ASEE 2022 ANNUAL CONFERENCE
Excellence Through Diversity
MINNEAPOLIS, MINNESOTA, JUNE 26TH-29TH, 2022 ASEE
Paper ID #37315

Title: Work in Progress: Gamification of education: Using Bartle's Taxonomy for inclusive educational practices

Lizabeth L Thompson (Professor)

Dr. Lizabeth Thompson is the Director of General Engineering and a professor in Industrial and Manufacturing Engineering. She holds a BS in Industrial Engineering from Cal Poly, SLO, a MS in Industrial and Systems Engineering and an MBA from University of Southern California, and a PhD in Education from University of California, Santa Barbara. She has been at Cal Poly for nearly 30 years and has held various positions on campus including Co-Director of LAES, Director of Women's Engineering Programs, and CENG Interim Associate Dean. Although she has taught over 25 different courses she current teaches Financial decision making, First year engineering, Senior project, and Change management. Her research is in Engineering Education where she has received $9.8 million of funding from NSF as either PI or Co-PI. She researches equitable classroom practices, integrated learning, and institutional change. She spent the 2019-2020 academic year at Cal State LA where she taught and collaborated on research related to equity and social justice. With her colleagues at Cal State LA she recently received an NSF grant called Eco-STEM which aims to transform STEM education using an asset-based ecosystem model. She is also a Co-PI on an NSF S-STEM grant called ENGAGE which is working to make a more robust transfer pathway for local Community college students. Dr. Thompson is a Co-PI on an NSF ADVANCE grant called KIND with other universities within the CSU. She is a co-advisor to Engineers without Borders, Critical Global Engagement, and oSTEM at Cal Poly.

Work in Progress: Gamification of education: Using Bartle's Taxonomy for inclusive educational practices

Abstract

According to an online source [1] in 2021 "the average player plays video games for five hours a day, a 14 percent increase from last year." As participants in the educational system, we might ask how we can make the learning process more like a game? This question leads us to a critical examination of the processes of information transfer prevalent in engineering education. We came to believe that much engineering curricula seek a perpetuation of archaic teaching models where professors are the gatekeepers of knowledge in an age where information is much more readily available than ever before. Game designers have recognized a need to understand how those outside their initial audiences seek pleasure from their game to avoid staleness in an age where information and media is available and consumed in gross quantities. They need to entertain their initial user base and expand beyond it. With a growing desire to make engineering more accessible to a diverse set of individuals, this paper will investigate strategies found in the video gaming industry which have captured the minds of millions of 16- to 26-year-olds. We are using Bartle Player Taxonomy and other reward structures to understand the engagement found in video games with hope that this can be applied to the engineering classrooms to increase student's intrinsic motivation for learning. Because Bartle's Taxonomy does not show up in academic publications, we are also challenging the traditional source of knowledge in academic publications by encouraging innovative approaches found on blogs and video sharing sites. We are not only making educational systems more inclusive but aim to challenge the paradigms about who creates knowledge. To bring this theory-based paper to practice we will include some concrete applications we have experimented with in a virtual reality electrical engineering lab experience at California Polytechnic State University, San Luis Obispo (Cal Poly, SLO). We seek input from the community about the theory and practice.

Introduction

The current generation of students are known as "digital natives," those who were born into the digital age, while many professors in higher education are "digital immigrants," those who learned to use technology as adults. This difference in orientation causes a disconnect in educational assumptions and processes. One area where this is evident is who has access to, and what is valid information. Some engineering educators maintain an oppressive "teachers are the guardians of information" in an age when information is readily available at students' fingertips. Students now do not have to rely on professors at universities to provide them with high-level knowledge. Beyond access to knowledge many educational systems are designed for the proto-typical student and utilizes many extrinsic motivators to drive students to success. Recognizing the diversity of learners and designing more for intrinsic motivation are also two areas where there is potential for improvement in higher ed. Since 2010, college enrollment has been steadily decreasing, with a staggering +6% decrease since 2019 [2]. Many had predicted an increase in college enrollment once vaccines for the COVID-19 virus had become available, however college enrollment rates continue to decrease.

While school enrollment rates continue to decline, the video game industry is growing its active population. The video game industry is constantly evolving in its techniques to reach a wide range of audiences, with many AAA games developers (games published by established companies generally with a large budget) using psychological understanding to engage the minds of their players. We propose that engineering educators consider adopting strategies used by video game developers, such as designing for different types of digital native learners and adopting more interactive and intrinsic learning elements where the professor can learn with the student. These strategies have proven successful in growing the gamer user base and may help to engage a broader more diverse student population.

Researching this issue widely has convinced us there is much to learn from materials not usually references in academic journals. Therefore, in addition to typical references, we are including references from blogs and video sharing sites.

Background

Engineering instruction often sees a perpetuation of archaic teaching models of learning and assessment. Some professors act as if they are all knowing gatekeepers of knowledge in an age where this is increasingly not true. This shows up in lecture-based instruction and grades as motivators. Currently, engineering is hallmarked for its rigorous testing standards, requiring students to memorize facts and figures and turn in every assignment at the required time, without regard for other classes, work, or other obligations. The course work is so rigorous that engineering students study at least 5 hours more than any other major, with the national average being at 19hrs a week. There are many schools in the US, however, that recommend their engineering students study 35+ hours a week outside of their normal class hours [3]. This level of required study at many prestigious engineering colleges, leads to only the privileged student who is financially able to dedicate this time. With the long study hours and the overwhelming amount of diverse subject matter that is constantly building upon itself, if a student falls behind, they are often seen in their professor's eyes as having not tried hard enough. Students who fail to grasp material in this fast pace and unforgiving environment often drop out of engineering and pursue alternate paths. Those from under-represented groups such as women and people of color are leaving engineering at a higher rate than the proto-typical white male students [4]. Before mass adoption of internet resources, this was an accepted, and almost encouraged, method of teaching as it weeded out the stragglers and left behind the best and brightest minds. However, as our consumer technology needs and wants to progress further and further each year, the demand for engineers grows more too. This inequitable method of weeding out engineers is no longer a viable path forward.

Students of today have found ways of circumventing the archaic teaching structures, with the biggest leap being during the COVID-19 pandemic. During this time, students became more detached from their professors, as both parties attempted to navigate online teaching. Professors attempted to utilize the same outdated teaching methods by being the purveyors of knowledge while bungling online classroom management and test proctoring. Meanwhile, many students took to websites such as YouTube or Khan Academy, to learn their courses and navigate through their homework. Students were able to see how others outside their college taught material and what resources were readily available for free, as opposed to the thousands of dollars spent on

tuition. From a student perspective, many colleges were reduced to paying someone to give them a piece of paper that said they understood the material. In the students' eyes, they saw that they could learn that material for free, without the rigorous learning environment while maintaining the ability to work a job at the same time. This realization that college material is no longer as unique as it once was, due to the readiness of information the internet provides us, make it more clear why there has been a large decrease in student populations since 2010, with the biggest drop of 6% occurring since 2019 [2].

While enrollment rates drop, the video gaming industry is constantly growing with no signs of stopping [1]. Game designers have recognized a need to understand how those outside their initial audiences seek pleasure from their game to avoid staleness in an age where younger generations are faced with sensory and information overload daily. Games have evolved from the straightforward "level clearing" of Donkey Kong to intricate systems with complex game mechanics [5]. Meanwhile, engineering education has stagnated in the Donkey Kong-esque play style where professors throw obstacles for their students to jump over as they climb to the top. Game designers have modified game mechanics by understanding audience preferences such as the "Bartle Player Taxonomy" to best encourage and reward their players even when requiring them to do difficult or menial tasks.

To gamify a system is not only to entice the player with fun and rewarding aspects, but to balance the time spent in the game and working on tedious content for greater rewards. As an example, in one Game Developers Conference (GDC) when discussing the complex and ever-changing reward system in an exploration within a AAA game, the speaker references understanding of motivation in her design.

> EX: If the player frequents a location often, items will be repopulated in the area, but the rarity of those items will drop, resulting in the player only finding common items. Item rarity becomes inversely proportional to the players visiting frequency. The rarest items within a game will be hidden in locations that are often hard to reach or require the player to be highly attuned to their environment [6].

Resource gathering in many games can be considered a very monotonous and time-consuming task, especially in games such as those in "Monster Hunter" or "Horizon Zero Dawn." This is no different than grinding away on home sets. Both these require players to spend dozens of hours to get to a more enjoyable or rewarding activity. This is an example of how the video gaming industry has successfully built self-guided learning as it maximizes a players internal motivation to master a game. Players have complete autonomy in what they play with greater diversity of genres and sub genres. They have a sense of community as they share tips and tricks with others through game forums. All these components (internal motivation, mastery, autonomy, and community) have been identified by Deci and Ryan [7] to be key in creating a successful self-guided learning environment. Seeing the parallels in the educational space opens opportunities for educators to learn.

Based on the nature of university admissions, students are already expected to perform well academically which fosters a more competitive and less friendly learning environment. This is magnified when professors grade on a curve as students are less inclined to help one another

because doing so may hurt their own grade in the end. On top of the competitive learning environment, professors expect students to develop the necessary skill set required for their future careers (like creativity and innovations), while at the same time they are faced with expectations of correctly solving complex problems with a single answer. This contradiction is displayed when you ask professors what their expectation is of their students and what students think is expected from themselves. Engineering professors expect innovative solutions to complex problems with answers that depend on the context. Students see the right or wrong grade with penalties for thinking creatively [8].

The absence of a student's creativity stems from the classroom environment and professors' methods of teaching that are out-of-date and lack the creativity demanded from students. In a study where gamified learning was implemented in engineering courses, over 90% of students said the immediate feedback from the gamified learning was helpful in some way, and over 65% thought the gamified learning was helpful in learning the subject matter [9]. With this feedback, we can see students largely found gamified learning as another helpful tool.

Though 40% of students did not think gamified learning added any more motivation, about 80% thought this form of learning was more enjoyable [9]. This is a positive sign that students are willing to adopt new approach and possibly encourage professors to update their methods of teaching. In another aspect of the same survey, students were asked what they believe is the purpose of using gamified learning, 70% of students believed that goal was to increase enjoyment and 5% of students determined the goal of gamified learning was not to improve their gaming skills [9]. This reflection in their responses show that students know gamified learning isn't like playing a game as they would outside of the classroom, but rather it is used as another tool to further their education in a modern way. From the responses of these engineering students, it is evident that the need for an overhaul in the typical engineering education learning environment is very much needed. While students are eager to accomplish new feats in their educational career, it is difficult for them to achieve those feats due to the competitiveness that is fostered, whether directly or indirectly, and lack of encouragement to explore outside of what their professor or lab manual is instructing them to do. This is further magnified through lack of communication between engineering students. Not many engineering students believe that one of the skills that they will be developing is communication, it is often a skill that is neglected.

The combination between competitiveness and lack of communication is not conducive to a learning environment which promotes collaboration and exploration. Quite a few engineering professors have been teaching for a long time and have yet to update the medium in which they teach their students. With an out-of-date style of teaching, engineering students seemingly lose interest. Gamified learning is still a relatively new field, the outcomes of the research thus far points toward the potential for gamified learning to engage a diverse set of learners in a way that improves well-being [10].

Bartle's taxonomy

In game design some use a categorization of players called Bartle's Player Taxonomy [11]. We found this useful in the design of a gamified electrical engineering lab course at Cal Poly, SLO. and by extension may be useful for others in thinking about the educational system as a whole.

To understand how people behave in video games Bartle's Player Taxonomy categorizes players into four simple categories: Achiever, Socializer, Explorer, and Griefer (sometimes referred to as Killer). Not only is this useful for design, it also recognizes the diverse personalities of players.

The first category of players is the "achiever" category. These are the people who want 100% completion of the game and want to show off their completion through noted milestones. They find satisfaction in clearing achievement boards and dominating the experience so that there is nothing left for them to do. In an educational aspect, these students would want achievements on their resume that shows off courses they've completed, prominent test scores, stats, anything that shows and highlights their skills and work they've put in. Professors can reward these students with extra credit and good grades, since students often measure grades as a sign of achievement.

The next category is the "socializer." This is an extroverted type of person who enjoys the sense of community created in gaming environments. Through interacting with other players in game and in gaming forums and channels, they craft their own unique experience. Socializers are very likely to collaborate and help each other out when someone is stuck. In the classroom environment, this can be seen as putting people into groups for projects and having students critique each other's work and help their peers through problems. Motivation for a socializer does not come from the class itself, but from the people around them in the class. Socializers in video games tend to make friends and use the game as a back-drop for their social interactions, bouncing between games with the same friends. This is similar in the classroom environment; these students are much more effective with a group around them. Creating projects where students are encouraged to collaborate is the best way to motivate one of these students.

The third category belongs to the "explorer." The explorer is the type of gamer that wants to explore the world and take in everything that the game has to offer. Their satisfaction comes through knowledge and discovery, they are true scholars. They don't mind putting in hours of work for a small prize, they see it as a special reward that the developers made for them and even if they end up disliking the reward, they still feel the need to experience what it has to offer. It doesn't take much to motivate these students as they pursue education simply for the sake of seeking knowledge.

The last category of players are the "griefers." This category could be summed up best as people with a very competitive nature. They want to know how they can manipulate the system to their advantage, even if it is in an unfair way. While the achiever wants to be recognized by their achievements and hard work, killers want to be recognized by doing better than others. These are the kinds of players that love seeing themselves at the top of leaderboards, whose achievements aren't necessarily what the game has to offer but instead what the competition has to offer. In the classroom, these are students who want better scores than their fellow classmates and aren't afraid to be wrong when it comes to answering questions they don't know. Reputation and recognition are the main metrics of success for these students. Rewards may be presented through comparison to other students' test scores, comparison of grades, and acknowledgement of their success.

Theory to practice

Guided by Bartle's Taxonomy and the pressing need to redesign education we have developed a testbed to incorporate gamified learning elements in a classroom. We are using software that has been developed for virtual reality (VR) in an Electrical Engineering lab. Focusing on engagement for the four player (student) types has informed many of the aspects of the educational experience. Students at Cal Poly, SLO have much experience in lab-based classes but sometimes experience them as a set of steps to accomplish or a recipe to follow instead of an enjoyable learning experience. In this VR Experience we find that it is possible to include some of the rewarding activities that VR games possess like fun sounds and lights, or hidden rewards, to engage students. As we continue to develop these experiences, we will add and adjust as game developers do to see what is most engaging to users. The VR software will allow us to slowly introduce new educational features. Our testing will take place over the following stages within an introductory electrical engineering lab.

Our preliminary work entails setting a benchmark for student performance in a traditional lab and a VR lab. In this test we will not be adding in any additional features for the VR students and will be supplying them with the same lab material and language as the traditional students. The purpose of doing this preliminary test is to establish that there will be no negative consequences towards student learning due to them being in a VR environment as opposed to a physical one.

Next, we will incorporate elements mainly for the "achiever" category of students with some undertones of assisting the "explorers" as well. In this round, we will be adding in a warning system to the environment when they mishandle the equipment. It will also trigger if the student overloads a component or fails to make a complete circuit. The warning system is not designed to catch simple errors, like if the student did not use the right value component as described in the lab manual, but will only interject at times when there would be a consequential error. In the tests involving the warning system, we will be seeing how students respond to having their mistakes being pointed out, but in a comical way. If the warning system is successful and students enjoy this system, then, when we do our performance test at the end of the trial, we should observe increased performance in those and more attention to equipment set up with the warning system students.

Our secondary round of trials will incorporate a social feature for students who make repetitive errors. When going through the lab if a student triggers the warning system more than three times in a designated time frame, their workspace will be locked, and they will be required to talk to another person in the lab before continuing. The purpose of this test is to determine how adding in community help can affect a student's performance in a lab. If the required social interaction is successful, then the students in the test group will see a reduction in errors as the trials conduct.

We will continue to add aspects from Bartle's taxonomy and continue to think about the educational experiences through the lens of gaming. Our hope is not only that education is as enjoyable and engaging as games, but that faculty learn with students about their experiences and passions.

References

[7] Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior*. New York, NY: Plenum.

[1] Sidhwani, Priyansh (2021) People spend 14% of their time on video games in 2020. https://techstory.in/people-spend-14-of-their-time-on-video-games-in-2020/ accessed February 6, 2022

[2] Whitford, Emma (2021) Enrollments Still Falling 2 Years Into Pandemic. https://www.insidehighered.com/news/2021/10/26/college-enrollments-continue-drop-fall accessed February 6, 2022

[3] Rincon, Roberta and Yates, Nicole (2018). Women of color in the engineering workplace https://alltogether.swe.org/2018/02/new-swe-research-women-engineers-color-early-career/ Accessed February 6, 2022

[6] Miller, Leah, (2019) Rewarding Exploration with Collectibles and Gatherables. Presentation at the 2019 GDC Level Design Workshop talk, https://www.youtube.com/watch?v=GlvGeiw3TDQ&t=1525s Referenced February 6, 2022

[3] ASEE Corporate member Council (2020), 2020 Survey of skills caps in recent engineering graduates ASEE report https://www.google.com/url?q=https://workforcesummit.asee.org/wp-content/uploads/2021/10/CMC-ebook.pdf&sa=D&source=docs&ust=1644180043555958&usg=AOvVaw1vrp1s7kv3Cxa8uay2mHnN accessed February 6, 2022

[8] Marasco, E. A., & Behjat, L., & Rosehart, W. D. (2015, June), *Integration of Gamification and Creativity in Engineering Design* Paper presented at 2015 ASEE Annual Conference & Exposition, Seattle, Washington. 10.18260/p.24334

[9] Mahmud, Z., & Weber, P. J., & Moening, J. P. (2017, June), *Gamification of Engineering Courses* Paper presented at 2017 ASEE Annual Conference & Exposition, Columbus, Ohio. 10.18260/1-2--28397https://www.youtube.com/watch?v=9vJRopau0g0 Accessed February 6, 2022.

[5] Rober, Mark (2018) The Super Mario Effect - Tricking Your Brain into Learning More | Mark Rober | TEDxPenn. https://www.youtube.com/watch?v=9vJRopau0g0 Accessed February 6, 2022.

[10] Cain, C., & Taylor, M. E., & Anderson, A. (2016, June), *Content-Independent Classroom Gamification* Paper presented at 2016 ASEE Annual Conference & Exposition, New Orleans, Louisiana. 10.18260/p.26582

[11] Kumar, Janaki Mythily, Herger, Mario, and Dam Rikke Friis (2021). Bartle's Player Types for Gamification. https://www.interaction-design.org/literature/article/bartle-s-player-types-for-gamification#:~:text=There%20are%20four%20player%20types%20according%20to%20Bartle%3A,define%20how%20you%20will%20cater%20to%20their%20needs. Accessed February6, 2022.