

Application of Serious Game Model on Simulation Training for Decision Makings of Project Management

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Abstract

This study develops a novel serious game foster decision making skills in project management based on role playing. It provides features such as accident event handling, resource allocation, selections of subcontractors, procurement and stock management, adjustment of project scheduling, and performance evaluations to be exercised by user online. In doing so, users can strengthen their project skills by managing a virtual project. Importantly, the proposed game provides users with virtual experiences to implement management and control tasks of a construction project, which is often difficult to offer in conventional training. The proposed system is an online game developed by using advanced web development tools with integrations of MySQL for project data management and MS project for project schedule update on the server side. Users are presented with a virtual project in dynamic scene image depicting a construction site, which changes as the game progresses. There are also images present various construction events. During game play, users can function as a project manager whom is responsible for making various decisions involving accident handling and resource allocation as the virtual construction project progresses. Results of the decisions made are obtained by real-time simulation based on project data, then are visually and interactively replied to the users to understand the subsequent effects of their actions. In this training mode, decision-based simulation can provide realistic and reliable consequences of their decisions. The virtual reality feature of this computer game offers an economic and viable alternative to actual project management experiences.

Keywords: serious game, decision simulation, virtual training, project management

1. Introduction

An increasing number of computer game modes that integrate a diverse array of knowledge skills have been adopted to facilitate professional staff training. In terms of training professional staff in construction engineering, related projects are characterized by customization, large scale nature, long construction time, high cost, unforeseeable circumstances, and potential risk involving construction safety. In contrast with other industries, a construction project must draw from the accumulated experiences of its professional staff. However, accumulating relevant experiences is rather difficult owing to the unique characteristics of construction projects, such as their large scale nature and high cost. Therefore, providing virtual work experiences through computer games that simulate a construction project setting is a viable alternative. Virtual operations can mitigate the risks incurred by direct physical exercise and are not subject to external weather factors. Moreover, users can be

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oriented on unfamiliar situations repetitively. In contrast with training in a conventional setting, computer games can save a substantial amount in project costs and waiting time by switching game scenes frequently and simulating different conditions, ultimately allowing trainees to accumulate relevant knowledge skills and experiences cost effectively.

Computer game applications in training can be divided into operational and role-playing modes. Trainees use the operational mode to simulate various workplace operations, e.g., driving an excavator or operating large-scale machinery, with a particular emphasis on fostering the adaptability of trainees to certain tasks [1-6]. Alternatively, trainees use the role-playing mode to manage a virtual company or shop from a managerial perspective and to devise responsive strategies based on information that the computer provides, ultimately allowing trainees to accumulate managerial experience [7-11]. Conversely, conventional modes for training construction engineering managers include classroom instruction, orientation on business practices, and site visits; of classroom instruction is the most prevalent. As is generally assumed, students acquire practical experience in construction management courses, when they actually lack praxis-based opportunities for exercise. Although some training curriculums provide students with opportunities to practice in an enterprise setting, student learning of construction work is insufficient owing to the short training period. Conventional learning is limited in its ability to only assign students a low-level task without actually participating in management tasks. This explains why students often struggle upon entering the industrial workplace, eventually learning only after a trial and error approach towards correct industrial practices and experience acquired over time. The training mode of a computer game allows the trainee to act as managerial staff involved in engineering projects. In addition to enhancing the simulation, security, and playfulness of training, integrating a computer game with construction engineering supplements training in addition to normal class instruction. At present, this computer game mode can offer a simulative scene to trainees, allowing them to feel by themselves and to visualize site situation using pictures and words, which will no longer be subject to individual imagination. During simulation, the game can incorporate the proposed solution derived from classroom case studies for analogous calculation and comparison with original estimates. As for security, the computer game can eliminate potential risks in an actual workplace training site and simulate accidents through a video clip, offering trainees with the emotions of an on-site incident without fear of injury.

Therefore, this work presents a novel computer simulation game to train construction project managers. The computer game contributes to the development of assistant training software based on decision-making management principles that combine simulation with engineering managerial knowledge. In this game, users serve as a construction site project manager responsible for a series of decisions, as presented in 3D and game formats. Related tasks include arranging labor, material quantity and equipment for each project, controlling the cash flow and construction period, selecting a contractor, ensuring safety in construction site management, performing field inspection and quality control, as well as forecasting weather-related factors to achieve construction project goals.

The virtual construction management practices taught in this computer game are an economical, safe, and interesting means of filling the gap between teacher-student interaction and simulation of actual construction management training in the field. By making decisions in a gaming environment, trainees can understand life-like situations found in actual cases through repeated feedback and practice according to performance evaluation. As is expected, this virtual construction game provides trainees with the unique opportunity to manage a virtual construction site. By applying concepts taught in virtual construction, trainees can learn from experiences involving inspection and verification, thus clarifying case studies presented in the classroom and strengthening their perceptiveness. Additionally, via this virtual medium, trainees can understand the implications of damage caused by improper management practices, without concern over actually losing money and compromising security. Trainees can repeat industrial practices through simulation based on their training results.

2. Content and Scope of Virtual Construction

The proposed game allows users to thoroughly understand decision making concepts in construction engineering. Although the main training objects are the on-site managerial staff, game contents encompass tasks of the project manager, construction site owner, and contractor, they are not limited to specific roles. Moreover, contents are delivered by assuming that users can comprehend situations based on clear instruction from the 3D animations, although it is not expected to simulate the actual situation completely and accurately.

As the proposed game simulates all work tasks involved in making construction project management-related decisions and schedules, this work selects the contents for a course called Project Planning and Control as the primary source for simulation. Initially, virtual construction scripts are sorted out from course-related contents involving construction management and administrative operations. Simulated construction contents are divided into four parts, as listed in the following. Based on the contents of each section, several parts are selected as the simulation script. Those contents are described briefly as follows:

- (1) Construction contracts and management: specifications based on construction contracts, bid package format, construction claims and disputes resulting from contracts, as well as provisions of changing orders following commencement of the project. The contract content format is added to the game script in order to describe the task of virtual construction in the proposed game;
- (2) Subcontract: construction bidding and the selection methods for a construction site owner to choose which company to cooperate with, including quality control methods to manage the subcontract after the project is initiated. The proposed game attempts to incorporate methods of selecting contractors and their effects into operating costs, quality, and time, as well as other effects into the game script;
- (3) Construction procedures: confirmation of the contract before starting the construction, daily management after the project is initiated, and accepting provisions after construction is completed. The proposed game attempts to incorporate management tasks conducted by the site manager into the game script in order to provide trainees with management training-related experience; and
- (4) Cost estimation and control: quantity takeoffs in the training of construction operation, measures to control costs and scheduling, and measures to allocate resources efficiently. The proposed game attempts to incorporate factors aimed at balancing resource allocation and controlling costs and scheduling into the game script to provide trainees with resource allocation-related skills.

The simulated contents originate from course instruction. Additionally, the game elements are embedded in the virtual construction of the script with reference to current operating modes and elements of a simulated business game in the current market. Finally, the estimated game script is prepared as the design basis of the simulated training contents for the game after discussing details with experienced staff. Fig. 1 shows the main contents of the game script of the proposed virtual construction. Tasks in this work include drawing up a construction contract initially, selecting collaborating companies, allocating resources efficiently after the project is initiated, controlling costs and schedules, handling unforeseen emergencies such as those involving construction safety, and evaluating the performance of construction quality after completion. Cumulatively, the above tasks form the basis for establishing a game-based training mode for decision making in construction management.

3. Analysis of System Requirements

Once the game script for virtual training and presentation of the game contents and interactive modes are established, this work further analyzes operating conditions based on the above considerations to prepare the details of system development. The training mode has the following system functions.

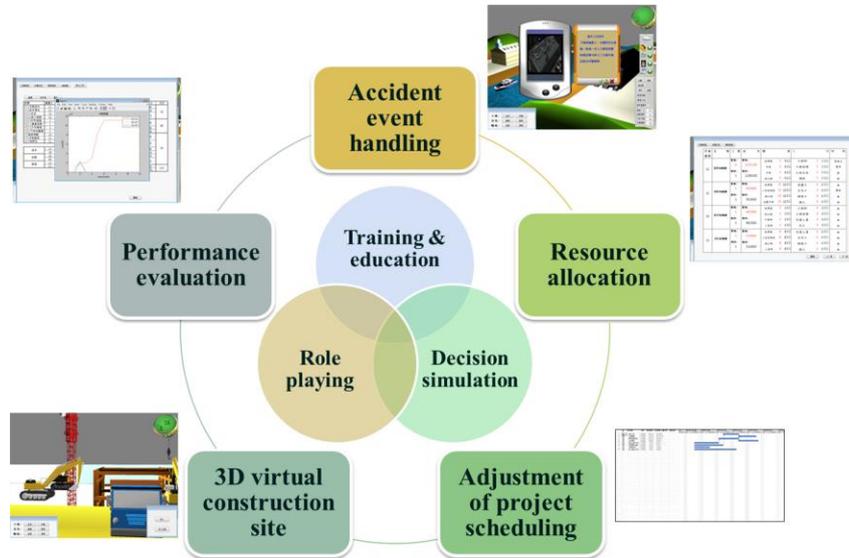


Fig. 1 Contents of the proposed training mode

3.1. Decision making

One of the key responsibilities of a construction manager is to make decisions in construction management. Whether making the appropriate management decision or not is one of the determinant factors for the success or failure of project management, and it is one of the key competencies that needs to be acquired first. Based on the script in this study, the management decision making given to trainees in the game includes two parts: decision making for emergencies and decision making for selecting the contractor. Emergencies are generally divided into two parts: those caused by climate and those caused by human factors. The disaster triggered randomly by the climate system of the game causes delays or a shut-down, and thus users must make a decision immediately. With regard to accidents caused by human factors, many accidents questioning construction safety caused by the incompetence of the cooperating company or by the improper habits of the construction workers are triggered in order for users to prepare solutions and select contractors carefully.

3.2. Resource allocation and management

During construction, the manager must arrange the resources including labor, money, and machinery, for reacting to various uncertain factors. These are very important as they can affect the schedule of the whole construction. Therefore, the virtual construction management presented in this study provides trainees with the function of adjusting resources used in construction.

The number and type of resources initially planned for each work item are the reference basis. After the scheduling is completed, the actual resource number is divided by the reference number. The ratio is divided into several blocks for different days, and the stepwise method is applied to reduce the days. The number of resources after adjustment is multiplied by unit price and days after changing. The obtained number will be the cost of the operation.

3.3. Schedule and progress control

Due to uncertainties in the simulation, the system allows users to adjust the operating resources according to the encountered situation. The original schedule and progress control are then changed with the occurrence of events and related arrangement. Moreover, based on the schedule and progress control, it is necessary to update the schedule and the cost. Therefore, the function of the dynamic treatment of schedule and progress control is required.

To attain the requirement of schedule and progress control, which is achieved by integrating MS Project, each game data in the main program is saved in a database, and then it is converted to the specified format set by the MS Project. All the kinds of operations in virtual construction can be arranged using this software. After finishing the operation arrangement, the updated scheduling information is stored back to the database and the main program for updating game status through reading the database.

3.4. Evaluation of management performance

In current project management practice, the evaluation of management performance as a management tool has been introduced. According to the resources to invest and the schedule, the performance index is calculated theoretically to help the manager control and determine in real time the effectiveness of the management strategy in use. Using the evaluation index can analyze the reasons why the results are not effective. This is to discuss further the occurrence point of the reason and to consider and acquire the improved method and make adjustments.

The game should provide the function of evaluating management performance in a virtual construction. Based on performance evaluation function offered by the system, users can check, during the game training period or after, their management strategy for resource allocation, cost and time control, and decision making. The proper evaluation theories, including the score index and S Curve, are selected to calculate real-time indexes and control curves based on all kinds of status data in the process of game such as loss amount caused by construction safety, types of accidents, and expenses.

4. System Implementation

The training system for the proposed game is developed based on the above functions. Five functional bars allow users to control and summon all functions. The functions of each function menu are listed as follows:

- (1) Main function toolbar: Users can access the contract contents and select the collaborating company from a list of many contractors, adjust the number of resources in each construction, shorten or extend the duration, rearrange the operating time to control construction operations, and make verifications and adjustments by accessing the performance scores;
- (2) Time status bar: This menu indicates the date in the game world; the operation is run based on it. Users can accelerate or decelerate the game speed, as well as stop the game;
- (3) Project status bar: Game climate can affect operation efficiency and the construction period. An icon denotes the current weather situation. Conditions of the worker, owner, finances, and duration are denoted by three lights, i.e. red, yellow, and green lights, to remind users to control them in real time;
- (4) Sub function toolbar for daily management: Users can give management instructions, such as orient the trainees, using various management functions offered in this functional toolbar;
- (5) Display area of virtual scene: The animations of construction operations and animations of triggered events are displayed here. Users can switch for a closer view of scenes on-site by clicking the building under construction.

5. Effectiveness Evaluation

Fifty students enrolled in a course on project planning and control at National Taiwan University of Science and Technology tested the effectiveness of the proposed game. User survey statistics reveal an agreement level of 4.32 out of 5 that this game benefits learning and that course contents are clearly understood. This game-based training is regarded to perform better in simulation, interest, interactivity, learning efficiency, and immersion than other training modes do. The leading five features selected are management decision making, 3D display of virtual construction site, tutorial hints, project scheduling, as well as resource allocation and management, respectively.

6. Conclusions

By applying role-playing functions and simulation games, the proposed game orients students on decision making in project management. For instance, in a virtual work site, users can act as site directors to conduct a series of daily duties. Based on the understanding and analysis of managerial experience and construction processes accumulated from managing virtual projects, a virtual training system design is planned to fulfill the function demand. Also, users do not need to be concerned with poor decisions that can incur property damage or budgetary loss. Additionally, the proposed virtual game can make modifications according to the feedback from the performance evaluation index after training. This feature helps users to determine and compensate for management limitations and other details to prevent time and financial loss resulting from a lack of experience or wrong judgment in their future work. The proposed game provides a virtual presence that allows users to observe the incident on site, as well as interact with each other in the decision-making process, which is in contrast with conventional classroom teaching methods. Moreover, the proposed game also ensures a better performance in terms of calculating costs and safety in practical training, which represents an advantage over practical training in enterprises, construction site visits, and other training modes.

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