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The Impact of Role-Play Gamification on a Freshman-Level Engineering Project Course

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Abstract

This abstract for a complete evidence-based practice paper addresses the topic of learning and motivation through gaming in a freshman engineering project course. Game play is becoming a popular learning strategy for the generation of digital natives entering college. A first-semester engineering project course often covers such topics as the engineering design process, teamwork, communication, prototyping skills, and basic circuits through active learning as the students create prototypes through various team projects. During a fall 2021 freshman-level engineering project course, student teams demonstrated their final prototype that incorporated electronics through a role-playing game. The game challenged the students to not only have a functional prototype, but to also work together as a class to complete the game. In previous semesters the student teams simply demonstrated their project prototypes to the class. The role-playing game was introduced to the course to encourage the understanding of electrical concepts and to improve the quality of the prototypes. The game also increased coordination within teams and among the entire class to have a successful outcome. Data was collected through a survey instrument at the beginning and upon the completion of the learning module. This paper will discuss the results of students' perceived learning, teamwork growth, motivation for the project, and the impact of game play in the class.

Introduction

The recent generation of students entering college are digital natives and require faculty to reassess the delivery of content through the use of technical innovations and different learning

environments. One strategy that is of strong interest to students entering college is through gamification of game-based learning [1]. Gamification takes elements of game play to situations that are considered routine. Game-based learning is an interactive way to pique students' interest in a topic that may seem mundane. Gamification is used in learning scenarios to stimulate interest and to motivate students to problem solve and learn [2-4]. The learning strategies through game-based play promote the application of technical skills and knowledge along with social skills through game play and game aesthetics. The collaboration between students is heightened since teamwork is often a necessity for the games. Subhash and Cudney's [4] research shows that there are benefits of gamification such as higher academic achievement and student participation. Often gamification is used to create a more memorable and meaningful experience for college students. Several common types of game play are board games, digital games, Jeopardy-style games, progression games that involve earning badges, escape rooms, and role-play. Earning badges and digital games are more common in the university setting and less is shown for role-play style games [4]. Based on the positive outcomes from gamification in the classroom, a game-based project was added to a freshman-level engineering project course at Arizona State University. The desire was that the game-based project would increase the students' interest in the project, but also give the students something to enjoy at the end of the semester.

The undergraduate engineering degree offered at ASU requires the students to enroll in a project course every semester. The first project course that the students take as freshmen is EGR 101: Foundations of Engineering Design I. Many introductory topics are covered in the course, soft skills such as email, teamwork, communication, and empathizing with a user are covered as well

as technical skills such as 3D design, computer modeling, and electrical circuits. These topics are integrated into individual and team assignments across several projects during the course. The students have several active-learning experiments where they complete a circuit with a light emitting diode (LED), use a breadboard and multimeter, and experiment with motors and sensors.

The last project culminates with the use of these skills and requires the integration of various electrical components. The students can choose to use a combination of LEDs, motors, switches, and sensors to develop a prototype product. The students must follow a five-step engineering design process of empathizing with a user, defining the problem, ideating, prototyping, and testing. In previous semesters the students had minimal time to develop the prototype, and would give a description of their user and demonstrate the prototype on the final day of class. Some students would put quite a bit of effort into the design, while others simply wanted to finish the design as quickly as possible.

Compared to previous offerings of EGR 101, the fall 2021 session had fewer traditional lecture classes and offered more skills-based, hands-on learning classes. The skills-based classes would start with a short lecture on the topic (10-15 minutes), then the students were given supplies; e.g. breadboard, wires, LEDs, infrared sensor, and battery, to create a circuit and experiment with the new technology. In this case, students could turn on an LED by waving their hand in front of the infrared sensor. Once all the necessary skills were covered, the students were introduced to the final project.

A new project was developed in fall 2021 to motivate the students to create higher-quality prototypes and to increase communication within the team and amongst other teams. More electronic devices (different sensors and motors) and more skills training (soldering) compared to previous semesters were offered to the students for the project as well. The user in the project is the student in the classroom trying to survive a zombie apocalypse. Two days before the zombie apocalypse the students presented an elevator pitch for their device that a buyer would want to place in their survival pack and vie for the following awards:

- Most Useful in a Zombie Apocalypse
- Most Professional/Ready to Take to Market
- Most Unique
- Best Overall Concept

The awards were voted on by the students and staff in the classroom.

On the day of the zombie apocalypse, the students play through a deck of cards to perform different tasks to secure the classroom, along with the uncertainty of a zombie infestation. The game is a combination of escape room and role-play style games. As the students play through the cards some of the students and staff become infected as zombies as the remaining team members and teams work to combat the outbreak. The teams assume different roles in the protection of the students. Some teams alert the students of impending zombie movement, other teams provide defense and safety features, and others have escape mechanisms. A sampling of the scenarios is shown in Figure 1.

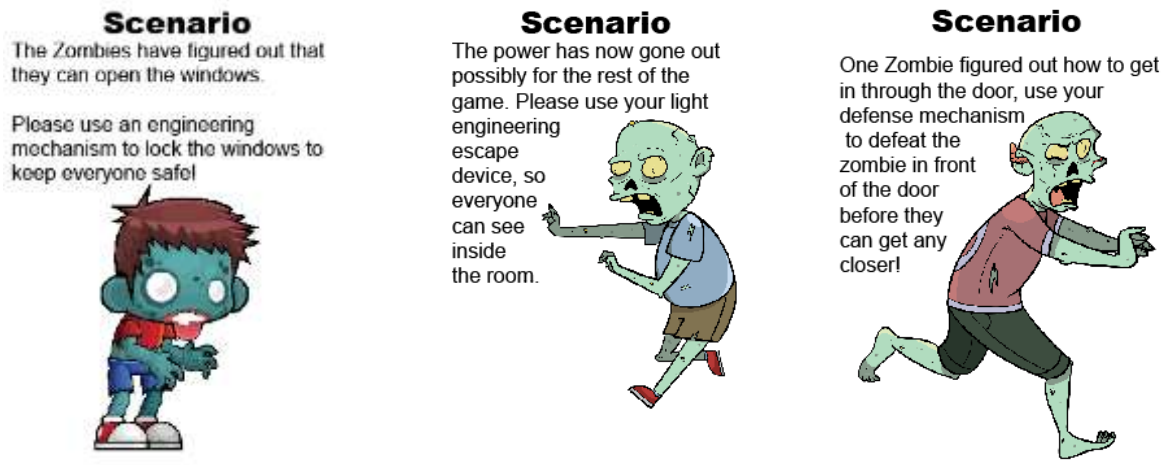

Figure 1: Example of zombie apocalypse game scenarios.

Research Method and Surveys

The research question being addressed is the following: "Is game play a motivating factor for freshmen engineering students to learn technical concepts and skills, produce better quality prototypes, and communicate with their team members for class projects?" The hypothesis is that due to gamification students will want to learn more about electrical concepts, and produce a better quality prototype to win awards from the elevator pitch and to compete in the game. This will increase their understanding of electrical concepts and team coordination within the team and amongst the entire class in order to have a successful outcome in the game.

The experimental method consisted of collecting a pre-survey before the students started to learn about basic electrical circuits, and then a post-survey after the project at the end of the semester. Relational data in the form of closed-questions were collected from the students in the form of two surveys.

The method for data collection was chosen to determine the students' perceived knowledge and to determine growth and motivation for teaming, prototyping, and their understanding of electrical concepts. Overall, the desire was to make the class more engaging and enjoyable for the students to learn. Next, the research design focused on what was known and what types of questions to ask. A pre-survey was given for a base assessment of the students' knowledge and interest of electrical concepts and their perceptions of projects and working in teams. Lastly, a post-survey was given to determine growth from the pre-survey, and to determine perceived motivation and growth around project work, teams, and game play.

The questionnaires were developed using a standardized survey. All the questions were on a 10-point Likert scale to eliminate a neutral response and ranged from "Strongly Disagree" for 1 to "Strongly Agree" for 10. The questions were all closed-questions, no open-questions or space for comments were given on the survey. Students were only allowed one answer per question on the numbered scale. The pre-survey was given before the students started the learning module about electrical concepts. The pre-survey begins with two questions about electrical concepts. The first question is about perceived knowledge on the topic and the second question is about interest in the topic. The next two questions ask about the students' interest in teams and project work, respectively. Lastly, the pre-survey ends with a question regarding project gamification vs. traditional classroom settings. The post-survey was given at the end of the learning module and project. The post-survey starts with the same first two questions from the pre-survey. These two questions gauge the growth in electrical concepts understanding and interest. The third question wraps up the topic of electrical concepts. The next seven questions are related to the game play involved with the project, these are followed by two questions about teaming, and then a final

wrap-up question asking if the students enjoyed the project and the game. The game play questions repeat the last question from the pre-survey and then dive deeper into the students' motivations to work on the project towards completion and have confidence in electrical concepts. There are slight nuances in the questions such as working on the project vs. completing the project, and stating that the game was fun vs. enjoying the overall project and game.

Rajendran and Shah [5] developed a questionnaire to gauge students' perceptions of gamification and collaboration, and then a second questionnaire regarding the knowledge content and specifics about the game used in their learning module for the English language. Manzano-Leon [6] developed a questionnaire that asked about improved knowledge content, motivation for the content, learning with team members and classmates, and overall enjoyment of the activity. Based on these prior studies four variables of measure were chosen for this research. The perceived knowledge gained and interest in basic electrical circuits, the quality of prototypes developed, improved teamwork, and enjoyment of the project/game, were the four variables measured.

The perceived knowledge gained and interest in basic electrical circuits were assessed by the following four questions:

- "I have a good understanding of basic electrical concepts" on both surveys
- "I am very interested in electrical concepts" on both surveys
- "The project helped me identify my weaknesses in electrical concepts" on post-survey
- "After completing the project and playing the game I feel more confident about electrical concepts" on post-survey

The quality of the prototypes developed were assessed by the following two questions:

- “Competing in a game gave me more motivation to work on the project” post-survey
- “Competing in a game gave me more motivation to complete the project” post-survey

Please note the difference in the questions where the first question measures the desire to work on the project and the second question looks at the desire to complete the project.

The improved teamwork aspects were assessed by the following three questions:

- “I like working in teams” on pre-survey
- “I was able to connect with my teammates” post-survey
- “I learned from my teammates” post-survey

The project enjoyment aspects were assessed by the following six questions:

- “I like project work” on pre-survey
- “I learn more with game play and projects than traditional class settings” on both surveys
- “The game was an appropriate way to check the success of my team’s project” post-survey
- “The game play was more motivating than a traditional project demonstration” post-survey
- “The game was fun” post-survey
- “Overall, I enjoyed this project and game” post-survey

Data Analysis

The data analysis consisted of investigating the pre-survey and post-survey with a final analysis to compare both surveys to indicate the amount of growth in each category. Since the survey used a Likert scale from 1 to 10 the mean and quartile values were tabulated for each question. The pre-survey results are shown in Figure 2. The pre-survey was given to 76 students with 72 respondents during the fall 2021 semester. The question numbers in Figure 2 refer to the following questions:

1. "I have a good understanding of basic electrical concepts"
2. "I am very interested in electrical concepts"
3. "I like working in teams"
4. "I like project work"
5. "I learn more with game play and projects than traditional class settings"

Question 1 had the largest spread of the lower and upper quartiles from 3 to 7, respectively. This indicates that there was a wide perceived knowledge of basic electrical circuits at the beginning of the learning module. This was expected to decrease in quartile range and increase in average on the post-survey results. There was a jump in numbers from question 1 to question 2, indicating that students want to know more about electrical concepts. Questions 3 and 4 indicate that students like working on projects slightly more than they like working in teams. In the pre-survey the averages fell in the middle of the quartile ranges, except for question 5. In question 5 the upper and lower quartiles are 10 and 8, respectively, with the average at 8.47. These values indicate that at least 75% of the class chose an 8 or above for the question, with a few lower

values bringing down the overall average. The students overwhelmingly selected that they learn more through the use of game play and projects than traditional lectures and exams.

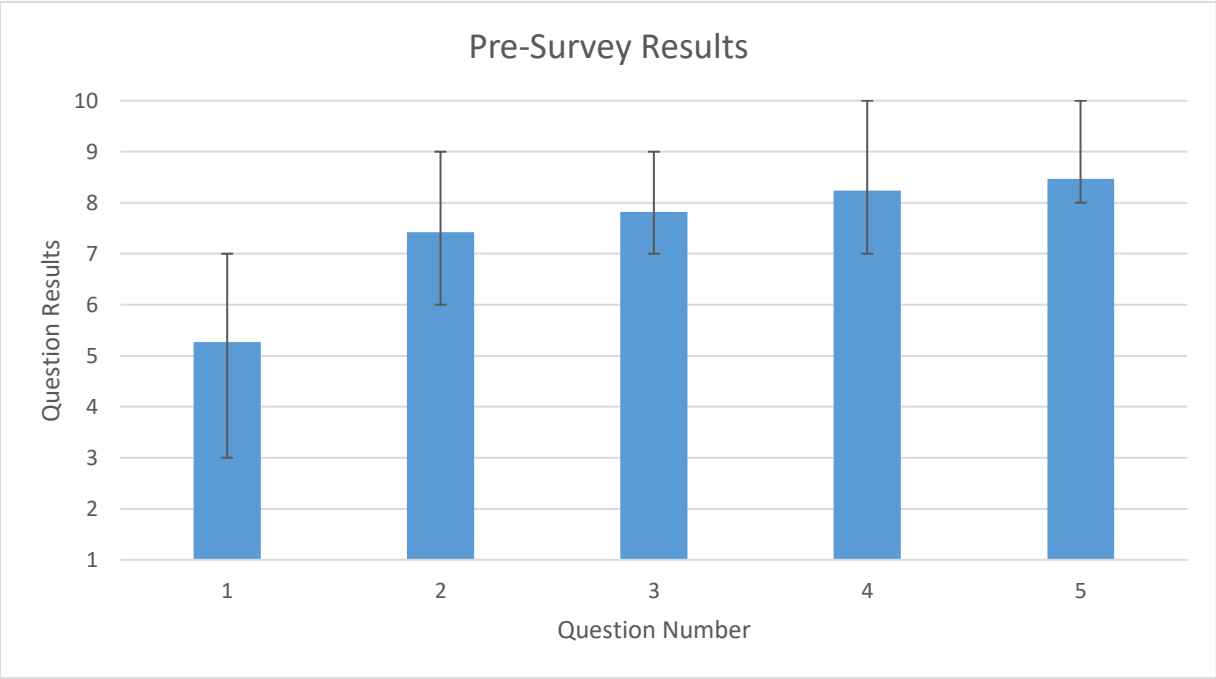

Figure 2: Response to pre-survey questions with the blue bars indicating the average response and the bar lines indicating the first and third quartile of the responses.

The post-survey was given to 77 students with 77 respondents on the last day of the fall 2021 semester. The question numbers in Figure 3 refer to the following questions:

1. “I have a good understanding of basic electrical concepts”
2. “I am very interested in electrical concepts”
3. “The project helped me identify my weaknesses in electrical concepts”
4. “The game was an appropriate way to check the success of my team’s project”
5. “The game play was more motivating than a traditional project demonstration”
6. “I learn more with game play and projects than traditional class settings”

7. “The game was fun”
8. “Competing in a game gave me more motivation to work on the project”
9. “Competing in a game gave more motivation to complete the project”
10. “After completing the project and playing the game I feel more confident about electrical concepts”
11. “I was able to connect with my teammates”
12. “I learned from my teammates”
13. “Overall, I enjoyed this project and game”

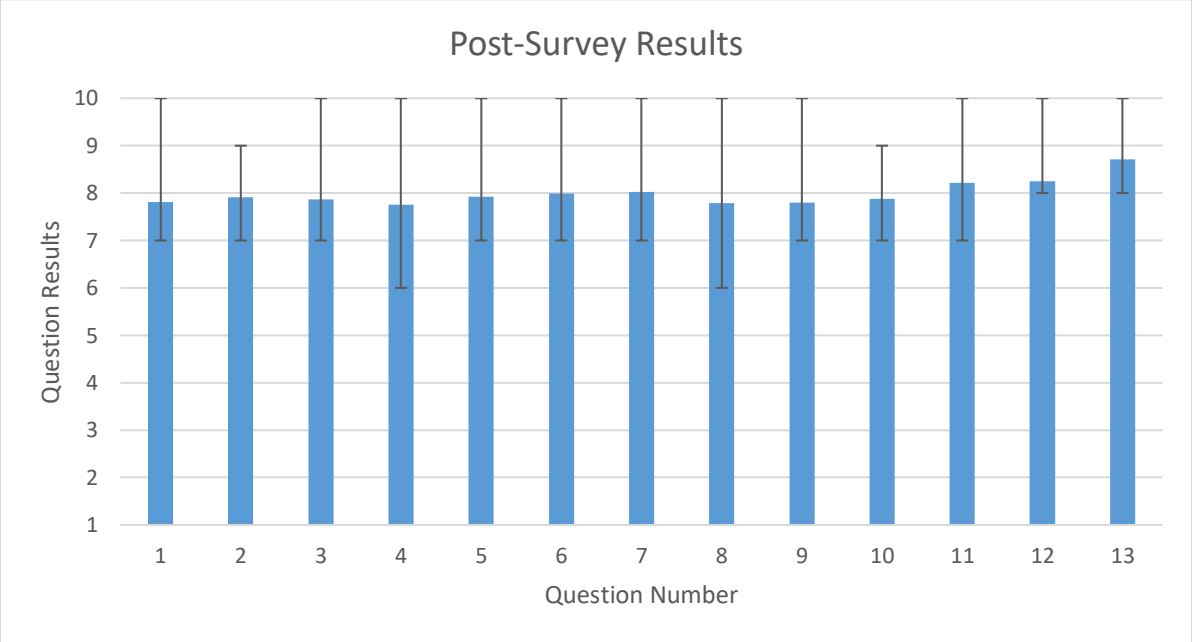

Figure 3: Response to post-survey questions with the blue bars indicating the average response and the bar lines indicating the first and third quartile of the responses.

Of the three questions that were repeated on the post-survey from the pre-survey, by far the most growth was seen with question 1 and slight growth with question 2 (perceived knowledge gained

and interest in basic electrical circuits, respectively). The other repeated question "I learn more with game play and projects than traditional class settings" appeared as question 5 on the pre-survey and question 6 on the post survey had a slight decrease in the average value and the first quartile value dropped from 8 to 7. This slight decrease could be explained by the difference in the number of students filling out the survey, from 72 students on the pre-survey to 77 students on the post-survey, or a slight change in attitude of learning styles. The questions regarding prototype quality remained high (questions 8 and 9 on post-survey). Questions on teaming showed growth (question 3 from pre-survey and questions 11 and 12 on post-survey) from the pre-survey to the post-survey. The questions regarding project enjoyment also remained high (questions 4 and 5 on pre-survey and questions 4, 5, 6, 7, 13 on post-survey).

A comparison of question 1 "I have a good understanding of basic electrical concepts", from the pre-survey to the post-survey is shown in Figure 4. This question shows significant growth. The average response was 7.74 and the first and third quartiles were 7 and 9, respectively in the post-survey. The average increased by 2.5 points and the quartile range decreased in spread and increased in value in the post-survey. The students have an overall perception that they have a much better understanding of electrical concepts, and this will give them the knowledge and confidence they need going into their next project course.

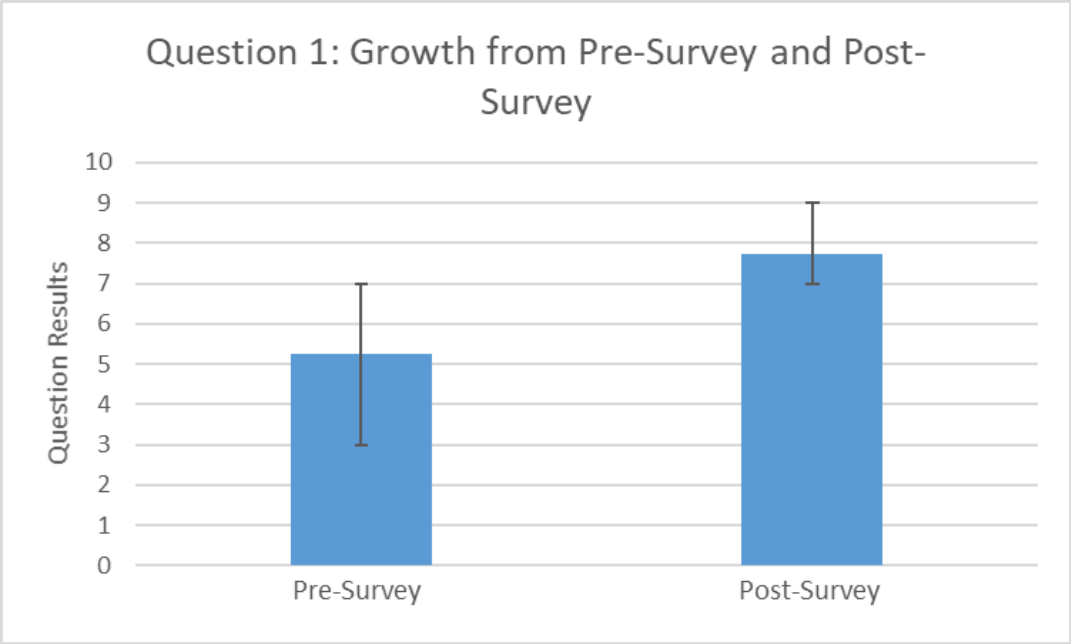

Figure 4: “I have a good understanding of basic electrical concepts” growth, blue bars indicating the average response and the bar lines indicating the first and third quartile of the responses.

The overall quality of the prototypes was much improved from previous semesters. Most of the prototypes had multiple electrical components; e.g. a pressure plate that triggers a switch to turn a motor that hits a cow bell as an alarm, a 3D printed housing that holds a switch and LED. Anecdotally, we saw much more interest, building, and effort in trying different electrical circuits in the creation of these projects.

Due to changes with EGR 101 from the COVID-19 pandemic and the restructuring of the class for fall 2021, there were no traditional grades for a direct comparison of the fall 2021 project with previous projects. Previous offerings used competency-based grading in a binary format, 0 did not complete the project and 1 completed the project. The fall 2021 offering of EGR 101 used a points-based grading system, where the overall average for the elevator pitch was 91.8%

and for the project demonstration/game was 95.1%. The prior three semesters were either online or hybrid (online/in-person mix) because of the pandemic, therefore the projects were designed around online simulators. Due to the change in grading and the in-person nature of the fall 2021 semester a comparison beyond anecdotal evidence of the quality of the prototypes was not possible.

Conclusion

Gamification was introduced to a freshman-level engineering project course during the fall 2021 semester. Students were excited about the prospect of playing a game to showcase their final prototype in the class. The hypothesis was that due to gamification students will want to learn more about electrical concepts, and produce a better prototype to win awards from the elevator pitch competition and compete in the game. This will increase their understanding of electrical concepts and team coordination within the team and the class in order to successfully complete the game. The hypothesis was tested using a field experiment in the classroom with surveys at the beginning and end of the learning module. The initial results from the pre-survey showed that the students were excited about project work and overwhelmingly learn more through game play and projects than in traditional lecture and exam-style classes. With the development of the surveys, the 10-point Likert scale seemed excessive, but the results show that the fidelity of the scale was needed to determine slight differences in the results. The post-survey results indicated significant growth in students' understanding of basic electrical concepts. The interest in electrical concepts also showed growth by the end of the project. Many indicators about the project, game, and teamwork received high marks from the students at the end of the semester.

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