



FACULTY OF TECHNOLOGY

# **UTILIZING AN EDUCATIONAL GAME TO TEACH PROJECT MANAGEMENT**

Kuisma Rautio

INDUSTRIAL ENGINEERING AND MANAGEMENT

Bachelor's thesis

April 2020



FACULTY OF TECHNOLOGY

# **UTILIZING AN EDUCATIONAL GAME TO TEACH PROJECT MANAGEMENT**

Kuisma Rautio

Ohjaaja: Jaakko Kujala

INDUSTRIAL ENGINEERING AND MANAGEMENT

Bachelor's thesis

April 2020

# ABSTRACT FOR THESIS

University of Oulu Faculty of Technology

Degree Programme (Bachelor's Thesis, Master's Thesis) Industrial Engineering and Management		Major Subject (Licentiate Thesis)	
Author Rautio, Kuisma		Thesis Supervisor Jaakko K, Professor	
Title of Thesis Utilizing an Educational Game to Teach Project Management			
Major Subject	Type of Thesis Bachelor's Thesis	Submission Date April 2020	Number of Pages 29 p.
Abstract			
<p>The use of serious – and more specifically educational – games as a teaching method is underutilized. Still, there has been an uproar of studies concerning these educational games in the last ten years, and more and more institutions are taking advantage of the interactive medium in teaching. This bachelor's thesis aims to gather relevant knowledge concerning the use of serious games and how they are designed. The knowledge is then used to analyse and measure the pedagogical value of an educational project management game called Project Business Game (PBG).</p> <p>The research in this thesis is divided into two parts. First, a literature review on relevant studies and literature is conducted towards the use and design of serious games. The most important aspects of project management are also presented to give a strong framework for the design of PBG. Then, the pedagogical value, enjoyment and functionality of game mechanics in PBG is analysed and measured using a small-scale questionnaire (n = 15) featuring closed as well as open-ended questions.</p> <p>The findings from the questionnaire seemed to indicate that although the game was found to be enjoyable and intriguing, the game's mechanics were still at an insufficient level. Some mechanics were seen as unintuitive and a few even outright harsh. A need for a tutorial of some sort was also voiced in the evaluation. Still on the other hand the participants agreed that they would like to have similar learning experiences in the future and that PBG helped to understand project management better. The challenge the game presented was also found to be difficult enough, although a bit too unforgiving to some participants. The literature review on the other hand presented the importance of designing an educational game with three important motivational aspects in mind. The good design of an educational game includes cognitive, emotional as well as social aspects, which all have an impact on the player. Also, the idea of reaching a feeling of flow – a feeling of complete absorption or engagement – was found to be important in the design of serious games.</p> <p>These findings can be used to improve the future development of Project Business Game as well as to provide a framework for the design of other educational project management games.</p>			
Additional Information			

# TIIVISTELMÄ

## OPINNÄYTETYÖSTÄ Oulun yliopisto Teknillinen tiedekunta

Koulutusohjelma (kandidaatintyö, diplomityö) Tuotantotalouden koulutusohjelma		Pääaineopinnojen ala (lisensiaatintyö)	
Tekijä Rautio, Kuisma		Työn ohjaaja yliopistolla Jaakko K, Professori	
Työn nimi Utilizing an Educational Game to Teach Project Management			
Opintosuunta	Työn laji Kandidaatintyö	Aika Huhtikuu 2020	Sivumäärä 29 s.
Tiivistelmä			
<p>Hyötypelien, ja erityisesti opettavaisten pelien, hyödyntäminen opetuksessa on hyvin vähäistä. Viimeisen kymmenen vuoden aikana hyötypelien käyttöä on kuitenkin alkanut kasaantua tieteellistä kirjallisuutta ja yhä useammat instituutiot ovat alkaneet käyttää hyväksi pelien interaktiivisuutta opettamisessa. Tämän kandidaatintutkimuksen tarkoituksena on kerätä asiaankuuluvaa informaatiota hyötypelien käytöstä ja niiden suunnittelusta. Tämän informaation pohjalta arvioidaan ja analysoidaan opettavaisen projektinhallintapelin nimeltä Project Business Game (PBG) pedagogista arvoa.</p> <p>Tämän opinnäytteen tutkimus jakautuu kahteen osaan. Ensimmäisessä tehdään kirjallisuuskatsaus hyötypelien käytöstä ja niiden suunnittelusta hyödyntäen relevantteja ja uskottavia tutkimuksia sekä kirjallisuutta. Myös projektinhallinnan tärkeimmät aspektit tuodaan esille rakentaen vahvan viitekehyksen PBG:n suunnittelua varten. Opinnäytteen toisessa osassa analysoidaan ja arvioidaan PBG:n pedagogista arvoa, nautittavuutta ja pelimekaniikkojen toimivuutta hyödyntäen pienimuotoista kyselyä (n=15).</p> <p>Kyselyn lopputulokset näyttävät indikoivan, että vaikka peliä pidettiin miellyttävänä ja mielenkiintoisena, pelin mekaniikat eivät olleet vielä tarpeeksi hiottuja. Osaa pelimekaniikoista pidettiin epäintuitiivisena ja jopa julmina. Tuloksista tuli myös ilmi, että peli kaipaisi enemmän pelinsisäistä opastusta. Pelaajat kuitenkin olivat samaa mieltä siitä, että he haluaisivat samanlaisia oppimiskokemuksia myös jatkossa ja että PBG auttoi heitä ymmärtämään projektinhallintaa paremmin. Pelin vaikeusaste oli myös tarpeeksi korkealla pelaajille, vaikkakin joillekin osallistujille jopa liiankin korkealla. Kirjallisuuskatsaus taas toi esille kolme eri motivoivaa aspektia, joita pitäisi hyödyntää hyötypelien suunnittelussa. Hyvä hyötypelien suunnittelu huomio pelien kognitiivisen, tunteellisen sekä sosiaalisen aspektin, joilla kaikilla on vaikutus pelaajan pelikokemukseen. Samoin myös <i>flow</i>-tilan, eli täydellisen syventymisen ja keskittymisen tilan, koettiin olevan tärkeä oikeaoppisessa hyötypelin suunnittelussa.</p> <p>Tämän kandidaatintutkimuksen tuloksia voidaan hyödyntää PBG:n jatkokehityksessä kuten myös viitekehyksenä muiden opettavaisten projektinhallinnan pelien suunnittelussa.</p>			
Muita tietoja			

# TABLE OF CONTENTS

1 INTRODUCTION .....	6
2 GAME DESIGN IN SERIOUS GAMES .....	7
2.1 Defining serious games .....	7
2.2 Gamification versus serious games .....	7
2.3 Supporting learning through games .....	8
2.4 Serious games & project management .....	10
3 PROJECT MANAGEMENT .....	11
3.1 Managing risks .....	11
3.2 Project network & critical path method .....	12
3.3 Procurement & material management .....	13
4 EVALUATING THE EDUCATIONAL PROJECT MANAGEMENT GAME.....	14
4.1 Game's learning goals .....	14
4.2 Case description .....	15
4.3 Data collection .....	17
4.4 Evaluation results .....	18
5 DISCUSSION .....	22
6 CONCLUSION .....	25
REFERENCES.....	26

# 1 INTRODUCTION

In the last twenty years there has been an uproar in studies concerning serious – and more specifically, educational – video games. This can be contributed to the fact, that in the last two decades video games (simply called games from now on) have become more widely known and used form of entertainment, and so the interest in games with non-entertainment purposes has also spiked. While these *serious games* – i.e. games made for other purposes than entertainment – do have a lot of studies behind them, there is a slight omission of knowledge when it comes to how these games are designed. While this topic can be observed from the point of gamification (Deterding et al, 2011), educational games – and all other forms of serious games – fulfil all the necessary requirements to be called proper games from the designer’s point of view. As such, when discussing the design of educational games, the elements from traditional game design should be kept in mind.

This thesis aims to gather the knowledge on how educational games are designed, how they aid learning and how an educational project management game can be designed. More focus is put into the design of educational games, as the end goal of this thesis is to provide the author as well as the reader a structure on how to design an educational game teaching project management for university students. To support this end goal, the following research questions have been set:

1. What are the components of serious – and more specifically educational – game design?
2. How do educational games support learning?

The research for this thesis is done in two parts. First, a literature study of credible research papers and books is conducted, building a concrete foundation for the best practices of educational game design as well as project management. Then a small survey in the form of a questionnaire (Gault, 1907) is conducted, where data concerning the pedagogical value of an educational project management game – called Project Business Game or PBG for short – is gathered and analysed for future research and game development purposes.

## 2 GAME DESIGN IN SERIOUS GAMES

### 2.1 Defining serious games

Educational games fall under the definition of serious games. Serious games as a phenomenon are not new by any means, as the term was coined by Clark C. Abt in 1987 in his book “Serious Games”. (1987) In it he goes on to state, that serious games “have an explicit and carefully thought-out educational purpose and are not intended to be played primarily for amusement. This does not mean, that serious games are not, or should not be, entertaining”. (Abt, 1987) An educational, serious game keeps all the elements that make a game worthy of being called a game but adds in an additional layer by teaching its players something about a given topic. The three most important elements in games are that they are interactive, are based on a set of agreed rules and constraints, and they provide a challenge for the player to overcome to reach a clear goal. (Wouters, et al, 2013) So, while a serious game might focus less on the entertainment factor, these basic elements are still very much kept intact.

Marsh (2011) had a more modern and broad way of defining serious games, as according to him: “Serious games are digital games, simulations, virtual environments and mixed reality/media that provide opportunities to engage in activities through responsive narrative/story, gameplay or encounters to inform, influence for well-being, and/or experience to convey meaning”. (Marsh, 2011) As so, nearly any game could be defined as a serious game, because it could be used for example for language training. To combat mistakenly labelling too many games as serious games, Girard et al. (2013) modified the definition so that “SGs [serious games] are VGs [video games] with a useful purpose”, and that “the utility of purpose has to be present from the outset (right from the very first step in the design of the SG) and not added to the game subsequently”. (Girard et al., 2013)

### 2.2 Gamification versus serious games

The term *gamification* is often thrown around when discussing serious games. Gamification refers to the use of game elements in a non-gaming-related – for example education – contexts. So whereas a *serious game* refers to the design of a full-fledged game intended for non-entertainment purposes, *gamification* refers only to the use of the

elements of games. (Deterding, et al., 2011) This distinction is indeed blurry, but important, since from the designer's point of view a serious game should adhere to the set rules of designing a game proper rather than just borrowing some elements from it. The result of serious game design will always be a game, while designing a gamified application can lead to a myriad of different outcomes, including a game.

There have been studies – of course – where the use of gamification has modified the learning outcomes of students. In a large-scale study ( $n > 1000$ ) done by Paul Denny in the university of Auckland, the use of badge-based achievement system within an online learning tool lead to a significant positive effect on the number of distinct days that students were active with the tool. (Denny, 2013) However, in the study only the participation and activity of the students was measured, so it could be argued that the actual learning of the students in this study was unchanged. And according to Domínguez et al. (2013), who conducted another study on the subject of gamification, to be able to reach the *flow experience* needed for engaged learning, the cognitive characteristics of videogames “cannot be exported to traditional educative content by any way without entering in the field of edutainment or serious games”.

### **2.3 Supporting learning through games**

Serious games can support learning in various ways. But to be able to support any learning at all, a game first needs to captivate its players by giving them a reason to stay and play the game long enough. According to Hamari et al. (2016) one of the most important ways to keep the intrigue of a player in a serious game is to make the experience just challenging enough, that the players are working at the edge of their abilities. This creates an aspect of thrill, which in turn enhances the engagement of the player towards the given task. In another study it was argued, that to design a serious game to be successful in teaching its players, it must generate a feeling of *flow*. (Kiili, 2004) This experience of flow was described as “a state of complete absorption or engagement in an activity and refers to the optimal experience” and one way to achieve the experience was to face a challenge that closely matched the skill level of the player. Once the feeling of flow has been achieved, the educational material can be introduced by a variety of ways. One of the most common ways being to hide the wanted material among the elements of gameplay. (Bellotti, et al. 2009), (Garris, et al., 2002) This way the player engages in a



*subvert* way of learning, where the learnable topics are not the main focus, but more as constants in the background.

Another way of increasing students' motivation towards learnable topics through games is to focus on the fundamental elements that make videogames interesting. According to Hammer & Lee (2011) games can be motivating because of the impact they have on three different major areas: the cognitive, emotional and social. The cognitive area can be reached by creating a set of rules and giving the player a challenge to solve within them, very much like how Hamari et al. (2016) described keeping the engagement of players through challenges. On the emotional side, serious games can invoke a plethora of emotions for the player from curiosity to frustration to joy. (Lazarro, 2004) At its rawest form, the emotional impact can occur in the form of anxiety produced by repeated failure, though games usually mitigate this with low stakes and immediate feedback loops. Socially games can impact the player by introducing them to new roles and identities, which they previously would never have even imagined. (Gee, 2008) These new roles can range from leaders to butchers to knights depending on what the given game's world allows. So, when a game can have a profound impact on the cognitive, emotional and social side of the player, the motivation seems to increase.

A big aspect of serious games supporting the learning is that by nature, games are an interactive medium. In contrast to the stereotypical education environment – where the learning is done by reading or hearing a teacher lecture about a given topic – serious games bring invaluable variety to the old, monotonous learning methods. In a case study conducted by Watson et al. (2011) students were observed learning the history of the second world war through an educational game called *Making History* over a brief period of three days. By introducing a learning experience through a game, the teacher was able to transform the teacher centric learning environment into a more student-centred environment, which cultivated student engagement and discussions outside of the classroom. These findings are congruent with a previous study, where the impact of game-based learning on educational effectiveness and student motivation was measured. (Papastergiou, 2007) The results of the study strongly hinted, that educational computer games “can considerably improve both knowledge of the embedded subject matter and student enjoyment, engagement and interest in the learning process”. In addition, the results showed no major differences in the learning gains of boys and girls, even though it was reported that “the boys of the sample exhibited significantly greater involvement

with, liking of and experience in computer gaming outside school as well as significantly greater initial knowledge of the embedded subject matter, and greater interaction among them during the intervention”.

## **2.4 Serious games & project management**

While the usual learning topics of serious games are – for example – calculus, history or other basic school subjects, games teaching project management in various ways have been developed. In Aalto University in Finland, to aid the teaching of university students in a software project management course, a serious board game was developed. This board game taught the basic principles of project management and more specifically the use of Kanban – a widely used scheduling system tool – in the form of a collaborative, physical board game. (Heikkilä et al. 2016) Another similar project was conducted in the Federal University of Santa Catarina, where another educational board game called DELIVER! was developed and its effects studied. The goal of the board game was to “teach Earned Value Management in monitoring and controlling the execution of a software project”, (Von Wangenheim et al. 2012) by writing and editing project plans, hiring human resources and executing simulated projects. Both serious project management board games had the learning goals of teaching the basics of a specific subtopic within the field of project management – be it either Kanban or Earned Value Management. Both board games were also meant to be played as a team competing among other similar teams with the goal of reaching the highest score in mind.

Serious video games have also been used to teach project management. One example comes from Brazil, where Lino et al. (2015) designed a game where players assumed the role of a project manager in a fictional firm. The learning topics once again hovered around the “common concepts and project management activities such as cost, time, risk and human resource management areas”. (Lino et al. 2015) The game was also evaluated using a questionnaire, and according to Lino et al. (2015) the game’s learning goals were met with the addition that the players felt the game to be motivating, relevant to the field of study, satisfying and fun.

## 3 PROJECT MANAGEMENT

### 3.1 Managing risks

One crucial part of project management is the identification and management of different kind of risks. “Project risk management (and much of mainstream project management) is concerned with attempting to identify all the foreseeable risks, assessing the chance and severity of those risks and then deciding what might be done to reduce their possible impact on the project or avoid them altogether”. (Lock, 2007) It is indeed the nature of uncertainty that describes the core of risk management, as often the objective is not to eliminate the risk or uncertainty altogether, but rather to control the underlying process and actively influence the impact of those risks. In addition, there is the aspect of risks being proportional to return, as usually in many forms of business life the greater the risk that you run, the larger the return could be. (Maylor, 2003)

The first step to risk management is often the *identification* of risks. The step is often described as “the process of identifying individual project risks as well as sources of overall project risk and documenting their characteristics”. (*A Guide to the Project Management Body of Knowledge*, 2017) It can also be a complicated one, as risks can occur in any kind project, at any time and can range from the most predictable variety to the most unexpected or bizarre. And as some risks can occur even after the project is completed and handed over, the overall process should never be taken lightly. (Lock, 2007)

The second step in risk management is usually the *quantification* of risks, where the question that needs answering is “just how risky is an event or activity”. (Maylor, 2003) Common method to determining the answer to that question is to first assess how likely a risky event is to occur and then estimate how big of an impact the event has on the project. The impact analysis can be qualitative, quantitative, or most preferably, both. In qualitative analysis a risk and its impact are characterized purely in a descriptive way, while in quantitative analysis the outcome is quantified by – for example – attaching a numerical score indicating the severity and likelihood of the risk. (Lock, 2007) The end result of risk quantification should be a list or matrix of some sort, where all possible risks are rated and categorized.

In the broad sense, the *mitigation* of risks – or the planning of risk responses as it is known in some cases – acts as the third and final step in risk management. Here, the process is to develop options, select strategies and agree on actions to address overall project risk exposure, as well as to treat individual project risks. (*A Guide to the Project Management Body of Knowledge*, 2017) Project managers in charge of risk mitigation have a lot of options to choose in this step. In his book Dennis Lock describes a total of six different ways of dealing with risks. First is to avoid the risk altogether. The second option is to take precautions in order to prevent or mitigate the impact a risk can have. The third, fourth and fifth options are to accept, share or limit the risk, respectfully. And finally, the sixth option is to transfer the risk to a third party for example by obtaining expert assistance from an insurance broker. (Lock, 2007) As demonstrated, it is important to follow through the whole risk management process right to the final mitigation phase, as the identification and quantification of risks are nearly useless if nothing is done to prevent or influence the impact the risks hold.

### **3.2 Project network & critical path method**

Planning and analysing the time, cost and quality of a project is one of the most important aspects project managers face during projects. In order to fully visualize the trade-offs, a technique is used where a large project is broken down into several activities. “The precedence-relationship among them [activities] may be visualized in a network representation of the project where arcs denote activities”. (Babu & Suresh, 1996) The different activities in each project must be executed in a certain order for the project to be completed with arrows or lines between the activity nodes indicating the dependency between one another. Chan et al. (1995) put it simply: “[a] network is a picture of a project, a map of requirements tracing the work from a departure point to the final completion objective”. (Chan et al., 1995)

Project networks on their own offer a good snapshot of the project, but without proper methods of analysing the snapshot, the outcomes might become hollow. One of the most known methods is the *critical path method* or CPM for short in which the project’s minimum completion time is calculated from the activity nodes’ estimated completion times. (Babu & Suresh, 1996) An early and late start and finish is calculated for each activity node, forming a path which indicates the longest combination of consecutive activity tasks. (Lu & Li, 2003) This longest combination of tasks is called the critical

path, as the combination defines the theoretical minimum for completing the project. Extra care should be taken for the completion of the critical path, as any delays that are realized within the path have a straight effect on the completion time of the whole project. CPM can be summed up to calculating the critical path from a project network and enforce its completion above all else. However, the method is not infallible, as it needs “the availability of deterministic time estimates for each activity”, which in real world problems are very difficult to forecast precisely. (Chang et al. 1995) Still, for simulations and simple projects the CPM is an efficient method for analysing project networks.

### **3.3 Procurement & material management**

One of the cornerstones of production and procurement philosophies is the use of just-in-time (JIT) manufacturing system. While not a new concept by any means (Schonberger & Gilbert, 1983), JIT has proved its worth as a classic purchasing philosophy, still strong in the modern days of manufacturing. (Inman et al., 2011) The basic principle behind the philosophy is twofold: the first part was the production system on JIT, described as “only the necessary products, at the necessary time, in the necessary quantity”. (Sakakibara et al. 1997) The second principle was a “respect-for-human” system with a focus on active employee participation, elimination of wasted movement, employee safety and entrusting the employees with greater responsibility and authority. (Sakakibara et al. 1997) As a solely manufacturing method JIT shines in large manufacturing firms to enhance the manufacturing and procurement side of project management. (White et al. 1999)

When it comes to construction projects, one common occurrence is the lack of materials. Thomas et al. (2005) presented a study, where more than 125 construction projects were observed, and found out that on most projects the issue was frequent and negatively affected labour performance. In order to combat situations where the lack of materials hampered the progress of construction projects, the use of inventory buffers was normalized. While Lean philosophies like JIT look to reduce inventories or even eliminate them completely, inventory buffers go totally to the opposite direction. Buffers operate by providing a cushion or shield against the negative impact of disruptions and variability by having a little bit of extra materials to complete construction tasks. (Howell et al. 1993) (Horman & Thomas 2005) This way even if some material orders are delayed or some tasks must be started before their allocated time, the project can move forward rather than staying stagnant.

## 4 EVALUATING THE EDUCATIONAL PROJECT MANAGEMENT GAME

The need to design an educational game with a focus on project management came from the university of Oulu, where the professors at the faculty of technology were trying to come up with new ways to teach project management to industrial engineering and management students. The development of the educational project management game – Project Business Game or PBG for short – has been an ongoing process, and as of writing this thesis is still unfinished. In order to evaluate the pedagogical value of the game as well as to provide ideas for further development, a brief survey was conducted.

### 4.1 Game's learning goals

The learning goals of PBG hover around the basic project management concepts and methods. These goals can be separated into four different sections, each presenting a different aspect of the game as well as a different topic for the player to learn. The four major learning goals are *scheduling & planning via a project network*, *resource allocation*, *inventory management* and *how uncertainty influences schedule and risk management in complex projects*. These learning goals are presented by a simple project plan, which the player must complete by buying and allocating resources while trying to stay under budget and mitigating any potential risks that might occur during the completion of the project.

The first and perhaps the most direct learning goal of PBG is project scheduling and planning via a project network. As each of the game's projects is presented as a network of activities, a player cannot help but learn to analyse and perceive the "big picture" of each project. Understanding the dependencies and priorities between different project tasks is also an important part of the game, as the projects within the game are not entirely linear in nature. Often times the player will have an option to complete different project tasks concurrently and with that the importance of realizing the benefits of using the *critical path method* (CPM) also rises. As the player focuses more on the completion of the tasks on the critical path, the more reliably the project will be completed in budget and in a timely manner. The design of the PBG encourages the use of CPM and it would not be unheard of for a player to theoretically learn the basic principles of CPM without realizing so.

In PBG materials can and must be ordered. The idea of teaching the players to use lean procurement methods – like the well-known JIT – as well as different sides of inventory management was a no-brainer in the design-phase of the game, as supply chain management is an integral part of many different kinds of projects. In the game players can make material orders, which then will be sent to the supply chain. There are also simplified choices to be made about which suppliers to make the material orders from, as some suppliers offer cheaper prices with the cost of longer delivery times. Additionally, once the material orders have arrived in the players virtual inventory, there is a risk of material deterioration or theft. This means that if a player makes material orders too soon, there is a chance that the material will not be usable at the exact time that it would need to be. As a result, the players intuitively start to follow the basic principles behind JIT, as they want to be able to use the materials at the exact time that they arrive from the supply chain.

To keep PBG from being too predictable and easy to play, uncertainty was designed into the game via risks. These risks could have a significant influence on the game results, depending on how the player acts when they are realized as each risk can be prevented or at least mitigated by careful project management methods. The risks that can be realized in-game function so, that every time the player has allocated his or her resources and wants to move forward with the project plan to the next week, there is a predetermined chance of a risk occurring. If a risk occurs, it will have an impact on the project in one way or another. For example, a complication with ongoing project tasks could occur, further delaying the completion of some tasks. The focus on the risk aspect of the game is in the management and mitigation process, since it is important to teach players that fully analysing the situation and preparing for different kinds of situations – not just the best- and worst case scenarios – truly does bear fruit.

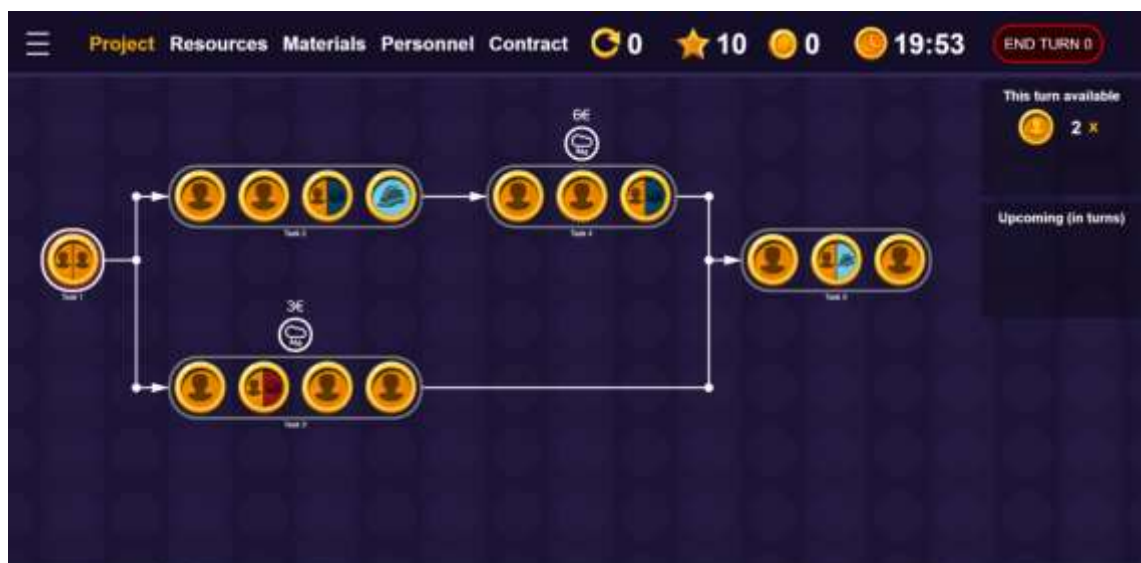
## **4.2 Case description**

The survey was conducted in Turku, Finland on the Åbo Akademi university. The testing of the educational project management game's prototype as well as the survey were a part of an advanced project-based management course. The participants were all enrolled on that course and at the beginning of the study all participants had completed a previous requisite course called introduction to project management. Thus, it can be assumed, that the participants were aware of at least the basic principles of project management. The

number of participants was 15. The study was held on a typical Finnish classroom setting, where each participant had access to a personal computer.

At the beginning of the study, the participants were instructed to read a manual on how the presented game would work. In this manual, a brief introduction of the game mechanics, rules and goals was provided. As the participants were already familiar with concepts such as the project network and critical path method, no further explanation on those topics were given. Instead, a list of three potential risks was provided giving the participants a hint as to what kind of risks to expect in the game. Then, after the participants were done with the provided material, a lecturer familiar with the educational game gave some final instructions on how the game would be played, after which the participants were free to initiate the testing of the game.

In the evaluation, the participants were instructed to complete a relatively short level, where the goal was to complete each task in a project network (see *figure 1*) successfully and within the given virtual budget. The participants had a total of 20 minutes to come up with an executable project plan and implement it in the game. Participants were instructed, that if they were unable to complete the given level within the 20-minute timeframe, the game would automatically end the session giving the participant the worst possible score. After the participants were through the level, they were instructed to fill a questionnaire regarding their experience with the educational game.



*Figure 1: The game level used on the evaluation.*



### 4.3 Data collection

For this thesis a brief survey was conducted in order to gather quantitative as well as qualitative data on the pedagogical value of the educational value of the project management game. The method chosen was the use of questionnaires, where information is gathered from participants in a series of questions or other forms of prompts. (Gault, 1907) The reasoning behind this decision was, that questionnaires could be conducted relatively cheap and usually have standardized answers as well as questions for simple data compilation. In addition, “[w]ell designed questionnaires are highly structured to allow the same types of information to be collected from a large number of people in the same way and for data to be analysed quantitatively and systematically” (Leung, 2001) and as such are a perfect research method – for example – in a bachelor’s thesis.

As both quantitative and qualitative data was needed, the questionnaire’s design included sections for both kind of data values. For the quantitative data, nine different closed questions were designed. These questions were in the form of statements, for which the participants were then asked to rate how much they agreed or disagreed with them. The questionnaire thus featured a 5-point Likert scale with the options of strongly disagreeing, disagreeing, neither agreeing or disagreeing, agreeing and strongly agreeing. The questions used can be seen on *table 1*.

<b>The Questions</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>
1. I enjoyed the playing experience.					
2. The game was easy to learn/understand.					
3. The actions in the game worked as I thought they would.					
4. I was able to complete the assigned level without trouble.					
5. I was able to use what I had learned on the course in-game.					
6. While playing I felt frustrated.					
7. The game helped me understand project management better.					
8. I thought the playing session was pointless.					
9. I would like to have these kind of learning experiences in the future.					

Table 1: Questions used on the first page of the questionnaire survey.

As for the qualitative data, two open-ended questions were provided in the questionnaire. The participants were asked to write in their own words what they thought was correct. The following questions were used:

1. In your own words, how would you describe the playing session?
2. In your opinion, what could be improved about the game?

Below these questions were empty boxes, where the participants were able to write their own answers. The decision to keep the open-ended questions to a minimum came from the fact, that the time for filling the questionnaire on the participants side was limited only to a few minutes. In order to respect the time limits provided, only these two open-ended questions were the ones used.

#### **4.4 Evaluation results**

The evaluation results from the closed questions can be separated into three different categories: (1) enjoyment and general feel of the game experience, (2) the game's playability and ease of use and (3) the pedagogical value of the game. Each of the three categories included three questions.

The first, sixth and ninth question on the questionnaire measured the enjoyment and general feel of the playing experience. On the first question "I enjoyed the playing experience" nine out of fifteen participants agreed with the statement, two heavily agreed and four neither agreed nor disagreed. Similarly, on the ninth question (figure 2) the participants reported wanting to have similar learning experiences in the future, as seven participants agreed, five participants heavily agreed and only three not agreeing or disagreeing with the statement. And finally, on the sixth question (figure 2) where the participants were asked to report if they felt frustrated while playing, three strongly disagreed, six disagreed, two agreed, two heavily agreed and two participants neither disagreed nor agreed.

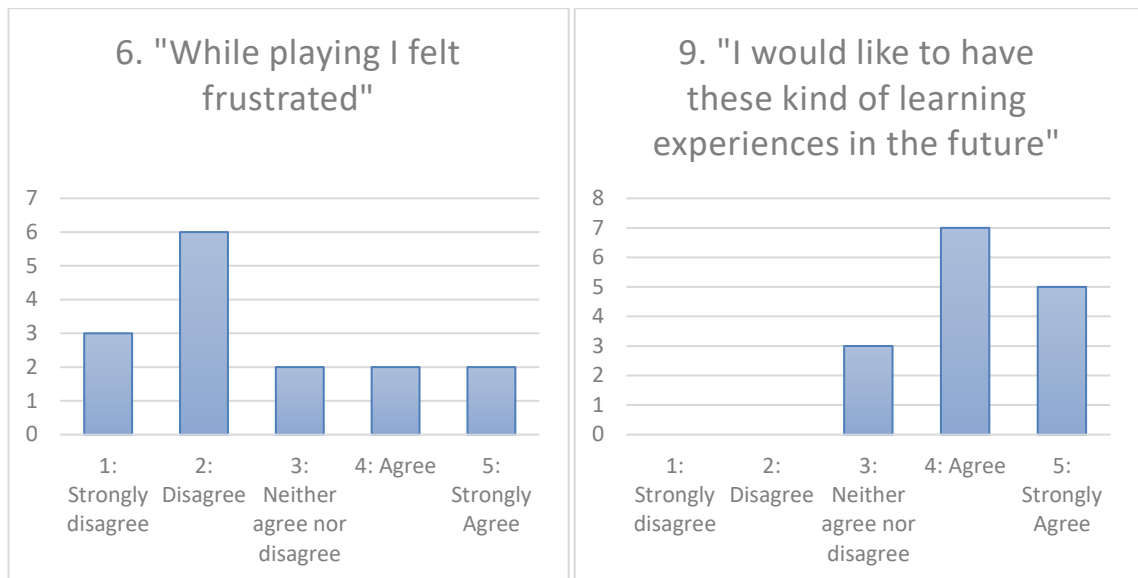


Figure 2: Answers to the sixth and ninth question on the questionnaire

To measure PBG's playability and ease of use, the second, third and fourth questions were used. On the second question where the participants were asked if the game was easy to learn and understand, one participant disagreed, six neither agreed nor disagreed, seven agreed and one strongly agreed. Surprisingly on the third question (figure 3) the participants had varying levels of answers, as six out of fifteen disagreed, three agreed, two strongly agreed and four neither agreed nor disagreed with the statement that "[t]he actions in the game worked as I thought they would". Though on the fourth question (figure 3) the participants still reported that the majority indeed were able to complete the level without trouble, as only one strongly disagreed, two disagreed, three neither agreed nor disagreed, seven agreed and two even strongly agreed with the statement.

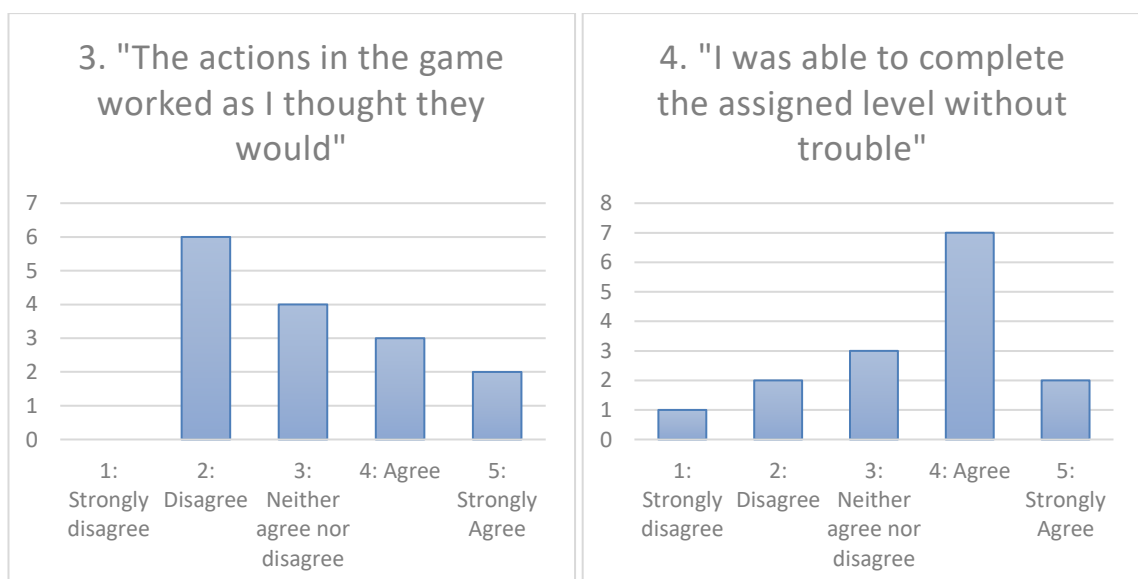


Figure 3: Answers to the third and fourth question on the questionnaire.

The pedagogical value of PBG was measured with the fifth, seventh and eighth question on the questionnaire. The answers from the fifth question (figure 4) showed that the majority was unsure if they were able to use what they had learned on the course in-game, as eight out of fifteen participants neither agreed nor disagreed with the statement. Two disagreed, two agreed and three participants strongly agreed though. On the other hand, on the seventh question (figure 4), where participants were asked if they agreed with the statement “[t]he game helped me understand project management better” the majority agreed, as seven agreed with the statement and three strongly agreed. Four participants neither agreed nor disagreed and one disagreed with the statement. And finally, on the eighth question on the questionnaire, where the statement was “I thought the playing session was pointless” all participants either disagreed or strongly disagreed with the statement with eight disagreeing and seven strongly disagreeing.

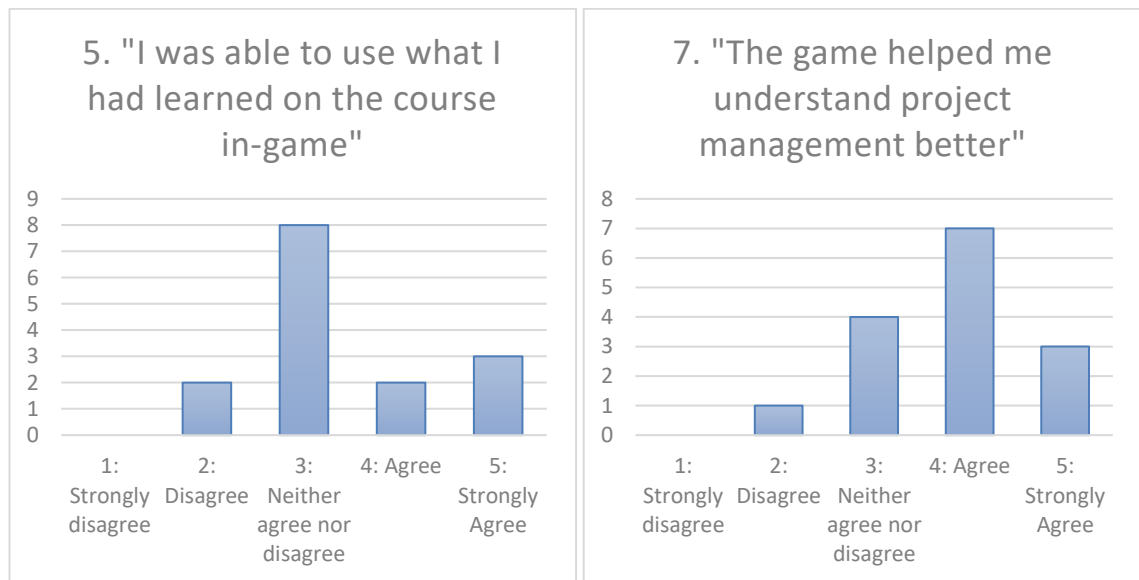


Figure 4: The answers to the fifth and seventh question on the questionnaire.

On the open questions the participants first brought up how they themselves would describe the playing session and then what part of the game could be improved. The results from the first open question showed five distinct thought patterns towards the playing session. First up it seemed that most of the participants enjoyed the experience as the sessions was described as “entertaining” and “fun with some practical learning”. Secondly many participants voiced their concerns on how much the playing session would have needed a better tutorial or a “proper plan” as one participant put it. Another one noted how “a short training session 5 minutes about basic functionalities would have been useful”. A few answers also focused on the unforgiving nature of the game, as some felt they were being cheated by the game. One participant described how they “got

bamboozled by the delays” and another how they “got a bit screwed by the game”. Some participants additionally noted how they felt that the game was “buggy” and hard to learn. And finally, the playing session – although not perfect by any means – seemed to be useful even in the context of learning, as it was described as “fun with some practical learning” and “a little stressful, but good”. One participant even answered that the game was a pleasant learning tool.

On the second open question, where the participants were asked what could be improved about the game, most of the answers focused on how the week display on the game’s resource ordering page was unclear. One participant in particular noted how it “could be more clear how the weeks were counted”. As with the first open question, another point that was brought up by many of the participants was that the game desperately needed better feedback and tutorials for the game’s functions. While all of the participants were given a paper of instructions beforehand, the game experience itself still seemed to be more unclear than necessary, as some felt that “there could be a few clicks learning trial instead of a long paper of instructions”. The third and final note that could be taken from the answers to the second open question was, that the game could be played as a team rather than individually. One participant described how they would have wanted to play and solve more complex projects together with a team.

## 5 DISCUSSION

The educational Project Business Game designed to teach basic principles of project management seemed to be entertaining and fun, while simultaneously having a lot of room to improve. The answers from the evaluation questionnaire seemed to indicate that the game's mechanics were still at an insufficient level. Numerous answers towards how some mechanics did not work as the players had thought and complaints about how the game seemed to cheat the players out of higher scores could also be taken as a sign that the game truly does need better instructions. This need was also corroborated by some players' comments on how to improve the playing experience by introducing the idea of tutorials in-game. Additionally, the game design's unforgiving nature through harsh risks could be improved by fine tuning the risks to be less back breaking.

As a learning tool PBG seemed to serve its purpose. Most of the players reported enjoying the game experience, which could indicate that the feeling of *flow* described by Kiili (2004) was indeed reached. Still, as some players showed a disconnect between being able to use what they had previously learned on the project management course to increase their chances in-game, it could be argued that as a serious game PBG has not reached its full potential. To aid PBG becoming a more useful learning tool, the game mechanics revolving around the resource subcontracting feature could be made more user-friendly by making the week display more intuitive. In order to keep the players' intrigue by having just the right amount of challenge, the game's difficulty could also be adjusted to better match the users' skill level, as according to Hamari et al. (2016) it is indeed the challenge itself that is one of the most important aspects of serious games.

Further improvement ideas towards the game can be seen when the game's design is analysed through Hammer & Lee's (2011) three sides of how an educational game can be motivating. PBG does include the cognitive side, as the game portrays a challenge – an obstacle – for the player to solve via an actionable project plan. It could be said that the game also featured the social aspect of serious games, as the players take on the role of a project manager (PM) to succeed in their endeavour. Still, the player taking on the role of a PM in-game is arguably rather transparent and it should be implied or told more explicitly, but functionally the social side is present. Lastly, it seems that the emotional side of the game is not as present as it could, since players were not invested in the actions of the game unless an upsetting risk happened to hamper their progress. While being able

to induce any kind of emotions is a good sign, the future design of the game should focus on cultivating a full range of emotions rather than just the hugely upsetting ones that come with actualized risks.

The two research questions set for this thesis were:

1. What are the components of serious – and more specifically educational – game design?
2. How do educational games support learning?

According to the brief literature study on the subject of serious and educational games, there seems to be three distinctive components to serious game design. The first being the idea presented by Hammer & Lee (2011), that a serious game must be designed in such a way, that it has an impact on the cognitive, emotional as well social side of the player. Then once the player is getting invested into the world of a serious game, the game should provide a challenge just hard enough, that the player is working at the edge of their abilities. As demonstrated by Hamari et al. (2016) having the player solve challenges that are just hard enough capture attention to the game and also increase the intrigue and entertainment towards the game. And finally, the last component in serious game design is to try to provide a sense of *flow* (Kiili, 2004) via the previously mentioned challenge factor or by other means, as a right mental setting is instrumental in learning through serious games. All of these three components are also built upon the pedestal formed by traditional video game design, which has its own complete set of characteristics.

As to how educational games support learning, the aspects of hard, solvable challenges and the feeling of *flow* are still present, as both support the learning process of the player. (Hamari et al. 2016) (Kiili, 2004) In addition, it seems that according to Watson et al. (2011) just having an interactive medium – such as a serious game – to learn topics in a classroom shifts the teacher-centered learning experience into a much more student-centered. This in turn seems to increase student engagement towards the learning topics and surprisingly also encourages learning outside the classroom, as the students are more likely to talk about the experience and compare their results. Of course, the aspect of competition provided by a serious game could also improve the learning process of players, especially when the experience is a shared one.

As with any study, there were limitations to this thesis as well. A sample size of fifteen participants does not provide enough information to draw hugely factual conclusions, even though it might indicate trends somewhat correctly. Using open questions on the questionnaire provided some good qualitative data, but the inclusion of closed questions in the hopes of gathering proper quantitative data left a lot to be desired. Especially since the timeframe to answer the questionnaire was so limited, it would have been more beneficial to only gather qualitative data. Additionally, the point of the questionnaire not being a standardized one was another limitation in itself. Not being able to compare the evaluation results to other studies limited the amount of useful data that could be gathered from said evaluation.

In addition to a small sample size and unstandardized questionnaire, the PBG itself set some limitations to this thesis. Many of the participants in the evaluation focused much more on the functionalities and errors of the game rather than on the pedagogical aspects. This can be largely attributed to the unfinished state of the game, as the participants were only able to play around with a working prototype of the game rather than a finished educational game. If the game would have had a more polished outlook and its mechanics would not have been so hard to understand, the participants potentially could have focused more on how well the game provided a learning experience for them instead.



## 6 CONCLUSION

The objective of this thesis was to study serious – and more specifically educational – video games, their design and how they support the learning of players. As an additional objective, these phenomena were observed in order to evaluate and improve an existing prototype of an educational project management game, Project Business Game (PBG for short). The study was done on two parts, as first a brief literature review towards serious games and their design, as well as the relevant aspects of project management, was conducted. Then, in order to study the enjoyment, game mechanics and pedagogical value of PBG, an evaluation (n=15) was conducted using a questionnaire.

The results from the evaluation seem to indicate, that the game experience was liked and viewed as entertaining but lacked proper instructions to be used as an excellent learning tool. The unforgiving nature of the game also proved to be too much of a challenge for most of the players, which goes against the good conducts of serious game design where the obstacle should be just challenging enough, but not too challenging. Some game mechanics such as the week display and resource subcontracting did not seem to be intuitive enough. Still, the learning experience was seen as useful and most of the participants agreed that the game had helped them understand project management better in some aspect.

The literature review provided relevant information on the two research questions, which were set in order to analyse the components of serious game design and how serious games support learning. In the design of a serious game, the designers should firstly focus on three motivational aspects, which have an impact on the player's cognitive, emotional and social side. The game should also be designed so that the players would constantly be working at the edge of their abilities by providing an obstacle that is just challenging enough for the player. Overcoming these challenges could then lead to a feeling of *flow* for the player, which would support the learning process in-game. Additionally, the use of interactive media – like games – enhances students' learning experiences by making them more enthusiastic and intrigued towards the learnable goals.

## REFERENCES

- Babu, A.J.G. & Suresh N. (1996). Project management with time, cost and quality considerations. *European Journal of Operational Research Vol. 88* (Issue 2), pp. 320-327
- Bellotti, F. et al. (2009). Enhancing the Educational Value of Video Games. *Computers in Entertainment Vol. 7* (Issue 2), article number 23
- Chang, I.S., Tsujimura, Y., Gen, M. & Tozawa, T. (1995). An efficient approach for large scale project planning based on fuzzy Delphi method. *Fuzzy Sets and Systems Vol. 76* (Issue 3), pp. 277-288
- Clark, C.A. (1987). *Serious games*. New York: University Press of America, Inc.
- Denny, P. (2013). The Effect of Virtual Achievements on Student Engagement. *Conference on Human Factors in Computing Systems – Proceedings*. pp. 763-772
- Deterding, S. et al. (2011). From Game Design Elements to Gamefulness: Defining “Gamification”. *Proceedings of the 15<sup>th</sup> International Academic MindTrek Conference: Envisioning Future Media Environments*, pp. 9-15
- Domínguez, A. et al. (2013). Gamifying learning experiences: Practical implications and outcomes. *Computers and Education Vol. 63*, pp. 380-392
- Garris, R., Ahlers, R. & Driskell, J.E. (2002) Games, motivation, and learning: A research and practice model. *Simulation and Gaming Vol. 33* (Issue 4) pp. 441-467
- Gault, R.H. (1907). A History of Questionnaire Method of Research in Psychology. *Pedagogical seminary Vol. 14* (Issue 3), pp. 366-383
- Gee, J.P. (2008). Learning and games. *The Ecology of Games: Connecting Youth, Games, and Learning*. pp. 21-40

Girard, C., Ecalle, J. & Magnan, A. (2013). Serious games as new education tools How effective are they? A meta-analysis of recent studies. *Journal of Computer Assisted Learning Vol 29* (Issue 3), pp. 207-219

Hamari, J. et al. (2016). Challenging games help students learn: An empirical study on engagement, flow and immersion in game-based learning. *Computers in Human Behavior, Vol. 54*, pp. 170-179

Heikkilä, V.T., Paasivaara, M. & Lassenius, C. (2016). Teaching university students Kanban with a collaborative board game. *Proceedings – International Conference on Software Development*, pp. 471-480

Horman, M.J. & Thomas, H.R. (2005). Role of inventory buffers in construction labor performance. *Journal of Construction Engineering and Management Vol. 131*, (Issue 7), pp. 834-843

Howell, G., Laufer, A. & Ballard, G. (1993). Interaction between subcycles: One key to improved methods. *Journal of Construction Engineering and Management Vol. 119*, (Issue 4), pp. 714-728

Inman, R.A., Sale, R.S., Green Jr., K.W. & Whitten, D. (2011). Agile manufacturing: Relation to JIT, operational performance and firm performance. *Journal of Operations Management Vol. 29*, (Issue 4), pp. 343-355

Institute, Project Management (2017) *A Guide to Project Management Body of Knowledge (sixth edition)*. Pennsylvania: Project Management Institute Inc.

Kiili, K. (2004). Digital game-based learning: Towards an experiential gaming model. *Internet and Higher Education Vol. 8* (Issue 1), pp. 13-24

Lazarro N. (2004). *Why We Play Games: Four Keys to More Emotion in Player Experiences*. Game Development Conference

Lee, J. & Hammer, J. (2011). Gamification in Education: What, How, Why Bother? *Academic Exchange Quarterly Vol. 15* (Issue 2), pp. 1-5

Leung, W.C. (2001) How to design a questionnaire. *Student BMJ, Vol. 9*

Lino, J.E.N., Paludo, M.A., Binder, F.V., Reinehr, S. & Malucelli, A. (2015). Project management game 2D (PMG-2D): A serious game to assist software project managers training. *Proceedings – Frontiers in Education Conference, FIE Vol. 2015*, article number 7344168

Lock, D. (2007). *The Essentials of Project Management (third edition)*. Hampshire: Gower Publishing Limited

Lu, M. & Li, H. (2003). Resource-activity critical-path method for construction planning. *Journal of Construction Engineering and Management Vol. 129* (Issue 4), pp. 412-420

Marsh, T. (2011). Serious games continuum: Between games for purpose and experiential environments for purpose. *Entertainment Computing Vol 2* (Issue 2), pp. 61-68

Maylor, H. (2003). *Project Management (third edition)*. Harlow: Financial Times Prentice Hall

Papastergiou, M. (2007). Digital Game-Based Learning in high school Computer Science education: Impact on educational effectiveness and student motivation. *Computers and Education Vol. 52* (Issue 1), pp. 1-12

Sakakibara, S., Flynn, B.B., Schroeder, R.G. & Morris, W.T. (1997). The impact of just-in-time manufacturing and its infrastructure on manufacturing performance. *Management Science Vol. 43*, (Issue 9), pp. 1246-1257

Schonberger, R.J. & Gilbert, J.P. (1983). Just-In-Time Purchasing: A Challenge for U.S. Industry. *California Management Review Vol. 26* (Issue 1), pp. 54-68

Thomas, H.R., Riley, D.R. & Messner, J.I. (2005). Fundamental principles of site material management. *Journal of Construction Engineering and Management Vol. 131*, (Issue 7), pp. 808-815

Von Wangenheim, C.G., Savi R. & Borgatto, A.F. (2012). DELIVER! – An educational game for teaching Earned Value Management in computing courses. *Information and Software Technology Vol. 54* (Issue 3), pp. 286-298

Watson, W.R., Mong, C.J. & Harris, C.A. (2011). A case study of the in-class use of a video game for teaching high school history. *Computers and Education Vol. 56* (Issue 2), pp. 466-474

White, R.E., Pearson, J.N. & Wilson, J.R. (1999). JIT manufacturing: A survey of implementation in small and large U.S. manufacturers. *Management Science Vol. 45*, (Issue 1), pp. 1-15

Wouters, P. et al. (2013). A Meta-Analysis of the Cognitive and Motivational Effects of Serious Games. *Journal of Educational Psychology, Vol. 105* (Issue 2), pp. 249-265