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ABSTRACT

Some 40 years after the inception of management simulation games, the effectiveness of games in management education/training remains unclear. Despite the lack of consensus regarding the teaching and grading methods to be used in conjunction with such games, it is clear that well-conducted simulation games can provide excellent experiential atmospheres for students of management. The following keys to success in applying games in management education and training programs have been identified: (1) define the game's pedagogical and learning context; (2) define the game's subject area and objectives; and (3) identify resource limitations such as limits on time and cost. From the beginning, most business games have focused on business policy and strategy and to a lesser extent on marketing. Games in the production management area have not been as popular and have not changed much since the early 1960s. Most games in the production management area require learners to make decisions regarding raw material ordering, setting production levels, overtime and regular labor hours, plant maintenance, and quality control. Some are competitive, and others are noncompetitive games. More games are needed to teach the newer concepts of just-in-time ordering, synchronized manufacturing, and material requirements planning. Also needed is more focus on global competition and service-type industries. (Contains 41 references.) (MN)

Simulation Games in Production Management Education - A Review

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SIMULATION GAMES IN PRODUCTION MANAGEMENT EDUCATION - A REVIEW

ABSTRACT

Simulation games have been used in management education for forty years. During this time there has been a steady growth in the number of available games and in the number of instructors using them. At the same time, a large body of literature has been published addressing the issues of the effectiveness of simulation games, the conduct of the games, and the design of the games. This paper reports on a study of this literature on the effectiveness of simulation games as an instructional tool. Some games designed for the production management area are then described.

Keywords: Simulation games, management education, production management, gaming.

1. Introduction

Simulation games are activities designed to mimic the reality of the external world, within the classroom, with the goal of instruction. The learning is intended to be experiential - the student experiences the studied phenomenon and learning proceeds inductively. While case studies and role-playing also aim to provide an experience with reality, the unique characteristic of simulation games is the incorporation of the time element - simulations imitate the passage of time and the students have to live with the results of their past decisions. Another characteristic of simulation games is their strong sense of make-believe, the sense of playing a game. Simulation games have been used in diverse areas of instruction - from aircraft simulator to simulation of interpersonal relationship in organisations. There is a wide range in the complexity of simulation games: from board games to computerised simulations. Even the simple act of walking may serve as a simulation for instructional purpose (Wu, 1988)! While a simulation mimics reality and is often used to predict what would happen in a given scenario, the word "game" suggests playfulness and competition. Simulation games combine these two characteristics. Games that explore business strategies for the entire organisation are called top management games, and games that have their primary focus on a selected functional area of business are called functional games. These functional games are available in the areas of accounting/finance, marketing, production, and human resource management.

The first simulation game for teaching business management appears to have been introduced in 1955. This game, called *Monopologs,* was developed by the Rand Corporation for teaching logistics to U.S. Air Force personnel (Faria, 1990). In 1956, the American Management Association introduced its *Top Management Business Game*, which was meant for training top management, and included decisions on production, marketing, assets, inventory, etc. The computations were performed on an IBM 650 computer (Kibbee *et al.* 1961). In this game, the players filled a form indicating their decisions, this information was punched into cards, and the computer program was run. The computer provided performance reports, and the cycle was repeated. By 1961, Kibbee *et al.* (1961) listed 31 computerised business games, five of which were production simulators. Since then there has been a steady increase in the number, sophistication, and adoption of simulation games (Faria, 1987; McKenna, 1991; Burgess, 1991, Wolfe, 1993b). The wide availability and use of business simulation games raises a number of questions. Are games valid as educational tools? How effective and efficient are simulations for educational purposes? What games are available, and what are their objectives? How to design these games? How to mount a simulation gaming module in a course? How widespread is the use of simulation games for instruction? Over the last forty years large number of articles and books have been written to answer these and related questions. This paper is not an attempt to comprehensively review this very large body of literature. The goal is to summarise selected writings in the area of the pedagogy of simulation games, and to discuss available computerised simulation games in the area of production management.

2. The pedagogy of simulation games

How valid are simulation games as educational tools? Games are often simply so much fun that students do not mind spending long hours on them. But do they learn anything? Could another teaching tool be used with more effect or with less resources? There exists a vast amount of literature which attempts to answer these questions. Greenlaw and Wyman (1973) reviewed the literature on the educational value of simulation games. Wolfe (1985) brought this review up to date to 1983. Keys and Wolfe (1990) have also provided a comprehensive review. These reviewers have lamented on the inconclusiveness of all this research. This section summarises some of this research.

The theoretical underpinning of simulation games as a learning/teaching tool is provided by the model of experiential learning. Kolb's (1984) experiential learning model is shown in Figure 1. According to this model concrete experience of a phenomenon in the real world triggers the learning cycle. This event is observed, and causes reflection in the student. The student forms abstract concepts and hypotheses to experiment with reality. These concepts are tested in new situations that provide concrete experience, which starts the cycle again. Simulation games provide the concrete experience needed in Kolb's model.

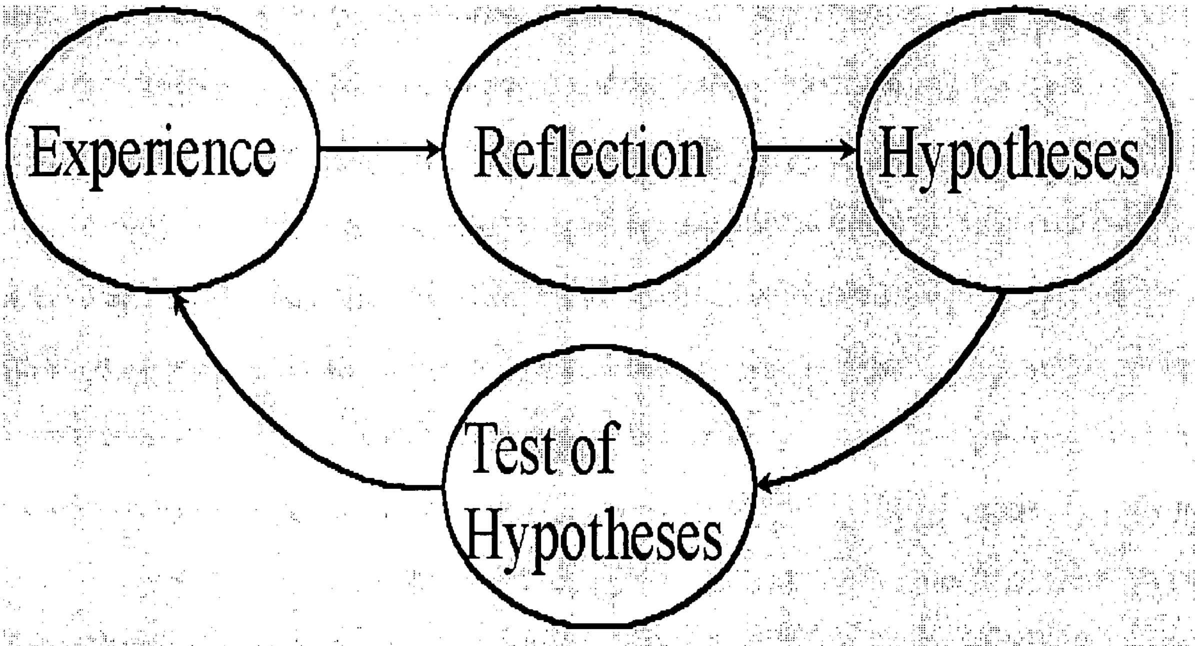

Figure 1. Experiential Learning Model

Besides simulation games, there are other means of providing the experience of reality to students - case study, role-playing, in-basket method, and incident process. The main advantage of simulation games over these alternates is the dynamic nature of the games. Having taken a decision in a game, the effect of these decisions persist into the future in the game. Another advantage is the verisimilitude offered - some games are able to provide a high level of make-believe and fantasizing. The strong interest that is aroused in the subject matter is itself of pedagogical value.

Raia (1966) in his often-cited study, carried out an experimental comparison between a simple game, a complex game, and readings. Boseman and Schellenberger (1974) used modified Raia's instruments to compare students who did only cases against students who did cases and games. Attempts were made to equalise the workload. They did not find the interest of game players any higher than non-game players. Their attitudes towards cases, management, course, and the instructors were not significantly different. Same results were obtained for perceived or actual learning.

Wolfe and Guth (1975) made an experimental comparison between a case-only and game-only approaches of teaching business policy. In their study, the game-only students achieved a higher level of examination scores than the case-only students. Students in the game-only section achieved a higher degree of principle and concept mastery, but the differences in fact mastery were not significant. However, their games-only section had a lot of structure - periodic reporting, class discussions of events, review sessions, self-appraisals, and diary of events. This structure and guidance essentially closed the loop of experiential learning (Figure 1) and may have contributed to the positive result as evidenced by a subsequent (Wolfe, 1975) study which did not have this guidance, and had a negative result

DeNike (1976) carried out an exploratory study attempting to explain the conflicting findings about the effect of simulation games on student motivation, factual learning, and attitude. He found that, like other instructional strategies, simulation gaming may be suited for students with some particular cognitive style: (1) gathering a great deal of information from listening to others, (2) deriving meaning from sounds other than words or numbers, (3) empathizing, (4) preferring peer-group interaction, (5) Able to operate in independent study settings, but preferring not to do so, and (6) reasoning through the application of rules and/or definitions.

Remus (1977) explored student attitudes after the conclusion of a business management course that included a simulation game. Like some earlier studies, he found that students' enjoyment of the game, their perception of acquired knowledge, their perception of the generalizability of the game, and their taking responsibility for the game results are all a linear function of the ranking of their performance in the game. It appears that only the winners of simulation games are positive about gaming. Since simulation games are often competitive, and there are invariably much more losers than winners in a competition, it appears that students' self-reported benefits will be negatively biased. This study points to the need of underplaying the competitive element in gaming. In a follow-up study, Remus and Jenner (1979) confirmed the earlier findings. They found that the rank to satisfaction relationship was weaker for multi-person teams as compared to single-person teams. The also found that, for the multi-person teams, high rank was associated with conservative, consistent, and systematic decisions. They (Remus and Jenner, 1981) also found that students come to a gaming class with rather high degree of educational expectation, and are somewhat disappointed with the experience; but they still recommended continuing the game in the course.

Parsuraman (1981) classifies the existing evaluation of simulation games into three methodologies - (1) Experimental evaluation, where the students are split into different groups which are exposed to different educational techniques. The efficacy of the techniques is then judged by a common examination at the end. Most of this type of evaluation has been inconclusive, and Parsuraman criticised this kind of evaluation on the basis that the common examinations test cognitive learning of the students, while simulation games actually teach the "process" of decision-making (and not cognitive learning). (2) Correlation between students' performance in the simulation games and their performance in other examinations and assignments in the course. Here, Parsuraman questions the simulation game performance as a measure of learning. (3) Surveys of student self-reports. Generally these surveys have shown simulation games on a positive light, but the ability of the students to judge the worth of games is questionable. Parsuraman concludes that the evaluations should actually test the appearance of reality in the games, and the worth of the types of decisions made in the games. He suggests that experienced practitioners, not college students, are better judges.

Ruohomäki (1995) discusses the use of simulation games from the viewpoint of learning theory. A simulation game combines the features of games (competition, cooperation, rules, participants, roles) and simulation (abstraction of reality by a model). Simulation games are used when there are not possibilities for students to get experience of the systems or situations in the real life - where reality is too expensive, complex, dangerous, fast, or slow. Ruohomäki identifies two purposes of simulation games: 1) understanding of reality - to describe, analyse, and evaluate realities, and 2) training - learn procedures, and carry them to work activities. To achieve these, a simulation game should include orientation to the game prior to the game, the game, a debriefing consisting of reflections and observations, and forming concepts and generalizations, and integration. Simulation games can provide an opportunity for the active experimentation phase of the experiential learning cycle. Participants can try out new solutions, and see the probable consequences. According to Ruohomäki, simulation games provide: 1) cognitive learning outcomes - information, principles, critical thinking, 2) attitude changes toward the subject matter, society, and oneself, 3) increased motivation and interest towards the subject, for doing research in that field, and 4) positive effects on groups - better communication, interactional skills, empathy for those in other roles. Simulation games provide active learning (vs. passive learning in lectures), So it is a student-centred method. It emphasises learning by doing.

Lane (1995) in a review of simulation games has crystallised some of the cautions to be exercised in the educational use of the games:

1. Learning objectives. It is easy to be sold by the gimmicks and fun in the games, but what will be learnt?

2. Supporting materials. There should be enough learning materials to support the game's objectives.

3. Other pedagogical tools. It cannot be expected that simulation games will serve all the needs of a course. At best they will supplement a well-designed course.

4. Bells and whistles. So much seductive technology is available that it is possible for the designers to be looking for appropriate topics for the technology, rather than finding suitable technology for the teaching objectives in hand. The use of animation, multi-media, and virtual reality may provide more fun than education.

5. Complexity. It is better to have a simple game serving a specific learning objective, than a complex game satisfying a number of objectives. Students may find it hard to capture the desired experience.

6. Briefing and debriefing. Evaluation of simulation games has shown time and again the importance of proper briefing and debriefing. Students cannot be left to decide on the rationale of the game, and to reflect on what happened.

7. Facilitators. The facilitators need to understand the simulations and the learning objectives thoroughly. Games cannot teach by themselves.

8. Resources. Computer software is famously known for underestimating the resource requirements. Games designers need to beware.

In a similar vein, Riis, Johansen and Mikkelsen (1995) suggest the following as the keys to success in applying games:

1. Define the pedagogical and learning context for the game.

2. Define the subject area and the objectives of the game

3. Identify the resource limitations such as the limits on time and cost.

In an interesting article, Partridge and Sculi (1982) present the perceptions of game participants on the managerial skills developed by top management games. They used the eight managerial skills identified by Mintzberg (1973) for this purpose. They compared the ranking of these skills, as ranked by senior managers in order of importance, with the ranking by game participants in order of game's contribution to the development of the skills. Interestingly, the ranking were in almost reverse order! Apparently, the games do not help in developing the most important skills - leadership and peer skills. The only important skill for which games were beneficial was "decision making under ambiguity". This study clearly depicts the quantitative bias of games as against the development of people skills. The authors suggest the use of cases in conjunction with the games to bring out the leadership and peer skills.

The latest wrinkle in the games scenario is the bundling of decision support systems (DSS) with the games. DSS provide the game players detailed modelling and decision making capability (Yeo and Nah, 1992). These can provide what-if scenarios, financial analyses, expert systems, and other decision support. So far, the benefit of DSS's to the students' learning in a games environment has not been demonstrated. Indeed, the benefits can be questioned: DSS may provide some of the answers the students should seek by themselves, and the ultimate DSS model will duplicate the model included in the management game, so everything will be transparent! But where the goal of the games is to encourage the practice of certain tools and techniques, e.g. Material Requirements Planning (MRP) and Linear Programming, a DSS incorporating these tools and techniques may be beneficial.

In conclusion, in spite of many anecdotal success stories and apparent student enthusiasm with games, the objective, experimental evaluation of game-based instruction, particularly as compared with case-based instruction, remains inconclusive. Obviously, it is hard to control for the quality of games as compared to the quality of cases, for the instructional style and structure, and for the enthusiasm on the part of the students and the instructor. Post-game counselling and review appears to make a definite positive impact on the effectiveness of gaming. The literature generally supports the notion that students usually find gaming enjoyable in spite of the considerable time taken up by it, and a well-conducted simulation game is at least not worse than a case study in providing experiential learning. But judicious use of both cases and simulation games in classroom should bring out the benefit of both techniques in the development of managerial skills.

3. Production management games

From the beginning, the focus of most business games has been business policy / strategy (Faria, 1987; McKenna, 1991). Marketing is the next frequent subject of business games. Games in the production management area do not appear to be that popular. This is surprising, considering that manufacturing processes are very amenable to modelling by computer simulation (Law and Haider, 1989), and computer simulation is said to be a very widely used tool for decision making in production management (Ford *et al.*, 1987). In this section some available games in the production management area are discussed.

Joblot is a computerised game which simulates a typical jobshop working on a contract basis (Churchill, 1970). Basic data on the environment is provided at the beginning - the market size, the number of competitive firms, aggregate information on raw materials and processes for the jobs etc. The students initially design the layout (process layout) of the job shop and decide on the number and type of personnel and equipments in various departments. Students make decisions at the beginning of every month about revising the plant configuration and personnel, overtime, scheduling the plant for the next month, allocating raw materials, purchasing raw materials, receiving contracts for previous bids, delivering jobs, and receiving specification for new jobs and making competitive bids for them. Computer simulates this scenario for a month. Contracts are awarded (after the passage of a month) on the basis of quoted price and previous delivery performance. Quality is not modeled. Each job is unique, with its own operation sequence and load requirements on specific processes. A complete financial picture including assets, liabilities, incomes and expenses is maintained. Costs, such as raw materials, labour, lease, equipments, insurance, power, office operation, engineering work, are represented. The firm may sell common stock, long and short term debts, and may buy marketable securities. Incorporation of layout is a unique feature of this game. The software provides a lot of realism, but the students are asked to do a lot of detailed work of scheduling and planning which may be tiresome.

PROSIM (Mize *et al.*, 1971) is a production simulator that is more complex than *Joblot*, but is not as competitive. Students attempt to minimise costs rather than interact against each other. PROSIM is a detailed, discrete-event simulator that simulates production of finished products described by a Bill of Materials product structure. A number of processes may be associated with each stage of the product structure. The enterprise is simulated from raw material purchase through production to sales. Detailed costs, process times, setup times, and other constraints on production are provided. Students are urged to develop a decision strategy, and refine it over a number of weeks of simulated time. This decision strategy should help them decide on forecasts, purchase orders, production orders, regular and overtime hours, and buffer sizes. Machine breakdowns and quality problems are not simulated. PROSIM runs on mainframe. The students submit decisions and receive detailed production reports each week. The reports provide information on purchase orders, status of production systems, idle times, setups, inventory status, labour costs, machine costs, overhead costs, shift change costs, material costs, ordering costs, carrying costs, and backordering costs.

Harms and Huff (1981) present a case and an associated computer program that links logistics planning at the warehouses of an organisation to the production planning of its factories. This material was developed for classroom use. The program is not a game in the sense that it deals with a static twelve-month planning horizon, and students develop a series of linked plans for the warehouses, for the transportation from factories to the warehouses, and for the factories. But the program could be made dynamic by simulating actual sales in current month, and doing the planning for a rolling horizon of twelve months. Using historical monthly data for three years of sales, the student first forecasts sales for the next twelve months. The monthly inventory orders for each warehouse are calculated to provide a specified service level, taking into consideration current inventory levels. For every month, a transportation problem is solved to determine the quantities to be shipped from each factory. Cost of overtime production is added to the transportation costs to calculate overtime production. This results in a master production schedule for each factory. The earlier stages of production are then scheduled, using back scheduling in MRP style. It appears that the models and the linkages are all computerised, and the decision making latitude left to the students is small.

Parker and Mackness (1986) describe a production simulation of an actual alternator manufacturer. Students decide on the raw material, labour, and machine hours available. They can decide on labour training, and machine maintenance. Periodically, they get reports depicting the production levels achieved and the financial performance. Although this game does not include detailed scheduling of the processes, it does capture a lot of the production management functions. Southern (1986) presents a computer aided production management (CAPM) system that is used to simulate a factory. CAPM works at the detailed level of scheduling of the processes. Students decide on the process capacity needed in each period of the simulation and thus gain practical experience in day-to-day factory management.

DECIDE-P/OM is a non-competitive production management game that is run on a mainframe computer (Biggs, 1987). Students make 49 periodic decisions involving two products in two production stages. These decisions include quality control (sample size, acceptable quality, control limits), maintenance, labour hours (regular and overtime) and other decisions. Students can use MRP to plan the production. Substantial feedback is provided by DECIDE-P/OM to the student: income statement, balance sheet, cash flow statement, materials management report, machine utilization and productivity report, labour availability and training report, input quality control report, and an interfirm management effectiveness report.

Learners can spend a lot of time learning the software involved in the game, rather than focus on the concepts. In the approach proposed by Laforge and McNichols (1989), students work with actual production management software (such as MRP), not as a static exercise but with some dynamism introduced by the instructor through time-phased external events such as master production schedule changes, vendor performances, market conditions and machine breakdowns. Students need to cope with these events just like actual managers would. The emphasis is not so much on gaming but on learning the production management software and associated interactions. Laforge and McNichols witnessed improvements in the performance of the students as the students' experience with the situation and the software grew.

Denton (1990) describes a classroom exercise called The Production Game. This game is not computerised - students manually produce the finished product from construction paper. Students form an organisation, and work with organisation charts, labour and material efficiencies, designing, planning, and worker evaluation and training.

Smith (1990) advocates the use of animation in computer simulations to illustrate production management concepts. He describes the use of SIMAN-CINEMA software to teach the differences between functional layout, cellular layout, and optimised production technology. Students observe the actual animation of part movement and the formation of queues. While the use of animation is unique in this paper, there is no dynamic decision making one would expect in a game. Another game without dynamic decision making is TRAIN-F (Wiendahl *et al.*, 1995). In this game, the participants select production planning and control parameters such as order release and capacity and see the effect of these parameters on various performance measures using discrete-event simulation. This is more of a what-if simulator than on-going game play where one lives with what decision was made earlier. The *FMS Design Game* (Garetti and Taisch, 1995) is still another discrete-event-based game that does not involve dynamic decision making. It is used to teach students the issues in flexible manufacturing systems (FMS) design. Students use a spreadsheet model to design the FMS on the basis of the average workload.

This design is improved further by using queuing models, called by macros in the spreadsheet. Finally, spreadsheet macros build input files for discrete event simulation, and animated simulation is carried out by calling a simulation package. The students are competing to configure the 'best' FMS according to multiple criteria.

To summarise, there are many production management games available for educational purposes, but the number has not grown in keeping with the growth in numbers for top management games and for marketing games. The available games provide an understanding of production systems more at the strategic level than at the tactical level, as discrete-event dynamic systems. There is a dearth of games that include new ideas such as just-in-time, synchronised manufacturing, cellular manufacturing, and flexible manufacturing. There is opportunity also for production simulators that will provide a test-bed for students' learning of commercial systems such as MRP packages and forecasting packages. Use of animation can be highly motivating to the students in classroom use of computers. Animation could be used to depict layouts, and part movement and processing. Graphics can be of use in preparing reports, and in the user-interface. Simulation games that tap this technology need to be developed.

4. Conclusion

Some 40 years after the inception of management simulation games, the effectiveness of games in teaching / learning management topics is still unclear. Nor is there consensus on the teaching and grading method to be used in conjunction with the games. But it is fair to say, from the numerous studies done, that a well conducted simulation game can provide an excellent experiential learning atmosphere for the student of management.

Games to teach production management games have not changed much since their beginnings in the early 1960s. They mostly consist of a number of decisions on raw material ordering, setting production levels, overtime and regular labour hours, and possibly some plant maintenance and quality control decisions. After these are input to the computer, the students get feedback by way of production levels, sales, and costs. The objective is to maximise profits or minimise costs over time.

There is a need for production management games to teach the newer concepts of just-in-time, synchronised manufacturing, MRP, etc. Global competition, service type industries, and service aspects of manufacturing need to be emphasised (Wolfe, 1993a). There is also the opportunity to use the superb animation capabilities of the microcomputer in teaching layout techniques, work design, material movement, and queue formation. Microcomputers can also be used to give the students immediate feedback on their performance. The development of decision support software such as MRP, forecasting, linear programming, and spreadsheet templates, which can be bundled with the games provides another line of future work.

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