Dr. Ing. Bassam A. Hussein E-mail: <u>bassam.hussein@ntnu.no</u> Associate professor *The Norwegian university of science and technology – NTNU Trondheim, Norway* Case study: Developing educational games in project management. - Evaluation and lessons learned -

Abstract

Well designed games can provide an excellent environment to develop project management competence. However, there are several requirements that must be satisfied in order to facilitate experience flow and competence enhancement while playing the game. The paper provide a literature review about these requirements and then gives a description to an educational game that was developed by students attending an Expert in Teams course at NTNU under the supervision of the author. The developed game is then reviewed with respect to the fundamental requirements that must be satisfied. The results of evaluating the developed game shows that the game provides a good framework for competence development and it satisfies (to a certain degrees) several requirements such as usability, skill matching, gameplay, problem solving and balance in a valid experimental learning context. The game is competitive and allows collaborative learning as well. The main problem solving domain of the game is within the theme of project planning and control, the game main shortcoming is that it does not support any competence development in the soft skills domain. The game is well suited to be used as educational tool for the students taking an introductory course in project planning and control. Although the work was developed within the subject of EiT, the paper does not provide an evaluation of the impact of this context on the resultant game design.

1 Background

The game development takes place in the context of the subject Experts in Teams (EiT) given at NTNU. The subject is compulsory to all the 4th year students at NTNU. There are about 1200 students participating in the subject. In order to handle this large number of participants, they are divided into classes (called EiT villages) of 30 students each. Each EiT village focuses on a particular theme and each student select the EiT village that suits his or her preferences or interest. The students in each EiT villages belong to a variety of study programs covering technology, natural science and humanitarian departments. The theme for EiT village that the paper considers is titled educational games in project management. The objective of the EiT village is to get the students to use their knowledge and skills to develop and test educational games in project management. The students group of their products.

This unique combination of students from both the genders, and belongs to different study program is an excellent case study for using interdisciplinary teams for the development of educational games in project management. The groups were divided so that at least one student in each group has skills in the subject of project management. Other group members belong to different study programs at NTNU. The groups themselves were given the opportunity to select the theme of their group. This work should be seen in its totality as student to student development effort. The following general guidelines where given to the student groups: the game:

The game should be competitive and encourages collaborative learning in groups of up to 6 persons. Collaborative learning is technique that is known to have significant advantages.

- Must have very clear learning objectives and is constructed to allow those to be discovered and/or reinforced through a valid experimental learning model [Kolbe 1976]
- It must be engaging
- It must have time line
- Problem solving area: Project management
- Challenges in developing educational games

One of the challenges of developing games is that of engaging students. [Noman, 1993] identified the basic requirements of learning environments as follows; 1) Educational games should engage and motivate players through direct experiences with the game world, 2) Games should provide possibilities for reflectively exploring phenomena, testing hypotheses and constructing objects.

[Kiili, 2005] presented an experiential gaming model that is based on experiential learning theory, flow theory and game design. The model stresses the importance of providing the player with immediate feedback, clear goals and challenges that are matched to his/her skill level. The paper emphasizes the need for integration of educational theories and game design to be able to design meaningful and engaging educational games. The products developed by student groups will be evaluated based on the following agreed upon characteristics of effective games:

1.1 Experience flow and usability

The optimal experience is attained when the player is completely engaged in the game activity. [Finneran and Zhang, 2003] distinguish between the person, the task and the artifact to perform the task by the person(s). This is especially applicable in computer mediated games. All three components, person, task and artifact, should be taken into account when building educational games. [Pearce & Howard, 2004] warns that the complexity of the task and the use of the artifact may detract from the user's attention. This would ultimately result in bad usability which in turn results in the player sacrificing attention and other cognitive resources to inappropriate activity. Game usability and experience flow can be enhanced by providing clear goals and appropriate feedback to the players.

1.2 Skill matching

The second requirement indicates that it is important that the challenge in the game should be closely matched to the skill level of the player(s). If the challenge is significantly greater than player's skill level, he or she may feel apprehension. In contrast, if the challenge is significantly lower than player's skill level, the player may feel bored. [Kiili, 2005] stress the importance of keeping a player in a flow state game. Games should therefore ensure that while a player's skill level increases the challenges in the game also should become more difficult. This can be achieved by constructing the game complexity for multiple levels of skills.

1.3 Gameplay

Good gameplay keeps a player motivated and engaged throughout an entire game. A gameplay is a linked series of challenges in a virtual environment. Gameplay also includes the actions that the players can take to meet challenges. [Kiili 2005] indicates that focusing on the educational goal or the technology on expense of the game play is not recommended. Thus, in educational game design both dimensions, educational goals and gameplay, should be balanced in order to achieve a meaningful result. One solution is to make the game adapt to a players' skill level as discussed above. In addition, challenges should be balanced so that the game's difficulty increases incrementally and dos not change arbitrary. If the challenge level decreases before the game is completed a player may lose interest in the game.

1.4 Problem solving

Games provide a meaningful framework for offering problems to students. In fact, a game itself is a big problem that is composed of smaller causally linked problems. The nature of challenges that constitute the problem can vary greatly. Problem solving can be associated with discovery learning. Learning environments such as games allow students to discover new rules and ideas or to enforce them rather than memorizing the material that others have presented. For example, simulation games offer possibilities to students to interact with the game by exploring and manipulating objects in order to test their hypotheses.

1.5 Balance

Educational games, should be balanced so that the main determining factor for the success of a player is the player's skill level. Although random events are possible, a better player should perform better in the long run.

Experimental learning model: Conceptual overview 2

[Kiili, 2004] stressed the need to form a model that can be used in designing and analyzing educational games by integrating educational theory and game design and taking into account gameplay and flow theory. The main purpose of the model is to link gameplay with experiential learning in order to facilitate flow experience. [David Kolb, 1976] suggested that people learn by going through a four-step cycle. He suggested that people learn by first having some sort of concrete experience, followed by reflectively observing what happened, then developing an abstract conceptualization, and ending with an active experimentation to verify the concept. An alternative definition of these steps is doing, thinking, modeling, and checking. In the model proposed by [Kiili 2005] problem solving (the tasks to be performed) is the heart of the model.





Problem solving can be a series of linked problems, both ill-defined problem and well defined problems. To overcome the challenges, a player generates solutions in the ideation loop reflecting lesser circulation. The ideation process is most fruitful if it is performed in groups, hence the emphasize on group work and collaborative learning in game playing. After the ideation phase the player tests ideas in the experience loop reflecting greater circulation and observes the outcomes of actions. It is important in this stage that the game provides feedback after the experimentation loop in order to facilitate flow experience.

The reflective observation of the feedback may lead to the construction of abstract concepts and enable the discovery of new and better solutions to the problems. In online learning environments reflection has been facilitated for example with conversation tools, intelligent tutorials, and computer-based tutors that can be utilized also in educational games. While testing solutions a player's skill level increases and he or she may achieve control over the game and the subject matter. If the performance of the player is based on only one particular solution, the gaming strengthens only those concepts that are related to this solution. As a result of one-sided activity in the game world the heart may become exhausted, leading to a reduction in the player's motivation in the long run. From a creative problem solving and comprehensive learning point of view it is important that the player endeavors to test different kind of solutions in order to expand knowledge on the subject matter. Generally, the task of the ideation loop is to cleanse the experience loop of old solutions by feeding it with fresh creative solutions to be tested and reflected.

3 Review of the developed game

We look now into one of the developed games and use the above guidelines as indicators for evaluating this game. The first game we consider is called Bobs Buildings [Nederegotten, et. el. 2006]. The game's purpose is to teach students some of the basic project management theory. In particular the game looks into the famous project management triangle cost, time and quality [Wysoki, 2004].



Figure 2. Project triangle

The learning goal of the game is to give the students insight regarding the importance of balancing the three variables. In addition to balancing these three variables, the game covers as well other parts of the curriculum in project management, such as network planning using precedence network, resource allocation and project follow up using the principle of earned value. Therefore, the game tends to cover

the hard concepts of project management, generally refer to in the literature by project planning and control [Rolstadås 2003]. The game challenge is to take the right decisions during execution so that project results will be optimum.

The game is organized as a competitive game, in which students take on the roles of project members in the same project. All groups are given the same project and are instructed to complete it within the specified time and budget constraints. The group who completes the project first wins. However, players must balance several competing concerns as they work, including their budget, to identify and mitigate the risks associated with project execution as well as the overall quality of the product. In essence, they must strive to follow proper project planning and control practices in order to avoid any undesirable consequences that might cause them to fall behind their opponent in the race to complete the project.

3.1 Game scenario

Detailed project planning is not part of the game, the game rather focus on decision making during project execution in order to deliver the project plan within the specified constraints. The decision making is facilitated by providing feedback about productivity, earned value and volume variance while running the game.

These are indicators that are usually used in real-world application in control process [PMI 2004]. Students are provided with a collection of work packages and a network diagram (Activity On Node) that symbolizes the work packages that must be completed for a family residence building project. The students must perform risk-assessments on all packages and distribute the available resources on the work packages. Collaborative learning is facilitated during the risk-assessment and the resource allocation phase. This phase of the game begins before starting the simulation. This will help the students to exchange knowledge and will facilitate group learning in project management.



Figure 3. Game navigation bar

Challenges: WBS of the project is given, it comprises 18 work packages and the total workload of the entire project is 2500 hours distributed on these work packages. The first challenge the group should resolve is to allocate the available resources on these work packages so that the project is completed within 85 days. The team has only 5 persons to assign to the different work packages, but two extra workers can be transferred from other projects within the firm, but then the cost is twice that of a normal worker.



Figure 4 . AON network for the game

After having completed planning the project; that is to try to allocate resources so that the project finishes within 85 days, the second challenge is encountered during executing the work, the groups should assess certain risk elements and mitigate these risks by buying themselves free from the impacts of these risk elements. Here again it is a question of risk impact analysis while considering the major project objectives. The idea generation phase here will be about finding the best ideas to allocate resources and calculations of risk impacts on both the time and project objectives.

3.2 The active experimentation phase and Feedback

During active experimentation (that is simulation), feedback is given through a global map. The global map is useful tool for the group to keep an overview over the whole network. Among the information presented on the toolbar the user can find the duration so far in the project, resources left, percentage completion of the project and actual time the group have used. To complete the project with success the group must stay within the budget, complete the project in 85 days or less, and not use more that 60 minutes on the task. As a tool for assessing the work so far, the group can access a progress-graph. Here the group can see the development of the project and see if things work out as planned. There is information boxes placed in the game that will help the students remember the theory from the project management course, if they have forgotten it. This makes Bobs Buildings a suitable game for students to play when they are in the middle or the end of a project management course.

3.3 Reflective observation

The information gathered from the global map about project performance can thus be used as a basis for reflecting on the plans that was previously mad as well as on the decisions regarding allocating risks that was taken in the previous phase.

3.4 Conceptualization

The reflective observation of the feedback may lead to the construction of abstract concepts and enable the discovery of new and better solutions to the problems at hands, this is may be in the form of reallocating the resources or to think different during risk analysis and mitigation.

4 Review and evaluation of the game

Experience flow: Experimenting with the game provides a moderate to high level of engagement in the game activity. The game distinguishes between the tasks (to deliver project within the specified constraints), the artifact (the computer screen, the global map) and the group of people that twill execute the task. Testing the game shown that artifact does not detract the user's attention, in the contrary, the artifact itself is an excellent tool for providing feedback when it's needed. We believe that the game usability was kept intact and playing the game does not result in scarifying attention and other cognitive resources to inappropriate activity.

Skill matching: The target group of the game is students taking an introductory course in project management. The game considers issues such as network planning, risk assessment, resource allocation and project follow up. Hence, the game is suitable for the target group. Thus, the requirement for keeping a flow state is intact. Regarding the requirement that the game should ensure that while a player's skill level increases the challenges also should become more difficult. Here the game fails to satisfy this dynamic requirement. This perhaps has its origin in that the target group is students with very limited skills in project management. Thus the game main objective is to provide other means to enforce and train these skills. Skill matching requirement can be enhanced by incorporating problems from the soft-skills domain in management such as communication and stakeholders' leadership as the game proceed

Gameplay: the game strongly satisfy the requirements for game play, keeping in mind that the game is group based, this feature will enhance the gameplay level of the game. The linked series of challenges are 1) allocating resources, 2) calculating the schedule, 3) assessing risk while simulating execution and in parallel assess and monitor cost and time progress. The game includes a series of linked and parallel challenges in a group based environment together with deciding on actions to improve project productivity.

Problem solving: The game provides a meaningful framework for solving, mainly will-defined problems; networking, resources allocation and follow up. The game provides as well a framework for ill-defined problem, risk assessment and decision making. However the depth of risk assessment part is not comprehensive and need to be redesigned to allow the students to practice problem solving for ill-defined problems or for testing hypothesis and constructing new ideas

Balance: Testing the game did not provide any indicators about game balance, the game needed to be tested with a wider group of students in order to see if player's skill has significant effect on the results of the game.

5 Discussion and conclusions

Project management profession is basically a system oriented problem solving tool. In projects, resources (materials, personal and equipments) are brought together for a period of time, focused on a particular goal, such as the development of a new product, and then disbanded and reassigned to another tasks. The management of such projects requires several types of skills, including project planning and control skills; this generally includes planning and managing project resources in an effective manner, 2) maintain clear accountability for the progress of the project towards the goal

Project leadership skills; this generally is about organizing teams and managing and communicating with people and stakeholders.

This organization of resources, goals, people, and limitations has inherent conflicts that must be understood, managed and simply kept under control through out the project life e cycle. These are the fundamental problems a holistic program in project management usually should address.

A typical project management course consists of lectures and assignments in which concepts and theories are transferred along with a small project which attempts to give students the opportunity to explore and learn in depth or solve a certain problem in project management [Hussein, 2005]. Although both of these components are essential, neither one provides students with hands-on experience regarding the project management as a problem solving tool. Namely, lectures allow only transferring of explicit knowledge and projects are so constrained by the time and scope requirements of the academic environment that they cannot be large enough to exhibit many of the phenomena occurring in real-world projects.

Games on the other hand can constitute a meaningful framework for offering problems to students. However, in order to maximize the effect of using games as educational tool it must be constructed to allow experience flow and competence acquisition. Experience flow and competence acquisition should be based on a experiential learning model and constructed in a competitive and collaborative environment. Problem solving is at the heart of this learning model. Problems should cover both well defined problems (project planning and control) and ill defined problems (soft skills) this combination of problems from both domain is fundamental to design games that matches players skills in a dynamic fashion

6 References

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