Gamification of a First Year Introduction to Engineering Course

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Abstract - This paper describes an effort to use gamification in a first year introduction to engineering course to increase student engagement and learning in engineering. Like many first year engineering courses, the freshmen introduction to engineering course at the University of Hawaii at Manoa has course objectives that help prepare students for engineering. These objectives include providing an understanding of the various engineering disciplines, the design process, effective problem solving, basic programming, and building academic community. In addition to those objectives, the freshman introductory course also provides an opportunity to establish good study habits, encourage student engagement and participation in class, build the perseverance needed to succeed in engineering, and help the undecided engineering student chose a discipline/major. Gamification is the use of game mechanics in non-game contexts and has been applied to many of the areas that are needed in such an introductory course, like user engagement, teaching, and assessment. Gamification methods leverage the user’s, in this case the student’s, desire to achieve objectives, compete and/or cooperate, and master skills to have the user learn the desired information and build desired habits. In addition, the gamification reward/recognition mechanism can be used in the course to identify strengths and weaknesses that may be recorded over the class to build a profile. The profile can serve as a way for students to better understand themselves for future improvement and aid in deciding on an engineering discipline/major. By gamifying the first year introductory course it is also hoped that habits of the mind are built early on that emphasize the rewarding feeling of studying and understanding. This paper describes the development of the gamified first year introduction to engineering course lessons, activities, grading, assessment, and structure. This gamified version of the introduction to engineering course will be offered for the first time this Fall 2015.

Index Terms – Engineering Design, First Year Course, Gamification

INTRODUCTION

Historically, games have played a large role in society to promote human interaction and as a tool to teach/pass down knowledge and skills. In modern times, games have become quite a successful sector of the entertainment industry which in part is due to the game elements/mechanics that create such captivating experiences. Games provide a welcoming environment that encourages motivation towards learning and engagement in an activity while fostering play and exploration, often within an active community. For those reasons, gamification appears to be a good candidate to enhance education in any field, including engineering. In the introduction to engineering course, one of the goals is to instill intrinsic motivation for learning challenging subjects and skills, which closely parallels the concept of a game. In addition, games often have thriving communities with active participation and communication amongst players which is highly encouraged for engineering students as it is shown to support retention [1]. Thus implementing gamification in the introduction to engineering course may be beneficial for reaching more students and supporting student’s long term growth and successful completion of the engineering curriculum. Gamification has been applied towards other engineering and science-related courses taught at the undergraduate level [2-4]. Some of these examples use game narratives and role playing to have students feel like they are immersed in an in-game world [2-3]. We are not necessarily planning to do this in the ENGR 101 course. Like some other gamified courses [4] we are trying to implement a course management system that allow for assessment and other interactive game mechanics that aim to increase motivation and engagement. A four system implementation for the gamification of the course is described.

BACKGROUND

I. Engineering 101 Course

The ENGR 101: Introduction to Engineering Course is a relatively new 3 credit hour course for first year freshmen. The course is intended to introduce the different engineering disciplines and the design process, provide basic programming and CAD skills, and prepare engineering students for academic success. The objectives of the ENGR 101 course are as follows.

• Provide an understanding of the engineering professions and its impact in Hawai‘i and society
• Provide an understanding of the study of engineering and what it takes to succeed as a student.
• Provide best practices for effective and efficient teamwork
• Introduce the use of Matlab for basic programming
• Improve communication skills for both oral and written technical reports and presentations
• Improve student's ability to recognize and apply appropriate problem solving techniques
• Provide an understanding of the engineering curriculum at UHM and the importance of engineering gateway math and science courses
• Increase academic community

Currently, ENGR 101 is not a mandatory part of the curriculum but it is intended to become mandatory in the future for all incoming freshmen. The pilot offerings of the ENGR 101 course had enrollments of around 17-25 students. This Fall 2015 the capacity of the course will be increasing to 60 students. Should the course become mandatory for all incoming engineering freshmen, the expected enrollment would be around 200 students. The course is broken into sections of 30 students for laboratory and all sections meet together for lecture. The class meets twice a week for a 1 hour lecture and once a week for a 2 hour laboratory.

In the pilot offerings of ENGR 101, many class activities and lesson plans were developed towards meeting the objectives of the class. In the first half of the semester, the labs are dedicated to programming with Matlab and computer aided drawing with Solidworks. The lectures and homework focus on developing problem solving skills, time management skills, technical communication, study habits, and career preparation. The second half of the course focuses on having students experience the engineering design process through student chosen product design projects. According to end of the course survey results and participation records, it was observed that for the most part students felt engaged with the class and felt more confident in their choice to study engineering. However, there were a few students who did not feel engaged and did not feel that the class helped them determine or clarify which engineering discipline to pursue. Applying game mechanics to the course will hopefully better serve these less engaged students while keeping the majority also engaged.

II. Gamification

Gamification has been defined as using game design elements in non-game contexts [5]. In education, this does not mean that a game is created that students play that teaches engineering. Instead it means that game elements and design are used to create a structure for encouraging the learning of engineering.

The current prevailing approach towards gamification is the use of sterilized game elements such as scoring, damage, rewards, and/or role playing to make challenging tasks fun while promoting a desired behavior. These elements provide goal oriented or extrinsic motivation to complete tasks. For example, Habit RPG (habitrg.com) is a web application that gamifies real life activities by taking elements of role playing games such as the quest system, avatar growth through a leveling, and rewards that can bought with currency earned in game by completing tasks. Recording habits and completing set daily tasks are treated as quests. As quests are completed, the avatar receives experience points, which raise the player’s level, and in-game currency to buy rewards such as items used to customize the avatar’s appearance. If quests are failed, the avatar loses health which can lead to game-death and loss of items. However this approach might be better suited towards short term change, as people are less likely to continue the gamified task/habit once the rewards have been removed [6,7]. Moreover, the use of extrinsic motivators such as a reward system may even reduce any pre-existing intrinsic motivation [8].

The previously mentioned approach to gamification is unlike actual game design, where elements are not added just to make the game fun, but designed together to create an experience that is enjoyable and engaging in itself. This more cohesive approach to gamification has been termed gameful design [7]. This gameful approach may be better for building a rewarding experience and intrinsic motivation that is sustainable in the long term.

In psychology, a core part of intrinsic motivation is a combination of volition and alignment with one's own goals, needs, values and identity [9]. Considering this, games can be viewed as being engaging for so many people because they are able to choose if and when to play them (within the boundary conditions of the game space) in a way that satisfies an individual’s perceived needs and philosophies. If this pathway to creating an engaging experience can be applied to formal education as deftly and successfully as it is in game design, then gamification would be a powerful tool.

IMPLEMENTATION PLAN

The RECIPE framework which follows a more gameful approach to implementation will be used towards the gamification of the ENGR 101 course. RECIPE stand for the following and promotes long term change [7]:
• Reflection – assisting participants in finding interests and past experiences that can deepen engagement and learning
• Engagement – encouraging participants to discover and learn from others interested in the real-world setting
• Choice – developing systems that put the power in the hands of the participants
• Information – using game design and game display concepts to allow participants to learn more about the real-world context
• Play – facilitating the freedom to explore and fail within boundaries
• Exposition – creating stories for participants that are integrated with the real-world setting and allowing them to create their own

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The information and exposition elements of RECIPE are present in the incorporation of engineering and other skill content areas into the assignments and lessons. Four systems that integrate the other elements of RECIPE make up the gamified structure of the course.

I. Profile system
An experience point system will be implemented along with grading that will help build a profile for each student. The profile will track the amount of experience points collected in different skill areas, such as the following. Students will then have a record of their strengths and weaknesses to reflect on for future improvement. In addition, students may gain better insight into the types of assignments that they either enjoyed or excelled at that could potentially help them decide on an engineering major. Also the profile could help them build confidence in their abilities which is important for enjoying what your learning.

II. Revival system
In order to encourage reflection and play, a revival system will be implemented to allow students to re-do some assignments for better grades. Often times, students will not look over the assignments after it has been graded and returned to them. To encourage that behavior, students will be notified if an assignment will have a revival opportunity to try again for more points. In games, when one fails a mission they will often revive with damage or item/currency loss but will have the opportunity to attempt to pass the mission again. Failing the mission does not mean that the entire game is over but it makes the player reflect on what they did well and what they need to fix/improve on the next try. In the course, the use of the revival system will allow students to re-do assignments that they did poorly on to earn some extra points but not full points. This helps to build a safe environment for students to experience failure and learn how to bounce back from failures. However, the revival system is not intended to be a crutch that students rely on for good grades so only some assignments will allow for revival.

III. Meaningful Choice System
The meaningful choice system's purpose is to provide students with a sense of autonomy. For each main lesson, students will be presented with a few options for the types of assignments that they need to complete and allowed to choose which assignment that they want to do. This encourages students to act on their own accord rather than being told exactly what to do. In addition, the perception that their decisions have an impact on their learning path make students more willing to try new things. The assignment options will each deliver the same content but will differ in the scenario so that each student may choose the option that feels most relevant to them. For example, in the laboratory students may be asked to create a program that uses loops to solve one of the following problems.

- Calculating the Young's modulus for several materials based on a data set of measurements.
- Sampling the voltage measurements from an IR sensor and calculating the distance from sensor to obstruction.

Both problems will require the students to use programming loops but they each provide different scenarios. A civil engineering student may find the first problem more relevant whereas an electrical engineering student may find the second problem more relevant.

IV. Party System
Teamwork is an important part of engineering practice and success as an engineering student. To facilitate the building of community and collaboration between students, the team or party system will be utilized in different parts of the course. The party system will allow for the creation of teams or parties that will work together to complete assignments. In games, creating parties encourages social interaction amongst players as well brings attention to how to balance a team with players of different skill sets. In the course, either the instructor or the students will be able to base party creation on student profiles. Students will become more self aware of their strengths and weaknesses and how that complements the team. Laboratory assignments will be done in pairs or parties of three. Some in class assignments will rotate between larger and smaller parties. The final project for the course will be done in lab parties of 30 which will be broken down into smaller sub groups to work on different portions of the project. Students will have the opportunity to experience failure and learn how to work in teams of different sizes. They will also get to work with many different people which will help to form stronger community and a sense of belonging within the class.

ASSESSMENT PLAN
To assess the effectiveness of the gamification of ENGR 101, students will be asked to complete the same end of course survey as given in the non-gamified ENGR 101. Results will be compared between the gamified and non-gamified surveys to determine the impact of gamification. In addition, to evaluate the change in feelings and attitudes towards engineering and learning, students will also be asked to complete the pre and post Pittsburg Freshman Engineering Attitudes surveys [10]. Survey results will then be analyzed to aid in improving the both the course content and gamification elements.

CONCLUSION
The benefits of gamification align closely with achieving the objectives of ENGR 101: Introduction to Engineering. It is hoped that the gamification of this course will lead to greater engagement with the students and thus increase their motivation to learn and be successful in engineering. A
four part system was described that will utilize game elements to meet the objectives of the course. An assessment plan is also described to evaluate the impact that the gamified course has on student attitudes towards engineering and learning. The gamified version of this course will be piloted this Fall 2015.

REFERENCES


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