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THE ROLE OF SIMULATION AS AN INSTRUCTIONAL METHOD TO IMPROVE STUDENT PERFORMANCE

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INTRODUCTION

This study chronicles the development of an instructional strategy that has increased the effectiveness of learning significantly in students that are taking a facility design and management class. (17) Collectively, the authors have taught over 25 years in the area of facility design and management. After numerous experimentations with different methodologies to increase the effectiveness of learning, the primary strategy became (20) (a) the use of lectures to develop basic knowledge and skills toward design and maintenance; then (b) extensive field trips that allowed students to talk with professionals and observe how the principles of design and management were implemented, and (c) the completion of a student-centered project where students developed and designed their own facility and then created a plan managed facility operation. In the quest for identifying effective educational strategies, it was discovered that simulation through the use of computer games was a useful method for increasing student motivation for learning and teaching concepts of design and management. (9, 14, 38)

During the experimental stage of applying computer simulations programs as part of the curriculum, a program called "Sims City" was tested. However, after using this particular program in class, the authors found that it was too difficult for students to learn and required an extensive amount of committed class time before most students could effectively manipulate the program. At one point, at the end of the class, a student recommended the use of Roller Coaster Tycoon as an experiential learning part of the instructional sequence. Taking the students advice in account, the authors replaced Sims City with Roller Coaster Tycoon and its associated programs, and found that they were much easier to learn and required sig-

nificantly less class time for students to gain the working knowledge necessary to operate the programs effectively. The use of these computer simulated programs offered students an opportunity to experientially apply the concepts of facility design and management discussed in class.

A virtual or simulated instructional method has a high degree of effectiveness. (3) When it is combined with other instructional techniques, its effectiveness is increased. (1, 33) The primary questions are, "what is the uniqueness of simulation and what is the most effective way to mix with other instructional techniques?"

The uniqueness of simulation is its ability to create circumstances and allow for hypothesis testing. (18, 24) This gives the student the opportunity to develop skills in judgment and problem-solving without mistakes being made in the real world situation. (4) Simulators in aircraft flight training, learning to drive automobiles, etc., have been used effectively in training. These are rudimentary skills and the larger question is "can simulation be used effectively in problem-solving?" Problem-solving is a complex task and is far beyond the development of skills. It involves judgment and the critics of simulation say that this practical skill can only be developed with experience, especially when crisis is involved.

One of the other important aspects is what other instructional techniques can complement simulation. (22, 31, 32) One of the problems in teaching a facility design and management course is the ability to have an overall perspective and how to fit the pieces together. (2) Simulation seems to be an excellent technique to add this dimension to other instructional techniques. (36) In order to develop an effective sequence, there needs to be a method to introduce the subject matter before the simulation exercise. (8) The purpose of this instructional focus should be on the development of content and its application. There also needs to be a follow-up to the simulation to allow the student to practice, in a "real world" setting, the principles and problem-solving skills learned. The focus of this instruction should be relating to the real world setting.

In recent decades, experiential education has gained popularity and support in the literature (6, 26, 34). Perhaps more importantly, is the connection made by Kolb (23) between experiential education and learning styles. Kolb (23) introduced a model of experiential education that focused on a cycle of learning that was designed to assist or accommodate four primary learning styles: (a) Divergers, (b) Assimilators, (c) Convergers, and (d) Accommodators. Divergers or Imaginative Learners (26) are those learners who perceive new ideas through concrete experience and then process new information through reflective observation. Assimilators or Analytical Learners (26) are learners who perceive new ideas through abstract conceptualization and then process new information through reflective observation. Convergers or Common Sense Learners (26) perceive ideas through abstract conceptualization and process best through active experimentation. And finally, Accommodators or Dynamic Learners (26) perceive new information through concrete experience and process through active experimentation. These four learning styles provide a guideline or framework from which to design educational experiences that provides learning environments that best accommodate learning styles.

Brook-Harris & Stock-Ward (6) identified and described four experiential learning processes that correspond with the four learning styles. The first part of the process

involves reflecting on past experiences related to a given topic. The second part of the process is "assimilating and conceptualizing" which transitions the learner from reflection to active learning. This is the part of the educational process that provides learners with concepts and theories about facility design and management. The third part of the experiential learning process involves some form of experimentation and practicing of new knowledge. Students move from abstract conceptualization to hands-on application and reinforcement of new knowledge and skills related to designing and managing a facility. The final part in this learning process is "planning for application," where students move from practical application of new knowledge or skills back to a conceptualization phase that encourages them to plan for future application of the newly learned knowledge or skill.

Experiential learning is an educational methodology that has had possibilities for the effective development of instructional strategies. (28, 30) There appear to be two primary thrusts to an experiential learning based method. One is the act of participation in real time exercises that develop knowledge, skills, and understanding about the conditions using field-based types of situations. This type of learning is effective because it shows the relationship between theory and practice and gives the student an opportunity to try various theories and hypotheses in a real setting. (25, 27) There is direct feedback as it is a real experience that allows the student to try different strategies and as these strategies are tried, learning occurs on an effective basis. Another approach to experiential learning is a simulation exercise or modeling that allows the individual to virtually test hypotheses and obtain feedback on their different types of outcomes associated with particular hypotheses. (37, 38) In many instances, it is not a preferred choice of learning because the real-life setting allows for a more effective instructional mode because all of the different conditions that exist cannot be simulated.

In a facility design and management course, it may be the only mode of experiential learning because it is impossible to complete an instructional cycle in regard to the construction of a facility. (35) This type of experiential learning has been used very effectively by such agencies as NASA, the U.S. military, etc. Instructional mode in these agencies has been simulation and development of a strategy, then trying the strategy and modifying the instructional strategy based upon the real world experience. These agencies have the luxury of a virtual experience, as well as real life learning exercises and modifying one in terms of the other. There are circumstances where the virtual, experiential learning method is the only instructional strategy possible. (15) These conditions are primarily to those that involve architecture and construction projects. It is more practical to use virtual experiential techniques because it is not possible to repeat the process in the real world. Once a project is started, then it has a certain completion and finality, based upon the research and development function. Architects, and those involved in the design phase of the building industry have been able to improve their understanding as well as their effectiveness in design through use of virtual or simulation types of exercises.

The purpose of this study is to examine the use of an experiential learning exercise that is virtual-based and its effectiveness upon the learning of students in a facility design and management class.

METHODOLOGY

Roller Coaster Tycoon is a simulation game that allows the student to design theme parks in a number of environmental conditions. It is a commercially-licensed program in a game format. The focus of the game is to design and manage a theme park so that it is a profitable operation. It is an interactive simulation that gives the student various conditions and causes him/her to manage the park based upon these changing conditions. As the game progresses, the student can add more features to the park. The park must be managed in terms of budgets, promotions, maintenance, etc. (16, 29) This is a simple program to use and most of the students were able to master basic skills in an hour.

This study was conducted over a four-year period involving eight semesters of the facility management class. The instructional methodology used in this study was designed to emulate the Brook-Harris & Stock-Ward's 1999 application of Kolb's model of experiential education. First, lectures and classroom activities were applied to allow students opportunities to reflect on past relevant experiences with facility design and management. And then new concepts and ideas were assimilated and discussed to help students develop the basic skills associated with facility design and management. Then after students gained working knowledge of basic facility design and management practices, field visits were taken to local establishments and students were asked to critique management function, in relation to facility design. These field visits allowed students to experiment and practice their new knowledge in a "real world" setting. And finally, through the application of Roller Coaster Tycoon and the completion of an individualized project, students were able to apply knowledge learned about facility design and management in a culminating facility design project. It was the same instructional method that had been used the previous four years, except a test was used in place of Roller Coaster Tycoon. Each individual Roller Coaster Tycoon project was completed on a disk and was evaluated by three content experts in design and Roller Coaster Tycoon. The projects were assigned an A, B, C, or D based on established criteria. As the content experts reviewed student Roller Coaster Tycoon projects, the following nine items were used to evaluate the quality of each project: park rating, financial statement, number and diversity of rides, completeness of design, sophistication of design, park theme/arrangement, number of guest, time, and guest satisfaction .

In terms of data collection, each student's Roller Coaster Tycoon scores, grade in the class, and overall GPA were collected for analysis. Additional course information was collected about the outcomes of the class in terms of their problem-solving ability. (21) There are different types of problem solving related to the measurement issue including: performance, task, relationship, and process. (10) The type of measure used in this study was the Social Problem Solving Inventory. (11, 12, 13) This is a multidimensional, self-reporting measure composed of 70 items assessed on a 5-point Likert-type scale. The instrument is comprised of two primary scales with seven sub-scales. The primary scales include problem orientation and problem solving skills. The problem orientation scale contains three sub-scales: cognition, emotion and behavior. The problem solving skills scale is divided into four sub-scales: problem definition and formulation, generation of alternatives, decision-making, and solution to implementation and verification. Because of the appropriateness for planning and design, only the problem solving scale was used for this study. Additionally, each participant completed a stan-

dard course evaluation instrument developed by the academic department. This course evaluation focuses upon instructor presentation style and course content. Qualitative information was also collected about the students' feelings about the Roller Coaster Tycoon and its use and role in the class. Comparisons were made on course grade, problem solving, and course evaluation pre and post the adding of Roller Coaster Tycoon as an instructional intervention. (19)

RESULTS

The first results being reported are the qualitative comments from the class. The first comment was that there were individuals in the class, who did not like the Roller Coaster Tycoon. The primary reason given was that they are not computer oriented individuals. The other comment made was that the Roller Coaster Tycoon was addictive and they would play the game incessantly. On a subjective level, 85% of the students had a very positive experience with Roller Coaster Tycoon and they indicated that the primary contribution of the game was that it helped them integrate all of the theories and principles. The primary advantages of using Roller Coaster Tycoon was that it allowed for the development of a common perspective among the students and promoted the synthesis of theory and practice through an interactive format.

Comparisons were made of individuals in the class based on GPA: students with GPAs below 3.0, and those with 3.0 or higher. Likewise, comparisons were also made between pre-Roller Coaster Tycoon installation in the class and post-Roller Coaster Tycoon. An analysis of variance framework was used as the statistical procedure with sample II. A 0.05 probability level was used as the primary significance level. Those participants who had below a 3.0 average increased their scores in the class from a 2.8 to a 3.2; and those individuals who had above a 3.0 average increased their GPA from a 3.2 to a 3.5. This indicates that Roller Coaster Tycoon in the class helped those individuals with a lower GPA significantly, but individuals with 3.0 or higher had a slightly higher GPA, but it did not significantly increase their class grade.

When the Roller Coaster Tycoon project was correlated to the class grade using the Pearson Product moment correlation coefficient, it was found that the correlation coefficient was .8 and the relationship was significant at the .05 probability level. The coefficient of determination was .64. There was a strong relationship between project grade and class grade, which indicates the importance of the project grade on students' performance in the class. An analysis was completed for those individuals who used the Roller Coaster Tycoon in the class. When the test grade was correlated with the class grade for those individuals who took the test instead of using Roller Coaster Tycoon, it was found that there was a 0.3 correlation. It was not a significant relationship between the test grade and the class grade. This indicates that the test was not nearly as effective as Roller Coaster Tycoon in correlating with grade.

Comparisons were made pre and post the use of Roller Coaster Tycoon between the course evaluations for those individuals whose GPA was below 3.0 (on a 4.0 Scale) and those with a GPA 3.0 or above. An analysis of variance format was used for the comparison. A 0.05 probability level was used as the level to determine significance. Course evaluation scores were the interval measure used for the comparison. It was found that there was a pre-Roller Coaster Tycoon score of 51 and a post-Roller

Coaster Tycoon score of 56 for those who had below a B average or above. For those who had more than a B average, the course evaluation was 63 pre-Roller Coaster Tycoon; and 62 post-Roller Coaster Tycoon. There was not a significant difference in course evaluation pre- and post-Roller Coaster Tycoon.

Problem solving and critical ability were assessed through student self-assessment. Comparisons were made by individuals in the class who had a below 3.0 average and a 3.0 average or above and who were pre-Roller Coaster Tycoon and post-Roller Coaster Tycoon. A problem-solving critical-thinking index was used as the interval measure. An analysis of variance format was used for the statistical analysis. A .05 probability was the level used to determine significance. For those with an average below 3.0, the pre-Roller Coaster Tycoon score was 3.3. The post-Roller Coaster Tycoon score was 3.3. For those who had an average 3.0 or above, the pre-Roller Coaster Tycoon score was 3.1 and the post-Roller Coaster Tycoon score was 3.3. This indicated that the Roller Coaster Tycoon helped those whose average was below a 3.0 GPA achieve more problem-solving and critical-thinking ability in the course. Those participants who had a 3.0 average or above had a slight increase in problem-solving critical-thinking ability but it was not significant. This indicates the importance of Roller Coaster Tycoon for individuals with an average of below 3.0.

CONCLUSIONS

Results indicate that experiential learning helps to solidify, bond and integrate subject matter. It makes the subject matter real and gives the student a chance to practice various hypotheses and modify these hypotheses based upon interaction. The virtual experiential learning does have a role and it is an important role, especially in courses that do not have a direct application to real experiential learning. Virtual experience, if incorporated into a course, has a particularly significant impact upon the individuals with a GPA below 3.0hn. The results also indicate that this type of virtual experience directly correlates with class grade better than a test. Some researchers think that game and simulation adds to the popularity of a course evaluation. It was not true in this study. However, an identified benefit from using a virtual experience was an increase in problem solving and critical thinking ability. The results are not definitive but suggestive of the type of studies that need to be completed with virtual experimental lessons. It is recognized that the data was collected over a six-year period: three years that were without a virtual experiential learning, and three years after. There could be some factors during this time period that allow for the results not to be a direct effect of the virtual experiential learning. There needs to be some experimental designs used to answer more definite questions with control groups. This is an exploratory study and the results are favorable and new studies need to be completed with more stringent methods.

There must be additional studies to find, in detail, the role of virtual experiential education in the development of instructional exercises. There is a body of literature, but ways have to be found to incorporate these types of instructional strategies into instruction. They seem to have a very definite role in helping students integrate their learning experiences and may even, in fact, increase their problem solving and critical thinking

skills as they learn to apply the information in different settings and the ability to try different strategies to be a success. This type of instruction is performance based and holds much promise for the future.

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