Use of Simulation Modeling in Sport Facility Resource Utilization

A Senior Honors Thesis

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ABSTRACT

Uncertainty in the business environment is a major threat for each and every organization. One such uncertainty is resource utilization. Proper resource utilization can be extremely beneficial to companies in any industry. One method of developing utilization strategies is the use of simulation modeling. Simulation models enable the user to visualize how altering different parts can change an entire system. It allows managers to test strategies and discover solutions to operational problems by mimicking the complex behavior of a system. Operations managers can test new ideas and options before actual implementation. Unfortunately, there has been little research concerning or using simulation models in the field of sport facility management. Like any other organization in a service-oriented business environment, a sport or recreation entity must also maximize resource utilization in order to maintain customer satisfaction and profitability.

It is relatively unknown whether new or existing sport facilities consistently make use of simulation methods to develop their own utilization strategies. With the purpose of illustrating the benefits this software can provide, using the software *Arena*, a simulation model will be created to replicate the characteristics and activities of a fitness center.

BACKGROUND

Operations Management

Operations are purposeful activities or actions that are carefully completed as part of a plan designed to attain pre-determined objectives. Therefore, operations management can be described as "the process whereby resources or inputs are converted into more useful products" (Aswathappa, Bhat & Shridhara, 2010).

Operations managers come across an assortment of problems and issues as they plan, organize, and control specific processes. As a result, a critical part of this profession is decision making. When making these decisions, operations managers must be concerned with how their actions affect human behavior. Consequently, the objectives of an operations manager can be divided into two categories; customer service and resource utilization (Kumar & Suresh, 2008).

Customer Service and Resource Utilization

The first objective of any operation is to satisfy customer wants and needs. Therefore, the operating system must have the ability to provide a specific service or product that can satisfy customers in terms of cost and timing. The operation must provide the "right thing at the right place at the right time" (Kumar & Suresh, 2008).

Achieving effective operations through the efficient use of resources successfully provides customer service. Inefficient use of resources leads to the stoppage and failure of an operating system (Kumar & Suresh, 2008). Thus, the inefficient use of resources means poor customer service. As a result, "the efficient utilization of resources is a major factor leading to the success of a business concern" (Dear & Sherif, 2011).

A resource-based view (RBV) approach is focused on paying attention to the character of the resources that create a sustainable competitive advantage for businesses. More specifically, the resource-based view distinguishes the inimitable, firm-specific resources that are unique to one firm from the general resources available to all firms in an industry (Gerrard, 2005). Recently, the RBV method is increasingly being utilized by sports and sports-related organizations.

Using the RBV, there are two factors that are required for effective use of an organization's resources. First, the size and composition of the available supply of resources must be optimized in relation to the organization's performance goals. Second, with the available supply of resources, an organization must maximize its attainable level of performance outcomes. While the first factor represents allocative efficiency, the second denotes technical efficiency (Gerrard, 2005). In order to accomplish both allocative and technical efficiency, an operations manager can use simulation modeling as an instrument to assist in the resource decision-making process.

SIMULATION

Definition

Simulation can be defined as "a broad collection of methods and applications to mimic the behavior of real systems, usually on a computer with appropriate software" (Kelton, Sadowski, and Swets, 2010). A *system* is a facility or a process such as a manufacturing plant, a fast-food restaurant, a theme park, or a fitness center. Systems are studied to measure performance or improve operation. A system can also be studied to aid in the design of a new system, if one does not yet exist (Kelton, Sadowski, and Swets, 2010).

Computer simulation is referred to as the "methods for studying a wide variety of models of real-world systems by numerical evaluation using software designed to imitate the system's operations or characteristics, often over time" (Kelton, Sadowski, and Swets, 2010). Basically, when using simulation, one designs and creates a computerized model of a real or proposed system. Its purpose is to conduct numerical experiments that result in a better understanding of the system's behavior for a specific set of conditions (Kelton, Sadowski, and Swets, 2010).

The popularity and extensive use of simulation is due to its ability to handle complicated models of complicated systems. Furthermore, with the advancements in software design, simulation has become quick, versatile, and powerful decision-making tool (Kelton, Sadowski, and Swets, 2010).

Simulation allows management to test performance models that might be extremely expensive, risky, and time consuming instead of experimenting with actually workers, equipment, and materials. Additionally, mangers can analyze the effects of a specific decision in a variety of situations. Thus, simulation software enables management to evaluate alternative design options when implementing new strategies ("Simulation models"). However, the main attraction of simulation is its ability of easily building and carrying out models along with generating statistics and presenting animations of the results (Montazer, Ece, & Alp, 2003).

Simulation began to be recognized and established in business during the late 1980s. This was due in large part to the personal computer. In the 1990s simulation began to mature throughout small and large firms. Businesses have adopted this tool to use during the early stages of projects, where it potentially has the greatest impact. With the introduction of faster computers, greater ease of use, and better animation, simulation has now become a standard instrument for many companies (Kelton, Sadowski, and Swets, 2010).

Since the 1990's, "computer-assisted simulation modeling as become more common as method of inquiry for operations management and the service industry…" (Montazer, Ece, & Alp, 2003). The extensive use of simulation allows managers to test new ideas and options before these ideas are actually implemented. "With simulation models, the manager can explicitly visualize how an existing operation might perform under varied inputs…" (Montazer, Ece, & Alp, 2003).

With increasing complexity and precision in an analysis, the need for assistance from computer-based tools such as simulation software increases. While spreadsheets and similar devices can sometimes be used, these instruments fail to accurately illustrate the randomness that is present in the actual utilization of resources. Simulation does however allow for the uniqueness of a real business environment. Instead of using of using average values and times, simulation software can depict the unpredictability and variability that exists in reality. Spreadsheets are static and generate quantitative results for only one moment in time. In contrast, simulations follow events as they occur and then produce time-related data. With this ability, simulation provides users with a much more accurate and truthful representation of a dynamic business ("Why use simulation?").

Such interdependencies that do exist in a business environment are critical components of a simulation study. Interdependencies like resource competition, skill level, order volumes, order types, and other significant factors can result in downstream delays which spreadsheets are unable to take into account. With the use of simulation software, users have the ability to locate potential bottlenecks before specific changes are made to a process ("Why use simulation?").

Another great advantage of simulation is the use of animation. Animation provides the user with feedback that finds bottlenecks and indentifies problematic elements in an accurate fashion. In addition, since ideas can be transmitted easily and clearly, animation is an extremely valuable presentation and training device ("Why use simulation?").

Due to its rapid expansion, it is almost a certainty that simulation will continue to experience speedy growth and become accepted as a conventional tool. The major obstacles preventing this are model-development time along with the modeling skills needed to build a successful simulation. Technological advancements have facilitated the development of faster model runs, more reliable animations, and comprehensive data analysis for simulation software. If simulation modeling is to become a standard, easy-to-use tool for effective decision-making, then this trend must continue (Kelton, Sadowski, and Swets, 2010). "The windows based simulation software such as *Arena*, have made simulation modeling not only affordable but relatively easy for managers to initiate simulation studies of a variety of situations including operations and processes, feasibility studies, business processes, human resource deployment, call center staffing, capacity planning and others" (Montazer, Ece, & Alp, 2003).

Business Process Simulation

Business process simulation is a dynamic method that backs the examination and enhancement of a business procedure by using a simulation model. As mentioned previously, simulation has the ability to represent the characteristics and behaviors of a system and also evaluate and predict the system's performance in a precise manner. When the inputs are the same as the real inputs, many contend that simulation is accurate and specific enough to make quality predictions. Therefore, historical input-output data from past years is needed for the successful of a simulation model (Zarei, 2001).

When design conditions of a model are constantly changing and being altered, the speed and accuracy of process simulation can save managers an exorbitant amount of time and money. Simulation software allows for the user to construct and observe multiple runs with optimal process designs ("Why use process simulation?").

Using Simulation

Organizations within the service industry are often challenged with making decisions about location, position, staff size, and task assignment. As an organization becomes more complex, these decisions become increasingly difficult. Dear and Sherif (2011) demonstrate this by using an example of a single bank in a small town. In this example, the bank needs to decide how many tellers to employ on a daily basis. If the bank has several different branches, the number of tellers needed at each individual branch is an issue. Given that customer arrival times will vary considerably, the bank may need part-time tellers at specific peak periods. Also, certain tellers and queues may be needed to service different types of transactions. A typical queue analysis would only be moderately effective in finding answers to these problems because it can only concentrate on steady-state solutions. Such a steady flow environment rarely exists in reality (Dear & Sherif, 2011). This is when computer simulation is needed.

The following step should be followed when implementing a simulation model ("Simulation models"):

1. Delineate the problem
2. Categorize the factors associated with the problem
3. Develop an analytical model
4. Construct strategic alternatives for testing
5. Implement the simulation
6. Analyze the outcomes of the simulation
7. Apply the analysis to an operational system

There are two general categories of simulation, deterministic simulation and discrete stochastic simulation. "Discrete stochastic simulation is a process-oriented estimation approach that measures the performance of a system and its responses to varying conditions" (Saunders, 2010). This form of simulation is most often used in healthcare systems. It has the capability of modeling events that generate both predictable and unpredictable processes over specific periods of time. Its uses include identifying opportunities for change, designing alternative business processes, and executing them. For example, it allows users associated with a healthcare organization to forecast the impact of change on a specific patient pattern or flow. It is also extremely beneficial in allocating and scheduling resources for specified processes and it allows users to examine how resources are utilized (Saunders, 2010).

Since simulation has the capability to realistically characterize extremely complex processes that have numerous variables, it can be applied to industries such as business, engineering, education, and research (Elam, Anderson, Lamphere, & Wilkins, 2011). For example, simulation modeling has being extensively used to deal with an assortment of problems in health care. Santibanez et. al. has used simulation to examine the simultaneous effect of resource allocation, scheduling, and operations on clinic overtime, patient wait time, and resource utilization for an ambulatory care facility. Throughout the analysis, the simulation software included the randomness and unpredictability that exists in every phase of the process. For this study, the random variables consisted of patient arrivals, consultation durations, and other process times (Santibanez, Chow, French, Puterman, & Tyldesly, 2009).

Ninfa M. Saunders (2010) also studied the application of simulation in healthcare organizations. These organizations are confronted with the task of converting huge amounts of data into useful information that management can utilize to make knowledgeable strategic decisions. Therefore, health systems need comprehensive, accommodating tools to help assist in managing the multiple variables and decisions that accompany facility planning. Simulation permits users to change their raw data into scenarios that can be tested, modified, and retested by using a reliable process that can be repeated until the best scenario is found (Saunders, 2010).

It can also be utilized to evaluate the performance of a production line that is under varying demand conditions. Faced with increasingly challenging issues such as globalization, increased world competition, and increased customer expectations, firms are looking for strategies to both improve performance and cut costs. Simulation modeling has become a popular device to be used for recognizing and solving questions about the effects changes will have on a process. In a study by McDonald et. al., simulation was used to evaluate proposed changes on a production line within a high-performance motion control products manufacturing plant located in Mexico. By using the results of the simulation model, potential bottlenecks were identified at each specific level of demand (McDonald, Van Aken, & Ellib, 2012).

Roger Dear and Joseph Sheriff (2011) used simulation to evaluate resource allocation problems such as staff sizing, location, and assignment decisions.

Costa et. al. used simulation methodology to optimize energy flows in sport and recreation buildings (2011). In this study, simulation was used to develop, test, and implement optimal operation strategies for sport facilities. The models provided an enhanced understanding of the problems faced by sport facility managers. Operational strategies were characterized as optimization scenarios that were tested in within the simulation model (Costa, Garay, Messervey, and Keane, 2011).

All of this research proves that simulation is a viable tool to use when dealing with a complex, service-oriented business in a real-world environment.

Arena

Arena simulation software will be used for this study. *Arena* provides interchangeable templates of graphical simulation modeling and analysis modules that join to create a wide variety of different simulation models. These modules are grouped into panels that can be switched by the user to choose which specific modeling structure will be used (Kelton, Sadowski, and Swets, 2010). Thus, *Arena* combines ease of use with flexibility to form one complete user-friendly package.

The modeling of processes using computer software so one can analyze process improvement strategies is another explanation of simulation. A process can be characterized as a sequence of steps that result in an outcome. Given that process changes are made to computer model, companies can save time, money, and manpower by using simulation (Elam, Anderson, Lamphere, & Wilkins, 2011).

Arena software makes use of probability distributions to replicate the variability in a process. It was developed and introduced in 1992 by C. Dennis Pegden, the founder and CEO of Systems Modeling Corporation, which is now part of Rockwell Software. As a high-level simulator, *Arena* operates by using intuitive graphical user interfaces, dialogs, and menus. The software makes choices from accessible modeling concepts, builds connections between them, and then runs the model. An animation then shows the system's components move and change (Elam, Anderson, Lamphere, & Wilkins, 2011).

Arena is meant for "dynamic, continuous, and discrete simulation" (Elam, Anderson, Lamphere, & Wilkins, 2011). "Dynamic" means that time plays a role and is a factor in the simulation. "Continuous" denotes that the conditions of the process change constantly, or continuously, over time. And "discrete" simulation is characterized by changes taking place at point in time divided by the occurrence of events, such as the arrival and departure of parts (Elam, Anderson, Lamphere, & Wilkins, 2011).

This software has been used in a variety of applications for process improvement such as manufacturing, supply chain/warehousing, packaging, call centers, health care, military/defense/security, and process re-engineering. Additionally, *Arena* has also been used to improve production and quality, a function that can save a significant amount of operations money (Elam, Anderson, Lamphere, & Wilkins, 2011).

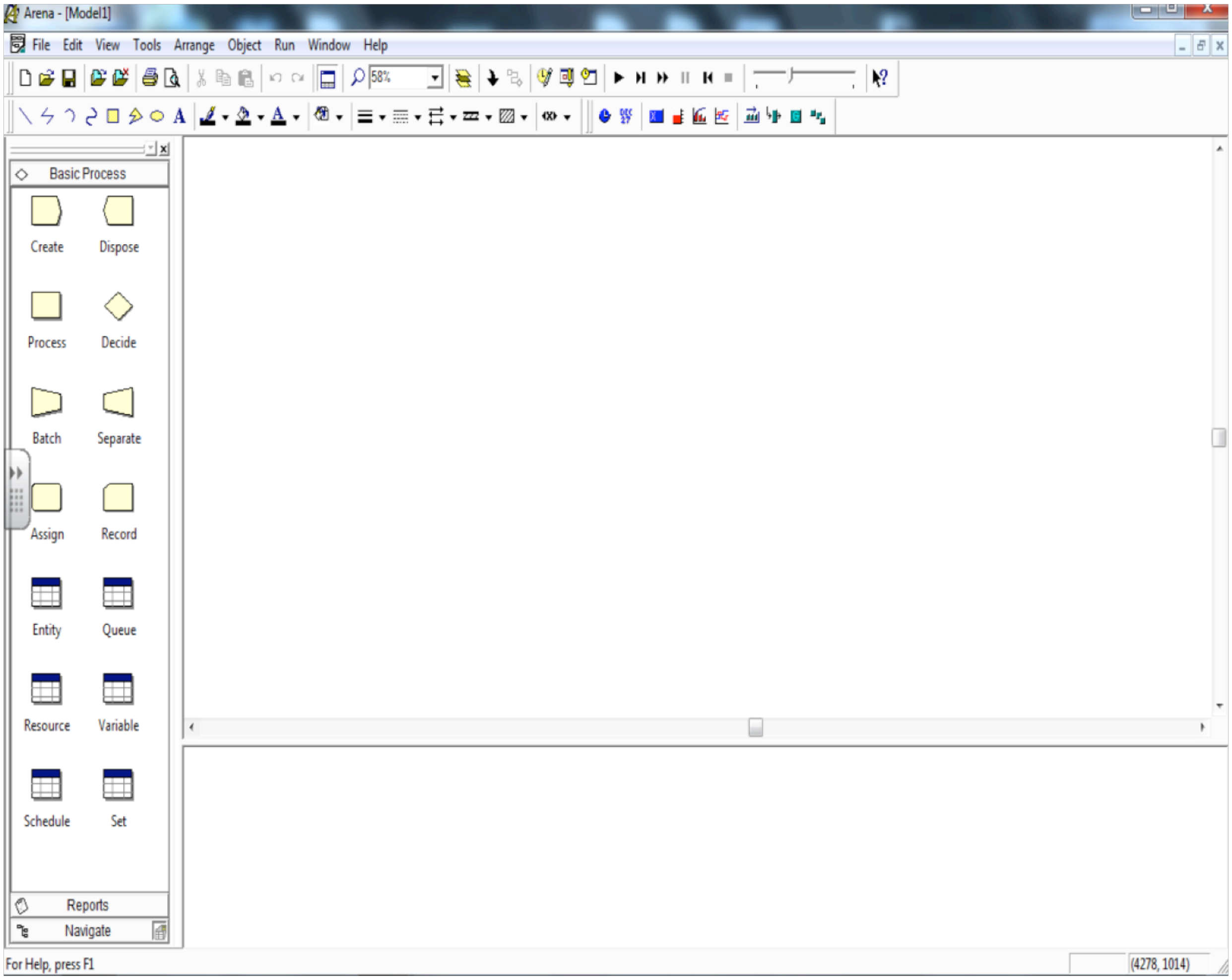
"Fitness Center" Model

With little research available on this subject, there have been very few signs of simulation use for the resource utilization of a sport facility. In order to demonstrate the benefits of simulation, using *Arena*, I will present a simulation model of my own. This minor study will show how sport facility managers can use simulation to assist them with decisions concerning resource utilization.

For a service-oriented business, such as a fitness center, a simulation-modeling endeavor is primarily about simulating the real world. Furthermore, it is about visualizing the coexistence of a variety of services through a computer. Service-oriented modeling activities promotes first developing a small replica or duplicate of the real world "big thing" in order to properly represent its key characteristics and behavior (Bell, 2008).

When creating a new model with *Arena*, a user begins with the blank *Arena* window depicted on Figure A. On the left side of the *Arena* window is the *Project Bar* labeled "Basic Processes," which contains all of the panels that one will work with. As shown, these options include create, dispose, process, decide, batch, separate, assign, and record. These are the fundamental pieces used to build a simulation model in *Arena*.

Figure A



The first step is to establish an entity, which is done by dragging the “Create” process into the *Arena* window. *Figure B* and *Figure C* illustrate how the user can control the characteristics of this entity. In my preliminary model the Time Between Arrivals for this entity, described as “Male,” was set at 10 minutes using a random (exponential) arrival type. Entities per Arrival will be 1 and the maximum number of arrivals is set at 100.

Figure B

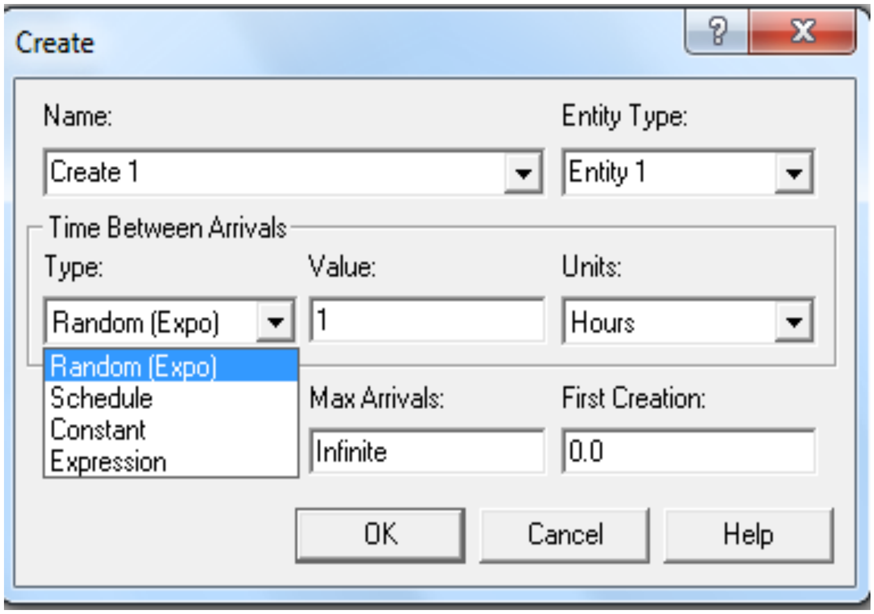
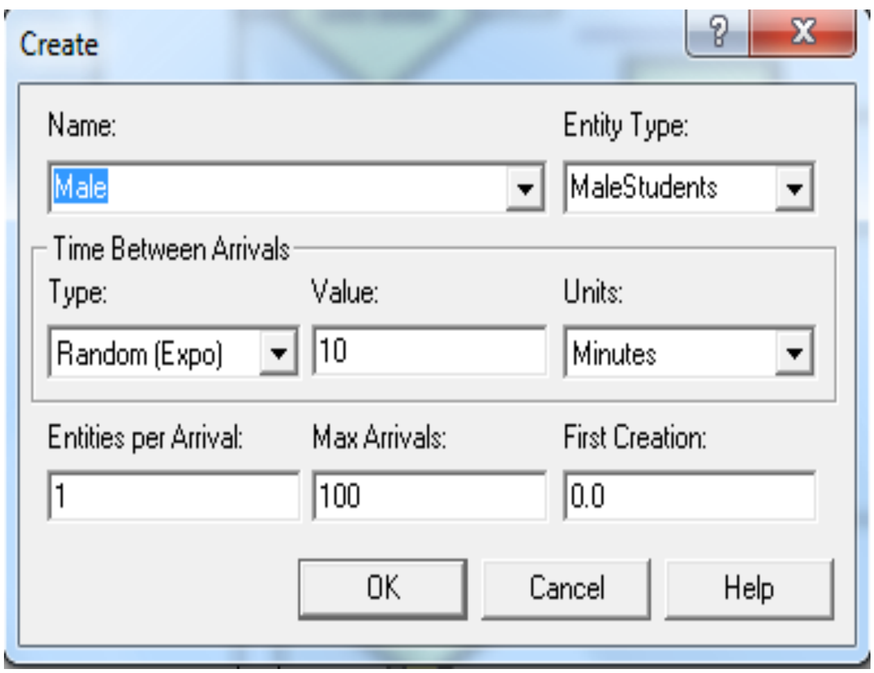


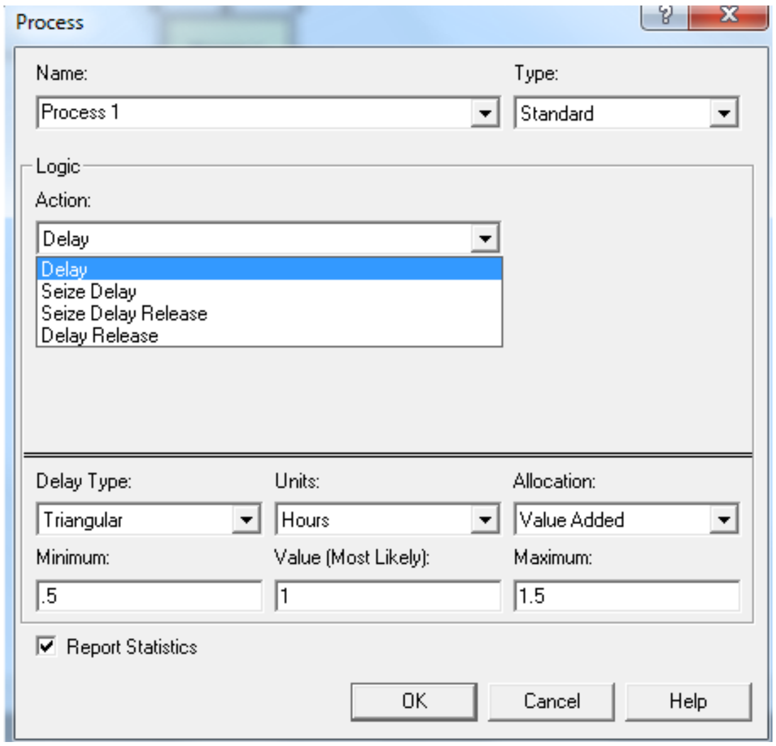
Figure C



Next, we select the “Process” panel and drag it onto the *Arena* window. A line linking the “Create” box to the “Process” box will appear. *Figure D* displays how a user can change the characteristics of a “Process.” For our preliminary model, we will label this process “Gym.” The

Action for this process will be "Seize Delay Release," meaning that this process will seize the entity; there will be a delay while the process is taking place, and then the entity will be released. Other factors to be altered include delay type, units (seconds, minutes, hours), and the minimum, most likely, and maximum amount of time an entity will be held in the process.

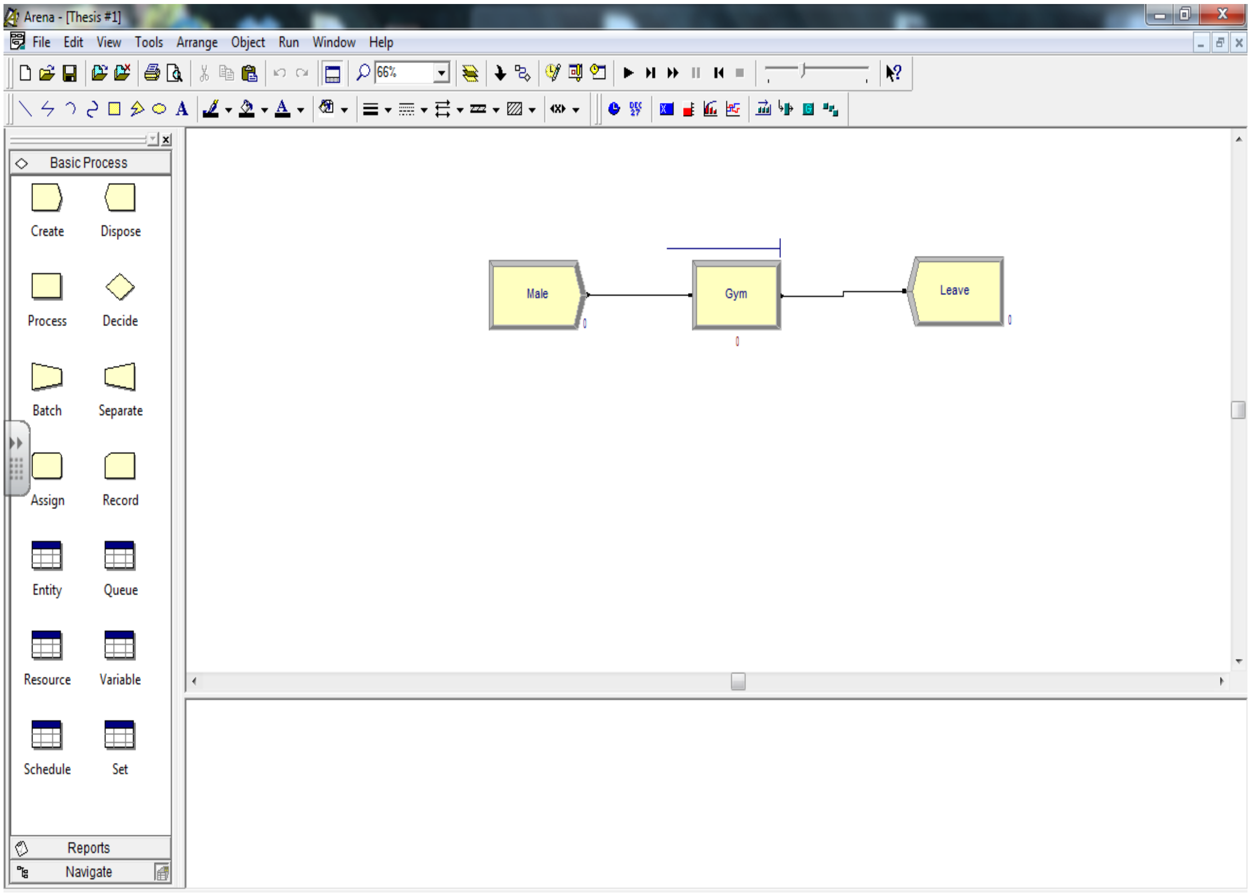
Figure D



As a final piece of this first model, we will place the "Dispose" box into the *Arena* window. This will be labeled "Leave" and will be linked to the process "Gym" that was previously inserted. *Figure E* depicts this preliminary model that we have put together. This is a very basic simulation model, but it provides a quick understanding of how to use the *Arena* software.

In order to build a more complex simulation model for a sport facility, we will insert additional pieces and make several other adjustments. This model will be constructed to resemble the environment of a fitness center.

Figure E



First, a second entity will be established using the "Create" tool. This entity will be labeled "Female," to accompany the entity previously marked "Male." These entities will represent male and female students entering a fitness center. Next, the process "Gym" in our first model will be renamed "Cardio." Also, a second process will be added to the *Arena* window and will be labeled "Weight Lifting." These elements represent two different processes a male or female student can use while at the fitness center. In reality, a male or female individual would have the choice as to which type exercise to perform. The individual would have to make decision based on the two options. Therefore, we will use a "Decide" tool in our model. As shown in *Figure F*, by using the "Decide" setting window we can implement a 2-way by Chance decision type that is true 50% of the time. This means that the entity will decide to do "Cardio" exercises half of the time and "Weight Lifting" exercises the other half.

Figure F

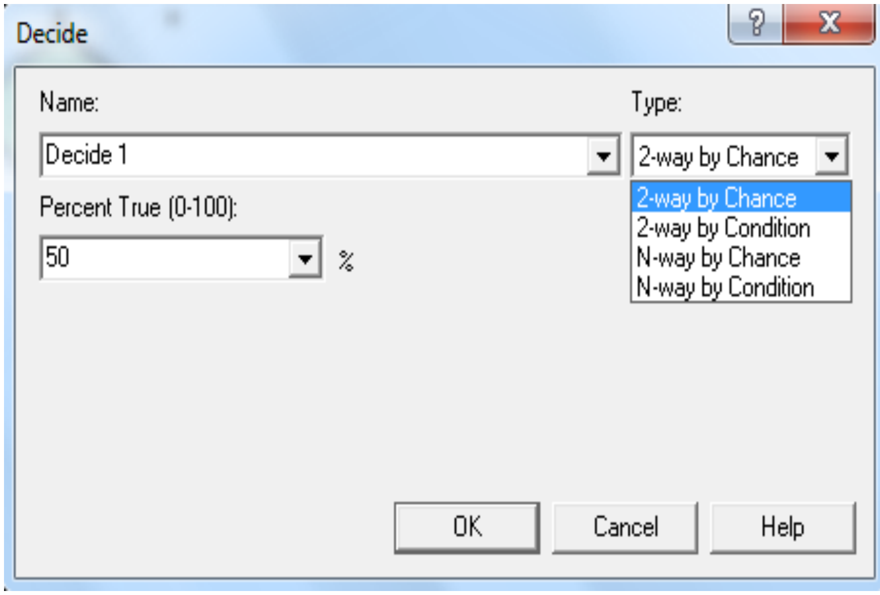
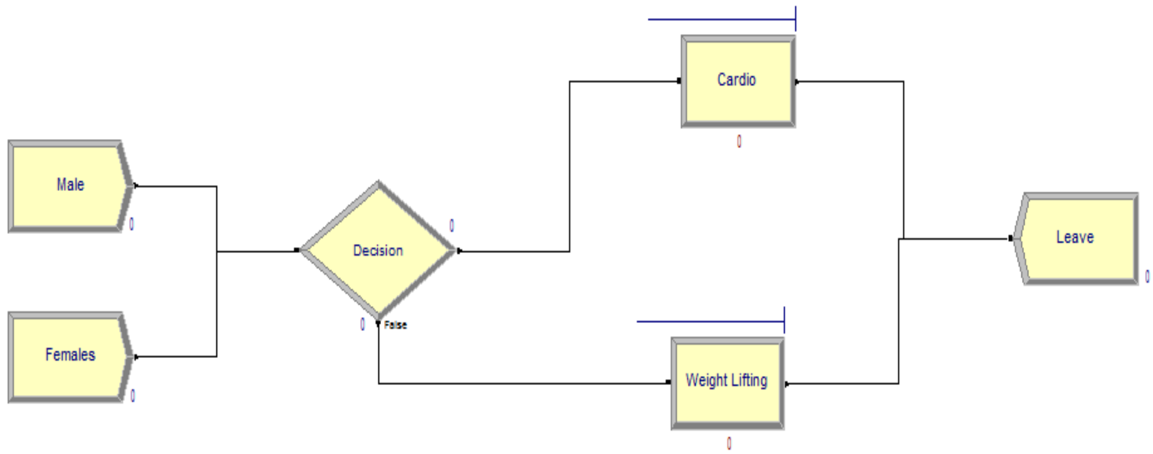


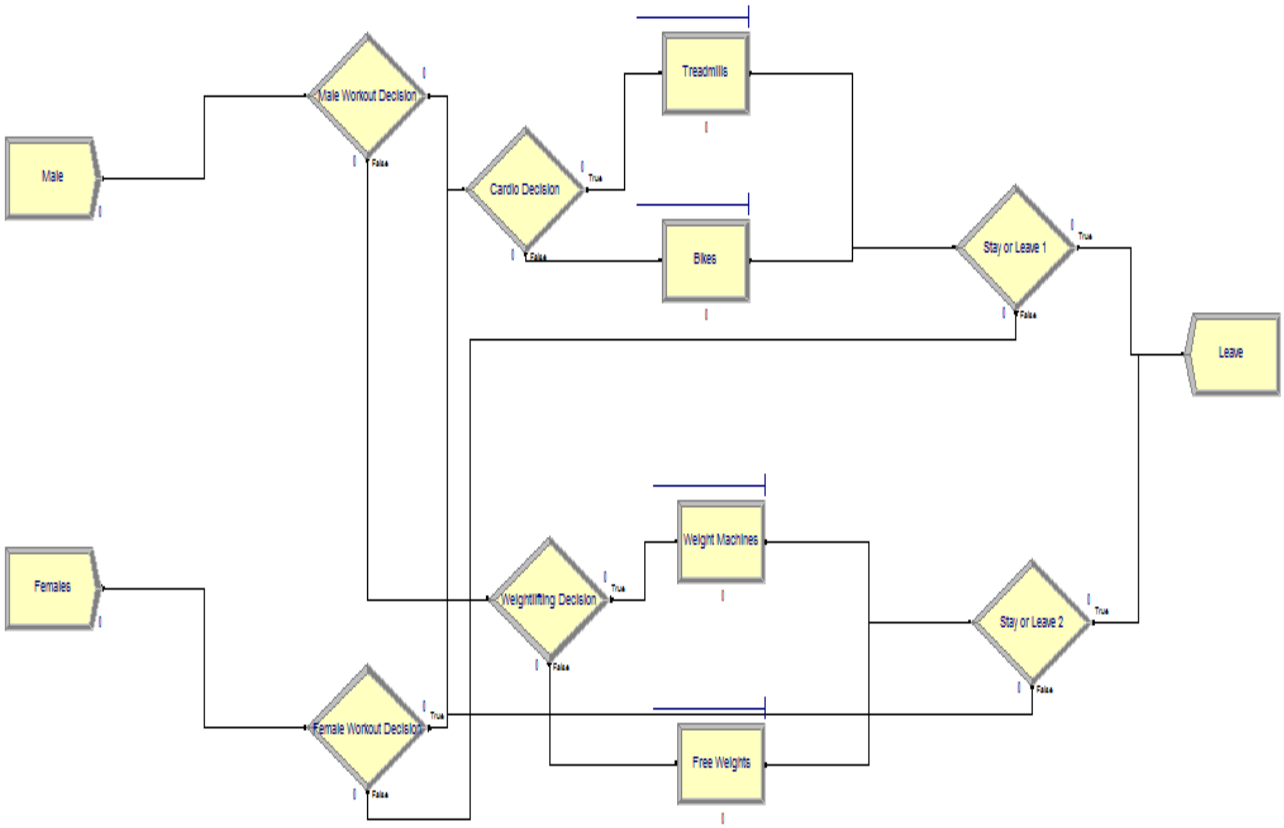
Figure G illustrates the layout of our updated *Arena* model. When a male or female enters the fitness center, they first make the decision of which type of exercise to perform. In this model, after the decision the male or female will then use “Cardio” or “Weight Lifting” equipment. These two processes represent the utilization of a fitness center’s resources. After completing the use of the resources, the individual will then leave the facility. Again, this particular example is still lacking some complexity. We will continue to build a more intricate and elaborate simulation model.

Figure G



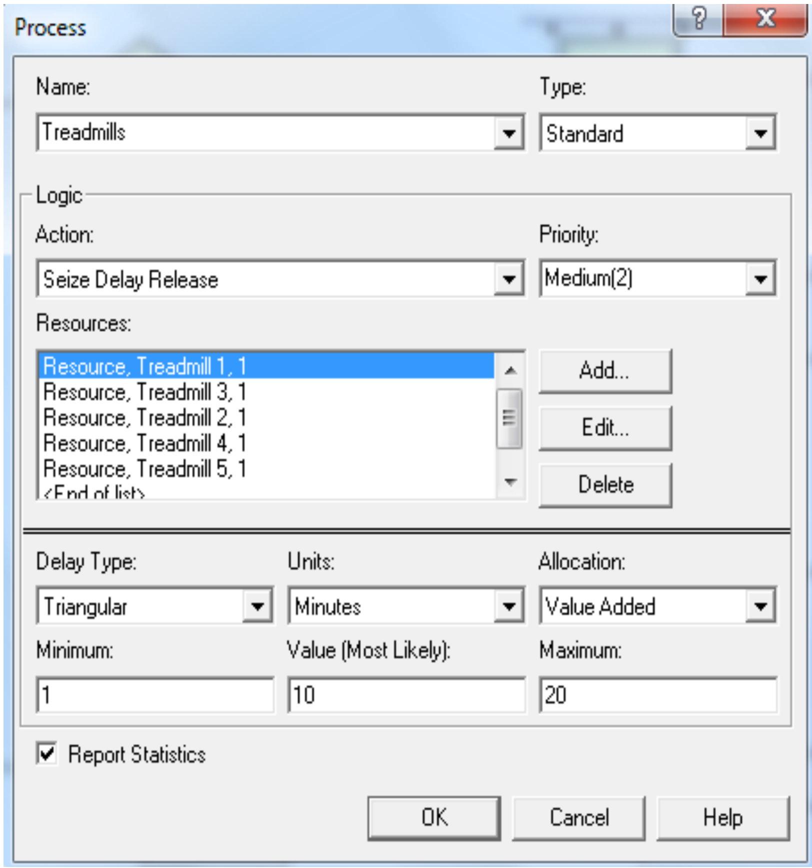
Our final model, *Figure H*, consists of several additional modifications, improvements, and assumptions. First, although the characteristics for both the "Male" and "Female" entities remain the same (random arrival at one entity per arrival with a maximum of 100 arrivals), they are now faced with separate decisions. There is now a "Male Workout Decision" and a "Female Workout Decision," instead of just one generic decision for both entities. This alteration was incorporated into the simulation model because male and female users of a fitness center do not usually exhibit the same habits and behaviors. The features of the "Male Workout Decision" were adjusted to 2-way by chance with percent true being 30%. Therefore in this model, once a male enters the facility, he will use decide to do a cardio workout 30% of the time and thus a weightlifting workout the other 70%. For the purposes of this study, we are making the assumption that males typically use weight lifting resources more often than cardio resources. Additionally, when configuring the "Female Workout Decision," we are assuming that females using a fitness center typically decide to a complete a cardio workout rather than a weightlifting workout. As a result of this assumption, the "Female Workout Decision" was designed to make a female entering the fitness center choose to use cardio resources 80% of the time, and weightlifting resources only 20% of the time.

Figure H



After going through this initial decision, each entity is then faced with the decision of which particular fitness center resource to use. Understanding that there are a wide variety of different resources available at a fitness center, for the purpose of this project we are going to limit the number of options to two cardio choices and two general weightlifting choices. When an entity comes upon the "Cardio Decision," he or she will choose to utilize a "Treadmill" 55% of the time and a "Bike" the other 45% of time. Furthermore, when an entity encounters the "Weightlifting Decision," the chance of selecting "Weight Machines" or "Free Weights" will be split at 50% each.

Figure I

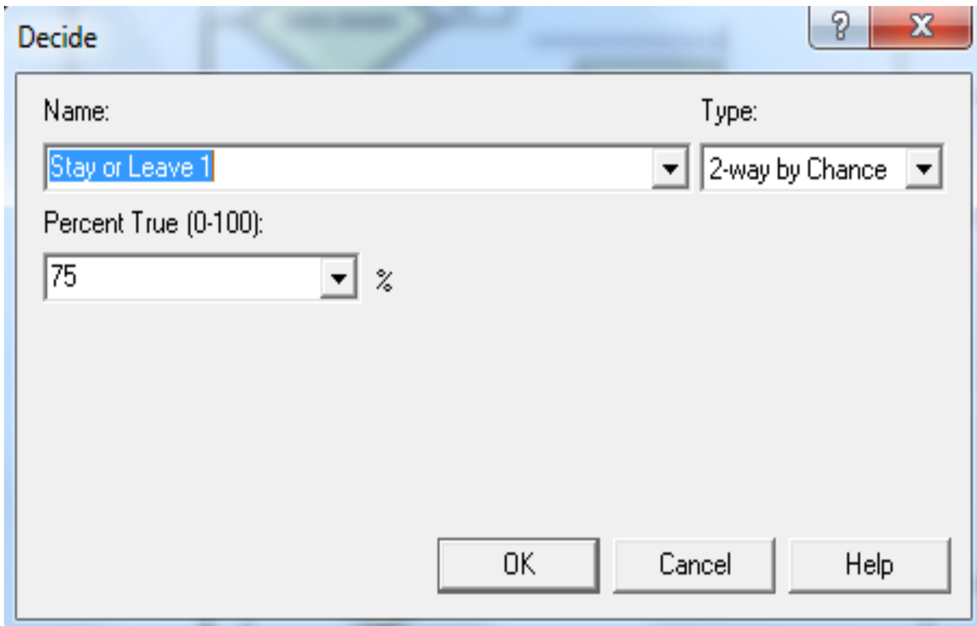


Above, *Figure I*, displays the characteristics of the first resource, labeled "Treadmills." As exhibited above, there are five different treadmills for individuals to use in the fitness center. The "Seize Delay Release" action will be used for the treadmills, and each of the other resources in the facility. Each treadmill will be most likely used for 10 minutes, but can be used anywhere from 1 to 20 minutes. The other cardio resource, "Bikes," consists of the same usage times as the "Treadmills." However, we are only using three bikes for this model, instead of five.

Similar to the number of "Bikes," there are three different resources that can be used for "Weight Machines" and "Free Weights." Again, the minimum usage time for "Weight Machines" is one minute with a maximum time of 20 minutes. The amounts of time an individual will most likely use a "Weight Machine" is still 10 minutes. These values will be slightly different for the final set of resources, "Free Weights." Here we will use a minimum usage time of one minute, a maximum of 30 minutes, and an average or most likely value of 15 minutes. We are making these alterations with the assumption that users will spend more time on average using free weights than they would with any of the other resources.

When each entity, male or female, has finished using a specific resource, they will enter another decision process. This decision tool is implemented to determine whether the individual will leave the fitness or continue to workout. As presented in *Figure J*, the entity will leave the facility at a 75% rate. The other 25% of time, the individual will remain in the fitness center and return to a "Decision" process in the beginning of the simulation model.

Figure J



Before running our simulation model, there is one final procedural step to manage. The "run time" is altered to allow the system to replicate a 16-hour business day. After this final characteristic is taken care of, we are ready to run our model. *Figure K*, shows our final model while in motion. The results, shown in *Figure L* and *Figure M*, represent the outcomes of our fitness center simulation model for one day of operation.

Figure L displays a queue analysis of our model. The free weights possessed the longest average waiting time of 0.9251 minutes and the treadmills had the second longest average waiting time of 0.7710 minutes. Both bikes and weight machines each had much lower average waiting times of 0.1363 and 0.1231 minutes respectively.

Figure K

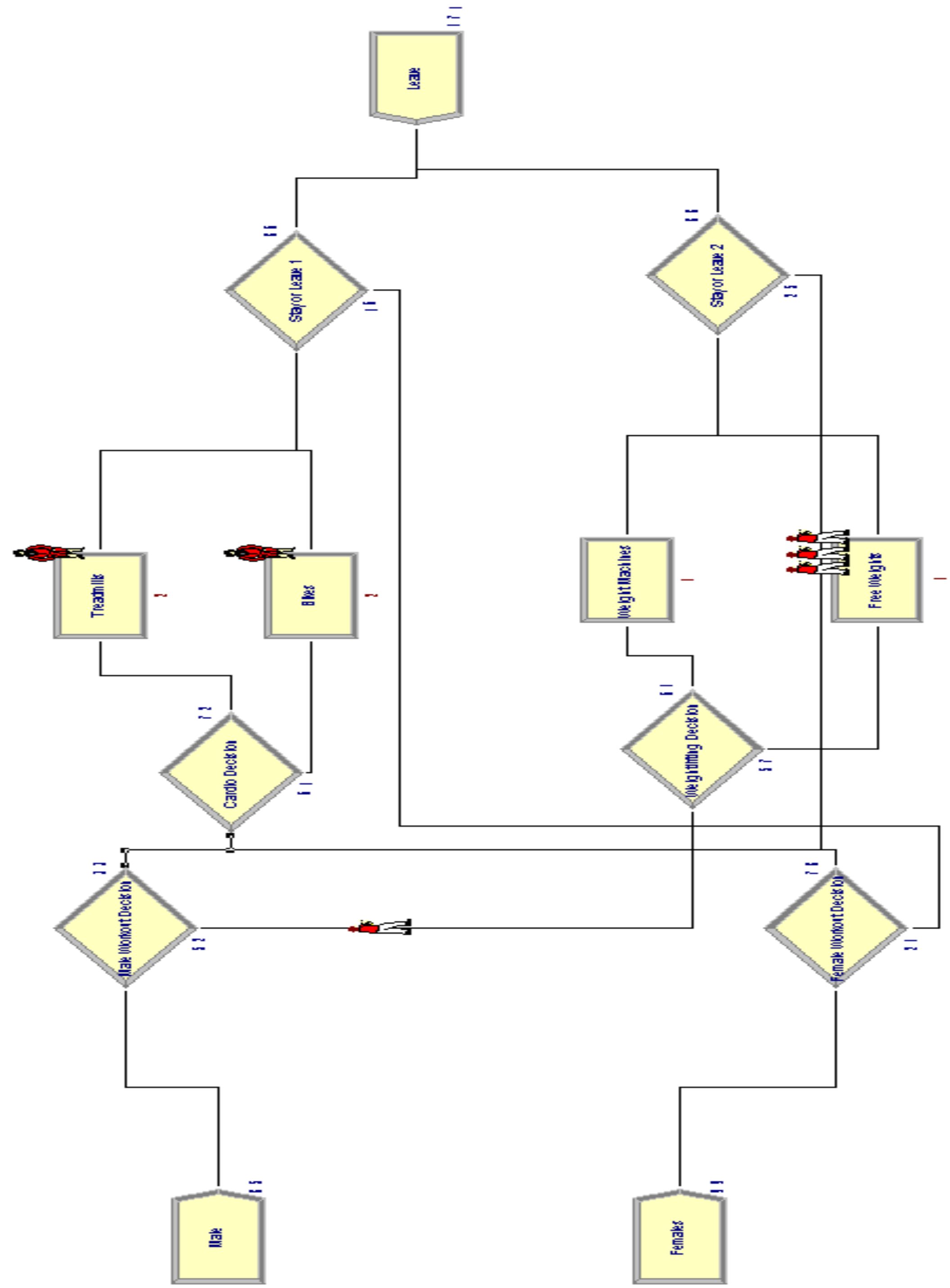

Leave
Stay or Leave 1
Stay or Leave 2
Treadmills
Bikes
Weight Machines
Free Weights
Cardio Decision
Weightlifting Decision
Male Workout Decision
Female Workout Decision
Male
Females

Figure L

Queue

Time

Waiting Time

	Average
Bikes.Queue	0.1363
Free Weights.Queue	0.9251
Treadmills.Queue	0.7710
Weight Machines.Queue	0.1231

Other

Number Waiting

	Average
Bikes.Queue	0.5792
Free Weights.Queue	3.5271
Treadmills.Queue	3.6744
Weight Machines.Queue	0.5077

As also exhibited in *Figure L*, both free weights and treadmills boasted the highest average number of individuals waiting in a queue. Treadmills held the highest average of 3.6744 people waiting, while free weights were a close second at 3.5271. Again, bikes and weight machines reported much lower results. The average number waiting to use a bike was 0.5792 people and 0.5077 for weight machines.

Figure M

Usage

Instantaneous Utilization

	Average
Bike 1	0.7290
Bike 2	0.7290
Bike 3	0.7290
Machine 1	0.6679
Machine 2	0.6679
Machine 3	0.6679
Treadmill 1	0.7744
Treadmill 2	0.7744
Treadmill 3	0.7744
Treadmill 4	0.7744
Treadmill 5	0.7744
Weights 1	0.9627
Weights 2	0.9627
Weights 3	0.9627

Number Busy

	Average
Bike 1	0.7290
Bike 2	0.7290
Bike 3	0.7290
Machine 1	0.6679
Machine 2	0.6679
Machine 3	0.6679
Treadmill 1	0.7744
Treadmill 2	0.7744
Treadmill 3	0.7744
Treadmill 4	0.7744
Treadmill 5	0.7744
Weights 1	0.9627
Weights 2	0.9627
Weights 3	0.9627

In the second report, represented in *Figure M*, the utilization statistics of each resource are given. According to these results, the free weights were the most utilized resource in the fitness center, as they were used 96.27% of the time. Since the free weights had the highest average waiting time and the second highest average number waiting, it makes sense that they would be the most utilized resource. Treadmills were utilized at a 77.44% rate, bikes at 72.90%, and weight machines 66.79% of the time.

With results such as the reports given in this study, sport facility managers can make informed, knowledgeable decisions. For example, by using the outcomes and findings of our simulation model, the manager could come to the determination that this fitness center is in need of more free weights. Perhaps the high average waiting time and average number waiting would result in customer dissatisfaction. Such dissatisfaction would initiate a variety of damaging effects to the fitness center. By adding more free weights, the average waiting time, average number waiting, and utilization would all decrease, thus preventing this potential customer dissatisfaction.

Opposition to Simulation

Simulation does however have some weaknesses. Since many real systems consist of uncontrollable and random inputs, many simulation models involve random, or stochastic, input components that cause random output. Therefore, running a simulation once is similar to studying a real system for just one day. Even if nothing is changed, the results will probably be different. This uncertainty in the model's results must be accounted for when designing and analyzing an experiment (Kelton, Sadowski, and Swets, 2010). Also, simulations can only assess information that is included into the model. Therefore, another weakness is the inability to evaluate factors that have not been incorporated ("Simulation models").

According to Marc Prensky (2002), it is important for people to realize that the transfer of success from a simulation model to reality is not necessarily guaranteed, particularly in highly complex, uncertain situations like economics, business, and human behavior.

As maintained by Prensky (2002), simulation input is not typically very lifelike. While a manager may think he or she has the ability to set variables such as pricing, in reality the presence of significant situational constraints do not allow this. Additionally, there is rarely just a limited choice of options to select from. In actuality, there is an endless assortment of choices that are available for every decision. In a simulation however, there is only specific number of possible inputs. When making real world interactions, people's responses to different situations are extremely more complex than any set of choices offered by simulation software. Furthermore, selecting from a menu of choices when using simulation for interpersonal situations leaves a lot of time for reflection. This is something that does not usually occur during interpersonal interactions. In real life, people just blurt out what they want, when they want. This is not something that happens when using a simulation (Prensky, 2002).

The second argument made by Prensky (2002) against simulation centers around calculations. He states that the creators of simulations lead people to believe that these models accurately reflect reality. However, according to Prensky, these models are "huge simplifications and approximations, invariably and notoriously incorrect in representing real-world behavior, except in a gross sense." Prensky cites several problems with simulation calculations.

First of all, many, if not all, situations are incredibly hard and perhaps impossible to model or copy. Certain circumstances, such as mechanical systems, can be modeled accurately because they are simple systems. Under specific conditions, a machine's behavior will always be the same. Even a system such as a military conflict can be modeled, although with less accuracy, by using rules of thumb or heuristics. For example, a larger force will likely defeat a smaller force. However, business is exceptionally more difficult to simulate or replicate than war. Many more variables are included and behavior is hardly ever repeated.

Besides the very basic level of "human nature," human behavior never repeats. People are too surprising, unpredictable, and often irrational to develop a model to replicate their decisions. Thus, classifying people into character types for the purpose of a simulation can be extremely inaccurate when compared to reality (Prensky, 2002).

Prensky's (2002) final argument focuses on output. According to Prensky, it is not difficult to obtain useful information or output from a simulation. He argues that no simulation output will be "real life," but will only ever be results of the variables the user chooses to include. The primary issue in simulation human behavior is putting together a sufficient range of behaviors so the simulation will be diverse and non-repetitive enough to provide output that is both realistic and useful.

The implication of these shortcomings is that users must take all simulations, especially those involving people, "with a very large grain of salt."

CONCLUSION

Response to Opposition

Although Prensky (2002) makes several assertions in opposition of simulation modeling, he believes that simulations can be used for testing what he calls “possibility space.” A manager will never be able to account for every possible decision a customer takes into consideration and thus incorporate each and every option in a simulation model. Uncontrollable randomness and uncertainty will always be present and an operations manager will never be able to make future predictions that are 100% accurate. However, by analyzing past tendencies and trends exhibited by customers, a manager can develop a “possibility space” of what is most likely to happen.

When an individual enters a fitness center, a manager can limit some uncertainty and create a series of probable options and outcomes. To generate a “possibility space,” a sport facility manager must feature the relevant factors and choices that consistently have a significant impact on the decisions made by users of a fitness center in the simulation. By doing so, a manager can put together a sufficient range of behaviors, thus resolving Prensky’s (2002) primary issue with simulation. Simulations can develop artificial worlds with equations and explore this “possibility space” that these worlds provide. Some of these possibilities may provide users with some interesting ideas about what might occur in real life. Properly dealing with, quantifying, designing, and analyzing a system can avoid much of the uncertainty present in a service-oriented business environment.

As displayed with the previous “Fitness Center” model, by looking at the results of the simulation study one can observe how efficiently each resource was utilized. After completing studies such as this one, sport facility managers can determine the correct amount of resources that are needed for efficient use prior to making costly expenditures. By looking at past data, such as the number of males and females that use a specific piece of equipment, and then running simulation models with varying amounts of different resources, management can also ensure customer satisfaction by providing sufficient resources.

Limitations

Simulation models can seize many, if not all, characteristics of a real-world environment. Unfortunately, these models can become extremely complicated. It can be difficult and time consuming to develop a useful simulation model and the statistical results may be complex and hard to understand. Effective utilization of simulation models can require a user to devote an excessive amount of time and effort to learn and understand the software. Additionally, simulation software may be too expensive for smaller businesses. The newest “Basic Edition” of *Arena* is listed at $2,495 (“Arena simulation software”). As a result of this, the student version of *Arena* was used for this study, which limited my ability to display all of the uses and benefits of this tool. However, despite these limitations I maintain that the advantages presented by properly utilizing simulation software outweigh the necessary initial investment of time and money.

SERC

The College at Brockport, State University of New York, will soon complete construction of a $44 million, state-of-the-art, multi-purpose Special Events and Recreation Center (SERC) that will include a new fitness center. As part of my research, I asked Scott Haines, the Director of Recreational Services at the College at Brockport, what strategy was used to determine the sufficient amount of resources needed for the new fitness center in the SERC. I also asked if computer simulation software was used at any point during planning process. According to Mr. Haines, he worked with several vendors to complete a “2D layout” of the equipment for the new sport facility.

Therefore, computer simulation software was used during the planning stages of the new SERC facility. However, it was only used to help establish the layout of resources within the fitness center. It is my understanding that a simulation model to determine the utilization of these resources, such as the one designed in this study, was not completed.

It is my belief that the use of simulation software for assistance in the resource layout of a fitness center can be helpful. However, if a simulation study is not used to determine resource utilization and the amount of resources needed, then a simulation model to manage the layout of these resources may prove to be useless. If a sport facility manager spends too much time planning the layout of resources but in the end has too many or too few resources, these efforts would serve no purpose. For example, after the completion of a new fitness center, an operations manager may come to the realization that the facility needs more of a specific piece of equipment, such as the case with free weights in our model. By using a layout model, such as what Mr. Haines used for SERC, the layout of a fitness center may initially be great, but if there are too few resources, the facility will still become crowded and long lines or queues will always be present. Thus, with the need to add more equipment, the current layout of resources is now irrelevant. However, by building a simulation model targeted toward resource utilization, analyzing the results, and applying the outcomes to the real-world environment; this situation would have been avoided.

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