

**CAN SIMULATION SOFTWARE INTEGRATED WITH GAMIFICATION
ENHANCE STUDENTS' UNDERSTANDING OF PROJECT EXECUTION
CONCEPTS BY IMPROVING LEARNING OUTCOMES?**

by

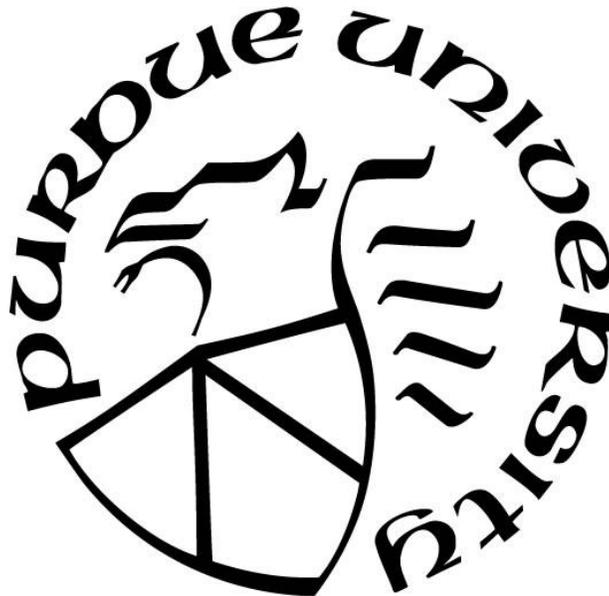
Sreemoyi Debroy

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**THE PURDUE UNIVERSITY GRADUATE SCHOOL
STATEMENT OF COMMITTEE APPROVAL**

Associate Prof. Jeffrey Brewer, Chair

Department of Computer and Information Technology

Associate Prof. Kevin Dittman

Department of Computer and Information Technology

Associate Prof. David Whittinghill

Department of Computer Graphics Technology

Approved by:

Prof. Eric Matson

Head of the Graduate Program

*To the Pokemon Go Community of West Lafayette which inspired my interest in the field of
gamification*

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GLOSSARY

Simulation – artificial environment created for the purpose of measuring an individual or team’s experience with reality (Bell, Kanar & Kozlowski, 2008)

Gamification - application of design elements of a game to non-game contexts for the purpose of engaging users and solving problems (Sammut, Seychell, & Attard, 2014)

LIST OF ABBREVIATIONS

SBT – Simulation Based Training

PTB – Project Team Builder

CNIT – Computer Networking and Information Technology

ROI – Return on Investment

ABSTRACT

Author: Debroy, Sreemoyi. MS

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Title: Can Simulation Software Integrated With Gamification Enhance Students' Understanding Of Project Execution Concepts By Improving Learning Outcomes?

Major Professor: Jeffrey Brewer

This research study explores the gamification of SandBoxModel's Project Team Builder, a project management simulation software. Scope, time and cost management are the triple constraints of project management with quality being the fourth dimension. The software provides a simulated environment where students are responsible for handling the aforementioned constraints with the objective of executing a complete project. This software is used to teach project management concepts to students who take the CNIT 480 – Managing Information Technology Projects course at Purdue University. The perception survey was used to analyze whether gamification had a significant effect on student understanding of project execution concepts. The triple constraint survey was used to analyze students' level of comprehension regarding the triple constraints after using the simulation software. Gamification was not a success in enhancing project execution concepts since no significant differences were found in student perceptions on comparing the data of the three semesters. However, simulation independent of gamification was successful in improving students' understanding of triple constraint.

CHAPTER 1. INTRODUCTION

This chapter provides an overall outline of the conducted research study. It comprises of the scope, significance, assumptions and limitations of the study.

1.1 Scope

This research study will examine alternative learning methods by using a simulation software to measure whether it can enhance student understanding of the skills that a project manager needs during the execution of a project. It will also assess whether the element of gamification can enhance student interest by improving learning. The project management simulation tool used for this research study is SandBoxModel's Project Team Builder. The students enrolled in CNIT 480 – Managing Info Tech Projects course at Purdue University will be used as the research subjects. As a part of the literature review, topics such as gamification elements of gamification and use of simulation for teaching project management courses have been covered.

1.2 Background and Significance

My interest in the area of gamification stems from my active involvement in the Pokemon Go Community at Purdue University. I have also been the teaching assistant for CNIT 480 – Managing Information Technology Projects since Fall 2017. Insufficient motivation of the students was one of the challenges that I faced. This is mainly due to the students' lack of understanding of the significance of the material and learning. My experience in the aforementioned areas leads me to believe that the incorporation of game elements into the simulation software can enhance the level of competition for the students.

The syllabus of project management concepts is theoretical in nature (Ibrahim, 2011). Students might find such a course uninteresting when taught theoretically (Ibrahim, 2011). The abstract nature of management of information technology systems makes it hard to teach this in a classroom (Ibrahim, 2011). The CNIT 480 – Managing Information Technology Projects course is mandatory for graduating seniors of CNIT. As a result of this, this course has several students who might not want to pursue a career in project management and hence not be interested in the

project management concepts. Real life projects could be used to teach project management concepts. Students would get a hands-on experience and better comprehension of concepts by working on such a project. However, the course has a large class size. If students were working of real world projects, limited amount of time could be allotted to every student. Thus, the incorporation of a project management simulation software blended with elements of gamification can help enhance the motivation and level of interest of the students. This in turn can lead to increased investment of time for mastering course concepts and ultimately enhance subject matter retention level. Standish Group's Chaos Report of 2016 shows that 71% of worldwide projects were either challenged or resulted in failures (Meier, 2017). Medium sized project had the worst performance (Meier, 2017). 57% of medium projects failed or were challenged. Hence, there is a need for good project management skills and this study will assess new methods of enhancing student understanding of project management concepts.

1.3 Research Question

Can simulation software integrated with gamification enhance students' understanding of project execution concepts by improving learning outcomes?

1.4 Assumptions

The research study was conducted with the following assumptions:

- No technical difficulties were faced by the students while using the SandBoxModel Software
- The students provided genuine and honest responses for the surveys.

1.5 Limitations

- The study will not consider personal characteristics such as age, race, gender or career perceptions and how they might affect student engagement in the area of IT project management.
- The sample used for research will comprise of students from two sections of the CNIT 480 course. Thus, it will be a convenience sampling and may not apply to the general population.

1.6 Chapter Summary

This chapters covers the scope of the research question for this thesis. The significance of the research question has been discussed in this chapter. The assumptions and limitations related to this study are also covered in this section.

CHAPTER 2. REVIEW OF LITERATURE

This chapter discusses various topics associated with this research. The concepts of e-learning, gamification and simulation have been covered in detail in this section. The existing literature on the use of project management simulation tools in the field of education has been discussed.

2.1 E-Learning Models

E-learning can be defined as the utilization of telecommunication technology for the deliverance of information for education and training (Sun, Tsai, Finger, Chen & Yeh, 2008). Wider geographical reach, increased learner control, cost effectiveness in the delivery and management of courses are some of the advantages of e-learning (Hu & Hui, 2012). This has led to a widescale adoption and implementation of e-learning courses by numerous educational institutions and professional organizations via the medium of an array of technology enabled platforms.

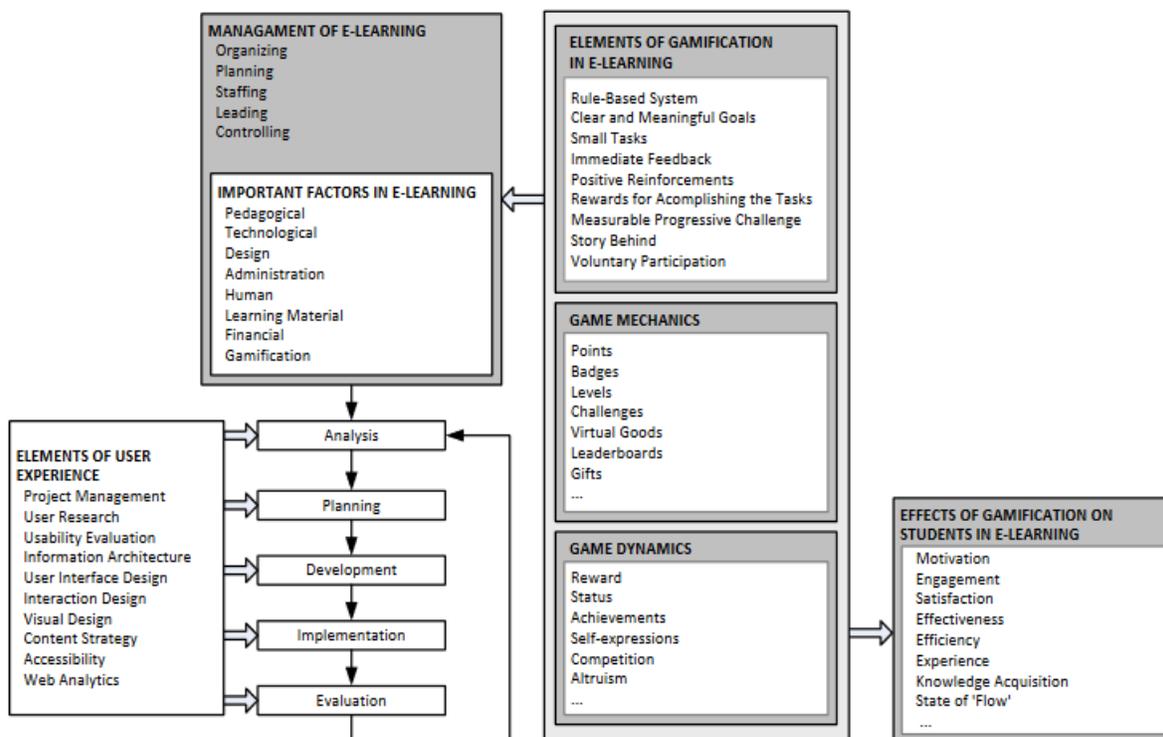


Figure 2-1 The model of introduction of gamification into the field of e-learning (Urh, Vukovic & Jereb, 2015)

The aforementioned model of e-learning contains an additional element of gamification (Urh, Vukovic & Jereb, 2015). The author further explains that this model's design has the capability of maximizing students' satisfaction, motivation, efficiency and effectiveness since it takes into account the modern theories and practices of education and e-learning. According to these theories, learning has the greatest impact when it is active, experiential, situation based, problem based and provides feedback in real time.

The right combination of e-learning and gamification that contains balanced tasks and skills can induce a state of flow for students (Csikszentmihalyi, 1990). Flow can be explained as a state during which an individual is completely focused and immersed in an activity he is performing. The feeling of flow is triggered by four common game elements: goals, rules, feedback and voluntary participation (McGonigal, 2011). The proper balance of difficulty level of tasks can induce a state of flow for players which is highly motivating. Furthermore, flow plays a pivotal role in the context of challenging activities during which an individual's skills and concentration are important for achieving a certain outcome (Jackson & Eckland, 2002).

According to (Strmečki, Bernik & Radošević, 2015), goal-based activities, reward mechanisms and progress tracking play a significant role in the core concept of games. Learners are expected to complete certain tasks in order to achieve previously laid out goals of an e-learning course. The author further states that progress tracking and reward mechanisms can be utilized for increasing the motivation and engagement of e-learning participants.

The following model of introduction of gamification into e-learning comprises of 5 main phases of e-learning system development.

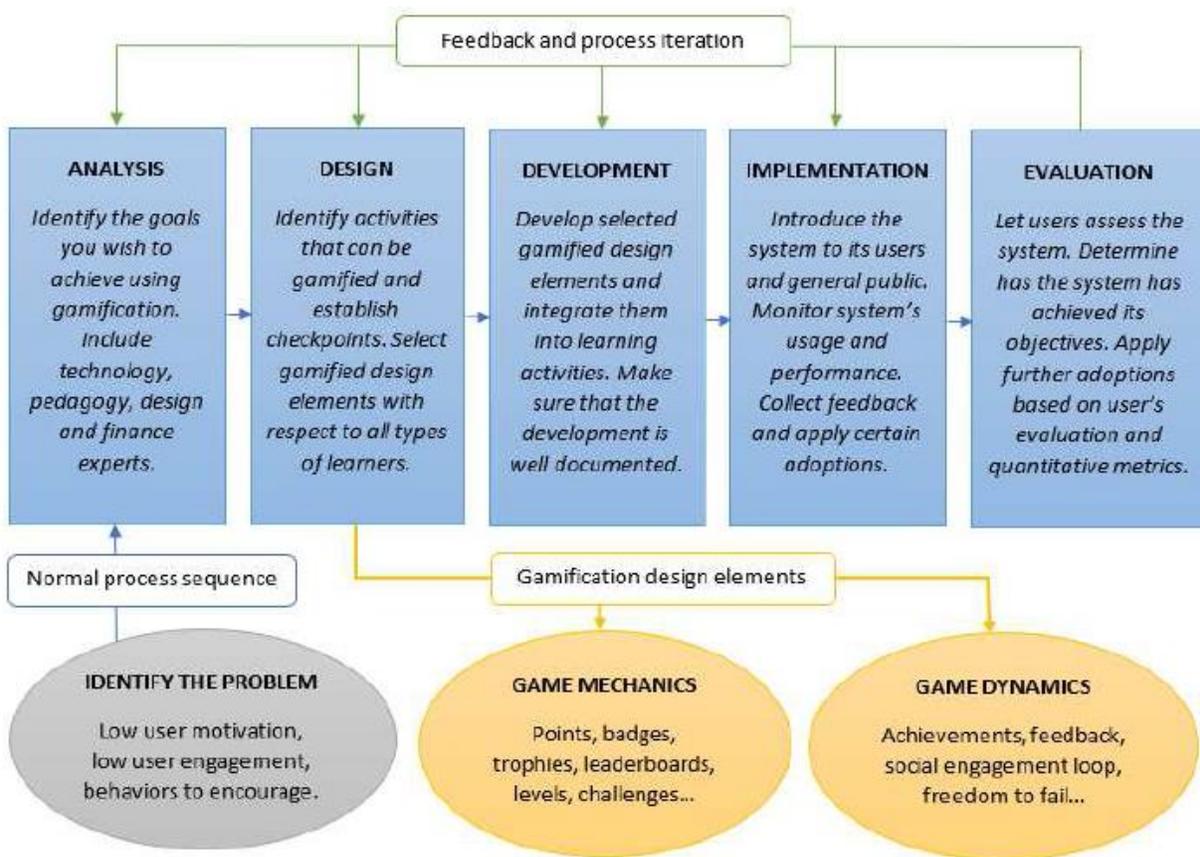


Figure 2-2 Phases of introducing gamification into e-learning systems (Strmečki, Bernik & Radošević, 2015)

- **Analysis Phase:**

The analysis phase involves the identification of goals that we want to achieve using gamification. Technology, pedagogy, quality design and finance are important components of

the analysis phase. Technology forms the basic crux for the implementation of any e-learning system. Pedagogy is focused on the practice of teaching and educational quality. It is very important to have good quality graphic design for systems that use gamified design elements. The lack of the aforementioned component can lead to poor or unsuccessful implementation.

- Design Phase:

The design phase involves the identification of activities that can be gamified and the creation of checkpoints for evaluation of a learner's performance in the context of those activities. The design phase addresses the cognitive area, emotional area and social area of experience. The cognitive area can be defined as a field within which students must attain a certain level of skills within a given set of rules. Virtual reward systems such as scores, experience points, achievements, animations and content address the emotional area of a student. Lastly, popular gamified elements such as leaderboards and badges impact the social area of experience since these elements are publicly displayed.

- Development Phase:

This phase involves the development of selected gamified design elements and their integration into learning activities. This phase relies heavily on technology. Proper documentation of an e-learning system helps in handling repair, adjustment and overall maintenance of the e-learning course.

- Implementation Phase:

The system is introduced to the users during this phase. Constant monitoring of the system is required for ascertaining optimal system performance. Feedback is collected from users for tweaking certain features to suit their needs.

- Evaluation Phase:

Users assess the implemented system in the evaluation phase and help in determining whether the system has achieved its required objectives. Satisfaction surveys, page views per visitor, frequency of visit, time spent on site and total time per user are some metrics for analyzing user engagement.

According to Biro (2014), gamification can be viewed as a learning theory that makes use of community-based evaluation systems and reinforcement. Social network forms the foundation of this theory. The author further explains that "community-based motivation and feedback process can be launched in order to be able to raise the level of engagement in the learning process for

each participating individual” (pg. 149). The gamification learning theory focusses on small achievements and paves the way for reaching the main goal or overall skillset via the medium of these multiple achievements. The partitioning of knowledge into small batches plays a significant role in building up the curriculum for a course. This learning theory also encompasses the visual aspect of the learning process with specific focus on the visualization of advancement in the learning process. The learner is considered the most important actor in the learning process. The author mentions that gamification motivates the learners to compete against each other for reaching higher levels or obtaining better rewards.

2.2 Gamification

Gamification can be defined as the application of design elements of a game to non-game contexts that is used for the purpose of engaging users and solving problems (Sammut, Seychell, & Attard, 2014).

2.2.1 Elements of Gamification

A gamification platform provides prizes or rewards for indulging in certain kinds of behavior that are desirable for gameplay (Spreitzer, 2013). These are the elements of gamification that keep players engaged and entice them to play the game again and again (Spreitzer, 2013).

According to Spreitzer (2013), the following are some examples of rewards used in a gamification platform:

- **Badges/Trophies/Achievement:** They are a symbol of a player’s competency and ability to surpass the required level of challenges in a game. Gamification provides a way for other players to see a person’s badges/trophies/achievements so that they can recognize a particular player’s individual gaming abilities. Most of these are locked in a game and can be unlocked only after the completion of a series of tasks.
- **Leaderboards:** A leaderboard is a public scoreboard. Such a scoreboard can enable players to see instant performance results on an individual and team basis. It uses competition to drive valuable behavior.
- **Points:** Points are a numerical value that increases or decreases based on a single action or a combination of actions. Points are useful for players who like to collect something. They can be used as a medium for providence of progression related feedback.

- Progress Bar: A progress bar shows how much progress a player has made towards the achievement of a game objective or goal.
- Feedback Loop: In a video game, a player receives real time feedback regarding how much progress he has made towards a specific goal, the location he is in at a specific point of time, time remaining, inventory items details and how other players are performing. As soon as a player takes an action, he receives instant feedback regarding that action.
- Quests: A quest can be defined as a hunt for a specific outcome such as collecting a specific list of items.
- Challenges: Challenges are similar to quests but differ in the level of difficulty and usually involve a limited amount of time during which the objective must be completed.
- Bonuses/Rewards: Bonuses or rewards are awarded to players for successfully completing a series of challenges.

2.2.2 Gamification in the area of Project Management

Satyajit (2015) has the following views about gamification in the area of project management:

Comprehensive game metrics, clearly defined goals and player roles provide real time feedback to players in games. Similarly, projects in the real world are carried out by team members who have unique roles in the project. Real life projects also have detailed objectives and intelligent metrics to measure progress. Gamification principles are focused on the ability to create and sustain relationships between the user (player) and the product (project or game). Engaging and motivating learning activities via the use of gamification has the ability to engage both the interested and non-interested parties. A sense of community can be established within a project by the use of gamification. This in turn could inspire engaged users to contribute at a higher level due to the factors of camaraderie and heightened sense of loyalty. The level of encouragement for each team member would be increased by accountable goals, clear recognition and reward policy. In summary, gamification deals psychologically with the minds of the players which can be beneficial in the area of project management. This is because project management largely involves

dealing with people, guiding them psychologically, tackling interpersonal issues and obtaining frequent updates about progress of multiple aspects of a project.

2.3 Gamification for Teaching Project Management

This section covers some case studies regarding the use of games and gamification elements for teaching project management concepts.

2.3.1 Trogon

According to Aseriskis & Damasevicius (2014), Trogon is a project management system (PMS) that has been gamified. The following are the main components of Trogon:

- J: J represents the jobs that are entered into the project management system
- B: B represents the badges that are defined in Trogon
- R: R represents the ratings based on the number of finished jobs
- W: W represents the registered workers
- F: F stands for the trees which represent jobs in the project forest
- P: P represents the points received by a worker
- I: I represents a month or a week
- T: T represents time in terms of 15 minute intervals
- D: D represents a function to determine the difficulty of jobs

Project tasks are entered into the system. Rewards are assigned for the fulfillment of each task. Tasks are further split into atomic jobs. Project managers can assign planned work time to these atomic jobs. A special skill badge can be assigned to each job. Employees working on this project can enter information regarding the results of their work. The completed jobs are checked by the quality engineer or project manager for defects and badges are awarded accordingly. The leaderboard and badge board make employee points and badges visible to all other employees creating an environment of competition. Each badge requires certain skills and the progress between the skills is demonstrated via the use of a progress bar. The best employee is rewarded every week. A project forest symbolizes teamwork. Unoccupied plots represent unfinished tasks. Areas containing trees represent finished jobs. Each tree has different characteristics that stand for complexity of a task and time taken to finish the task. A forest view is created through these

trees. A project manager can visually evaluate and compare complexity of jobs performed and also the skillset possessed by each employee.

Aseriskis & Damasevicius (2014) explains the results of the survey conducted to gather views about Trogon as follows:

60 participants in the age range 18-25 were asked to participate in a survey regarding their experience with Trogon. Only 30 responded to the survey. 22 of the participants were male and 8 were female. 23 of the participants worked with information technology systems. The survey results revealed that the gamified Trogon system had good usability since it received an average score of 71 out of 100. No usability differences were discovered between men and women. Leaderboard was the gamification element that was easiest to understand. Non-IT users assigned a lower score to the Trogon project management system.

2.3.2 Crashing Games and E-learning Simulation

Rumeser & Emsley (2017) recruited 126 Management of Project students from the University of Manchester to participate in the following two types of learning mechanisms:

- **Crashing Games:** These games contain multiple small projects which are a part of a large program. Participants have to crash or accelerate a single project and then work with other teams to accelerate the larger program. At every step, participants need to calculate their cost and schedule details and analyze how it is affecting their project and the program.
- **E-Learning Simulation Exercise:** This exercise involves repetitive calculations while completing each step of a small project. Learners work individually on that project and receive direct and detailed feedback after the completion of every step.

Rumeser & Emsley (2017) further add that Index of Learning Style questionnaire comprising of 44 questions was used to identify learners' learning styles. A second questionnaire consisting of multiple choice questions was used to ask questions about preference between the two learning mechanisms. A chi square test was performed to ensure that the tendency of data was not due to chance. The Index of Learning Style Model contains four dimensions: active vs

reflective, intuitive vs sensing, global vs sequential, and visual vs verbal. The following are the tendencies of each dimension:

- Active Learners: Those learners who comprehend and retain information by actively doing activities.
- Sensing Learners: Those learners who prefer learning facts and do not like hands on work.
- Visual Learners: Those learners who remember what they see.
- Sequential Learners: Those learners who use sequential or linear steps to understand concepts or find solutions.

Rumeser & Emsley (2017) conclude that “only the 'intuitive vs sensing' and 'global vs sequential' learning style dimensions affect learners' learning method preference. The majority (i.e. 78%) of intuitive learners prefer the more complex crashing games, while 54% of the sensing learners prefer the less complex e-learning simulation exercise. On the global vs sequential dimension, 59% of global learners prefer the crashing games, while 54% of the sequential learners prefer the e-learning simulation exercise” (pg. 3). The chi square with 95% confidence interval revealed that “the intuitive vs sensing dimension affects learning method preference either toward less or more complex games or simulation” (pg. 5).

2.3.3 Deliver

Deliver is a board game which was used to teach Earned Value Management for software projects to undergraduate students enrolled in two software project management courses at the Federal University of Santa Catarina – UFSC during the second semester of the year 2010 (Wangenheim, Savi & Borgatto, 2012).

According to Wangenheim et. al. (2012), the following are the main components of the game that is provided to the students:

- Slides: The slides contained explanation of the game
- Template: The template contained the project plan, register of costs spent and status report (one per pair of players)
- Game board: One game board was assigned to each group of four players
- Instruction sheet: One instruction sheet was assigned per group
- Game pawns: One game pawn was assigned per pair of players

- Dice: One dice was assigned per group of players
- Money: Notes of denominations \$100, \$500 and \$1000 were used in this game. 70 notes of each denomination was provided per group
- Human resource cards: One set of 24 cards was assigned per group
- Risk cards: One set of 33 cards was assigned per group

The instructor first introduces the concepts of EVM to the students (Wangenheim et. al., 2012). The students start the planning phase by recruiting necessary human resources from a pool of available human resources. Onboarding and Offboarding is allowed only at this point of time or at a milestone during project execution. Each human resource has the characteristics of productivity level and weekly salary. Productivity level is the determinant for the number of spaces a project team can progress during each game. This is calculated by multiplying the productivity level with the dice number. Players estimate the project duration based on the number of expected game rounds. Each game round is equal to 1 week. The author mentions that “total number of activity units to be worked until delivery is fixed for all groups of players defined through the number of space on the game board. Typically, it takes about 7–10 game rounds to finish the project arriving at the delivery space” (pg. 290). Allocated human resources receive a weekly salary at the completion of each game round. Estimates of project costs are chalked out on the basis of salaries of allocated resources and estimated duration within a total project budget of \$20000.

Wangenheim et. al. (2012) further explains that results are written in the project plan. This includes duration estimates or number of game rounds, human resource costs and management reserves for risks. BAC or budget at completion is calculated by summing up the total project cost. The author mentions that “during the game execution, the pairs of players advance on the game board, simulating the execution of the project by throwing a dice” (pg. 290). The following steps are taken on the basis of the number that shows up when the dice is rolled:

- Dice Number between 1 and 4: Dice Number X Sum of the productivity factors of the team’s human resources. Advance the corresponding number of spaces on the board.
- Dice number is either 5 or 6: Pick a risk card and follow instructions written on the card.

Wangenheim et. al. (2012) explains that a pair of players must monitor and control project execution using EVM at each milestone between project phases. Also, a status meeting needs to

be held at this point of the game for analysis of SPI – Schedule Performance Index and CPI – Cost Performance Index. A prediction of EAC – Estimate at Completion needs to be made. Resources may be hired or fired based on performance and the project plan is updated accordingly. The pair of players who first deliver the project to the customer by arriving at the space delivery without running out of money during project execution is the winner.

Wangenheim et. al. (2012) used a standardized questionnaire based on Kirkpatrick's level 1 (motivation, user experience and learning) to assess student perceptions regarding the EVM game. A five-point Likert scale was used to answer the questions. The results revealed that the game helped in reinforcing and teaching the calculation of performance indicators and also illustrated and motivated the usage of EVM. An additional learning outcome showed that students perceived the low estimation precision in the beginning of a project which increased as the project was executed. Majority of students gave positive reviews to Deliver and expressed that the game was an enjoyable experience for them. The characteristic of social interaction was highlighted very positively by the students. The game was rated high on elements of fun and immersion. The game was considered an appropriate medium for enhancing previously acquired knowledge about EVM. Complexity of game rules was comprehensible and all students were able to play the game at their first try. The dice rolling which is dependent on luck and appropriate presentations of challenges throughout the game were two areas which could be improved upon.

2.4 Simulation Based Training

Simulation can be defined as an artificial environment that has been created for the purpose of measuring an individual or team's experience with reality (Bell, Kanar & Kozlowski, 2008). Simulation based training tools or SBT tools that use a computer based synthetic environment are discussed in this section. Simulation based training has been used in areas such as quality management, process reengineering and supply chain management (Solan & Shctub, 2017). The three pillars that form the foundation of learning through simulation are learning from content, learning from experience and learning from feedback (Solan & Shctub, 2017).

2.4.1 Advantages of Simulation Based Training

The following are a list of advantages of using simulators as a tool for learning:

- **Hands-on Experience:** Simulation software enable students to get a hands on experience about developing and executing a project plan and analyzing the impacts of their decisions (Solan & Shctub, 2017).
- **Immediate Response to Decisions:** Simulators enable a person to obtain immediate response from the system after he/she makes a decisive action (Thomas, Purdy & Fandt, 1997).
- **Eliminates Risk:** Learning on the job does not encourage making risky or innovative decisions (Salas, Wildman & Piccolo, 2009). This is because such decisions have real consequences for the employee who makes it, the project being worked upon and the organization (Salas et. al., 2009). Simulation eliminates the risk of suffering unfavorable repercussions that the students might face while working on real world projects (Solan & Shctub, 2017).
- **Similarity to Real World Project:** A good simulation tool provides a realistic model of interdependence of decisions that is made by a project manager (Nguyen & Paschal, 2002). Thus, this kind of training decreases the gap between the artificial learning environment and the real-world environment (Solan & Shctub, 2017).

2.4.2 Challenges of Simulation Based Training

The challenges faced by the implementation of simulation based training in the field of education are as follows:

- **Understanding Individual Differences:** The technical prowess, previous knowledge and the disposition of an individual are certain factors that influences how a participant approaches, interprets and responds to training (Bell et. al., 2008).
- **No correct blend of simulation and teaching:** There is no precise information that lays out the design requirements for a good simulation based learning that can be used as a perfect model for teaching project management concepts (Subramanyan & Moorthy, 2016).
- **Poor leveraging of learner control:** Participants of a simulation based training often do not assess their current knowledge level accurately (Bell et. al., 2008). Insufficient time investment to training, taking shortcuts and skipping over important learning opportunities

with the objective of just getting the work done results in performance deficiencies (Bell et. al., 2008).

- Solitary Learning Experience: The availability of online simulation training has made it convenient for trainees to use the simulation tools at their own disposal (Bell et. al., 2008). This often creates a solitary learning experience that reduces the advantages of social interaction and collaboration in training (Bell et. al., 2008).

2.5 Simulation Based Training Tools

This section talks about various simulation based tools that have been implemented in the field of education for teaching project management concepts.

2.5.1 SandBoxModel's Project Team Builder (PTB)

SandBoxModel's Project Team Builder (PTB) is a simulation tool that can be used as a teaching aid for teaching project management concepts (Coffani, 2013). Project Team Builder (PTB) has been used as a research tool for conducting studies in Pennsylvania State University and The Australian National University located in Australia and USA respectively (Davidovitch, Parush & Schtub, 2006). These studies varied in the levels of prior project management knowledge possessed by the participants (Davidovitch et. al., 2006). The objective was to establish the circumstances under which SBT enhances the knowledge of participants and the overall learning process (Davidovitch et. al., 2006). The PTB tool provides task information, resource information and general information for different difficulty level projects (Davidovitch et. al., 2006).

According to Davidovitch et. al. (2006), the goal of a participant is to maximize the amount of cash at hand at the end of a project execution. This can be achieved by scheduling resources, onboarding and offboarding resources at the correct time and by using the rushed mode of work that includes overtime. The results of the studies revealed that the dearth of sufficient theoretical knowledge regarding project management principles did not enhance SBT based learning for the participants. On the other hand, the students who had prior experience of project management work did not learn much from the tool. Thus, the conclusion of this study was that only an appropriate level of prior knowledge in the project management area, enhanced the knowledge of participants by using SBT.

In a second case study conducted by Coffani (2013), a group of students at Technion Israel Institute of Technology in Haifa were taught basic principles of project management. There were 10 students each from undergraduate and graduate groups. They were enrolled in a project management course where the final project was to manage an important and complex project using PTB. The software was taught by the professor of this course and was a requirement to pass the course. The students were then required to answer a list of questions as a part of an interview. The responses from the interview were used to derive conclusions about the PTB tool.

The objective of the Coffani (2013) was to identify the best technique among Microsoft Project, Project Team Builder, and Microsoft Project and Project Team Builder combined, for managing and controlling a project. The author concluded that new and expert users preferred to use Project Team Builder only rather than working with the combination of MS Project. PTB was found to be more practical and easier and preference was given to PTB for scheduling and planning a project. The author also found that a group of students found MS Project to be more useful for the management of complex engineering projects. Lastly, the need to collect more data for the evaluation of the real performance of the combination of PTB and MS Project has been highlighted.

2.5.2 The Incredible Manager

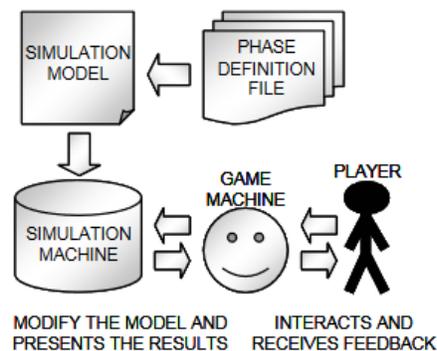


Figure 2-3 The Game Structure (Dantas, Barros & Werner, 2004)

The Incredible Manager is a game based learning approach in the context of project management (Dantas, Barros & Werner, 2004). A student is given the responsibility of a manager and asked to plan and control software projects within the given time and cost constraints (Dantas

et. al., 2004). Danats et. al. (2004) lists the following three main components of this game as follows:

- The Simulation Model: Uncertain aspects of the known aspects of a real-world project are simulated and presented to the student in the form of a scenario.
- The Simulation Machine: The simulation machine has the capability of translating and simulating system dynamics models. It controls simulation steps, calculates model equations with the goal of evaluating systems element behavior displayed by the student.
- The Game Machine: The student interacts with the game machine and in return receives visual feedback. This machine comprises of continuous game phases. A certain set of characters participate in each phase of the game. The three characters are:
 - Manager: This is the role of the player and involves tasks like project planning and decision making.
 - Developers: The team of developers is responsible for developing the project and each developer possesses unique characteristics such as hourly cost and work hours per day.
 - Boss: The boss represents all the stakeholders and can accept or reject the project plan.

Dantas et. al. (2004) further explains the breakdown of the simulation game using the following five steps:

- Begin Phase: In this step, the player is presented with the project description document that consists of components like the description of the product to be delivered, functions points, constraints, schedule and budget.
- Project Planning: The player recruits the required resources and also estimates the number of days required for the completion of each task.
- Planning Acceptance: The project plan is sent to the stakeholders for acceptance who have the right to reject the plan if overall estimates exceed the overall constraints of the project. Under such circumstances, the player has to chalk out a new project plan.
- Project Execution: Visual effects and project reports show exhausted developers, postponed tasks and tasks without funds. This step gives the students the

opportunity to make decisions on the fly in order to ensure that the resources last till the end of the project.

- End Phase: A phase ends when all resources have been spent but the project is incomplete or the resources have been efficiently spent leading to the successful completion of the project.

According to Dantas et. al. (2004), two studies were conducted using a mixture of bachelors and masters students at two different Brazilian universities. All subjects were provided adequate training regarding project management practices and game utilization. However, only one student was able to successfully complete the project. The surveys filled out by the students indicated that the SBT was considered motivating, practical, dynamic and enjoyable. The following table shows the game based learning evaluation results:

Table 2-1 Game Based Learning Evaluation Results (Dantas et. al., 2004)

	<i>Raised</i>	<i>Indifferent</i>	<i>Reduced</i>	
<i>PM Skill</i>	100%	0%	0%	
<i>Interest in PM</i>	87%	13%	0%	
	<i>Good</i>	<i>Indifferent</i>	<i>Bad</i>	
<i>Game-based Training</i>	100%	0%	0%	
	<i>All</i>	<i>None</i>	<i>Lots</i>	<i>Few</i>
<i>Presented Lessons Learned</i>	0%	0%	100%	0%
	<i>Yes</i>	<i>No</i>	<i>Much</i>	<i>Little</i>
<i>Was the training fun ?</i>	47%	0%	53%	0%

2.5.3 SESAM

According to Mandl-Striegnitz (2004), the SESAM project contains a simulator using which the students can take up the role of a software project manager. In the winter semester of 2000-2001, the SESAM project was implemented by the Department of Software Engineering at the University of Stuttgart as an alternative approach for teaching the concepts of project management to undergraduate students. A group of 40 third semester undergraduate students were

exposed to a programming course and a lecture and tutorial on project management. Information regarding the software project to be managed during the simulation is provided by the instructor. This includes project characteristics such as estimated project size and customer objectives such as time, budget and quality specifications. The students are responsible for making decisions such as hiring members for a team, assigning tasks to the team members and controlling the progress of the project. Monitoring the project status and taking corrective actions are other responsibilities. These decisions are to be taken based on the project objective and the system's reactions.

Mandl-Striegnitz (2004) further explains that a feedback session was organized by the instructor that covered particular aspects of the project. Some examples of project aspects are:

- Human Resource Management: Checking of the qualifications of the staff before hiring or assignment to tasks (Mandl-Striegnitz, 2004).
- Monitoring and Control: Regular monitoring of project status and formal review of all milestone documents before the commencement of the next project phase (Mandl-Striegnitz, 2004).
- Quality Management: Checking of consistency between products and ensuring that quality assurance activities such as reviews and software tests have been performed (Mandl-Striegnitz, 2004).

During the feedback session, the instructor presents views of available project data (Mandl-Striegnitz, 2004). Each view is connected to a specific aspect. This in turn is connected to learning objectives. The author explains this with the example “one view focuses on how the effectiveness of quality assurance activities is influenced, while another view concentrates on the influences on consistency between documents” (pg. 4).

The students are allowed to repeat the project so that they can implement the learning from the feedback session into the second simulation run (Mandl-Striegnitz, 2004). This is ultimately followed by a final feedback session. Questions such as aspects where improvements were made in the second phase, the implications of those improvements on the project outcomes and remaining problems are discussed in this session. The students were asked about their views on SESAM at the end of the training course. The students responded positively for questions regarding learning the functions of project management and managing the difficulties of a software project. The feedback session was considered to be a crucial part since it helped in

figuring out how to make improvements for the next simulation run. The chance of repeating the project by using different management strategies was also welcomed by students.

2.5.4 Euro Wonderland

Briers (2013) states that a case study was conducted on a gamified PMBOK based project management course for junior IT project managers in Europe. These employees work for an IT company called CTG Europe. This 2 day project management course has been organized for more than 10 years. The course is conducted in a room where all the project management activities are simulated. A national park is the second venue for this course where 8-10 project managers are shouldered with the responsibility of managing the startup of an entertainment park located within the national park. Role playing, realistic scenarios and common project stakeholder characters are some elements which are utilized by the junior project managers to plan and implement the entertainment project within the given scope, time and cost. The game simulates real life project changes such as a new ride request for the park or protest from ecologists to provide a learning opportunity for dealing with change management. Work breakdown structure, task lists and network scheduling are examples of some components of the PMBOK that are addressed by this game.

Briers (2013) further adds that Kirkpatrick model was used as the tool for measuring the extent of effectiveness of the gamified training by measuring changes in behavior. The following is the breakdown of the four levels of the Kirkpatrick model:

- Level 1 (“Reaction”): Did they like it?

Employees gave high scores for the game design, offsite location and the collaboration/exploration model that involved team competition. Majority of the participants mentioned that the gamified project management course highly motivated them to work longer for their company. On the basis of the aforementioned positive reviews, the author concludes that the gamified project management course increases employee satisfaction rate. This has a positive impact on the employee retention figures for CTG Europe.

- Level 2 (“Learning”): Did they learn it?

A gamified quiz was used to measure the retention level of what was learnt during the simulation course. Bonus points, penalty points, intergroup collaboration, intra group

collaboration via competition were the elements used to incentivize the participants to get a high score on the quiz. On comparing quiz results taken in a traditional classroom setting with the quiz results taken after the simulation course, it was discovered that participants scored higher in the latter quiz. Also, the simple context of the entertainment park was considered to be very realistic and fun by the participants which increased their motivation. In summary, this level of the Kirkpatrick model, enabled a better knowledge retention both from a qualitative and quantitative point of view.

- Level 3 (“Behavior”): Did they use it?

A long term behavioral change was measured for the participants after 6 months of the training. It was observed that the junior project managers who were a part of the training were more eager to follow the simulated approached compared to the other project managers. Thus, the author concludes that level 3 promotes a higher actual usage of knowledge.

- Level 4 (“Result”): Did it impact the bottom line? What is the Return on Investment (ROI)?

Briers (2013) concludes that the offsite training course involved additional costs for renting a house and gaming material. But the overall costs were still lower than sending employees to a similar external course that comprises of overnight stay at hotel rooms along with decreased level of the fun element. Since the techniques were comprehended and retained in a better manner, the author further concludes that the IT projects for CTG Europe are better managed. It is also mentioned that over the next few years, fewer projects went over budget and budget issues were handled efficiently. Risk management was also enhanced by the gamified course training. Overall, there was a positive ROI for CTG Europe by investing in the gamified project management course.

CHAPTER 3. METHODOLOGY

3.1 Research Question

Can simulation software integrated with gamification enhance students' understanding of project execution concepts by improving learning outcomes?

3.2 Research Setup – Fall 2017 & Spring 2018

Fall 2017 was the first semester when the simulation software was introduced to the students in the CNIT 480 – Managing Information Technology Projects course. There were four assignments with increasing level of difficulty. Students formed teams of three. The teaching assistants introduced the students to the SandboxModel Simulation Software during the lectures. Students documented the steps they took to complete each simulation assignment using a journal template provided to them. A completed Gantt chart and final project metrics were additional requirements of the journal. Full points were given if the project was executed within the given time and budget and the journal was filled out with proper details. The fourth assignment was an extra credit assignment and offered a bonus of 25 points to the teams who completed it. At the end of the semester, a perceptions survey was filled out by the students that asked them questions about their personal experiences while doing the simulation homework. The survey was posted as a word document on Blackboard Learn. The survey responses revealed that the students found the simulation assignments too easy.

In spring 2018, the difficulty level of the last two simulation assignments was increased by adding more tasks and resources, decreasing the resource show up rate, changing the quality values of each resource and reducing the amount of total cash available per simulation. The element of gamification was injected into the simulation assignments. Using the model of introduction of gamification into the field of e-learning, the following game elements were incorporated into the assignments (Urh, Vukovic & Jereb, 2015):

- Leaderboards: Leaderboards were used to display the score of each project simulation executed by the teams. The scores for the top ten teams were displayed on the leaderboard.

This element allowed students to see which scores were the highest for the current project and enabled them to compare their performance with the highest scores.

- Points: Each assignment was worth 20 points. The point breakdown was:
 - 5 points were awarded for completing the assignment according to instructions.
 - 5 points were assigned for the completion of the journal with proper rationales and pre-execution steps. During the grading of each assignment, a pre-created rubric based on systems thinking was used to assess students' comprehension level. Developing journal responses received a score of 1, emerging journal responses received a score of 3 and proficient journal responses received a score of 5.
 - The overall value score of every simulation was gamified and was worth 10 points. The team that had the highest project value received 10 points. The rest of the teams were given points based on the closeness of their value to the highest value obtained.

Points are a visual indicator which were awarded on the basis of the quality of the journal entries.

- Feedback: The leaderboard was regularly updated during the week of each simulation assignment. The students were able to see the scores of the top 10 teams in a real time scenario. They also had the opportunity to resubmit their assignment multiple times if they obtained a higher project value. However, the resubmission was allowed only till the deadline. The leaderboard acted as a medium of feedback for the students regarding the value score they attained for their project. After the submission of each journal, the teaching assistant provided feedback using the grading rubric.

The students took a survey about the triple constraints (scope, time and cost) before the introduction of the simulation tool. The instructor and teaching assistants introduced the students to the SandboxModel Simulation Software during the lectures. Following that, the students completed four simulation assignments using the tool. This semester, the students were split into teams of two. They retook the same triple constraints survey after the completion of four assignments. The pre and post triple constraint surveys helped in understanding whether the students were able to better comprehend the concept of triple constraints in project management after using the simulation software. Blackboard Learn was used to create and post the surveys.

The perception survey from last semester was used to create a point of comparison to see if student perceptions were improved by introducing gamification.

The research strategy for this paper can be explained using the model of phases of introducing gamification into e-learning systems (Strmečki, Bernik & Radošević, 2015). The main goal of teaching the triple constraint of project management to students using a gamified simulation software was decided during the analysis phase. In the design phase, the value score for every project scenario was gamified. The teams who managed to obtain the highest value score received the maximum points and the rest of the teams were allotted points on the closeness of their value to the highest value obtained. The development phase comprised of the creation of leaderboards, feedback using grading rubrics and points division per assignment. The simulation software along with game elements was introduced to students by the teaching assistants and professor during the implementation phase. This phase also involved clarification of student doubts. The students took the perception survey during the evaluation phase. The survey results were used to assess whether there was an enhancement of the subject matter comprehension of triple constraint of project management.

3.3 Research for Fall 2018

In fall 2018, the simulation assignments were introduced earlier in the semester i.e. during the ninth week of the semester. The perceptions assignments were used to assess whether gamification played any significant role in enhancing understanding of the triple constraint among students. The triple constraint survey was used to test whether the knowledge absorption of students increased after using the simulation software. Lastly, a qualitative theme analysis was conducted to identify the likes and dislikes of the students regarding the gamified simulation.

3.4 Subject Recruitment Process

Students from the CNIT 480 course were approached to take part in this study. The students were informed about the surveys during a class lecture. The surveys were created on Blackboard Learn. The students submitted the surveys on Blackboard for participation points.

3.5 Population and Sample

A convenience sample was used for this research study. The population was all the students who took the CNIT 480 course and the sample was the students who took the CNIT 480 course in the fall 2017, spring 2018 and fall 2018 semesters. Personal characteristics such as age, race and gender were not collected as a part of this research.

3.6 Data Collection Procedures

The data was collected through surveys posted on Blackboard. A five point Likert scale was used for collecting the responses of the perception questions which were used to record student perceptions of the simulation tool. SPSS software was used for data analysis.

3.7 Data Analysis

A chi square test was used to determine whether the introduction of gamification had any statistically significant difference in student understanding of project execution concepts. The chi square test was also used to measure whether students had a better comprehension of the triple constraint of project management after using the simulation software.

3.8 Trustworthiness

The validation procedure used for this research study was expert judgements and reviews. The research was reviewed in detail by a committee who have valuable teaching experience and expertise in the fields of technology, education, simulation and gamification. The aforementioned fields are all major components of this study. Hence, the committee members' inputs and directions during the timeline of the research study will help bring validity and reliability. Also, a representative of the statistical consulting department guided and reviewed the data analysis of this research.

3.9 Safety Concerns

The survey questions do not delve deep into the personal mindsets of the students. Thus, they are not exposed or compelled to answer any emotionally strenuous questions. The students will be taking the surveys in a classroom environment which is not hazardous in any way.

3.10 Timeline

Data Collection: By third week of April, 2018

Thesis Proposal: By last week of April, 2018

Data Analysis: By first week of November, 2018

Thesis Defense: By third week of November, 2018

CHAPTER 4. RESULTS

4.1 Chi Square Test Results

The data from the Perception Survey was analyzed using the chi square test with the objective of assessing any difference in student perceptions between the gamified and non-gamified semesters. The responses comprising of ‘Strongly disagree, disagree and don’t know’ were grouped together. This group had scores ranging from 0-3 and were categorized as negative responses. The responses comprising of Agree and Strongly Agree were grouped together. This group had scores ranging from 4-5 and were categorized as positive responses. The hypothesis used for data analysis was:

Null hypothesis: Student behavior towards the question has no significant association with the year information that represents the gamification.

Alternative hypothesis: Student behavior towards the question has a significant association with the year information that represents gamification.

The following are the chi square results for the first 8 questions of the Perception Survey:

Perception Q1: The simulation helped me better understand the importance of the critical path in managing schedule.

Table 4-1 Chi Square Analysis Perception Question 1

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	7.818 ^a	2	.020
Likelihood Ratio	9.635	2	.008
Linear-by-Linear Association	6.821	1	.009
N of Valid Cases	185		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 8.13.

Since the p-value 0.020 is less than the significance level $\alpha=0.05$, the null hypothesis was rejected, and it was concluded that gamification had a significant effect on student behavior towards the question. Thus, gamification played a significant role in helping students understand the importance of critical path in managing schedule.

Perception Q2: The simulation helped me better understand how to allocate and manage resources.

Table 4-2 Chi Square Analysis Perception Question 2

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	3.121 ^a	2	.210
Likelihood Ratio	3.378	2	.185
Linear-by-Linear Association	2.920	1	.088
N of Valid Cases	185		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 8.89.

Since the p-value 0.210 is greater than the significance level $\alpha=0.05$, the null hypothesis was not rejected, and it was concluded that gamification did not have a significant effect on student behavior towards the question. Thus, gamification played no significant role in helping students understand the allocation and management of resources.

Perception Q3: The simulation helped me better understand tradeoff analysis between time, cost and scope.

Table 4-3 Chi Square Analysis Perception Question 3

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	.674 ^a	2	.714
Likelihood Ratio	.666	2	.717
Linear-by-Linear Association	.349	1	.554
N of Valid Cases	185		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 15.75.

Since the p-value 0.714 is greater than the significance level $\alpha=0.05$, the null hypothesis was not rejected, and it was concluded that gamification did not have a significant effect on student behavior towards the question. Thus, gamification played no significant role in helping students understand the tradeoff analysis between time, cost and scope.

Perception Q4: The simulation helped me better understand the project manager's role during project execution

Table 4-4 Chi Square Analysis Perception Question 4

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	4.141 ^a	2	.126
Likelihood Ratio	4.291	2	.117
Linear-by-Linear Association	.046	1	.829
N of Valid Cases	185		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 15.50.

Since the p-value 0.126 is greater than the significance level $\alpha=0.05$, the null hypothesis was not rejected, and it was concluded that gamification did not have a significant effect on student behavior towards the question. Thus, gamification played no significant role in helping students understand the project manager's role during project execution.

Perception Q5: The simulation helped me better understand the importance of project planning.

Table 4-5 Chi Square Analysis Perception Question 5

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	6.578 ^a	2	.037
Likelihood Ratio	6.586	2	.037
Linear-by-Linear Association	3.813	1	.051
N of Valid Cases	185		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 10.92.

Since the p-value 0.037 is less than the significance level $\alpha=0.05$, the null hypothesis was rejected, and it was concluded that gamification had a significant effect on student behavior towards the question. Thus, gamification played a significant role in helping students understand the importance of project planning.

Perception Q6: The simulation was fun and interesting.

Table 4-6 Chi Square Analysis Perception Question 6

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	16.963 ^a	2	.000
Likelihood Ratio	17.533	2	.000
Linear-by-Linear Association	16.408	1	.000
N of Valid Cases	184		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 23.24.

Since the p-value 0.000 is less than the significance level $\alpha=0.05$, the null hypothesis was rejected, and it was concluded that gamification had a significant effect on student behavior towards the question. Thus, gamification played a significant role in making the simulation fun and interesting for the students.

Perception Q7: Working in teams was the best way to do the simulations.

Table 4-7 Chi Square Analysis Perception Question 7

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	.012 ^a	2	.994
Likelihood Ratio	.012	2	.994
Linear-by-Linear Association	.004	1	.952
N of Valid Cases	185		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 18.29.

Since the p-value 0.994 is greater than the significance level $\alpha=0.05$, the null hypothesis was not rejected, and it was concluded that gamification did not have a significant effect on student behavior towards the question. Thus, gamification played no significant role in the context of teamwork for the simulations.

Perception Q8: The simulations were too easy.

Table 4-8 Chi Square Analysis Perception Question 8

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	11.980 ^a	2	.003
Likelihood Ratio	11.322	2	.003
Linear-by-Linear Association	10.613	1	.001
N of Valid Cases	185		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 11.43.

Since the p-value 0.003 is less than the significance level $\alpha=0.05$, the null hypothesis was rejected, and it was concluded that gamification had a significant effect on student behavior towards the question. Thus, gamification played a significant role in making the simulation too easy.

4.2 Fisher's Exact Test Results

The Triple Constraint Survey data was analyzed using the Fisher's Exact test. Students took this survey before and after using the simulation software. Students who had copied their answers for the pre and post surveys were given a pre-score of 0 and a post score of 0. If the level of understanding for the students remained unchanged for the triple constraint before and after using the simulation, they were given a pre-score of 5 and a post-score of 5. If students had a better understanding of the triple constraint after using the simulation software, they were given a pre-score of 0 and a post score of 5. References to the simulation in terms of balancing the triple constraint, fast tracking, parallel tasks and quality values for resources were some keywords used to assess the level of student understanding.

The fisher's exact test is used to in this case. The null hypothesis is that the simulation software and student understanding of triple constraint are independent of each other. The alternative hypothesis is that the simulation software has a significant influence on student comprehension of the triple constraint of project management. The following are the results of Fisher's Exact test for the Triple Constraint Survey:

Table 4-9 Fisher's Test Results for Triple Constraint Survey

Chi-Square Tests					
	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	19.861 ^a	1	.000		
Continuity Correction ^b	17.593	1	.000		
Likelihood Ratio	26.442	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-Linear Association	19.693	1	.000		
N of Valid Cases	118				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 8.50.

Since the p value 0.000 is less than the level of significance $\alpha=0.05$, the null hypothesis was rejected, and it was concluded that the simulation software has a significant influence on student understanding of the triple constraint of project management.

4.3 Qualitative Theme Analysis

The Perceptions Survey contained open ended questions about what the students liked and disliked about the simulation. A qualitative theme analysis was conducted to analyze the student responses for these questions. The following overarching themes were identified:

Likes:

- **Relatable to real world projects:** The simulation provided students the opportunity to get hands on experience with simulated scenarios of real world projects. Also, the effect of decisions made by students were available for them to see in real time.
- **Team Work:** Several students enjoyed working in teams since that allowed them to have a variety of ideas on the table and think through different perspectives.
- **Different from other homework:** The simulations broke the monotony of normal lectures and other homework assignments. They were considered to be a better method of learning for project management instead of lectures. Some students even called the simulations the best part of the course
- **Learned about Triple Constraint:** Students found the simulation software to be really useful in obtaining a better understanding of scope, time and cost concepts of project management. Resource management was found to be an important focal point.
- **Favorable aspects of simulation:** The simulations were found to be a fun, interactive, interesting and engaging way of learning about project management. The color codes for resource availability was found to be beneficial. The graphs for resources helped in visualization. Some students considered the simulation to be a game. The gamification aspect made it competitive which was an enjoyable experience.
- **Unpredictability of resources:** Students liked the challenge of resources not turning up for work.

Dislikes:

- **Team Work:** Many students found it difficult to work in teams and preferred to do the assignments individually. It was mentioned that while one team member was working on the simulation, the other member/members often tended to slack. Some team members were not cooperative at all and all the work fell on the shoulders of one person. Some

students found it difficult to make time to meet during the final semester which was a backlog. Working with teams made the simulations time consuming.

- Writing Journals: The documentation of the steps and rationales for executing the simulation was found to be tedious and unnecessary. The journal instruction, expectations and layout were disliked by the students.
- Incompatibility issues: The software could not be used on Macs. The limitation of Edge and Internet Explorer browsers was an unpopular aspect.
- Difficulty of simulations: Some of the simulation assignments were found to be very difficult. It was hard to execute till the end at the first try.
- Difficulty in understanding the software: Some students did not like the GUI of the simulation software. The interface was not very easy to use and there was no proper documentation for the use of each feature of the interface.
- Randomization of Resources: The unpredictability of resource attendance was disliked by a number of students. It seemed more like trial and error till the correct results were achieved.
- Limited challenges: The major risk was employees not turning up for work. There were no other risks to tackle.
- Inability to save: The lack of save or undo features were detested by students.
- Test Subjects: Some students felt that they were being used as test subjects for the simulation. The simulation assignments were skewed more towards gaining research results of how students behave when they are placed in a certain environment instead of being focused on enhancing educational goals.
- Unclear resource show-up messages: The pop-up error messages that contained explanations about the unattendance of a resource were found to be inadequate. Clearer explanations were required for such scenarios. These error messages could also be made more interesting. For example, 'Oh no, Engineer Annie lost a foot jumping from a train/car and now you're down an Engineer!'.

CHAPTER 5. DISCUSSION

The purpose of this study was to identify whether simulation software integrated with gamification can enhance students' comprehension of project execution concepts by the improvement of learning outcomes. Students who took the CNIT 480 course in Fall 2017, Spring 2018 and Fall 2018 were used as subjects for this research.

It is important to consider certain methodological limitations for interpreting the results for this study. Convenience sampling and exclusion of personal characteristics such as age, gender and career perceptions restricted the extent of analysis that could be conducted.

The analysis of perceptions of students towards the simulation software reveals that gamification was not successful in enhancing students' understanding of project execution concepts. The only areas where gamification showed statistically significant difference in student understanding was the importance of critical path in managing schedule and importance of project planning. On comparing the data of the three semesters, no statistically significant differences were observed in student perceptions regarding project execution concepts. Gamification was only used in the Spring 2018 and Fall 2018 semesters.

However, the analysis of the triple constraint survey data showed that the simulation software was significant in enhancing student understanding of the triple constraint of project management i.e. scope, time and cost. Qualitative theme analysis of student perceptions provided an insight into the aspects of the simulations that were liked and disliked by the students. There were very few comments regarding the gamification aspect but the simulations were found to be interesting and engaging by the students. It helped them better understand the triple constraint of project management in a real-world context. However, it is important to note that certain aspects like the journal writing, unavailability of saving option, incompatibility of the software with Macs and other browsers and the randomness of resource unattendance were disliked by students. These are potential areas for improvement. It is interesting that the aspect of team work was both liked and disliked by the students.

It can be inferred that the simulation was an overall success in the improvement of learning outcomes i.e. the triple constraint but the gamification aspect did not have an important part to play in the educational aspect. Overall, the gamification aspect was not a prominent area of focus in student responses. However, gamification made the simulations fun and interesting. The

qualitative theme analysis adds to this inference since students appreciated the competitiveness caused by the gamification of the project benefit score. We can further conclude that the game aspect made the groups compete against each other to get a better benefit score. It improved the engagement factor of the simulation assignments but did not play a significant role in enhancing the subject matter expertise of the participants. This can be because only one aspect of the simulation was gamified. Limited game components were utilized in this research study due to the layout and restricted abilities of the project management simulation software. The software only focusses on the areas of scope, time and cost. Other important knowledge areas of project management such as communication management, risk management etc. are not addressed by this software which could have heightened the overall challenge component.

CHAPTER 6. CONCLUSIONS

The study concluded with the result that gamification did not have a significant role in enhancing student understanding of project execution concepts and only simulation was effective in improving the subject matter comprehension regarding the triple constraint of project management. There were no statistically significant differences in student perceptions on comparing the data from Fall 2017, Spring 2018 and Fall 2018 semesters regarding project execution concepts.

The triple constraint survey results showed that the simulation software was effective in enhancing the learning outcomes of project execution concepts. The qualitative theme analysis further revealed that the simulation software was considered as a fun, interesting and engaging way of teaching project management concepts. Thus, it can be concluded that the simulation independent of gamification was a success.

Since personal characteristics were not considered while conducting this research, it is difficult to conclude whether they had an influence on the results of this study. It is important to note that this course is mandatory for graduation and the career interests of students might not be in alignment with the objectives and learning outcomes of this course.

Further research in this area can focus on creation of scenarios that are related to the major concentrations or career interests of students. Individual characteristics can be taken into consideration for assessing whether the gamified simulation is more popular for a particular demographic group. Students can be split into groups of domestic and international students or grouped by first language preference. The gamified simulation was only implemented in CNIT 480 course. The sample size is limited in this case. A larger sample size would facilitate a wider pool of subjects for carrying out this research. Gamification of the cash amount left at the end of project execution, addition of more dynamic and interesting error messages for resource unattendance which are relatable to the real-world happenings and incorporation of other aspects of project management such as risk management are some supplementary ideas for enhancing the simulations.

APPENDIX A. PERCEPTIONS

This Survey was created by Professor Kevin Dittman who is an Associate Professor in the Department of Computer Networking and Information Technology at Purdue University. This survey gathers the perceptions of students about the simulation software they used for CNIT 480 – Managing Info Tech Projects course.

Thinking about your personal experiences in doing the project simulation homework, to what extent do you agree with the following statements? *(Hi-light in Yellow the best response to each statement.)*

Statements about the Simulation	Strongly Disagree (1)	Disagree (2)	Don't Know (3)	Agree (4)	Strongly Agree (5)
a. The simulation helped me better understand the importance of the critical path in managing schedule.	1	2	3	4	5
b. The simulation helped me better understand how to allocate and manage resources.	1	2	3	4	5
c. The simulation helped me better understand tradeoff analysis between time, cost and scope.	1	2	3	4	5
d. The simulation helped me better understand the project manager's role during project execution	1	2	3	4	5

e. The simulation helped me better understand the importance of project planning. 1 2 3 4 5

f. The simulation was fun and interesting. 1 2 3 4 5

g. Working in teams was the best way to do the simulations. 1 2 3 4 5

h. The simulations were too easy. 1 2 3 4 5

i. What did you like best about doing the project simulations?

j. What did you like least (other than not being able to save) about doing the project simulations?

k. Additional Comments.

APPENDIX B. PROJECT MANAGEMENT TRIPLE CONSTRAINT PERCEPTION

In your own words, explain the triple-constraint of project management based on your prior project experiences and what you've learned in this class.

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