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SIMULATION RESEARCH IN THE HOSPITALITY INDUSTRY

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ABSTRACT

This review of the literature presents in-depth research pertaining to simulation modeling in the hospitality industry. The authors' intent is to expand the readers' knowledge about simulation modeling and to provide a more complete discussion of what is known about simulation theory in the hospitality literature. Further, information is provided to assist decision-makers, training professionals, and hospitality educators with theoretical and methodological suggestions specific to evaluating simulation's effectiveness and to provide a framework for understanding the enormous contributions to the simulation literature that have been made over the past four decades. A chart of simulation, indicating definitions and applications, is provided. Two comprehensive tables describing and categorizing articles in this area are also provided. The research shows substantial use of simulation modeling in both hospitality operations and education. It further shows some major methodological shortcomings. Keywords: simulation; analytical uses; instructional systems assessment.

INTRODUCTION

Following the advice of two prolific authors on simulation – Wolfe and Crookall (1998, p. 10) – who said "individuals who know their own literature very well, must also learn and build on the literature of the simulation/gaming field if they are to the push the [simulation] field forward," this review presents in-depth research pertaining to simulation modeling in the hospitality industry.

The specific purpose of this article is to expand the readers' knowledge about simulation modeling definitions

and applications, and to provide a more complete discussion of what is known about simulation theory in the hospitality literature. A second goal is to assist decision-makers, training professionals, and hospitality educators with theoretical and methodological suggestions specific to evaluating simulation's effectiveness. Finally, a third important goal is to provide a framework for understanding the enormous contributions to the simulation literature that have been made over the past four decades.

Definitions generally fall into two categories: iconic and symbolic, with the latter divided into three more specific types: discrete, continuous, and combined event. In simulation literature, models have been created for two separate applications. The first application is the creation of a simulation model as an analytical tool or component thereof. The second application is a simulator whose purpose is to create an instructional system or learning environment. Although these two applications often overlap when a simulation model is created and used, it is important to differentiate these two models based on the creator's primary objective(s). By differentiating these two types of models, rubrics and constructs can be created to assess the effectiveness of using simulation as an instructional system.

In four-year academic institutions, foodservice management education is often taught as a sub-discipline of hospitality management education. Further, hospitality management education relies upon many of the theories, principles, and methodologies created by management and business education. Therefore, to give the readers an encompassing perspective of simulation in hospitality, it is important first to discuss simulation in business and management, then simulation in the hospitality industry.

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SIMULATION: A DEFINITION

Simulation modeling is a well-established technique that duplicates the "features, appearance, and characteristics" of a real business or management system through an iconic or symbolic model (Render & Stair, 1997, p. 692). Simulation modeling is referred to as computer simulation when these models are created and executed using computers.

Iconic models are sometimes called simulators because of their visual, auditory, and kinesthetic representations of a real system. An example of an iconic model is a flight simulator. Typically, these iconic models "are used primarily for training purposes" (Pegden, Shannon, & Sadowski, 1995, p. 5).

Using a symbolic method, simulation models attempt to replicate the characteristics of the system through the use of probability distributions, mathematics, or simple object representations. An example of a symbolic technique in simulation is the Monte Carlo method. For a complete discussion of Monte Carlo simulation and applications in the hospitality industry, see: Atkinson et al., 1997; Field et al., 1997; and Sheel, 1995. Some symbolic simulations also utilize alphanumeric data for representation (Race & Brook, 1980).

Computer simulation can be further defined by describing its underlying model as discrete event, continuous event, or combined event. A discrete event computer simulation uses "blocks of time during which no changes to the system state occur" to simulate variables within the model (McHaney & White, 1998, p. 193). This type of computer simulation uses the arrival of entities or the completion of an event as a cue to adjust the computer simulation time clock. Each movement in time takes place instantaneously, or "in discrete steps" (McHaney & White, 1998, p. 193). An example of a discrete event computer simulation is to observe the behavior of a model of the customer flow in a quick service restaurant. Events such as the arrival of a customer, the completion of cooking a hamburger, and the exiting of a customer from the restaurant all allow for the adjustment of the time clock and the manipulation of variables that are affected by each event.

Continuous event computer simulations allow variables within the model to be continuously changing. These models are "based on a defined relationship for the state of the system over time" (Pegden, Shannon, & Sadowski, 1995, p. 433). An example of a continuous event computer simulation is to observe the behavior of a model simulating the oil temperature in a deep fryer at a quick service restaurant.

Suppose a restaurant manager wanted to determine how many deep fryers were needed to perform optimally during the lunch rush. One would first need to determine the maximum capacity of the current fryers. To do this, a manager could first analyze the types and intervals of frozen food being dropped into and removed from the fry oil and

their effect on oil temperature. This analysis is useful because as each food item is dropped into and removed from the deep fryer, its associated temperature, size and density affects the oil temperature. The collection of observational data on the usage of the deep fryers could be used to determine the effect of each food item on the temperature of the fry oil. Then, a model could be created representing the fry oil temperature fluctuation during the lunch rush. A determination could be made to see if the fry oil temperature were to go below a critical level for the proper cooking of a particular food item. Because it would be important to know if the oil temperature ever goes below a critical level, continuous event computer simulation methods would need to be implemented. A combined event model would incorporate both discrete and continuous variables.

ANALYTICAL USES OF SIMULATION IN BUSINESS AND HOSPITALITY

BUSINESS

Researchers in the fields of simulation, operations research, and management science have found that simulation is one of the most widely used decision-making tools currently being utilized in industrial organizations (Harpell et al., 1989; Eldridge & Watson, 1996). The rapid evolution of computer technology has changed the development and implementation of simulation. To assess this phenomenon, a longitudinal study of the use of simulation in US industrial organizations has been ongoing since 1977 (Watson, 1978). Follow-up studies were conducted in 1982 by Watson and Christy and again in 1983 by Christy and Watson. The most recent chapter of this study was conducted by Eldredge and Watson (1996) and assessed several descriptive components of the use of simulation in the business and manufacturing industry.

In the Eldredge and Watson study, a ten percent systematic random sample was drawn from a population of 4,000 companies. The response rate of the latest study was 37 percent. The study found that 90 percent of the responding companies use simulation, up from 80 percent in 1977. Almost 60 percent of these companies use simulation for engineering purposes and over 50 percent use it in the management science area. Only nine percent of the companies use simulation to assist in the areas of personnel or human resources. The study also found that over 85 percent of these companies now use PCs to run their simulations. Seventy-three percent of these companies are now using FORTRAN as a high level language for simulation modeling. Further, GPSS, SLAM, and SIMSCRIPT are the most widely used simulation languages. SIMAN is being used by approximately 11 percent of the respondents. Unfortunately, none of these articles discussed the frequency of simulator or simulated environment use. The study found that only 25 percent of the companies use animation in their simulation models.

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Further, only two companies rely solely on animation for presentation.

The Eldredge and Watson study is now five years old. With the rapid evolution of technology, many of these findings seem quite dated. The vast majority of academic institutions offering courses in simulation modeling for Industrial Engineering or Management Science students use object-oriented simulation software. Although there is a great deal of FORTRAN code (the mother code of simulation) still being used to run simulations in business, development trends in this area seem to be pointing towards graphical user interfaces and full animation such as ARENA. See: <http://www.arenasimulation.com/> for a complete discussion of the future of simulation.

HOSPITALITY

Although very little work was found discussing the analytical use of simulation in hospitality (only Sheel's discussion of using Monte Carlo simulation to assist in hotel operation decision making [1995] was discovered), there is a 40-year history of simulation's use in the foodservice industry as an analytical technique. Most of these analytical techniques were adapted from industrial engineering approaches to work and production measurement.

Imagine attempting to analyze a national foodservice distribution system with thousands of products, components and distribution centers. It would be almost impossible to effectively evaluate all of the complexities taking place. Using a simulation, one could emulate this complex system and evaluate pertinent statistical information. An analyst could then add or change variables in the mathematical or symbolic model and evaluate their effect on the entire system. This scenario is one of the best ways to use simulation models as a managerial tool. Many authors and researchers involved in quantitative analysis believe that "simulation is one of the most powerful analysis tools available to those responsible for the design and operation of complex processes or systems" (Pegden, Shannon, & Sadowski, 1990, p. 3). Today, symbolic simulations are primarily used as tools to analyze systems in science, technology, engineering, and manufacturing. They have not yet been widely utilized in solving the complexities associated with foodservice operations, but they are equally applicable.

There are many similarities between a foodservice operation and the heavily studied areas of manufacturing and processing. In fact, many foodservice managerial techniques have been adopted from these fields. Most simulation in education and training has been reserved for iconic modeling, but because this type of modeling must closely duplicate the system it is simulating, it can be extremely expensive to develop and implement. A more cost-effective technique for the foodservice industry would be to develop a symbolic representation of a foodservice system that would allow managers to analyze changing variables. Furthermore, several research studies have shown

that lowered fidelity or more simplistic graphical representations in a simulation model can actually increase the effectiveness of a simulation, thereby focusing the attention of the user on specific details (Alessi, 1988; Dwyer, 1974; Gagne, 1954; Hatzipanagos, 1997; Miller, 1974). Such a simulation could be economically developed and would utilize a standard personal computer rather than expensive simulating equipment.

Thirty articles and presentations that used simulation as an analytical technique in foodservice and hotel operations were found. These articles discussed using simulation to analyze work production, facility layout, food purchasing, competitors, front office management, customer traffic, buffet service flow, and dish circulation.

The article "Predetermined Motion Times - a Tool in Food Production Management" describes a technique called Methods-Time Measurement (MTM) (Montag, McKinley, & Klinschmidt, 1964). MTM allows for a manual operation, such as slicing carrots, to be broken down into the required motions, then assigns a standard time for each motion. This technique is then incorporated into a simulation model to effectively simulate the flow of food production in an institutional setting. This technique is also applied in an article entitled "Entree Serving Times," in which a simulation model for evaluating the flow of food entrees in an institutional setting is developed (Beach & Ostenson, 1969). Earlier, Ostenson, Moy, and Donaldson (1965, p. 379), also developed a simulation model that attempted to optimize "existing cafeterias and design future foodservice systems."

In the 1970s and 1980s, a few articles were authored describing ways to simulate a food production process. Bloetjes, Aleta, Breunig, & Schwam (1971) discussed how to effectively develop a production model to minimize employee work hours. Lambert and Beach (1980) developed a model to schedule the cooking and freezing of food products to effectively utilize a foodservice operation's resources. Swart and Donno (1981) attempted to combine many typical components of a foodservice operation into a simulation model. The article, entitled "Simulation Modeling Improves Operations, Planning, and Productivity of Fast Food Restaurants" describes how Burger King Corporation used simulation to "dramatically improve efficiency, productivity, and sales in its more than three thousand restaurants worldwide" (p. 35) In sum, Burger King developed a general purpose restaurant model through its Operations Research Department in the late 1970s, then broke this model into three interrelated subsystems: the Customer System, the Production System, and the Delivery System. This model assisted Burger King in improving its productivity at several different levels within the organization.

In the late 1980s and early 1990s, the rapid evolution of powerful personal computers allowed individual foodservice operators to utilize sophisticated simulation software applications. Since that time, several articles have discussed the implementation of simulation models within areas of the

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foodservice industry. Andrew, Lambert, and Lambert (1986) developed a simulation model of a pizzeria to illustrate the analytical capabilities of simulation modeling. The model was written in an early version of the SIMAN simulation language. Parkan (1987) discussed the development of a simulation model for the evaluation of a food court. The model simulates the operations of multiple fast food restaurants within close proximity of each other and evaluates how customers select lines, then balk or renege while waiting in a restaurant's queue. In the same year, Hott and Kilgore (1987) discussed using an animated simulation model to assist hospitality managers in making decisions. They described the development of a restaurant staffing and front desk checkout animated simulation developed in SIMAN. Hott (1986) had also discussed this topic at an annual CHRIE conference.

In the 1990s, several articles pertaining to simulation in the foodservice industry were presented during the Annual Winter Simulation Conference. In 1991, an article was presented by Kharwat of the Operations Research Department at Pizza Hut, Inc., entitled "Computer Simulation: An Important Tool in the Fast-Food Industry." In 1994, the article "An Object Oriented Simulation Model for Determining Labor Requirements at Taco Bell" was presented from the Operations Engineering Department at Taco Bell Corporation (Godward & Swart). At this same conference, Stephen L. Jaynes of AutoSimulations, Inc. and John O. Hoffman of Taco Bell Corporation discussed the use of "Discrete Event Simulation for Quick Service Restaurant Traffic Analysis." The next year, Stout (1995) presented an article on "Modeling a Hospital Main Cafeteria."

Another simulation article related to the foodservice industry was presented at the 17th Annual International Conference on Computers and Industrial Engineering. This article discussed the issue of "Solving a Cafeteria Dish Circulation Problem by Computer Simulation" (Shen, Scheller, & Wolfe, 1995). Field et al. (1997) discussed how to use simulation to compare two styles of buffet service – front- and back-loaded. Front-loaded buffet operations require customers to pay when they enter the restaurant whereas back-loaded buffet operations require customers to pay after they have finished their meals.

SIMULATION AS INSTRUCTIONAL SYSTEMS IN BUSINESS, HOSPITALITY, AND FOODSERVICE EDUCATION

BUSINESS EDUCATION

Role-play, simulation, and gaming research tend to be lumped together by authors who attempt to evaluate the educational effectiveness of these methods in business and management. Literature evaluating the effectiveness of simulation and gaming has been around for almost forty years (Wolfe & Crookall, 1998). However, there is

controversy over assessment techniques and conclusions and these topics are still debated vigorously. Many authors who have attempted to review all empirical works that assess simulation and gaming have proposed a startling conclusion: there is a void of rigorous research on assessing the effectiveness of simulation models as instructional systems.

Wolfe, an oft-cited author in the crusade against poorly designed assessment research in simulation and gaming, has been discussing the shortcomings of empirical studies in this area for over 20 years (Wolfe, 1976; Wolfe, 1985; Wolfe, 1990). In 1981, he reviewed the Association for Business Simulation and Experiential Learning (ABSEL) proceedings from 1976-1981. ABSEL, formed in the late 1970s, is the nation's largest gaming/simulation group. Its primary goal is to "promote the value of experiential methods of learning" (Goosen, 1988). He found "an almost total absence of true experimental designs. [They all] failed to meet the criteria of external validity [and very few] met the criteria for internal validity" (Wolfe, 1981, p. 72). He updated this study in 1985 and came to similar conclusions.

Miles et al. (1986) describe several articles that attempted to assess the body of literature that focused on comparing simulations to other instructional methods. Their insight provides readers with a solid reference to this controversy:

These comprehensive reviews point out that the comparative studies that have been conducted have generated inconclusive and contradictory findings. Some of the studies have found simulations to be superior to the other forms of pedagogy whereas other studies have found the reverse to be true; still other studies have found no differences among varying pedagogies (p. 8).

Butler et al. (1988) analyzed the research that has appeared in *Simulation and Games* – arguably the leading journal in the science of simulation and gaming – and the ABSEL proceedings. They contend:

that most attempts to show that learning is associated with simulations have fallen short of the mark. The difficulty of developing such evidence takes on special significance for those who are using simulation and/or games or those who are considering their use. Two factors in particular seem to have impeded development of sound knowledge in this area: (1) inadequate attention to the design of research studies and (2) the lack of a paradigm to guide investigation of learning outcomes.

In 1990, Wolfe reviewed numerous studies of computer-based business games and concluded that little can be said about the effectiveness of these games related to fidelity, facilitation, concept complexity, time

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considerations, and simulation selection. Wolfe and Crookall (1998, p. 8) continued this discussion by stating:

The educational simulation/gaming field has been unable to create a generally accepted typology, let alone taxonomy, of the nature of simulation/gaming. This is unfortunate because the basis of any science is its ability to discriminate and classify phenomena within its purview, based on underlying theory and precepts.

Some authors have discussed the benefits of simulation in terms of dynamic knowledge. Hays and Singer (1989, p. 193) state that "gaming [simulation] is more applied and dynamic." Further, they argue that the functional application of static knowledge is one of the benefits of simulation. Another benefit, as stated by Pierfy (1977) in his review of simulation studies, is that trainees who used simulation increased their level of retention. However, as discussed earlier, there is a large debate about the validity of such claims.

HOSPITALITY EDUCATION

Several articles discussing the use of simulation in hospitality education were found. These articles prophesied the future uses of simulation, defined it as a component of a team role-playing game, or alphanumerically simulated data from hospitality operations.

In 1996, Kluge compiled a comprehensive review of articles related to information technology applications in the hospitality curriculum. He reviewed 102 articles and found that only 18 were empirically based, six of which were based on "experimental designs testing alternative forms of instruction on students" (Kluge, 1996, p. 49). The author eloquently summed up the gap in this body of research:

First, there are few if any "landmark" studies related to computers in the curriculum. No one author or authors have surfaced as leaders of this area of study which impacts the education of tens of thousands of students. As in marketing, financial management, and operations, someone needs to assume responsibility for orchestrating a more organized approach to researching concepts related to information technology in the hospitality curriculum.

Second, there is a severe lack of significant empirically-based research. We need to be determining the skills our students will require objectively to ensure they are being properly prepared for future careers, and we need to empirically test different instructional methods to continue to improve teaching and instructional delivery. Third, we should be more actively examining the role of information technology as it relates to instruction in all subjects in the discipline, making sure we are taking full advantage of this instructional medium of the present and future.

Finally, we need to look down the road and make sure we are including the future of information technology in what we are teaching today. It is time that hospitality educators get together and focus a significant amount of energy on defining the role of information technology in the hospitality curriculum. (Kluge, 1996, p. 49).

Although Kluge credits Evans and Matthews (1985) as the first published study of computer use in the hospitality curriculum, articles dating back to 1969 when McCowan and Mongerson first discussed a "simulated instructional model for educating mentally retarded students for employment in the hotel-motel industry" have been found.

Boger and Brewer (1997) briefly discussed the plausibility of developing virtual realities for learning through the use of the Internet. In this distance education model, students could be involved "in decision making simulations related to hospitality and tourism management" (p. 61). Kasavana (1996) described simulation broadly as an application area for instruction in hospitality education. Pederson and Pederson (1993) described how to improve simulation in a hospitality curriculum. They did not discuss any specifics of the model.

An article using symbolic simulation as an educational tool for the hospitality industry was also published. It discusses a simulation that combines team role-playing with the manipulation of data from operations. Russell and Russell (1997) discuss the utilization and effectiveness of a simulation in the development of the Hotel Operators Training Simulation (HOTS). This simulation approximates the operational components of an eighty-room hotel by first providing students with a text-based case study of the hotel. Student teams develop a strategic plan and manipulate alphanumerical operations data such as average daily rate, budgets, and expenses. Team performance is measured by such variables as gross profit and occupancy and is compared to the performance of other teams. The authors have also seen some preliminary development of alphanumeric simulators of hotels' and restaurants' operations data at annual Council of Hotel, Restaurant, and Institutional Educators (CHRIE) conferences.

SHARES (Student Hotel and Restaurant Enterprise Simulations), developed by Richard Brush (personal conversation, 1997), is an alphanumeric oriented simulation. It utilizes Microsoft EXCEL and allows students to input or adjust operations, financial data and accounting data. Mark P. Talbert and Associates have also developed alphanumeric simulations for the hospitality industry (personal conversation, 1997). CHESS (Competitive Hospitality Education Simulation Series), Yield Lab, and Menu Dynamics are alphanumeric simulations that allow students to manipulate data from operations. Other management games – such as Top of the House – have also been seen. However, these alphanumeric simulators do not provide a visualization or graphical representation of the dynamic processes of a hospitality operation.

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FOODSERVICE EDUCATION

The publications that focused on simulation in foodservice operations discussed the utilization of symbolic simulation models to analyze a particular area within the foodservice industry. Some of the articles also considered simulation as a method of training and education in the foodservice industry. However, they discussed simulation in broad terms (Mahoney, 1981; Sawyer et al., 1986), defined it as a role-playing game or "skit" (Miller & Poorani, 1996, p. 51; Paulson, Baltzer, & Cole, 1989), or alphanumerically simulated data from hospitality operations (Chase, 1983). Although this last method is an effective use of simulation, it does not provide the learner with a dynamic environment, only a scorecard composed of numerical observations of that environment.

A good example of this dilemma can be found in an article written by Foucar-Szocki (1989). He describes a restaurant simulation where students take the role of a restaurant manager and try to maximize profitability. The simulation described in this scholarly article is actually a role-playing game where students are provided with economic, financial, and demographic data and then required to fill out several "data sheets." Dynamic information is not provided nor is there any use of computerized simulators.

Literature in other disciplines regarding the utilization of simulation as a method of education and training was also found (Gray & Waitt, 1982; Boreham, 1985; Simonson & Thompson, 1990; Alessi & Trollip, 1991; Berger, Fulford, & Krazmien, 1993; Percival, Lodge, & Saunders, 1993; Mellar, Bliss, Boohan, Ogborn, & Tompsett, 1994; Muhlhauer, 1995; Forcier, 1996). Although Mann (1993) describes the potential of a virtual reality scenario to assist in educating and training waiters and foodservice managers, no work has been found that discusses simulation as an educational and instructional tool to assist learners in visualizing the dynamics of a foodservice operation. However, the authors are working on research in this area.

THEORETICAL AND METHODOLOGICAL LITERATURE REVIEW OF SIMULATION IN HOSPITALITY OPERATIONS AND EDUCATION

HOSPITALITY OPERATIONS

Table 1 summarizes the contributions made to simulation theory and identifies the limitations to methodological issues apparent in many of these articles. The table describes the instrument or simulation model used and briefly summarizes contributions to theory development and significant results or interpretative comments.

The first discussions of simulation in the hospitality literature date back to the 1960s. These described time and

motion studies (Montag, McKinley, and Klinschmidt, 1964; Ostenso, Moy, and Donaldson, 1965; Beach and Ostenso, 1969; Guley and Stinson, 1980; Lambert and Beach, 1980). More sophisticated simulations were introduced in the 1980s by Swart and Donno (1981) who incorporated operations research tools; by Andrew, Lambert, and Lambert (1986) who used SIMAN to model foodservice decision-making; and by Parkan (1987) who introduced more complex modeling. The first use of animation in simulation was introduced by Hott and Kilgore (1987) and was enhanced in 1991 by Kharwat.

In 1988, Lambert and Lambert's article was the first to use simulation as a decision-making tool in a hotel operation. The focus of this simulation was optimum hotel reservation policies; a year later Lambert, Lambert, and Cullen (1989) adapted their earlier model to help predict cancellation rates.

Most simulation theory in the 1990s addressed specific hospitality operational problems: Durocher and Niman (1993) prepared a literature review focused on the integration of information technology, service quality, and new organization structures. This review provided an interesting framework for future empirical testing. Godward and Swart (1994) focused on labor requirements; Jaynes and Hoffman (1994) on traffic flow; Swart (1994) on operations research; Stout (1995) on cafeteria modeling; Shen, Scheller and Wolfe (1995) on dish demand problems in cafeterias; Farahmand and Martinez (1996) on simulating drive-through and lobby management; Nettles and Gregoria (1996) on elementary school cafeteria; Field, McKnew and Kiessler (1997) on buffet management; Starks and Whyte (1998) on training tutorial; Hueter and Swart (1998) on yield management; Baker and Collier on yield management; Palmer (1999) and Cacic and Olander (1999) on hotel construction loans and hotel financial performance, respectively; Thompson (1999) on modeling dinner party arrival patterns; and Church and Newman (2000) on fast food service delivery systems. Chou and Liu (1999) stressed the importance of using statistical methods in simulation design and validation.

While there were substantial applications of simulation theory to the hospitality industry during the three decades following the first applications in the 1960s, there were some significant methodological issues not addressed in the majority of these articles. For example, most were scholarly publications and did not provide empirical assessments evaluating the effectiveness of the simulation models; few agreed on definitions of simulation making it difficult to compare across studies or to generalize to a broader population; and while some comparative studies exist, they are most probably inappropriate as they lack a common definition and conceptual framework. Few studies cited in this review have provided validation procedures and where they exist do not relate to a theoretical framework. Similarly, where simulation theory has been used in hospitality education, there are few empirical studies aimed

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at evaluating the effectiveness of the simulation in achieving educational outcomes (see Table 2).

HOSPITALITY EDUCATION

Simulation modeling has been used in hospitality education to plan curricula (McCowan and Mongerson, 1969); and to increase students' foodservice experience (Mahoney, 1981; Chase, 1983; Kent, 1985; Hott, 1986; Sawyer, et al., 1986; Paulson, Baltzer and Cole, 1989; Foucar-Szocki, 1989; Mann, 1993; Corsun et al., 1995; Fawcett, 1994, 1995; Feinstein and Mann, 1999; Brozik and Zapalska, 2000). Specific uses and instructional applications of simulation theory as suggested by these authors include: teaching and development of students' management decision-making, manpower scheduling, quantity food production management, restaurant management, and financial management. Further, simulation modeling has been used to assist students in the development of decision-making and problem-solving skills (Chase, 1983; Foucar-Szocki, 1989).

A number of articles were also found that highlighted the use of simulation theory to bridge the gap between theory and practice (Miller and Petrillose, 1992; Burbidge and Schachter, 1994; and Corsun, Inman and Muller, 1995). Again, most simulation articles published in the hospitality literature are scholarly versus empirical publications. This may be appropriate as educators are beginning to explore the uses and most effective models for supporting hospitality students' education. On the other hand, the profession must address the definitional, procedural, and evaluative issues identified in Table 2.

SUMMARY

The definitions and applications of simulation theory have been discussed in this review. Research shows substantial use of simulation modeling in both hospitality operations and education. It further identifies some major methodological shortcomings. Although some studies have included all of the appropriate elements of the model, other authors have selectively used only one or more of its components. Unfortunately, this body of literature provides no apparatus to assess the effectiveness of a simulation model.

Although research on simulation in the hospitality industry has been around for almost 40 years, very little headway has been made on the creation of an academically acceptable methodology for evaluating simulation as an instructional system. As stated in the introduction, several comprehensive reviews of simulation assessment literature have concluded that this problem stems from poorly designed studies and the lack of a generally accepted research methodology.

Research efforts related to simulation theory could conceivably end if there were no known definitional or application components. That is not likely to be the case.

Questions about the meaning and uses of simulation theory have been raised, and while it is clear the profession still does not fully understand the theoretical underpinnings, there is substantial interest on the part of operators and researchers to address at least the evaluation issues.

It is evident that the future of hospitality education will involve more sophisticated analytical techniques and instructional systems using the latest technological equipment. However, the benefits of these powerful tools cannot be evaluated until a methodology of assessment has been created.

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Table 1

Theoretical and Methodological Review of Simulation in Hospitality Operations

Date	Author(s)	Contributions to Theory Development	Methodological Issues	Statistical Technique/Assessment Instrument/Simulation Model Used	Results/Interpretation, Comments
1964	Montag, McKinley, and Klinschmidt	First discussion of using simulation in foodservice.	Scholarly publication.	Non-computer based simulation. Used Methods-Time-Measurement (MTM) Procedures.	Simulating food preparation is an effective method of estimating labor-times of food production tasks. Compared predetermined motion times to methods-time management.
1965	Ostenso, Moy, and Donaldson	Early use of computer-based simulation in foodservice; discussion of mathematical underpinnings of model.	Scholarly publication.	Simulator written in FORTRAN and used Monte Carlo model.	Simulation can be used to evaluate solutions to problems and optimize components of a foodservice operation.
1969	Beach and Ostenso	Early study using simulation to evaluate the relationship between employee service and customers counts.	Limited discussion of simulation development. No validation procedures included.	Monte Carlo simulation; descriptive data. Used methods-time-measurement (MTM) procedures.	Simulation is an effective tool for evaluating service time, use of employees, and optimal combination of menu items. Focused on determining whether the methods-time measurement (MTM) procedure could accurately predict entrée serving times.

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Date	Author(s)	Contributions to Theory Development	Methodological Issues	Statistical Technique/Assessment Instrument/Simulation Model Used	Results/Interpretation, Comments
1980	Guley and Stinson	Tested priority dispatch rules based on time standards	Good methodology. Limited generalizability. Findings limited to one facility.	Operations research. Hueristic simulation model.	Simulation provided a model of a ready foods system. Production schedules developed were compared with measure of performance.
1980	Lambert and Beach	Focused on dietitians' use of simulation to analyze equipment and labor utilization.	A computerized model was built but not assessed in real-world situation.	Used material requirements planning (MRP) system.	Model reduced fluctuation of required labor time, timely data for allocating resources, and the importance of scheduling flexibility. Model created around a hypothetical production system with a 1,000-meal requirement, 450 paid labor units, and eight pieces of equipment.
1981	Swart and Donno	Describes how the use of simulation dramatically improved productivity, efficiency, and sales in more than 3,000 Burger Kings.	Scholarly publication.	Operations research methods.	Thorough discussion of the implementation of a simulation model and the adoption of operations research methods.
1986	Andrew, Lambert, and Lambert	Step-by-step discussion of developing a simulation model for a smaller foodservice operation.	No explanation of why or how this method is effective. Scholarly publication.	SIMAN simulation.	Simulation should become more useful and an integral component in foodservice manager's decision-making process. A simplified example of a pizzeria was used.

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Date	Author(s)	Contributions to Theory Development	Methodological Issues	Statistical Technique/Assessment Instrument/Simulation Model Used	Results/Interpretation, Comments
1987	Parkan	First discussion of the effectiveness of simulation of a non-stationary arrival system in a foodservice operation. Observations of 25 consecutive weekday lunch periods.	Limited generalizability, focused on customer renegeing and balking. Lacks thorough discussion of arrival estimation.	A terminating simulation based on a Bayesian approach. Used GPSS simulation software.	Simulation assisted in identifying the relationship between reduction of staff and service time. Model was far more complex than initial observation suggested.
1987	Hott and Kilgore	A formal article of Hott's previous presentation in 1986; one of the first discussions of animating simulation in hospitality.	No definition of simulation provided. Scholarly publication.	SIMAN and CINEMA simulation was used.	"A picture can be worth a thousand summary statistics" (p. 40).
1988	Lambert and Lambert	First article focusing on uses of simulation as a decision-making tool in a hotel operation. Explains how to develop the model (30 trials).	Model designed for particular property.	Model based on Monte Carlo simulation.	Effective tool for evaluating optimum hotel reservation policies.
1989	Lambert, Lambert, and Cullen	Adaptation of model published in 1988 article (30 trials).	Model designed for particular property.	Regression used to predict cancellations.	Simulation assisted in increasing reservations to maximize occupancy and profit.
1991	Kharwat	Discusses the effectiveness of animation and module based development in simulation.	Limited explanation of level of effectiveness. Scholarly publication.	Animation and module based simulation.	Simulation assists foodservice operations receive answers faster and more cost effectively. Focused on the fast-food industry.

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Date	Author(s)	Contributions to Theory Development	Methodological Issues	Statistical Technique/Assessment Instrument/Simulation Model Used	Results/Interpretation, Comments
1993	Durocher and Niman	Presents a framework to help test the potential benefits of successful integration of information technology.	Scholarly publication.	Model integrates information technology, service quality, and new organizational structures.	Literature review and framework provided; needs empirical testing.
1994	Godward and Swart	Discusses the financial impact of simulation on the bottom line of a multi-unit foodservice operation.	Does not discuss specifically how simulation saved money. Scholarly publication.	ADME, SIMTAC, MODSIM II, and SIMGRAPHICS.	Teams who developed and implemented model were awarded the president's medal for their work. A discussion piece focusing on how Taco Bell implemented a simulation to assess their labor requirements.
1994	Jaynes and Hoffman	Explains how to use simulation as a graphical depiction of a dynamic system.	No valid procedures discussed.	AudoMod Simulator.	Simulation has assisted in graphically representing traffic at potential and actual Taco Bell sites. Articles focuses on simulating traffic around QSR's.
1994	Swart	Discussion of simulation as a component of operations research in foodservice operations.	Scholarly publication.	N/A	A discussion piece.
1995	Sheel	Discusses the uses of Monte Carlo simulation to run "what if" analysis in a hotel operation.		Model based on Monte Carlo simulation	Provides a case example of implementing a simulation for decision making.

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Date	Author(s)	Contributions to Theory Development	Methodological Issues	Statistical Technique/Assessment Instrument/Simulation Model Used	Results/Interpretation, Comments
1995	Stout	Explains the step-by-step implementation of a complete simulation model of a cafeteria.	Scholarly publication.	N/A	Thorough explanation of how to use a particular simulation modeling software package.
1995	Shen, Scheller, and Wolfe	Solves a complex supply/demand dish problem in a cafeteria.	No detailed model development; similar to Parkan (1987). Implementation and evaluation not thoroughly discussed.	SLAM II simulator utilized.	A quasi-optimized dish room layout was implemented; cafeteria increased flatware inventory; effectiveness was not evaluated. Conference proceedings.
1996	Farahmand and Martinez	Discussion of using cases and sensitivity analysis in conjunction with simulation for making decisions.	Limited explanation of benefits of using scenarios.	WITNESS	Focuses on simulating a drive-through and lobby of a QSR.
1996	Nettles and Gregoira	Descriptive study applying ARENA to school aged children.	Limited generalizability. No verification or validation of simulation discussed.	ARENA simulator utilized.	This is a description of using the ARENA simulator to assist elementary school cafeteria managers make decisions.
1997	Field, McKnew, and Kiessler	Discusses a step-by-step method of using simulation as a decision-making tool.	Limited discussion on use of the power of simulation and of validation procedures.	Monte Carlo model used in SLAMSYSTEM	Simulation was used to assist managers make decisions regarding configuration of a buffet restaurant. "Simulation can play a viable role in decision making by hospitality management" (p. 79).

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Date	Author(s)	Contributions to Theory Development	Methodological Issues	Statistical Technique/Assessment Instrument/Simulation Model Used	Results/Interpretation, Comments
1998	Starks and Whyte	Discusses the importance and methods of validating and verifying a simulation.	Limited empiricist's interpretation of validation. Scholarly publication.	None discussed.	A limited tutorial on how to develop and implement a simulation in the foodservice industry.
1998	Hueter and Swart	Integrated simulation as a component of a labor-management system.	Scholarly publication.	MODSIM. Incorporates operations research methods.	This model has been very effective in optimizing labor components in Taco Bells. It incorporates operations research methods in management decision making.
1999	Baker and Collier	Simulated performance of yield management heuristics. 1000 independent, 14-night replications were done for 5 heuristic models.	Operating environment classifications are subjective.	Tukey multiple comparison approach.	Heuristic selection is dependent on the environment; more research needs to be done in this area.
1999	Cacic and Olander	Uses Monte Carlo simulation to evaluate profitability of hotel investments	Compares different types of appraisal techniques	Monte Carlo simulation	Simulation is an effective model to use in Hotel valuation
1999	Palmer	Explains how to use Monte Carlo simulation to provide a more accurate method of evaluating hotel construction loans.	Scholarly publication.	Monte Carlo simulation	Simulation can provide a more accurate and meaningful interpretation of a complex set of variables. Solid discussion of Monte Carlo simulation, including mathematical illustration.

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Date	Author(s)	Contributions to Theory Development	Methodological Issues	Statistical Technique/Assessment Instrument/Simulation Model Used	Results/Interpretation, Comments
1999	Chou and Liu	Discussion of the importance of simulation validation.	Limited discussion of data collection procedures.	SIMAN simulation software utilized.	Statistical methods should be used in simulation development and validation.
1999	Thompson	Discusses the use of simulation to evaluate actual vs. forecasted demand.	Scholarly publication.	Poisson distribution and random numbers used to replicate customer arrival stream.	Poisson distributions have been shown to replicate dinner party arrival patterns. This model can be used in hotels, theme parks, and restaurants.
2000	Church and Newman	Discusses the superiority of simulation over tracking and queuing models for assessing fast food service delivery systems.	Scholarly publication.	Not discussed.	The use of simulation software might reduce the problems that exist in fast food service delivery systems in the UK.

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Table 2

Theoretical and Methodological Review of Simulation in Hospitality Education

Date	Author(s)	Contributions to Theory Development	Theoretical and Methodological Issues	Statistical Technique/Assessment Instrument/Simulation Model Used	Results/Interpretation, Comments
1969	McCowan and Mongerson	First article discussing the use of simulation in hospitality education.	Introduces a method of assessment but does not implement. Scholarly publication.	Critical Path Method.	Provides a clear definition of simulation and discusses the use of the Critical Path Method for planning and evaluating curricula.
1981	Mahoney	Discusses the relevance of using simulation to increase students' foodservice experience.	Scholarly publication. Simulation not clearly defined.	N/A	Simulation provides immediate feedback and develops students' concept of self.
1983	Chase	Simulation assist students understand components of managerial decision making in 2-year and 4-year colleges and industrial workshops.	Scholarly publication.	N/A	Author suggests that the high level of competitiveness in—and motivation of—simulation increases recall and reinforcement of information in students. Developer of software wrote article; no external review at this time.

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Date	Author(s)	Contributions to Theory Development	Theoretical and Methodological Issues	Statistical Technique/Assessment Instrument/Simulation Model Used	Results/Interpretation, Comments
1985	Kent	There are benefits of combining simulations for more effective instruction.	No definition of simulation. Scholarly publication.	MENU ENGINEERING, CRASE	Discussion piece comparing MENU ENGINEERING to CRASE. These two products , when used together, provide “memorable lessons in profit maximization” (p. 87).
1986	Hott	Simulation models can be easily crafted using an off-the-shelf software package.	Scholarly publication.	SIMAN	Simulation is an effective teaching aid in foodservice operations. Three models were created to assess manpower scheduling and table assignment in a foodservice operation.
1986	Sawyer, Coiucci, Pearson, Graves, Knight, and Koch	Discussed the great potential for foodservice simulation.	Not a clearly defined simulation model. Scholarly publication.	N/A	Simulation development can be very time consuming. A summary of recommendations made at a conference held at Michigan State University in 1984.
1989	Foucar-Szocki	Discusses the use of simulation to assist students in foodservice management decision making.	Broad interpretation of simulation; definition not referenced or supported. Scholarly publication.	The Restaurant Simulation.	Students found the simulation to be an excellent tool in teaching managerial decision making.

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Date	Author(s)	Contributions to Theory Development	Theoretical and Methodological Issues	Statistical Technique/Assessment Instrument/Simulation Model Used	Results/Interpretation, Comments
1989	Paulson, Baltzer, and Cole	First empirical study assessing the effectiveness of simulation in an instructional setting with 147 quantity food production students.	Not a clearly defined simulation model. Descriptive statistics.	Computer Anxiety Index (CAIN); Kolb Learning Style Inventory; Psychomotor Assessment Instrument	Evaluated the effectiveness of simulation in conjunction with two other types of instruction for teaching cashiering. Simulation was the most effective in increasing psychomotor skills and minimizing computer anxiety.
1992	Ferreira	Addresses criticisms of using case studies as the sole method of instruction by adding simulation	Scholarly publication.	Case study and simulation.	Reviews benefits of case study and simulation effectiveness in marketing education.
1992	Miller and Petrillose	Computer simulation designed to address breadth and depth deficiencies of practicum experiences.	Scholarly article.	LODGMATE, CHASE, TOP-OF-THE-HOUSE	Addresses an important education issue. Use of simulation to develop students' understanding of how hotels are managed in competitive environments.
1993	Mann	Article describes using simulators as virtual educational tools in foodservice operations.	Hypothetical and futuristic perception of simulation. Scholarly publication.	None described.	Prophesied the future of hospitality education.
1994	Burbidge and Schachter	Describes procedures used to close the gap between theory and practice in Switzerland hotel schools.	Scholarly publication.	Non-computer human simulation.	Model helped to bridge gap between theory and practice. It is now used in both academia and industry.

Statistical

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Date	Author(s)	Contributions to Theory Development	Theoretical and Methodological Issues	Technique/Assessment Instrument/Simulation Model Used	Results/Interpretation, Comments
1994	Fawcett	Explains that simulation assist students understand the complexity of foodservice operations.	Does not explain how author came to conclusions. Scholarly publication.	CRASE	The simulation improves motivation, enthusiasm, communication skills, and self-management skills. It also develops skills related to foodservice and assist in understanding the dynamics of an operation. Describes and critiques the use of the CRASE simulator.
1995	Fawcett	Discusses the use of CHRASE to educate European hospitality managers	Scholarly Publication.	CHRASE	A rehash of the author's previous work in 1994.
1997	Ferreira	Students were tested on decision-making as well as operational performance.	Combination of scholarly and theoretical.	Student simulation on strategic planning (TOP-OF-THE-HOUSE).	Students showed performance increases (cumulative profits and return on sales) and were able to forecast market and competitive conditions.
1999	Roberts	Discusses pros and cons of using simulations in education.	Scholarly publication.	None	Conclusions not supported by research.

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Date	Author(s)	Contributions to Theory Development	Theoretical and Methodological Issues	Statistical Technique/Assessment Instrument/Simulation Model Used	Results/Interpretation, Comments
1999	Feinstein and Mann	First discussion of using simulation to teach the dynamics of a foodservice operation; 15 participants.	Very theoretical. Primarily a Scholarly publication.	SIMAN and ARENA	Simulation is effective in allowing learners to visualize a foodservice operation. Article focused on developing and implementing a simulation model for educating foodservice managers.
2000	Brozik and Zapalska	Students can learn by doing.	Discussion of a role-play, not a simulation model.	The Restaurant Game.	It is unique in that students have complete control over the learning process. Students acquire information through listening and observation.