Simulating Construction Project Management with Human Factor as an Educational Supplement

B. Gokhan Celik, Ph.D.
University of Southern Mississippi
Hattiesburg, Mississippi

This study presents a preliminary methodology to build project management simulation software with integrated human behavioral factors for use in construction management education. The current approach to project management education pays little attention to daily team and client related people management challenges of a project manager. Students receive very static information compared to the dynamism of issues project managers face daily in the industry. Simulations in construction education, reduces the level of student disconnection from the actual world experience. The simulation concept introduced in this study, is an interactive web-based series of sessions that allows individuals or groups of students to make construction project management decisions. These decisions include a wide range of topics such as construction accounting, cost analysis, scheduling, safety, team management, client relations, and ethics. This study also introduces a preliminary concept to eliminate the randomness of a simulation environment by utilizing the stochastic frequencies of outcomes collected via industry questionnaires. This paper argues that it is crucial to teach students of construction management programs, different principles and phases of a construction project, as well as the personal, social and technical tools to effectively communicate and make decisions to become successful in their career paths.

Key Words: Simulation, Project Management, Construction Education, Human Factor

Introduction

Preparing students to manage construction jobs has always been challenging for higher education institutions. From a student's perspective, they may experience the age-old dilemma of not being hired or promoted due to lack of experience, which is difficult to gain if companies will not hire without real world experience. It is a fact that even after spending many years in the construction industry, individuals who are promoted to a project manager position will be exposed to a struggling period. Instruction methods used in many construction management programs are based on the traditional methods of stand-alone courses as a core of their educational system. Sawhney and Mund (1998) state that instruction methods used in majority of construction engineering and management curricula rely, mostly on traditional methods such as exposing students to applied science courses. This conventionalism in the construction education creates the problem of students having difficulty in comprehending the connections between individual courses and their real world applications. Most of all, students struggle with social aspects of project management in real world, which involves more than managing time (schedule), budget (cost), material, labor, and equipment (resources) (see figure 1).

Figure 1: Traditional understanding of project management in construction

Construction project management, in more detail, can be described as the art of coordinating human and material resources to achieve project objectives within time, budget, and quality. However, the current approach to project management education pays little attention to daily team and client related people management challenges of a project manager other than their requirements for internships which help increase students' exposure to real world and human related management challenges.

Students receive very static information compared to the dynamism of issues project managers face daily in the industry. Simulation and gaming theories have been used at various institutions and programs to create a real-world like experience for the students. While conventional methods provide answers for "What happened, and how and why?" simulations help students answer "What if?" questions (Dooley, 2002). These efforts may eliminate the problems associated with students not being able to relate the tools being taught in-class, to the actual real world applications. Simulations in construction education, reduces the level of student disconnection from the actual world experience that increases the life time of usefulness of the tools being taught. This, in return, increases the interest level that is known to help instructors deliver information more effectively. However, many of these efforts lack the artificial intelligence to duplicate the behaviors of typical project-related teams and individuals. This includes management of project team, and job related public, as well as the ability to respond to non-job related company expectations, and ethical considerations in addition to the traditional cost, budget, and resources triangle (see figure 2).

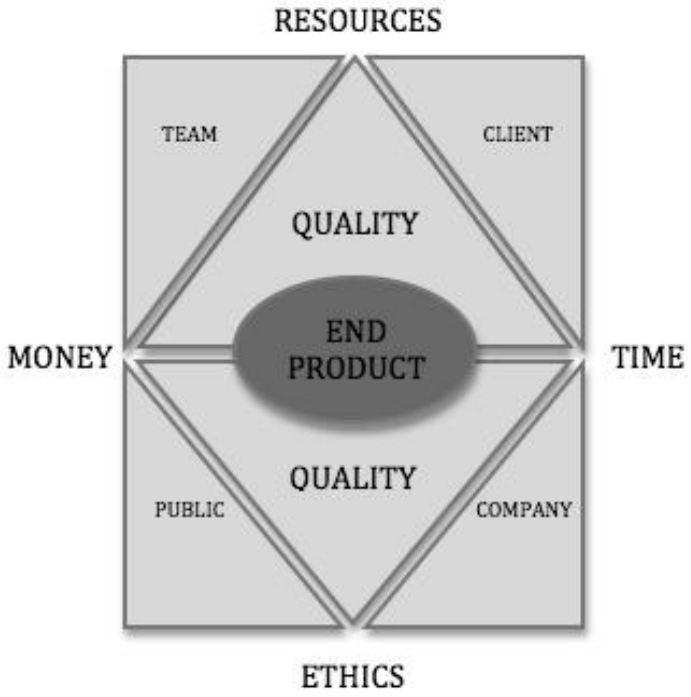

Figure 2: Holistic simulation approach for construction project management

Instructional Innovations in Project Management Education

Construction industry is not the only discipline that requires a solid knowledge of project management. Many other programs include project management courses in their curricula. A variety of disciplines from military science to business administration and engineering, have been conducting research on advancing the science and art of project management by developing innovative instructional technologies to be used in teaching project management. Literature for project management research presents that there are two main groups of researchers based on their concentrations. First is the group who work on improving the transfer of information of the well-known fundamentals of project management, to the students. Another group of researchers focus on understanding and further questioning the fundamentals of project management itself. Soderlund (2004) argues that a potential cause

for poor project management is because researchers spend too much time on project success and failure, but very little time on how projects behave, which often is related to the human factor involved in the process.

Current literature presents that business administration related project management simulations are far more advanced than same applications available in the construction management area. Project management simulations are widely available in many industries both for post academic industry training, and as an instructional tool during academic education. Construction management programs have also designed, tested and implemented innovations such as internships, multi-based learning, service learning projects, simulations, and games (Park and Meier, 2007). Internships in particular are one of the most successful educational tools in construction management to expose students to the real world challenges. The advancement in 3-D virtualization, combined with traditional construction management education, helped create simulation technologies such as "4D virtual construction" as a management tool (Park and Meier, 2007). These new generation simulations allow students to practice their skills in construction materials and methods, construction estimating, scheduling, and construction project management courses (Sawhney and Mund, 1998). Another example of a simulation tool for construction management students is called the Building Industry Game (B.I.G.) where students create groups to submit bids for sample projects. B.I.G. allows students to make strategic decisions to balance time, cost and quality (Johnston et al., 2003). Some other new generation construction simulation tools have been concentrating more on a graphically constructible format for a true representation of constructing an actual project. Many of them fail to represent the potential effects of, and the variance in team behavior, ethics, availability of resources, or other human generated or environmental risks. While researchers are continuously improving the shortcomings of simulations in construction management, there is still a need for studies that concentrate on simulating human factors such as risks associated with team, public, supervisor, and client management, along with ethical considerations for a more accurate representation of the actual world. It is also important to note that ABET accredited technology programs are required to observe the ability of students to understand professional, ethical and social responsibilities as a part of program outcomes (ABET, 2007)

There are a number of commercially available web based project management training courses that concentrate particularly on general business administration. These web-based software engines run simulations using artificial intelligence to mimic a range of behaviors of typical project-related people. By going through an actual project that simulates the desk of a project manager, users are guided towards making decisions to move forward on the simulated project. Graphical representation and the use of 3-D modeling in the general business administration simulations are nowhere as advanced as the construction related simulation engines, while their content appears to be a more realistic representation of the real world due to increased human behavior integration. One of the private institutions, which offer simulation based project management training, is Synergest, Inc. Synergest offers services in management training, consulting, coaching, and tools for project management (Synergest, 2008). According to Synergest's website, their simulation software includes over 108 possible personalities built into the simulation, with an unlimited number of combinations of traits. Synergest software gives you the ability and the opportunity to manage your virtual boss, the virtual customer, the virtual team, and of course, the virtual project (Synergest, 2008). It is evident that construction management education and training programs need similar human behavioral reinforcements in the project management simulation research. This study presents a preliminary methodology for simulating a construction project management that takes human factor into consideration.

Construction Management Simulation with Human Factor

The conceptual project management simulation introduced in this paper, is an interactive web based series of sessions that allows individuals or groups of students to make construction project management decisions. These decisions include a wide range of topics such as construction accounting, cost analysis, scheduling, construction safety, team management, client relations, and construction ethics (see figure 3).

A web-based system would allow the simulation to be accessible by students from remote locations to increase its ease of use for group work and assignments. Utilization of a web-based system would also help realize a continuously updated decision-outcome database. One of the crucial sections of the simulation is to build and utilize a database that can present multiple outcomes for each and every decision made by the users (See Figure 4).

Figure 3: Decision topics to be utilized in decision making processes

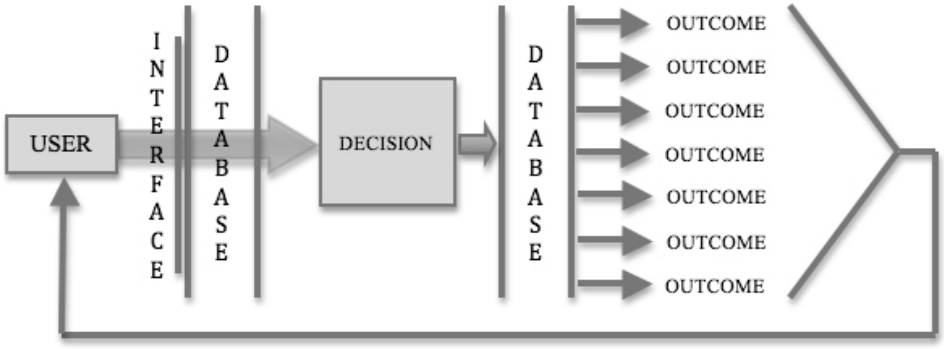

Figure 4: Decision making process in relation to simulation database

The population of the database can be built by using industry data from a number of projects and from industry experts and professionals via web based questionnaires and face-to-face interviews. This phase in the project can be divided into two categories:

- Questionnaires to determine potential outcomes of decisions.
- Questionnaires to determine frequency of different outcomes.

First category of questionnaires is to be used for determining the possible outcomes of certain managerial decisions. The questionnaires in this category would be structured unconventionally, since not every participant will receive the same set of questions. Database would be built gradually in time, by using sets of responses from certain individuals as the basis of new questionnaires to be reviewed by other questionnaire participants. Incorporating the responses of industry participants for developing new sets of questions, would allow creating a broader list of potential outcomes that take human factor into consideration. Second category of questionnaires then would utilize the list of outcomes for each decision and determine their probabilities of occurrence in the actual world. Since this study intends to include human factor into the simulation process, it aims to target individuals from different backgrounds, positions, and career levels in the construction industry as the subjects of the multi-phased questionnaires (see figure 5).

Once a preliminary database is built, it can be configured and stored on the World Wide Web as a Microsoft Access or SQL database that can continuously be updated by new industry participants' responses. This would help keep the simulation software up-to-date with the industry as long as the questionnaires are managed on a web-based environment where continuous participation can be possible.

Preliminary methodology of this simulation does not include 3-D construction simulation, but instead keeps the visualization graphics to a simple project manager's desk approach. Users who log in to the web based simulation would be welcomed with a selection of initial project scenarios based on:

- Project Type.
- Project Phase.
- Project Location.
- Project Size.

Once the project is selected, simulation would start for the users where they are given a project management challenge on each screen. Users would need to make a single decision from multiple choice options determined by the questionnaires, in order to proceed to the next screen. The possibility of a certain outcome appearing on the succeeding screen can be based on a random selection. However, one of the goals of this study is to eliminate the randomness of a simulation environment. This can be achieved by utilizing the frequency of a certain outcome chosen by industry participants in the second category of questionnaires, as a basis of a stochastic modeling. Parallel to the actual world, a stochastic modeling approach in the simulation engine would help create a spontaneous simulated management environment that can possibly present a different outcome for users even if and when they make the same decisions.

To further clarify, let us assume that there are four potential outcomes of a certain decision and Outcome A was circled 40% of the time in the industry questionnaires while Outcomes B, C, and D each were chosen 20% of the time. In this case, instead of a direct random selection between Outcomes A, B, C, and D, a stochastic model in the simulation will adjust the occurrence of selection process based on the aforementioned percentages. Keeping the databases, the questionnaires, and the simulation online would allow these percentages to constantly change based on continuous industry participation. Each screen of the simulation software would carry a set of items constantly on a sidebar. Users would be able to explore the sidebar to find project documentation such as construction documents, budget, schedule, job site photos, and daily and monthly reports, depending on the project phase chosen at the beginning. Sidebar can also include items such as an inbox and calendar. Users may receive messages from anyone including their virtual supervisors, virtual team members, virtual clients, etc. during the duration of the simulation. These messages would appear in their inboxes every time simulation software chooses to update or modify a user's current set of goals or tasks. Once a student receives a message in the inbox, any related tasks and their deadlines can automatically be entered into students' calendars located on the same sidebar. Once again, students would need to make decisions based on interactive online data, in order to be able proceed to the next screen.

The web-based simulation engine can also allow students to upload documents as their responses to certain managerial challenges. In some cases, students would need to not only make a decision, but also attach the associated document(s) in order to proceed to the next screen. A sample screen of the web based user interface can be seen in figure 6.

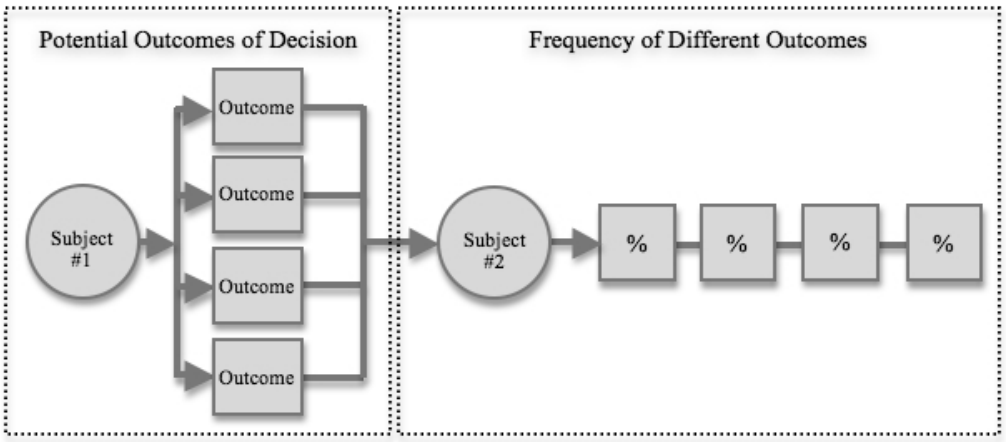

Figure 5: Questionnaires to build an outcome database with frequency of occurrence.

Every decision that is made by the students should be stored in an "assignments database" where the instructor can track and compare users' decisions in a web-based environment. This would allow instructors to track the status of students' progress in the simulation, while giving them the ability to create partial assignments as well as seeing their results immediately when a decision is made. Database should also be able to manage uploaded files by the students, along with the decisions made in the simulation. This would allow students to upload files related to the virtual schedule, budget, change orders, request for information letters, submittals, daily or monthly reports, transmittals, correspondence letters, and etc.

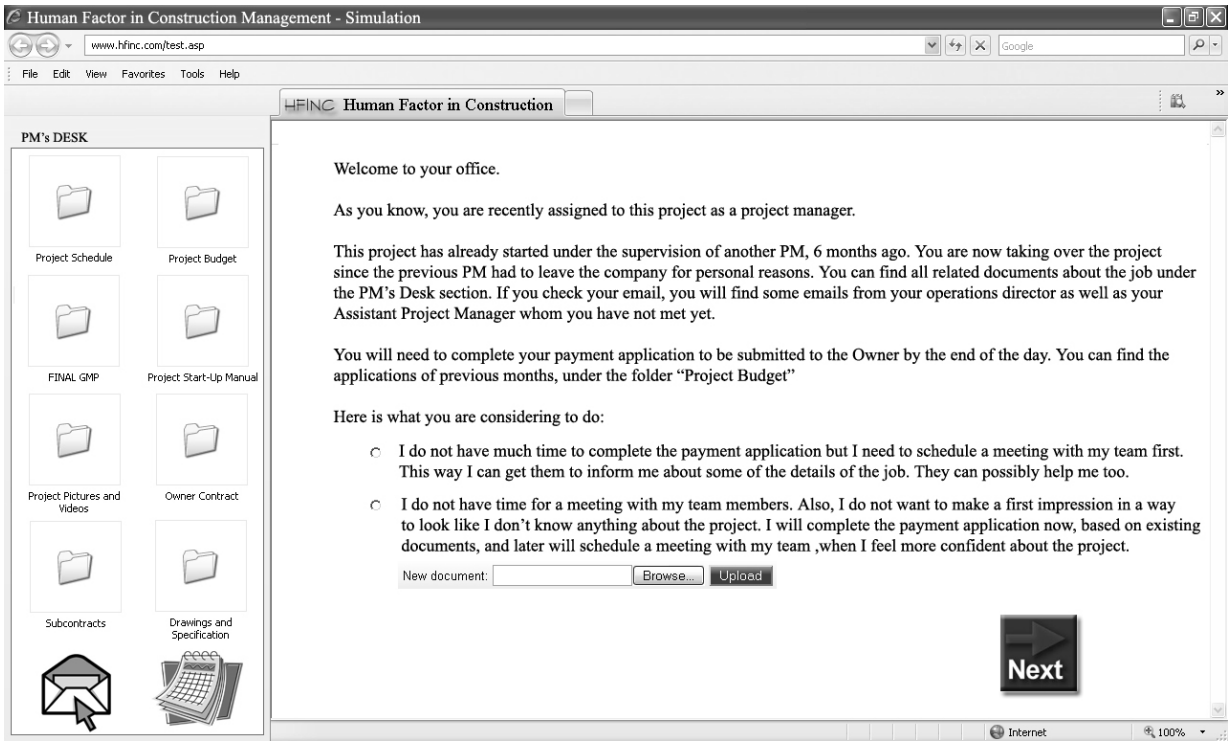

Figure 6: Sample design of a template screen for proposed simulation study.

Conclusion

Project management simulation is an interactive session or series of sessions that allows users individually or in groups, to make project management decisions. Users can act like project managers to the challenges already configured in the simulation software. Reactions from users are converted in a decision making process by allowing them to proceed to a following web based screen only if they make a decision. These decisions then are stored along with user uploaded files on an online database for the instructors' review and use for discussion. Using industry data from different projects and experts would help demonstrate common patterns of failure that causes project teams to be unsuccessful due to schedule delays, budget overruns, quality deficiencies, team conflicts, ethical failure, or marketing and human resources related problems.

It is important for construction management students to experience the daily tasks of a project manager before they find themselves struggling with certain decisions in the middle of a very fast paced industry. They need to be able to understand not only the theoretical fundamentals of a construction project, such as cost estimating, scheduling, planning, safety, and cost analysis but also more qualitative areas such as team management, leadership, ethics, marketing through public and client management. A study conducted via postal and electronic survey of 113 project management related personnel in South East Queensland during October 2002, indicates consistently with many other studies that the most important skills that an effective project manager should possess are the ability to communicate, followed by the ability to meet project objectives and the ability to make decisions in general (Lei and Skitmore, 2004).

It is crucial to teach students of construction management programs, different principles and phases of a construction project, as well as the personal, social and technical tools to effectively communicate and make decisions, which would eventually promote success in their career path. Exposing students to real-world simulations early in their education as a supplement to their internships would help them relate better to the theories and solutions traditionally being taught for the remainder of their education.

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