

## **Peer-based Gamification Products Critiquing: Two Case studies in Engineering Education**

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# Peer-based Gamification Products Critiquing: Two Case studies in Engineering Education

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## Abstract

Gamification has been emerging as a pedagogical tool over the past few years, and numerous studies report positive outcomes from games applied in educational environments. However, researchers rarely discuss the gamification development process. Little work has been done to analyze their gamification in terms of usability, game elements, etc.. In addition, in most previous studies, students are the end user, and only get involved in the final test to provide data on motivation, engagement or learning outcomes. Under the circumstances, the following questions are left unaddressed: how to evaluate the effectiveness of a gamification product in education? What do students learn when they create and critique gamification products? This paper proposes a peer-based gamification critique process based on peer-developed game products. We expect such a process will provide valuable feedback from an end-user perspective and that the outcomes will help to answer the above questions.

This present study is an extension of a previous research cycle in which end users (students) developed gamification products to help students learn challenging concepts in industrial engineering courses. We selected four final gamification products for further evaluation: “Avengers”, “Bake-off-453”, “Gulf games” and “DungeoNIOSH”. These games are intended to teach the concepts of: “Discrete probability distributions”, “Gulf of evaluation vs. Gulf of execution”, “Interaction effects” and “NIOSH Lifting equation”. The first two are basic concepts in statistics, and the last two relate to the human factor/ergonomics domain. In this study, we had two student teams conduct a critique of these gamification products as their Capstone project. Peer-based critiques consist of three main steps after matching the teams with their interested game products: firstly, critiquing the gamification product from a game perspective, including metrics like what types of game elements are included, interactivity, motivation, engagement level, et al. secondly, evaluating the gamification products on aspects of education and focusing on the learning effectiveness; finally, critiquing gamification products based on usability guidelines and principles. Student teams were instructed to specify each criterion and cover all three aspects. At the end of this paper, two case studies are presented, showing the final critique criteria developed by student teams. Most importantly, we will collect valuable insights from end users, i.e., what they can learn from the critiquing process, what lessons we can learn from their feedback. These will provide us with meaningful information to help evaluate gamification products designed to enhance engineering concept learning.

## Keywords:

Peer-based Gamification, Engineering Education

## Introduction

Gamification is commonly known as the application of game elements in non-game contexts [1]. Game elements include badges, score systems, leaderboard, levels and so on, and they tend to motivate the game player to engage. In recent years, gamification has seen a rapid application in the education field due to the fact that game products can enhance student engagement in learning through an increase in students’ motivation [2-8]. In order to motivate students to learn,

gamification uses game mechanisms, like clear, achievable goals [2-4, 8], challenges and quests [3, 5, 7], frequent feedback [2, 4, 9], a narrative context around a task [10], an encouraging competition [6], and visual display of progress [4, 7, 11]. Typical gamification research involves empirical investigation of the effectiveness of pre-designed gamification products via means of direct and indirect observation and pre-/post- test. However, outcomes from gamification studies in educational settings have been inconsistent. Although some studies showed positive or partially positive effects of gamification on student learning [12-15], other studies indicated no differences or negative results in gamification groups compared with non-gamification groups [16, 17]. The main reasons for mixed results of gamification research in education were argued to be likely because of using various game elements (i.e. badges, score, leaderboard, etc.) together with a limited time period [18].

Furthermore, previous researchers rarely discuss the gamification development process, and little work has been done to analyze or evaluate gamification products in terms of usability, game elements and education. Besides, in most previous studies, students play a role as the end users, and are only involved in the final test procedure to provide data on motivation, engagement, or learning outcomes. Under the circumstance, the following questions are left unaddressed: how to evaluate the effectiveness of a gamification product in education? What would students learn if they create and criticize gamification products? To answer the above research questions, this paper proposes a peer-based gamification critiquing process based on peer-developed gamification products. Both the development and critique processes were applied through Capstone projects. Capstone projects in the United States have become increasingly popular among many engineering education programs under ABET requirements since the 20th century [19-21]. Capstone projects are different from traditional engineering courses in terms of providing senior-standing engineering students with experience solving “real world,” open-ended problems.

During the Spring semester in 2016, we coordinated Capstone projects as well as a senior-level design course, in both of which student teams developed gamification products in order to help end users (students) master important engineering concepts. Later, in the Fall of 2016, two Capstone teams (different teams from the previous semester) were formed to critique the pre-designed gamification products. This paper discusses the critique process and presents two case studies, showing the final critique criteria developed by the student teams. Most importantly, we expect to collect valuable insights from end users, i.e., what students can learn from the criticizing process, and what lessons we would learn from their feedback. These would provide us with meaningful information to evaluate gamification products designed to enhance student learning of engineering concepts and provide valuable feedback from the end user perspective.

### **Method/Process**

As mentioned in the introduction, this present study is an extension of a previous research cycle in which end users (students) developed gamification products to help students learn challenging concepts in industrial engineering courses. We selected four final gamification products for further evaluation in this research cycle: “Avengers”, “Bake-off-453”, “Gulf games” and “DungeoNIOOSH”. These games intend to teach the corresponding concepts, respectively: “Discrete probability distributions”, “Gulf of evaluation vs. Gulf of execution”, “Interaction effects” and “NIOOSH Lifting equation”. The first two are basic concepts in statistics, and the last two relate to human factor/ergonomics domain. These four gamification products will be

described in brief later. In this study, two student teams conducted the critique as their Capstone projects. The project process and time-line is shown in Figure 1 with a detailed description below.

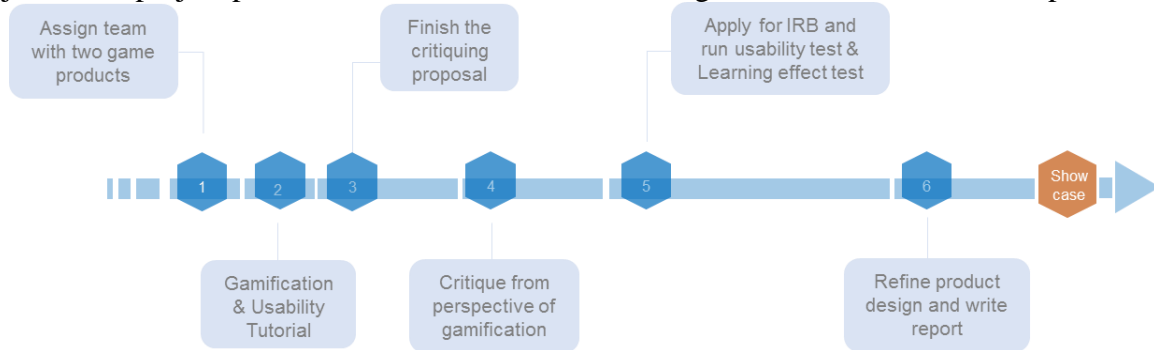


Figure 1 Project Process and Time line

Stage1 (one week):

Assigned team two game products based on their interests; the game products were developed by previous students, not by these students

Stage2 (one week):

The investigators taught the teams gamification concepts and basic game elements at the beginning of the semester, and provided a tutorial on usability tests as well as a brief guideline of the criteria the teams should pay attention to.

Stage3 (two weeks):

Teams familiarized themselves with the game products and then made a plan for how to critique them; they needed to gather all the information and methodology that could help with the critiquing process; in the end, they wrote up a proposal stating their plans. The proposal was viewed by instructors for Capstone and feedback was provided to the team; necessary corrections were recommended;

Stage4 (two weeks):

Student teams first developed their own critique criteria from a gamification perspective since the usability test or learning effect test needed IRB approval; teams critiqued the products based on their gamification criteria; the design and corresponding recommendations were proposed; a mid-term report was required.

Stage5 (three to four weeks):

Student teams prepared the IRB application (all test designs included) and once it was approved, participants were recruited for the usability test and the learning effectiveness test; students collected data based on their own test design and analyzed the data; in the end, students provided improvement recommendations according to their test results.

Stage6 (two week):

Student teams concluded all the findings and submitted a final report; both teams presented their projects to the instructors.

One thing we need to address here is that the main objective of this project is to learn lessons from the critiquing process, especially in the case that both the designers and the critics of the gamification products are the end users, that is, students. However, considering that students may not have any background information about gamification, necessary tutorials were provided. Some general framework was also provided as a guideline. The guideline provided three critique criteria: gamification perspective, usability perspective, and learning effectiveness perspective.

## Results

This section summarizes the critiquing results of two case studies, conducted by two student teams, each of which dealt with two gamification products. In each case study, the student team developed a set of criteria to evaluate the two gamification products and they proposed improvement recommendation based on their findings. At the end of the section, we included a questionnaire aimed to collect feedback from the two student teams.

### Case study 1

#### *Gamification product description:*

The first game is called Gulf, which is aimed to help students distinguish two human factor concepts: gulf of evaluation and gulf of execution. The gamification product consists of three levels: easy, medium and hard. It provides various examples including some website and apps to demonstrate the design flaws. Then the users need to figure out whether the problem is due to the gulf of evaluation or the gulf of execution. The other game is Avengers, which adopts Avengers as the background story and helps users to identify discrete probability distributions and to learn joint probability. The game includes (1) coin flipping as the real-world example to help understand the distribution feature and (2) a set of questions as a self-test for the users.

#### *Criteria of critiquing:*

Student team 1 developed the following criteria (see Table1).

Table1 Critiquing criteria and formats from Team 1

Criteria	Definition	Format	Product applied
<b>Gamification perspective</b>	Examines the product for its adaption to the core properties of gaming	Scale scoring for the predefined game elements (see Table2)	Gulf
		Own Survey (see Table.3)	Avengers
<b>Educational perspective</b>	Revisits the learning concepts and rates the product's impact on addressing these concerns	Pre- and Post- test with control group (lecture)	Avengers
		Own Survey (see Table.3)	Avengers
<b>GUI Design perspective</b>	Aims to evaluate the overall usability of the application	Ten heuristics with six tasks, total ten heuristics are shown in Table 10	Gulf
		Own Survey (see Table.3)	Avengers

Table 2 Scale scoring for gamification elements from Team1

Score	Description
<b>1</b>	Gamification element not displayed
<b>2</b>	Lackluster implementation, improvement needed
<b>3</b>	Basic integration
<b>4</b>	Full integration of gamification elements

For Gulf, gamification perspective scales and the Ten Heuristics approaches (for more information, please check <https://www.nngroup.com/articles/ten-usability-heuristics/>) were applied. The scale scoring system was designed as in Table 2.

For Avengers, student teams conducted a pre/post-test with a control and treatment group. The control group was presented a short lesson in the form of a PowerPoint review on the concepts of

joint probability and discrete probability, while the treatment group played and completed the Avengers game. Both the pre- and to post- test consists of seven test questions. They also developed the survey shown in Table 3 and collected subjective feedback from the treatment group in terms of the education as well as the usability.

Table 3 Survey for the gamification group

Domain	Question	Rank
Gamification and Education	Do you often play games?	Yes/No
	Did the structure of the game increase your want to learn the material?	Strongly Agree
	The gamification method of learning joint distribution was easier to understand and retain compared to how it was taught during class?	5 <input type="radio"/>
	The gamification method of learning discrete probability distribution was easier to understand and retain compared to how it was taught during class?	4 <input type="radio"/>
	If joint distribution or discrete probability distribution were to appear on the exam, did the game make you feel confident in knowing how to complete questions involving those concepts?	3 <input type="radio"/>
	Were there enough questions to help in learning the material?	2 <input type="radio"/>
	Would timing the question make the application more effective and realistic?	1 <input type="radio"/>
	Would adding explanations to why the answer was correct or incorrect help you understand the topic more?	Strongly Disagree <input type="radio"/>
	What gamification aspects (points, badges, leaderboards, levels, feedback) would help in motivating you to learn?	Strongly Disagree <input type="radio"/>
Usability	I think that I would like to use this system frequently	Strongly Agree <input type="radio"/>
	I found the system unnecessarily complex.	Strongly Agree <input type="radio"/>
	I thought the system was easy to use.	5 <input type="radio"/>
	I think that I would need the support of a technical person to be able to use the system.	4 <input type="radio"/>
	I found the various functions in this system were well integrated.	3 <input type="radio"/>
	I thought there was too much inconsistency in this system.	2 <input type="radio"/>
	I would imagine that most people would learn to use this system very quickly.	1 <input type="radio"/>
	I found the system very cumbersome to use.	Strongly Disagree <input type="radio"/>
	I felt very confident using the system.	Strongly Disagree <input type="radio"/>
	I needed to learn a lot of things before I could get going with the system.	Strongly Disagree <input type="radio"/>
Overall	Please add suggestion(s) to the box below about the game design and game elements. Your feedback is greatly appreciated.	Open ended

Notes: "System" in this questionnaire refers to the "Avengers"

*Critiquing results and recommendation:*

Gulf game: Table 4 shows the critiquing results including students own comments from the perspective of gamification. Students scored badges the highest and points, leaderboard, progression, and status the lowest. The average rate is 1.88. The evaluations result in the following five recommendations for improvement: (1) Add points systems to each difficulty/stage where players receive points after each problem, (2) Incorporate leaderboard, (3) Add fun and interesting rewards, (4) Integrate all three difficulty levels (easy, medium, hard) into one, and (5) Have ranks within the leaderboard to indicate player status. Table 5 summarizes the results from GUI Design perspective based on the Ten Heuristics. Six tasks were conducted and the most frequent usability problem was 'user control and freedom' showing five times out of six tasks in gamification. The solutions to improving were proposed as in the table.

Table 4 Gamification aspect critiquing results- Gulf game

Gamification element	Definition	Alternatives	Score	Comments (simplified)
Point	Numerical units indicating progress	Experience, Points, Score	1	The game does not employ the any element of a points system.
Badges	Visual icons signifying achievements	Trophies	4	The game utilizes the badge element effectively. Use Bronze, Silver, Gold badges as a trophy system to indicate the level of mastery.
Leaderboards	Display of ranks for comparison	Rankings, Scoreboard	1	The concept of a leaderboard is not present within the game.
Progression	Milestones indicating progress	Levelling up	1	The game does not contain any milestones for clear indication of progression.
Status	Textual monikers indicating progress	Titles, Ranks	1	The game does not use titles, ranks or any textual monikers to indicate the player's progress.
Levels	Increasingly difficult environments	Stage, Area, World	2	The game is separated into 4 levels: tutorial, easy, medium and hard. The player freely selects the level and remains within the 'level' until completion. Measure of difficulty was dependent on the length of the problem as opposed to actual difficulty of the task itself. In no way does the game integrate a sense of different stages, area, world or environment.
Rewards	Tangible, desirable items	Incentives, Prizes, Gifts	2	The game only uses the badges as a reward. The game also provides complementary text when player answers question correctly.
Roles	Role-playing elements of characters	Class, Character	3	The game does a good job in "fitting" the player into a specific role. However, it lacks a degree of freedom where the player is not in control of its character. It lacks the element of class, where individual players may perceive themselves as a unique character.

Table 5 GUI Design aspect critiquing results- Gulf game

Task	Failed Heuristic	Description	Solution
Open application and begin at the home page	3: User control and freedom	3- No 'back' option; does not support undo and redo	3-Integrate a 'back' or 'undo' button
Begin and advance through tutorial	3: User control and freedom; 7: Flexibility and efficiency of use	3- Same with above 7- Users are forced to participate in tutorial regardless of experience	3- Same with above; 7- Make the tutorial as an option
Select degree of difficulty	3: User control and freedom	3- Same as above	3- Same as above
Advance through module by completing questions	3: User control and freedom	3- Same as above	3- Same as above
Select the next difficulty or repeat current difficult	3: User control and freedom; 9: Help users recognize, diagnose, and recover from errors	3- Same as above 9- A design error prevents the completion of the game, and no error messages were displayed	3- Same as above 9- no solution provided
Exit application when all difficulties are mastered	10: Help and documentation	10 – No documentation or help is provided	Make the tutorial as an option

Notes: Numbering the heuristic helps to organize the results (see Table 10 for the definition), please check <https://www.nngroup.com/articles/ten-usability-heuristics/> for more information in terms of the Ten Heuristics

Avengers game: There were 9 participants for the control group and 10 for the treatment group (all undergraduate students, gender information was not specifically recorded). It was a between subject design. The correctness of each question was counted and the increment of the percentage correctness was calculated, and positive Correctness Increment values refers to positive learning effect (see Table 6 and Figure 2). Results show that the gamification group indeed improved the test performance, more effectively compared to the lecture. The overall results were inconclusive considering that the lecture was given by students, not advisors. The student team failed to discuss the survey results in detail. Final recommendations for the Avengers game included: (1) deleted the coin flipping section; (2) Integrate a 'back' or 'undo' button; (3) Help or documentation for user reference; (4) Make the tutorial optional.

Table 6 Pre- and Post-test results -Avengers game

	Pre-test correctness (count)		Post-test correctness (count)		Correctness Increment (%)	
	Control	Avengers	Control	Avengers	Control	Avengers
Q1	2	2	2	3	0	0.1
Q2	1	1	2	4	0.11	0.3
Q3	1	1	2	9	0.11	0.8
Q4	2	0	3	4	0.11	0.4
Q5	4	3	3	6	-0.11	0.3
Q6	8	7	8	9	0	0.2
Q7	0	1	1	3	0.11	0.2
Ave.	2.57	2.14	3	5.43	<b>0.05</b>	<b>0.33</b>

Notes: Questions were not included due to the length limit, they were all related to the probability distributions and the joint probability

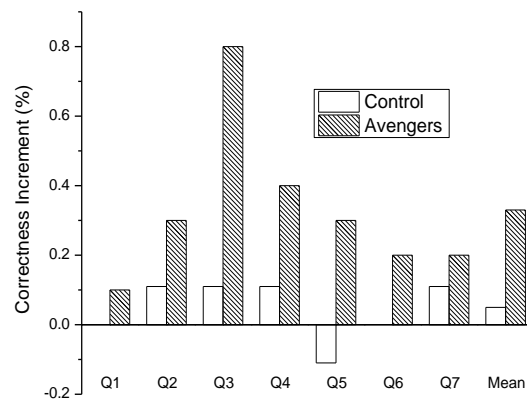


Figure 2 Correctness Increment Results

## Case Study 2

### *Gamification product description:*

The first gamification product is DungeoNIOSH, a game aimed to help users better understand the National Institute for Occupational Safety and Health (NIOSH) lifting equation. The NIOSH lifting equation has many variables and limitations that are difficult to memorize and may get product users confused. The other game is Bake-off-453, which attempts to help users understand the concept of interaction effect through a bakery game.

### *Criteria of critiquing:*

Student Team 2 developed the criteria in Table 7. They mostly critiqued the DungeoNIOSH, and applied the Ten Heuristics to the Bake-off-453. They developed a pre- and post-test with no



control group, along with the Gamification & Learnability survey, and the Usability survey shown in Table 8.

Table 7 Critiquing criteria and formats from Team2

Criteria	Definition	Format	Product applied
<b>Gamification</b>	Critiquing game products in terms of whether the product provides better learning experience	Gamification Survey- questions were integrated with learnability	DungeoNIO SH
<b>Learnability</b>	To see if the game products can enhance the concept learning	Pre- and Post- test (No control group)	DungeoNIO SH
		Learnability survey-questions were integrated with gamification	
<b>User interface</b>	Usability	Ten Heuristics	Bake-off-453
		Usability Survey	DungeoNIO SH

Table 8 Survey questions from Team2

Domain	Question	Rank
<b>Gamification and Learnability</b>	Do you regularly play game?	Yes/No
	Do you agree or disagree with the following statement: I am familiar with Game elements such as level, badge, leader-board, and ranking?	Strongly Agree 1 – Strongly Disagree 5
	Would you continue to play the game to complete it in a faster time?	Yes/No
	Would you try to best your classmates time?	Yes/No
	Do you agree or disagree with the following statement: These game elements increased my enjoyment of doing activities?	Strongly Agree 1 – Strongly Disagree 5
	Do you agree or disagree with the following statement: These game elements would motivate me to participate more than I would have otherwise?	Strongly Agree 1 – Strongly Disagree 5
	Would this game be a helpful way to enhance teaching?	Yes/No
	What game elements made you enjoy playing this game?	Open ended
	What could be added to make this game more fun? (Eg: Score, Badge, Level, Ranking, Feedback, Avatar, etc.)	Open ended
<b>Usability</b>	I think that I would like to use this system frequently.	Strongly Agree 1 – Strongly Disagree 5
	I found the system unnecessarily complex.	
	I thought the system was easy to use.	
	I think that I would need the support of a technical person to be able to use this system.	
	I found the various functions in this system were well integrated.	
	I thought there was too much inconsistency in this system.	
	I would imagine that most people would learn to use this system very quickly.	
	I felt very confident using the system.	
I needed to learn a lot of things before I could get going with this system.		
<b>Overall</b>	Are there any suggestions you would make to improve the User Interface of this game?	Open ended

*Critiquing results and recommendation:*

**DungeoNIO SH:** A total of 15 participants (all undergraduate students, gender information was not specifically recorded) were recruited for the tests and the survey. First, the results of the pre- and post-tests showed that the average score for the pre-test was 3.08 out of 6 and the average result for the post-test was 5.18 out of 6. This shows us that the students did learn from playing the game and that the game is an effective way of teaching. Second, key findings from the Gamification & Learnability survey showed that participants would choose to replay the game to get a better score. They also would try to beat their classmates and they believed that the game should be implemented as a way of teaching. In terms of the redesign recommendation, the team

decided to make improvements based on participants' feedback, including providing penalties and hints, and adding a character or avatar.

Bake-off-453: The Ten Heuristics was used to evaluate the user interface design of this game. The student team walked through all the Heuristics, and the results were summarized as in Table 10.

Table 10 Ten Heuristics results for Bake-off-453

Ten Heuristics	Comments	Solution
1: Visibility of system status	The game keeps the user informed at all times because through every screen there are instructions on what to do.	-
2: Match between system and the real world	This game matches real world language. It is a simple game and has simple instructions, even when explaining graphs the game uses common knowledge language	
3: User control and freedom	This system <b>does not</b> clearly show an exit button. If a user accidentally clicks a button by mistake, the user needs to figure out how to proceed from that screen or needs to restart the game.	add a "Back" button in order to return to the previous screen
4: Consistency and standards	This game is very simple, there are only a couple of buttons to click	
5: Error prevention	There is <b>no</b> error prevention in the game. In order to return to the previous page is either restarting the game or finishing the task to return to the home screen.	add a "Back" button in order to return to the previous screen
6: Recognition rather than recall	All the buttons or objects that are needed to be pressed on are visible due to them being big buttons.	-
7: Flexibility and efficiency of use	As the game starts, there is a good description of what will happen throughout the game. That makes the game easy to use. A short game, not too many buttons to click.	-
8: Aesthetic and minimalist design	This does not apply due to this game needing to have an educational aspect	-
9: Help users recognize, diagnose, recover from errors	This does not apply because there is no error message that will pop up in the game.	-
10: Help and documentation	There is <b>no</b> help button, report, or a document explaining the walkthrough of this game, or to explain what is needed to successfully complete the game.	Add a small symbol, a question mark in the corner, when clicked would address objectives of the game and display hints.

## Discussion

Given the fact that a guideline with three critique criteria (gamification, education, usability) was at first provided to the student teams, it was not a surprise to find that both teams developed criteria containing these three perspectives. The detailed formats were different based on their own understanding of the criteria and the game products. First, from the gamification perspective, both teams developed their own questionnaire to address this perspective, but integrated gamification with the education/learning effectiveness in those questions. It is understandable since the gamification was applied to the education domain. Most of the questions focused on the motivation created by the gamification products. Student teams believed that if a game product motivates end users to study more, then the product performs well from the perspective of the gamification. Team 1 also created a scaling system to critique

the game product based on the use of game elements, the judgment was from the student team themselves. Team 1 believed that products should contain game elements in order to be considered to be good game products. Second, from the educational perspective, both teams designed a test in order to make a judgement on whether the game products would enhance learning, which was pretty common in literature [22, 23]. The difference was that Team 1 designed a control group with a PowerPoint tutorial while Team 2 did not. Both teams found a positive outcome. However, with no control group in Team2, the better performance could also be due to reviewing outcomes from the pre-test question. For the survey questions related to education, both teams focused on the subjective confidence of mastering the knowledge. Third, from the usability perspective, Ten Heuristics and a self-designed survey were both used by the two teams, which was predictable since the tutorial given includes these methodologies. One limitation of this study was that due to the design of the Capstone course, the study investigators had in total three meetings with the student teams, offering limited instruction, resulting in some uninformed data analysis and usability evaluation processes. For example, student did not apply all the critiquing criteria to both gamification products or they did not run standard statistical data analysis on the collected data. Also, the pre- and post- test questions may not be effectively enough to test students' understanding of the concepts. In addition, students failed to report the demographic information of their test participants. However, the quality of the analysis procedures was not the focus of this study.

After applying the designed criteria to the assigned game products, the two teams gave their recommendations to improve the products. Since both teams have a positive outcome in terms of learning effectiveness (education perspective), neither of them recommended changes on the fundamental designs related to the education. For example, all the game products included some quiz questions for the end users to answer, but neither team actually made changes, such as choosing different questions, to the Q&A section. One exception is that in the Avenger game product from Case Study 1, the original game includes one-coin flipping section to help end users understand the distribution, but Team 1 decided to delete this part because they thought it was useless. In fact, the tutorial section in this game was insisted by an instructor when the game was developed (from a previous project in which gamification products were developed), but students may have a different opinion on this section, which may explain the tangential feeling of this element and the recommendation for its removal. All the other recommended changes were from a usability perspective, except that Team 1 recommended a gamification change to the Gulf game, i.e. adding points systems. Most of the recommendations were related to the usability, which was not surprising, since usability issues are more apparent than others. This phenomenon indicates that students focus more on the practical part of the game products, and, as the end users of the products, they could not identify as many reasons related to the tutorial/educational designs of the gamification products, but were able to identify challenges such as interactions with respect to the use of these products. In other words, they are experienced with practicing the questions offered by the instructors, but not experienced with creating the tutorial materials. For the educational gamification products, the end users, i.e., students, can offer valuable feedback on the usability and the practice of knowledge, but can contribute little to the design ideas of the products in terms of how they will help students master knowledge. This is where the instructors/educators should contribute. This was also proved by the previous Capstone project,

in which the gamification products were developed by student team under the guiding of the course instructors.

### Lesson learned

(1) Students are the end users of gamification products, and their feedback on the products is important. However, students are not experienced in education and gamification. They tend to focus more in their critiques on the use of the products instead of the design of the games. However, when we develop gamification products, we should consider the potential gap between the instructor and the students. The former may pay more attention to the material and ways of describing the concepts, while the latter might only focus on the practice part and whether it is attractive enough for them to keep 'playing' the gamification products. We believed that leveraging both sides will help to generate more effective design ideas for gamification products.

(2) When it comes to gamification critiques, we found the three criteria (gamification/game element, education/learning effectiveness, and usability/GUI design) are the basic ones to consider. Both student teams developed a detailed format for each critiquing criterion. They provided a general framework to evaluate or critique existing gamification products.

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