales force size—a subset of the real levers that were available to AT&T management. Each team is given a hard copy of three STELLA graph functions on which they can draw time profiles for price and sales force. The teams are asked to justify their choice of time profiles and predict the likely effect on market share, competitor sales, and sales expense to revenue ratio. During the remaining class time as many teams as possible are given the chance to explain their customer migration strategy and to simulate it on-line in the classroom.

The Lessons. Simulations show a wide range of outcomes. Some teams lose market share rapidly and also incur high sales expenses. Others maintain a much higher market share with low expense to revenue ratio. This diversity resembles the diverse outcomes of the real AT & T operating companies. The successful teams recognized that a high lease price for the old base can be very profitable (milking the old base) but also creates vulnerability if competitors aggressively market the new technology. However, by using some of the extra funds from the old base to finance sales force expansion, growth of competition is restricted, and the expense to revenue ratio is reduced. The model-with-case also demonstrates that features of behavioral decision-making (customers' imperfect knowledge of products, technology and prices) create both opportunities and pitfalls in the implementation of strategy.

Research questions on teaching systems thinking

The amount of research into management education pales in comparison to its importance in society. For better or worse, the foundation of American management is taught in MBA programs, and European management education is moving toward a similar system. The performance of entire economies would seem to rest on the quality of management education, but research on measuring and increasing the effectiveness of management education is nearly nonexistent, at least by comparison to, say, economics, which is in turn paltry by comparison to research in the physical sciences. The process of teaching what is known about management has changed little from a century ago. Researchers write articles and books, and teachers as individuals use the books to build curricula, with little or no evaluation of effectiveness or comparison with alternatives, and few resources available for innovation. There is adequate research in management, as evidenced by publications and the number of experts in business schools and corporations. But possible teaching technologies for passing that knowledge to younger generations are sorely neglected.

In our view, perhaps more important than merely creating a new teaching technology is measuring its effectiveness in objective, scientific fashion, and understanding as well how and why it is effective. What follows here is a taxonomy of what we believe to be the three facets of effective systems thinking as it is brought to bear on strategic and policy issues, and the contributions we expect system dynamics and computer-based case studies to make to the teaching of each facet of systems thinking skill.

What are the elements of systems thinking skills as they apply to strategy? Consider what happens in the design of a strategy. Often, new strategy initiatives begin with someone, the CEO perhaps, stepping back from day-to-day business operations and coming up with a new idea that in retrospect is obvious. There seem to be at least three elements of the process. First, asking the right questions to discover the most important facts might be called *investigation*. Second, stepping back and ignoring some facts while expressing others in more general terms, recasting them into a new framework, is *conceptualization*. Third, if the "creative leap" recasts the situations so that an already-known theory of business applies to it, that is *theory application* or *transfer of learning* to a new situation.

The stock-in-trade of professional system dynamics modelers, like effective executives, similarly involves the same skills of investigation, conceptualization, and transfer. But unlike most executives, most modelers believe their skills to have been developed by a systematic process of education and apprenticeship. The central research question here—the hypothesis to be tested—is that elements of systems thinking, modeling, and case studies can enhance the skills of investigation, conceptualization, and transfer.

Investigation/Learning Strategy. Morecroft (1988) describes simulation models and model-based games as *microworlds*, which are simpler and create outcomes faster than reality. Senge (1989b) advocates using models to learn from (rather than to convince by weight of authority). Unfortunately, research suggests that a disappointingly small fraction of people have learning skills sufficient to discover how things work, in the microworlds, and by extension, in real life. Wheatley, Hornaday, & Hunt (1988) found that students enjoy standard management games but argue that performance in the classroom or later life is not enhanced by games. Senge (1989a) describes a workshop where participants played a game (based on a dynamic model) much like they would a video-game, with fast play, little time out for discussion or reflection, no explicit learning strategy, and in the end, very little learning. Moreover, even "knowing the ground rules" through extensive conceptualization of the model structure before playing game didn't allow the participants to discover how to change the behavior of the system.

The primary contribution of computer-based case studies is creation of an environment in which actual investigation can occur. A lecture *about* investigation is no substitute for actual investigation, any more than being told *about* solving algebra problems is a substitute for actually solving them. An important side effect of doing actual investigation is fun. The learning process incorporates discovery, enjoyment, play, and sometimes competition. People can sustain interest in the subject matter, and the learning experience is more powerful and enduring.

A second contribution the models-with-cases can make to investigative skills is to support using the scientific method -- hypothesis formation, designing tests, evaluating results of tests. With a microworld, the computer can either be used to efficiently explore a large number of meaningful experiments, or it can be used to randomly search for winning strategies, with no idea as to why those strategies are effective. Senge (1989a) suggests that the critical elements of effective learning strategy are a clear business strategy with an explicit rationale and expectations of behavior for key variables before playing, coupled with careful explanations of gaps between expected and actual behavior after playing. Indeed, participants the the Sloan School's People Express exercise are asked to state explicit predictions (hypotheses) about the effects of policies, and discuss results afterward.

A third contribution of system dynamics to investigation is furnishing conceptual tools and results. As a profession, system dynamics has a body of knowledge about how problems in complex systems arise, and a language for describing them. These aid conceptualization also, but to the extent that systems principles tell one what to look for, they also increase effectiveness of investigation. For example, if a problem persists despite efforts that apparently should solve it, one should look for feedback loops that compensate for the solutions and perpetuate the problem behavior. Many of Senge's "System Principles for Leadership" (1986) are in fact principles to aid investigation.

A fourth contribution is computer support for reflection and hypothesis testing . Intellectual skills, unlike physical skills, require more than just repetitive practice. People need time out to conceptualize what has happened and learn from it at an abstract level suitable for application to other situations. In a typical many-learners-one-instructor situation, it is easy for an individual to "spin his (or her) wheels" trying strategies that aren't working. In a one-on-one situation, an instructor can call time out and suggest different strategies; eventually, computer software will detect repeated failures and offer suggestions. Similarly, one-on-one instruction frequently uses explicit statements of hypotheses, experimentation, and pointed questions that encourage the learner to look at the results carefully, compare them to the original hypothesis, and state what has been learned. Again, the same software that allows a learner to experiment with different policies should perform these additional pedagogical functions.

Conceptualization / Abstraction. Conceptualization complements investigation: once information is acquired, some skill is required to use it effectively. It has been said that asking the right question is halfway to finding the answer. This is particularly true in dealing with complex business situations, where creating the right concepts makes things almost obvious. (Graham 1977 Chapter 1 provides detailed discussion on the role of conceptual tools in the creative and analytic processes.)

The primary contribution system dynamics makes to conceptualization skills is a well-worked out hierarchy of formalisms for moving between detailed descriptions of a situation and abstract descriptions. The most-discussed advantage of the case study method is the real-life detail. Dreyfus and Dreyfus (1986, pp. 16-19) cite experiments where real-life detail was critical to problem-solving ability, even though the details were not logically necessary. But if the case materials have a truly realistic amount of detail, learning from the case becomes as difficult as learning from real life. Case studies, both written and computer-based, can be made almost arbitrarily detailed or misleading. The level of detail with which learners must deal, then, is an important dimension in the educational process, and models-with-cases offer carefully-controlled treatment of level of detail.

The People Express case handles the conceptualization and abstraction processes through a series of transitions from the detailed to the abstract: It begins with the Harvard Business School case (rich in detail, without exposure of much underlying theory), goes to the briefing book (almost as rich in detail, but organized to show cause-and-effect structure more clearly), and then immerses learners in the simulation game (much less extra detail about cause and effect, but detailed, quarter-by-quarter decision making, and clearly dynamic behavior). The instructor then analyzes simulations (where decisions are replaced by decision rules and examination of behavior at particular points in time is replaced by examination of curves over time), and finally, discusses behavioral principles.

The Intecom PBX case similarly uses a series of transitions, beginning from the Harvard Business School case, to alternating use of STELLA maps (that build up the cause and effect structure in small steps) and board diagrams (that allow detail-rich discussion of customer, sales force and competitor behavior), to small group discussion of migration strategy, to instructor-led consideration of simulations, and finally discussion of strategic lessons (that ties simulated behavior to system structure). (Recent experiments to involve management teams in conceptualization and model-based learning have also made specific use of transitions using conceptualization tools—starting from loosely structured discussion, to maps, to friendly algebra and to partial model simulations, Morecroft, Lane and Viita 1989). Kim (1989) describes the use of conceptualization tools in a learning setting; Gould's (1989b) research will investigate their effectiveness.

At some point, sufficiently elaborated software should support learners in the conceptualization and abstraction processes. Other business simulation games offer a very detailed environment, in terms of receiving memos on the current state of the (simulated) business, memos asking for decisions, newspaper reports on the state of the (simulated) industry, and so on. At first, such detail is useful for orienting a learner and giving a reassuring sense of familiarity. But later, such details become clutter which obscures the underlying issues. Giving learners the ability to turn off such "realism" may ease the conceptualization of the dynamic issues in more abstract terms. Likewise, the "management information system" of the People Express game gives more detailed information than learners can usually use in playing the game. As a learner's understanding of the dynamic issues grows, it may be productive for the learner to tailor the information system to display a succinct summary of the information normally used in decision making. Finally, as learners begin to see that decisions are created by decision rules, it would be useful to allow learners to specify decision rules instead of continuing to plow through game play time step by time step.

A second contribution, tightly linked to the first, is simulating the modeling experience. Neuhauser (1976) argues that the value of games comes from the process of building the model used in the game; thus the game designers find them interesting and useful while the learners who merely play the games may become bored and disenchanted. Toval and Flores (1987) make the same claim, and argue it is the process of model-building which generates deep knowledge of the systems under study. Certainly this is the experience of professional model builders.

As an approximation to the model-building experience, one computer-based case study uses explicit conceptualization exercises prior to playing the computer simulation game (Kim 1989 and Moissis 1989). The learners use causal loop diagrams coupled with paragraph-long "mini-cases" to begin thinking about major interactions in their particular case. As a result, they are thinking about important feedback processes evident in their case, and be formulating their own initial hypotheses regarding causes of behavior and possible remedies, all in relatively abstract terms consistent with a system dynamics model and game. Their conceptualizations can then be compared to assumptions built into the formal model. This gives the learners knowledge of what's in "the black box." It also helps to develop familiarity and skill with thinking how feedback process can explain behavior, and of course, conceptualization skill.

Theory Application / Transfer Skills. The ability to apply knowledge to new situations is the fundamental goal of all education. Even so, we have no directly-measured clinical experience with the reverse of the transitions described above, where learners begin from an abstract theory and apply it to another real situation. Prior research suggests transfer of concepts from one situation to another is difficult, though some investigators are rather more optimistic than others (Nisbett et al. 1987). A large literature suggests the traditional case method is not well suited to teaching systemic thinking and the ability to transfer insights from one problem to another (Kardes 1987, Nisbett et al. 1987). Kardes suggests that an important reason is the relative weakness of theory teaching, compared to the example teaching in the case method. He cites experiments where teaching by examples was more effective than purely theoretical teaching, but teaching that combined theory and example was more effective than either pure case. Equal amounts of time were spent for each trial.

The experiment cited by Kardes, then, suggests a major contribution available from models-with-cases: An explicit, well-worked out theory relating directly to the case materials, and in a form amenable to transfer to new situations. (As an example of the desirability of integrating theory and cases, consider the major success of Porter's framework for strategy analysis.) A model not only provides a game-playing environment for experimentation, but it also provides a tested theory of why the system behaves as it does, and why some policies succeed and others fail. Moreover, the theory is stated in relatively abstract terms that facilitate application to new problems. Bakken's (1989) and Gould's (1989b) research will measure ability to transfer learnings from one case to another and hopefully identify factors that aid or hinder that transfer. Bakken will measure it by game performance, and by assessment of verbal protocols (running commentary by learners as they play).

A second contribution comes from the ability to identify cases that deal with common dynamic issues. The idea has existed within the system dynamics field for twenty years or more that there is a small number of fundamental corporate problem behavior modes (perhaps twenty), and that an equal number of moderately-sized models could describe the fundamental lessons needed to control them. This is the idea of the generic model of a corporate problem—a model with "no brand name." (Paich 1985) discusses the concept at a general level; (Graham and Scogin 1985) describe a generic model of the problems encountered in automating production; (Graham 1988) offers a candidate list of generic corporate problem modes. For example, the People Express model embodies the same dynamics identified in (Forrester 1968) and that have recurred with variations many times since in system dynamics studies.

From a somewhat different perspective, (Sterman 1987b and c) and (Diehl 1989) begin to identify generic deficiencies in the way people normally perceive and act on problems embedded in complex feedback systems.

How should systems thinking skills be measured?

Throughout this paper it has been suggested that computer based case studies can enhance the quality of learning. How can the effectiveness of a model-with-case be determined? There are a variety of possible measures:

1. *Self-evaluation.* Let participants rate how much they learned. This has the difficulty raised by Wheatley, Hornaday, & Hunt's (1988) of reporting enjoyment without significant and lasting learning.
2. *Game performance* on the model of the case. This can either be simple scoring (did learners under conditions A score higher than under conditions B?) or by mathematical analysis of the changes in implicit decision rules being used (as in Sterman 1988b and c, Moissis 1989).
3. *Protocol analysis of game play.* Transcriptions of running commentary by game players coded (by independent coders) for systems thinking content.
3. *Verbal or written examination on the case.,* he traditional grading scheme for case studies. To reach scientific conclusions, however, a reliable and repeatable grading scheme is needed. And such evaluations measure the ability to talk about issues rather than willingness or ability to act on them, either in a game or on the job.
4. *Game performance on a model of a related case.* Unlike the measures above, this metric explicitly measures the ability to transfer insights from the case to new situations.
5. *Verbal or written examination/discussion of a related case.*
6. *Self-reporting on usefulness on the job.* This measure rests heavily on the perceptiveness and introspection of the learner, which may be taxed to identify changes in problem-solving approaches, especially if several people in the work group have had the same training: "We've always thought systemically like this, haven't we?"
7. *Protocol analysis of performance on-the-job.* Transcriptions or notes taken by an observer of actual business meetings are scored for systems thinking content (or specific lessons from the original case). (Anderson 1977) used this procedure to measure the use of systems thinking concepts in a bureaucracy; (Argyris *et al.* 1985) make more general use of this investigative technique to measure the dominant concepts people use in practice. Any such experiment has difficulty in controlling for e.g. the background of the participants, the investigator, and even the presence of an investigator (i.e. the Hawthorne effect.) Wolfe (1985) notes the extensiveness of such difficulties as a partial explanation for the diversity of conclusions about the effectiveness of management games.
8. *Job performance.* Improving job performance is the ultimate goal of management education, but the effects of education on job performance is the most difficult.measure for which to maintain adequate experimental controls.

There is a spectrum of measurement methods; in general, the closer a measure is to measuring actual usefulness, the more logistical and control difficulties it presents. Because somewhat different characteristics are measured by each, and because the effects of computer-based case learning on job performance is unlikely to be measured directly, a multiplicity of the less direct measures are needed to form valid conclusions about effectiveness of management education. For example, in one study in progress, managers at the Hanover Insurance Company participate in a three-day "learning laboratory" in which a CBCS and simulation game are used (Senge 1989). The effectiveness of the workshop is measured by (i) learners' subjective reports of the usefulness of the program, (ii) demand within the organization for the workshop, (iii) subjects' performance in the game relative to optimal perfomance, and (iv) performance on an examination to be administered some time after the workshop (Moissis 1989).

Work on measurement methods is progressing in several projects. As mentioned above, the experiments described in (Moissis 1989), (Gould 1989b), and (Bakken 1989) are under way at MIT. The Educational Testing Service of Princeton is currently attempting to define metrics for systems thinking so they can evaluate the effectiveness of system dynamics in high school curricula including physics, chemistry, and social studies. Pilot programs are underway in Brattleboro Vermont and several other school districts in the United States.

Conclusion

Effective management education is important to individuals, corporations, educational institutions, and ultimately, society in general. The preceding discussion has strongly suggests that considerable improvement is available in management education, in certainty about how to teach, in formalizing instruction in the area of systems thinking applied to strategic analysis and execution, and in technologies available to assist in teaching. Computer-based case studies—models-with-cases—seem to offer considerable potential in all of these areas.

Moving forward with computer-based case studies will require collaboration among numerous stakeholders: Corporations and managers to fund, to serve as test sites for, and in some instances, be final users of models-with cases; Modeler/researchers to create the cases and do the painstaking measurement necessary to establish findings with certainty; and universities to provide institutional support for both research into management education and for integrating models-with-cases into the standard curricula. Such a complex collaboration will require considerable time and money from all concerned, but the payoff portends to be orders of magnitude larger.

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