PMS – A Simulation Game for Interactive Learning of Software Project Management

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Abstract. Successful management of software projects requires both theoretical project management knowledge as well as practical reality-like management experiences. Simulation Based Training provides a hands-on approach to explore the complexity of managing projects through rapid and inexpensive experimentation. Most of the existing project simulation game focuses only on the management of time, scope, cost, and human resource. There are relatively fewer products which focus on project stakeholder management, communication management and quality management.

In this paper, a project management simulation game, PMS, is introduced to support the interactive learning of software project management. The game design, implementation and how it may support the learning of software project management concepts in different knowledge areas are discussed.

Keywords: Software Project Management, Project Management Simulation, e-Learning, Simulation Based Teaching.

1   Introduction

IT projects are plagued by poor quality and schedule/cost overrun. To improve the quality of IT projects, better education of (future) project managers is essential. Simulation games have been adopted by many universities throughout the world to support the teaching of project management [1]. Simulation Based Training provides a hands-on approach to explore the complexity of managing projects through rapid and inexpensive experimentation. The user will take the role as a project manager and make project decisions in some pre-defined project scenarios (e.g. manufacturing printers, building a high-tech large scale shark aquarium). Many of the existing project management simulation games only focus on the time, scope, cost, and human resource management in Project Management Body of Knowledge (PMBOK) [2]. Relatively fewer existing products focus on project stakeholder management, communication management and quality management of software projects.

In this paper, a project simulation game, PMS, is introduced for supporting the learning of software project management. Students will act as a project manager in a hypothetical software development project scenario. In addition to scope, time, and human resources management, the game also focuses on project decisions for communication

management, stakeholder management, and quality management. Students are required to analyze the stakeholders' needs and expectation, properly define the project scope, and communicate with the stakeholders throughout the project. Students are also expected to conduct quality review activities early and develop prototypes for demonstration so as to improve the software quality and increase the stakeholders' satisfaction.

This paper is organized as follows. In section 2, related studies will be reviewed. The game design will be discussed in section 3. In section 4, the implementation will be discussed. In section 5, summary and future studies will be presented.

2   Related Studies

Simulation Based Training is recognized as an efficient and effective way for teaching and learning complex, dynamic systems for engineering and business curriculum [3]. Drappa and Ludewig developed a simulation game for software engineering education named SESAM [4]. The game adopts a rather low-level modeling approach. For example, bugs multiplication and additional communication effort due to more team members are simulated in the game. The game, however, interacts with students with plain texts without any graphics. The authors evaluated the educational value of the game through controlled experiment and case study, and they showed that the simulation software is a powerful tool for project manager training. Dantas et al. developed a simulation game called 'The Incredible Manager' to assist students to learn project management knowledge through experience from simulation [5]. The game has project members and project phases defined. Distinct models for each scenario with uncertain aspects were also developed.

Harvard project management simulation game[1] is designed for letting the students to explore the trade-offs among the three major project management levers: scope, resources, and schedule and the effect of team morale on project attributes. The user will take the role of a project manager who will make project decisions on some pre-defined project scenarios (e.g. manufacturing of printers). Project Team Builder is a project management simulation game with a scenario editor for creating custom project scenarios [6]. The game mainly focuses on time, scope, cost, human resources and risks management. SimSE is a computer-based environment that facilitates the creation and simulation of real-istic game-based software process simulation models [7]. It supports different software development processes, such as Waterfall, Extreme Programming, rapid prototyping, and Rational Unified Process. Lee proposed an Excel-based project management simulation game to facilitate the teaching of project management in a classroom setting [8].

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[1] Project Management Simulation: Scope, Resources, Schedule V2. Available at
  `http://cb.hbsp.harvard.edu/cb/product/4700-HTM-ENG`

3   Game Design

3.1   Overview

In the game, the user plays the role as a project manager in a software development project. The user should analyze the stakeholders' expectation and preferences, prioritize the project requirements, and define the project scope to meet the expectation of the stakeholders within the project constraints (e.g. scope, time, cost, quality). During project execution, the user should make appropriate decisions to motivate the project team to achieve good morale, communicate with stakeholders to achieve good stakeholder satisfaction and monitor the project progress in different dimensions (e.g. time, quality). Figure 1 shows the various entities in the simulation game. The attributes for the different entities in the game is shown in Table 1.

Requirements: Functional and non-functional requirement which form the scope of the project.

Stakeholders: Stakeholders are people who are involved in or affected by the project (e.g. project sponsors, customers, system users, suppliers, etc). Stakeholders may have different expectation on the functional/non-functional requirements of the system. Each project stakeholder has their own level of *satisfaction* towards the project outcome.

Activities: An activity is an abstraction of a unit of work to be performed by team members in the project. The effort required to complete activities increases if more non-core requirements are included in the project scope.

*Team members***:** Activities are performed by a team member. Different team members have different skill levels/expertise.

Project team: A project team is composed of one or more team members. The project team should communicate with stakeholders early and regularly so that they fully understand the project's benefits and the most updated project status.

Defects: Defects are mistakes or faults that may be generated in a software development project when performing project activities.

Fig. 1. Overview of the game model

3.2   Game Decisions and Causal Model

The user should make a number of management decisions to plan for the project. Based on the analysis of the project stakeholders, the user should properly define the functional and non-functional requirements to be completed in the project. The user should also choose appropriate team members to be included in the project team and assign them to complete the project activities.

The project will start after the project planning is completed. The user should arrange management activities during the project execution to manage the project team and stakeholders. Examples of management activities are shown in Table 1.

Table 1. Game Attributes

Entity	Attributes	Description
Stakeholder	Project Under-standing	The extent to which stakeholders understand about the project (expected project outcome and benefits, current project status, etc).
	Satisfaction	Stakeholders' satisfaction towards the project outcome.
	Importance	The power and level of influence of the stakeholder on project outcome or decisions.
	Project Interest	The stakeholder's level of concern for project outcomes.
	Communication Preference	Communication preference is the way the stakeholder wants to be communicated with. This includes face-to-face meeting, virtual meeting, detailed status report and prototype demonstration.
Team Mem-ber	Project know-ledge	Team members' knowledge about the project objective, scope, stakeholders, most updated project status, etc.
	Morale	The level of motivation and enthusiasm of the team member towards their work.
	Fatigue	The level of tiredness of the team member. A team member may make more mistakes if he/she is tired.
	Daily Cost	Salary of the team member per day
Project team	Teamwork	How well the team members can work together as a team to achieve the project objectives
	Requirement Understanding	The extent of project team members' understanding of the stakeholder's true needs and expectation on the project or final product.

Table 2. Management activities during project execution

Category	Management activities
Team Management	Organize a Project Kickoff Meeting
	Creation of Team Slogan
	Reward and Recognition
	Half-Day Off
	Social Gathering
	Training/Coaching
Internal Communication	Internal Meeting
	Social Interaction /Management Wandering Around
External Communication	Status Review Meeting (Face to Face/Virtual Meeting)
	Brief/Detailed Status Reports
Quality	Requirement Review Meeting
	Code Review Meeting
	Prototype Preparation and Demonstration
Time Management	Overtime
Others	Purchase (e.g. Project Portal)

At the end of the game, the user's performance will be evaluated based on Stakeholder Satisfaction, Time, Quality, Cost, Scope and Team Morale (refer to Table 3). In this paper, we will focus on the stakeholder satisfaction and quality dimensions.

Table 3. Dimensions for evaluating the game performance

Dimension	Description
Stakeholder Satisfaction	The stakeholders' perception towards the project and final product. The stakeholder satisfaction is affected by the project scope and the communication with the project team. Important stakeholders (with high influence over the project decisions and outcome) will have higher weight towards the stakeholder satisfaction score.
Time	The time required to complete the project
Quality	The total number of defects in the final product.
Cost	The amount of financial resources spent on the project.
Scope	The requirements that are completed by the project. Users will get higher score if more non-core requirements are included in the project scope.
Team Morale	The average morale of the team members in the project team.

Understanding project stakeholder's perception and expectation during project development is essential for improving the chance of project success [9][10]. An effective project manager should analyze, evaluate, and deliver messages in different communication channels (e.g. status meeting, status report) to ensure the effectiveness of the communications. Fig. 2 shows the causal diagram for the stakeholder satisfaction dimension in the game. From the stakeholders' profile, the user should analyze the stakeholders' needs and communication preference. Based on the importance of the

stakeholders, the student should properly define the project scope by prioritizing the needs of the different stakeholders. During project execution, management activities such as status review meetings and status report should be adopted to communicate with stakeholders early and regularly so that they fully understand the project's benefits and the most updated project status. In the game, stakeholders with higher interests to the project will require more frequent project update. If there is insufficient communication between the project team and stakeholders, the stakeholder's project understanding will decrease and this may decrease the stakeholder satisfaction.

The stakeholders may have different personality types and they may prefer different communication style [11]. In the game, different stakeholders have different communication preference (e.g. face-to-face meeting, virtual meeting, and detailed status report). Appropriate communication channel should be adopted to increase the stakeholder satisfaction.

In software projects, stakeholders often do not have a very clear understanding of what they really need or want. Due to the intangible nature of software and uncertain outcome of IT projects, it is challenging to represent the key facets of software in a way which is accessible to all stakeholders [12]. Prototype is a working replica of the system or particular functions. Through prototype preparation and demonstration, stakeholders can better understand the user interfaces and features of the final products. This helps increase the stakeholders' understanding and maintain the stakeholders' satisfaction.
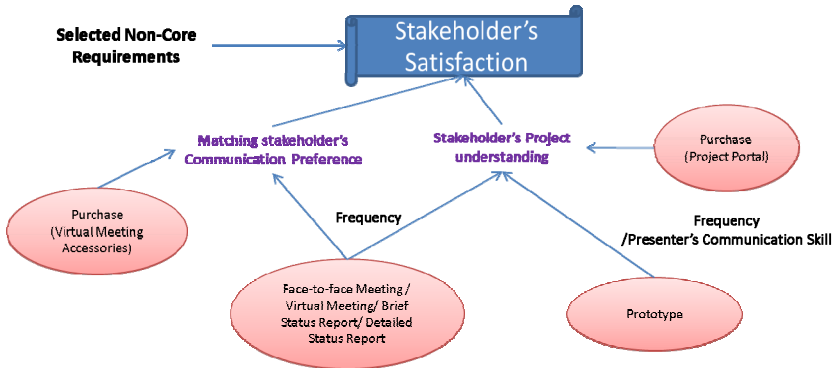

Fig. 2. Causal Diagram for Stakeholder Satisfaction

Studies have shown that the majority of the defects identified in the software testing phase are introduced in the requirement or design phase [13]. Since defects generated may multiply the defects in the downstream activities, defects identified later in the software development lifecycle are more expensive to fix than defects identified at early stages. The game models three types of defects: requirement defects, user interface defects, and coding defects. In the game, the defects generated earlier in the project may increase the defect generation rate of subsequent project activities. Therefore, the defects should be discovered and fixed early by requirement review and code review. During prototype preparation and demonstration, team members can also gain

a better understanding of requirements, evaluate system feasibility and validate the system design. In the game, the user interface defects can be discovered and corrected during prototype demonstration to the stakeholders. The development and demonstration of prototypes may also increase the requirement understanding of the project team. As a result, fewer defects will be generated in subsequent project activities.

4   Implementation

4.1   System Components

Fig 3 shows the system components:

Project Scenario: A project scenario is an XML document which defines the entities (e.g. team member, stakeholder, activities, and their dependency, requirements, sudden events) and the game attributes (E.g. initial cash, target completion date).

Scenario Builder: Custom project scenarios can be created by scenario builder.

Game Rule: An XML document defining the rules for the game (e.g. effects of management activities, number of action points per week, causal relationship of the different game attributes)

Game Configuration tool: Defines the game settings and causal model in XML format.

Game Engine: The project scenario will be read and executed by the game engine. The game rules and causal model are enforced by the game engine.

User interface: Graphical user interface for interacting with the users.
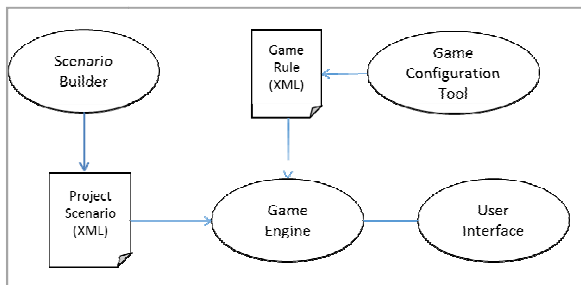

Fig. 3. System components

4.2   Game Features

A hypothetical project scenario is created to illustrate the features of the game. The user will act as a project manager in a company and plan for the video contest application development project (refer to Fig. 4). In the project, there are five stakeholders and eight potential team members.
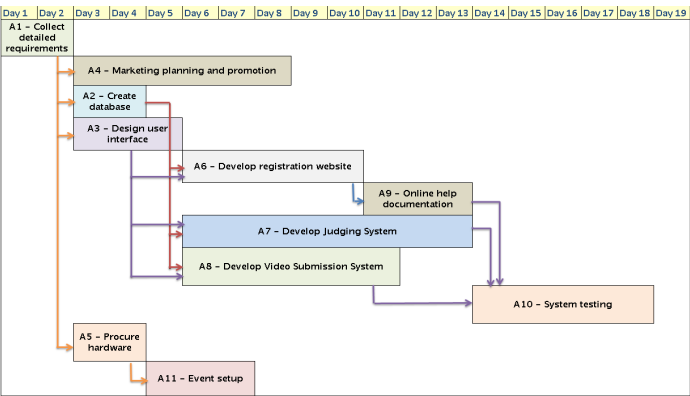
Fig. 4. Project Schedule for the hypothetical project

During the planning phase, the user may select a subset of non-core requirements to be included in the project scope (refer to Fig 5). As time and human resources are required to complete the selected optional requirements, the user should strike a balance between stakeholders' satisfaction, project duration and cost. The user should also select appropriate team members to form the project team and assign them to the project activities (refer to Fig. 6).
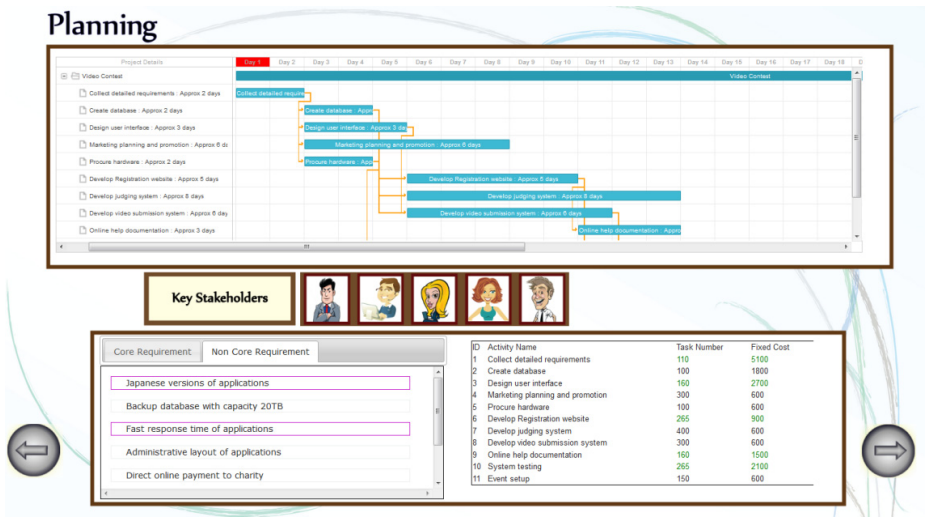

Fig. 5. Selection of non-core requirements
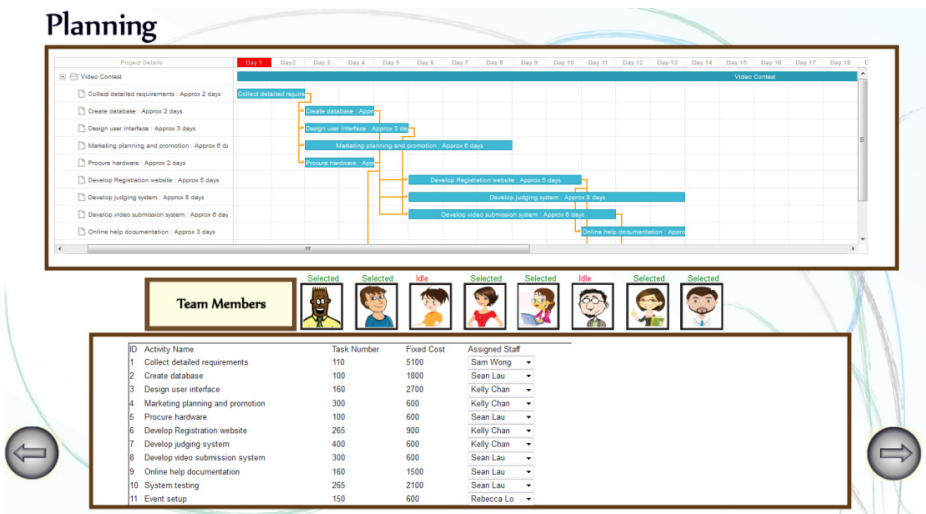
Fig. 6. Team Selection and Activity Assignment

Comprehensive stakeholder profiles and team member profiles are created for the game (refer to Fig. 7). The user may review the stakeholder profiles to understand the stakeholders' needs and expectation on the project. The user may also review the team member profiles to understand the skill level and the various attributes of the different team members.
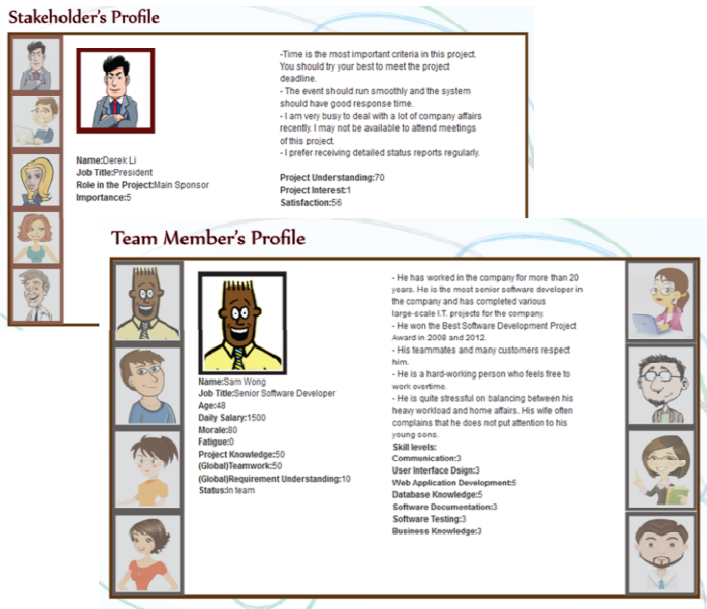

Fig. 7. Stakeholder Profile and Team Profile

The project will start after the project planning phase (refer to Fig. 8). Different options are available for the user (e.g. adjusting team member's assignment to activity, viewing the sudden events that have occurred, reviewing charts/project information). On every Monday, the user may plan the management activities for the coming week (weekly decisions) (refer to Fig. 9). Users will be given action points for planning the management activities in the current week. For instance, suppose the user intends to prepare and demonstrate a prototype in the current week. A stakeholder should be selected for attending the presentation and a team member should be chosen as a presenter. Choosing a presenter with good communication skill has the bonus effect of increasing the project stakeholder's satisfaction.
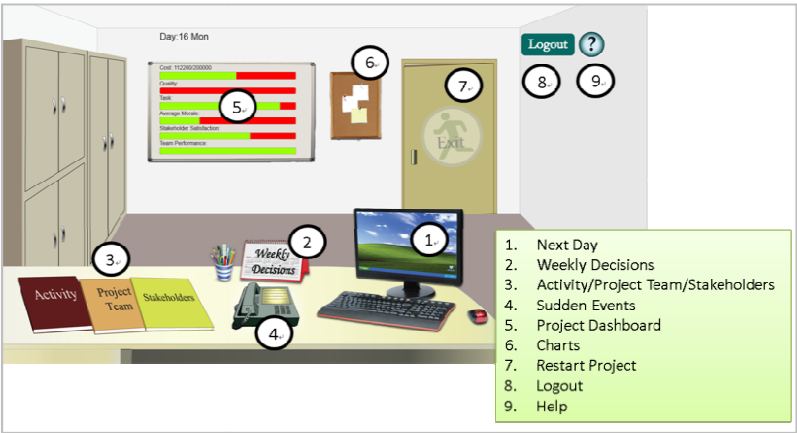

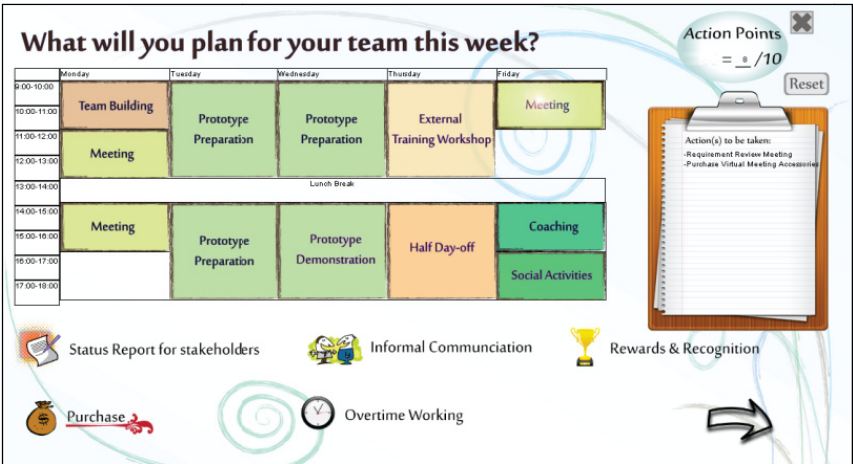**Fig. 8.** Office Environment during project execution

Fig. 9. Weekly Decisions Options

Users may click the next day button to proceed to the next day. A daily summary will be displayed to summarize the project progress. The user may review the planned management activities in the current week, current progress of each project activity, and the number of defects generated in the project.

To monitor the project progress, the user may view the project dashboard (which show the progress bars for Quality, Complete Tasks, Average Morale, Stakeholder Satisfaction and Team performance). The game also provides charts for users to review the project performance over time. Fig. 10 shows the average stakeholder satisfaction chart. The stakeholder satisfaction drops over time because of inadequate communication between the project team and the stakeholders.
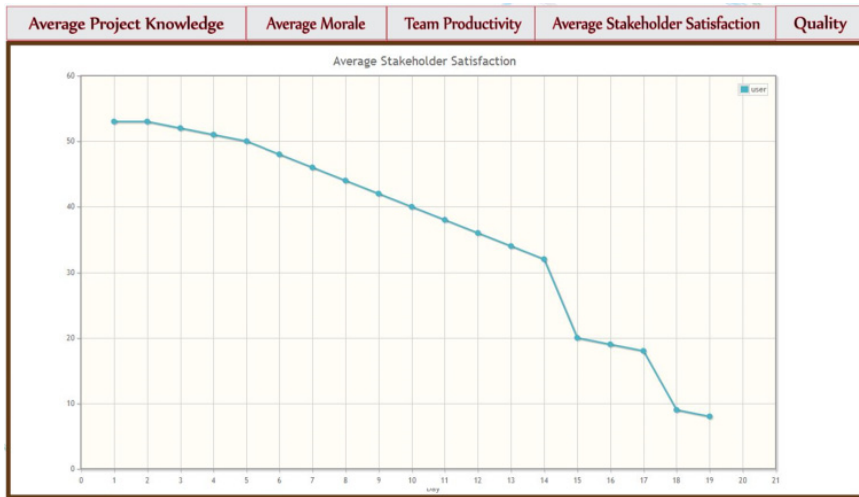

Fig. 10. Average stakeholder satisfaction Chart

The game ends when all project activities are completed. A page will be displayed to show the project management performance under the different dimensions (refer Fig. 11).
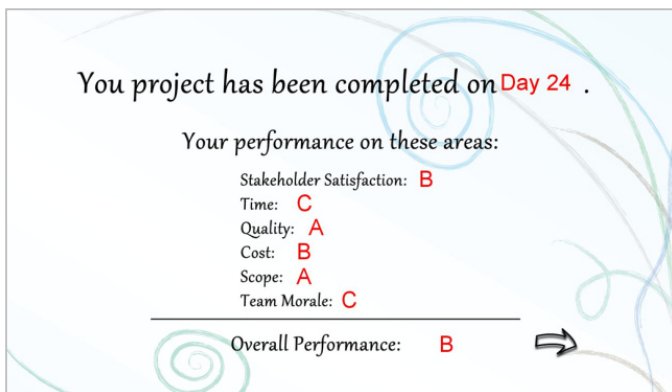

Fig. 11. Project Completion Page

5   Summary and Future Work

In this paper, the design and implementation details of a project simulation game, PMS, is presented. In addition to scope, time, and human resources management, the game also focuses on project decisions for communication management, stakeholder management, and quality management. Our future work is to extend the game to include more project management decisions and sudden events. Also, the effectiveness of the game for the teaching and learning of software project management concepts will be evaluated.

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