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On the Successful Use of Gamification Techniques; Maintaining Professionalism and High-Quality Education While Incorporating Game Design Elements

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My name is Lucas Buccafusca. I am currently a teaching faculty at Johns Hopkins University in Electrical and Computer Engineering. I received my Ph.D. in Industrial and Systems Engineering at the University of Illinois at Urbana-Champaign, earned my Masters in Electrical and Computer Engineering from the University of Illinois at Urbana-Champaign in 2017 and my Bachelor's degree in Electrical and Computer Engineering in 2013 from the University of Colorado at Boulder. My pedagogical research interests are on improving the quality of collegiate classroom environments through the use of nontraditional techniques and active participation by instructors. These include the use of failure as a teaching tool, humor and empathy as a means of connecting with students, and gamification. My technical research interests are Distributed Control, Learning, Distributed Optimization and Nonlinear Systems. Applications of my research are primarily used for Wind Farm arrays.

On the Successful Use of Gamification Techniques; Maintaining Professionalism and High-Quality Education While Incorporating Game Design Elements

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Abstract

The advancement of active learning methodologies as a means to drive student engagement and information retention has led to a blossoming renaissance in the field of teaching. One such new pedagogical technique to increase motivation in young scholars is that of 'gamification.' Gamification is the process of taking elements from other forms of media (specifically those of board games or video games) and applying them in an academic setting. By incorporating these techniques, it aims to increase student participation and encouraging them to develop logistical skills or behaviors that are conducive to skilled learners. However, gamification is not an all-purpose solution that can be implemented haphazardly. This work discusses not only the potential gains when gamification is done properly, but also many of the pitfalls and potential issues that can arise when game mechanics are inserted into the collegiate classroom.

Introduction

The rise of *gamification* has redefined some classic perspectives on how to encourage student engagement. First defined in 2011 as the 'incorporation of game elements in non-game contexts' it has been an active topic in research. Whether it be in software development [1], politics [2], or the workplace [3], the idea of incorporating game elements to enchance performance is rapidly being implemented. Such is the case in learning as well. Gamification is a new tool in making the student environment more effective and dynamic than the traditional classroom model [4]. Gamification is a natural application of experiential learning, wherein students learn by doing i.e. being actively engaged in material with tasks, problems, or projects. Trivial examples of gamification to enhance learning include those of educational games or in self-teaching tools such as Khan Academy or Classcraft.

Early discussions of gamification in the classroom share the opinion that gamification has the potential to improve learning, if it is well designed and used correctly. Recent works have thus attempted to isolate the performances of students when individual elements of gamification are incorporated [5], [6], [7]. Applications of these methods in primary school classrooms has shown

a higher satisfaction, motivation and greater engagement of students [8]. When remote learning was necessary, these techniques showed similar positive effects in e-learning [5].

One major study observed that the research of gamification as a pedagogical tool notes that there are certain classifications for implementing such methods [9]. To ensure clarification throughout this work, the elements of gamification are formalized in order to evaluate it holistically, to discuss current implementations and future possibilities, and better understand the theoretical rationale behind gamification [10]. Specifically, successful descriptions of such methods in the classroom involve three factors: game mechanics, game dynamics, and aesthetics [5], [11], [12].

Game mechanics are the means by which one converts specific inputs by the player into specific outputs. These are the are the base components such as rules, basic actions, and rewards. Game dynamics dictate how the players interact during the game, traditionally the means by which the players are involved in playing. Typically these involve player feedback in some loop; causing skill to come from repeated interactions. Game aesthetics are how the mechanics and dynamics interact with some form of artistry, to produce cultural and emotional outcomes. Traditionally this is examined through player expression interwoven with some underlying means. Such examples include character creation, exploring environments, or storytelling. These three categories help specify the different aspects of gamification, and each have been utilized in a variety of ways in the K-12 classroom [13], [14], [15].

Many of the studies done on gamification have been implemented exclusively in the primary school domain [16], [17], [18], [6]. While there have been several works focusing exclusively on the application in the realm of higher education [19], [20], [21] many are statistical analyses of performances or analyzing the specific impact of one implementation of game mechanics or dynamics. These reviews, while helpful as a baseline indicator of gamification performance, often overlook some of the critical aspects that arise by introducing games into a technical vocation; causing a natural conflict between professionalism and game elements. It's been shown that these single-classroom analyses may provide conflicting feedback or might be poorly representating the true educational responses [22]. This work aims to define where the incompatibilities arise and proposes methods to preemptively address these issues.

The remainder of the work is structured as follows; first, specific examples of the factors of gamification and their game counterparts are listed. Further discussion follows the benefits and pitfalls that can arise when implemented in an academic framework. Documented examples are cited and discussed. Following that, the next section discusses the potential issues when incorporated in the collegiate classroom; specifically those corresponding to maintaining a high level of professionalism in technical vocations. Lastly, potential solutions to these specific problems are addressed.

Gamification Elements in Education: Benefits and Disadvantages

The traditional implementation of gamification in primary school classrooms is accomplished by incorporating elements that make videogames entertaining and using those to motivate players (in this case, students). Classic examples of gamification in classrooms can be seen in Table 1.

Many of the game design principles have direct parallels with many of the latest teaching

Table 1: Examples of Gamification Elements

Gamification Element	**Usage in Games**
Points/Achievements /Progress Bars/Badges	Tangible evidence of accomplishments, completion of tasks or mastery of material.
Instantaneous Rewards	Encourages continuation while playing since there is no downtime. Immediate positive reinforcement for successes.
Levels/Quests/Missions	Enforcing a structured path whose completion builds on prior events.
Avatars/Digital Characters	Using storytelling or new identities to cause shifts in perspectives.
Leveling up/Ranking	Opening advanced problems, quests, activities and clearly identifying completion of certain tasks.
Leaderboards	Encouraging mastery through competition and repeated exercises.
Party Forming	Having multiple team-members collaborate to tackle a larger foe or problem.

philosophies. It has been shown that the most utilized and successful usages of gamification in education are visual demonstrations of success, increased social engagement, the ability for students to fail with limited repercussions, and rapid feedback [4].

Benefits of Gamification

Surveys that have collated results of the use of gamification have found that there are numerous benefits that arise from the incorporation of game elements as an instructional tool [9], [23]. These systematic literature reviews expose that of the published works on gamification are aligned in their summaries: when done properly, gamification has positive results on information retention, motivation to learn, and mastery of targeted skills. Favorable outcomes using this supplementary technique have been reported ranging between 85%-90% in published works [9], [15], [23].

Arguably the most consistent conclusion across the literature is that gamification can increase motivation in students, causing them to more actively engage the material and retain it for longer. Through the use of goals, achievements, and rewards, a positive feedback loop is constructed and thus often increases satisfaction. This then leads to a subsequent increase in performance.

The incorporation of game elements can lead to a more relaxed and collaborative environment and increased motivation. Through this lens, students are often more constructive and productive. This tends to lead to better student mental health and increased productivity [20]. Students who are actively engaged with the game elements within a course become more motivated to attend, interact with faculty, and continue to pursue knowledge beyond the scope of the covered material. Students wanting to explore additional material (in games typically known as Downloadable Content, that which is beyond the scope of the main game), can be encouraged to seek out additional topics that can enhance their own learning. This can be curated on an individual student basis, based on preferences and lead to bonus rewards, either in the gradebook or in self-improvement.

In addition to individual benefits, the incorporation of team-based game elements (such as by diving a course into groups, but encouraging them to collaborate) can have advantages in social skills. Helping build dynamic communications between both teammates and other groups helps develop confidence and often improves and becomes cooperative interactions in the future.

Gamification can help make learning more interactive, engaging and memorable, thus directly leading to better learning and student outcomes. Since many gamification elements are heavily tied to technology, one can design an underlying system where student performance is provided instant feedback and progress tracking. This allows learners to monitor their progress and adjust their approach or study habits on specific topics according to their own performance. Rapid feedback allows for students to correct errors in their own knowledge easily without unnecessary struggles or delays.

Instructors can also use gamification in order to iterate on courses. Due to the nature of documented achievements, improved collection of results and analysis is far easier. Collecting and synthesizing data is done in a more engaging method, which can lead to better quality information and insights [24].

Leaderboards, levels, and badges help to demonstrate accomplishments and improvement. This can be especially useful where its hard to measure performance, such as learning or skill-building. Furthermore, due to the ability to repeat tasks, problems, or skills, students can continue to repeat on their own performances to reinforce material.

Disadvantages of Gamification

Gamification is not a universal catch-all solution to every learning environment and there are some major potential disadvantages that can undermine or worsen the learning process. Fundamentally, gamification fails when the theoretical benefits of proposed methods do not align with the the practical understanding or applications therein [25]. Consider the following example: an ideal instructor, acting purely for the means of imparting knowledge on a group of learners, aims to incorporate game elements within their classroom. By including a published leaderboard on student performances on examinations, they seek to use competition as a means of self-motivating students. However, rather than encourage students to improve for their own sake, it causes those at the bottom of the leaderboard to be discouraged because others may have had prior experiences. This information inequity means that not all students were on the same starting point, and thus lead to students abandoning interest in the material altogether. One overarching connection between the failures of gamification is when done poorly, there is often a degradation in professionalism or respect for the material, coursework, or instructor.

In some students the fast pace and immediate feedback can shorten their attention span or dedication to the material [26]. Instead of correcting potential issues, instead it can lead to discouragement and a disheartening abandonment. Furthermore, if other parts of the student's education are not on the same pace for pace and feedback, it can trickle into other facets of their academic schedule [27].

When gamification is done well, the rewards are supplementary when compared to mastering of material. However, students can become enamored with the competitive aspects of gamification (or their corresponding rewards) and it becomes more about winning than learning. Since gamification heavily relies on rewards or incentives to motivate students, it becomes easy for there to be a shift in focus. That is, if the rewards become the dominant factor in the classroom, learners may lose sight of the underlying task or goal and become focused on the rewards themselves. Overemphasizing external rewards (in the form of badges or achievements) in gamification can lead to

less self-motivation and instead increasing that of extrinsic motivation. Intrinsic motivation, or the motivation that comes from within, leads to better performance than extrinsic motivation, or the motivation that comes from external factors such as rewards [28].

A studied fact is that in the classroom, regardless of teaching style, method, or practice, ultimately some students won't be motivated [29]. There will be some students that simply are demoralized by the gamification of learning. Whether there are misconceptions about the process or a lack of appeal, there is very little that can be done to correct this. Furthermore, learners may dislike the competitive nature of some aspects of gamification and it can cause friction in the classroom; encouraging students to compete rather than collaborate.

Gamification can sometimes have unintended consequences, such as encouraging unethical behavior or promoting negative competition. This is an active topic of research, as there are numerous ways in which the incorporation of gamification has led to major issues [30]. Examples of this include psychological distress, exploitation of the game elements, privacy-related issues, and lack of performance. While this is not an exhaustive study, works exploring stress induced by gamification demonstrated that subjective stress can lead to conditions such as anxiety, hostility, and depression, all of which are harmful [31]. If leaderboards are implemented without the means of hiding personal identities, there arises the issues of a transparency of individual performance. Students can algorithmically deduce the status of their peers, which has numerous ethical and social issues.

Gamification is often based on a one-size-fits-all approach (consistency across badges, quests, etc.), which may not be appropriate for everyone. This lack of customization on a personal level can lead to different groups of students losing interest. Some may find the games too difficult or too easy, or may not be motivated by the same types of rewards and incentives as others. It's bee shown that inappropriate or poorly implemented game elements can demotivate users [32].

There are also plenty of practical implementations of gamification that can stunt motivation in the methodology. Gamification relies heavily on technology (both for rapid feedback, and any large-scale leaderboards), and technical issues can disrupt the experience and decrease motivation. These can range from incorrect grading (where the student inputs the correct solution, but the grading software has specific criteria for marking it as correct) to crashing altogether. Furthermore, it can be expensive to implement, especially if it requires the development of said technology or software [33].

Incorporating Gamification Tools in the Collegiate Classroom While Maintaining Professionalism

While incorporating gamification elements in technical vocations (such as engineering) have prove fruitful outcomes, studies with such integrations continue to have consistent issues in balancing the game elements with that of a professional environment [20], [34], [35], [36]. In this work, we aim to isolate key factors that are necessary to ensure the friction between a healthy classroom is not offset by a lack of formality.

Scaling Game Elements with Difficulty

When comparing identical gamification elements in various fields the authors in [20] concluded that engineering students preferred rewards for difficult challenges, whereas the students in the social sciences enjoyed when the rewards were accrued for smaller tasks and compounded over a longer period of time. This brings up an important aspect of gamification applications: the corresponding rewards need to be tailored to the audience. This can mean scaling the points with the difficulty or dividing them accordingly for smaller tasks based on the academic area or year of study of the learners.

Maintaining Transparency on Implementations

Recent developments in pedagogy have explored the fact that students perform better when their relationship with the teacher is one of mutual understanding [37]. That is, having teachers and students as collaborators both contributing to the goal of enhancing the knowledge of the learner. To that end, transparency is one of the key factors that should be exposed to students. A clear definition of the nature of the class structure, how the gamification elements can contribute to their learning, and pointing out the potential pitfalls at the start of the lecture.

Remain Focused on Material

In order to avoid distractions and an unprofessional environment, instructors should bring the attention back to the material being presented and not the mechanics being used to transmit it. This regular redirection of the attention of the students is necessary to guarantee that the motivations are not on the rewards of the game itself, but rather the mastery of the content. Furthermore, the frequency of the game elements can be a crucial indicator of whether student attention is being divided, rather than refocused on learning [22].

Avoid 'Pointification'

One key factor that helps ensure that the focus of the class moves away from 'pointification', that is, using only points or badges as a means of demonstrating mastery. These basic implementations of gamification can be detrimental in the long-term. Once the novelty of such a methodology wears off, the underlying focus on studies lose effectiveness [22].

Ensuring that the badges or achievements are not solely tied to student grades is the easiest such protection against pointification. The rewards may impact the grades, but should not be the only parameter impacting student success. Otherwise, students will hone in on skills or task that maximize the expected number of points, not those that will offer the greatest long-term yield in performance.

Practical Implementations of Gamification

Given the discuss of potential pitfalls above, instructors aiming to incorporate gamification into their collegiate classroom need to be proactive for successful such implementations.

As such, some of the best usages of gamification in order to maintain professionalism in the collegiate classroom are those wherein the elements are woven into high-frequency, low-stakes activities. These have little to no impact on student grades (and thus avoid the potential increase in stress) and can be done in a logical, structured manner. One such example would be a short quiz-style engagement at the start of every class on the material from a prior lecture. Learners could be encouraged to speak to neighbors (or work in preset groups), and submit their answers with some remote-submission device. The results would be presented anonymously (thus ensuring no student is singled out for mistakes), and the instructor can lead into a discussion on the correct solution. Positive student performance could lead to badges (based on attendance, high correct answer percentage, or other positive markers) that would be tied to achievements in the class. This would be one such example of a pedagogically useful, socially engaging, and intellectually challenging integration of gamification elements for students, while maintaining the notion of a professional environment centered on learning.

Conclusions

The work presented herein described the nature of incorporating gamification elements into collegiate classrooms. The major issues that arise, specifically those that cause the educational environment to become less professional, are all prevalent and should be taken into account in order to have a successful implementation. As long as instructors are proactive in the implementation and potential risks, the resulting rewards can be beneficial to learners along an axis that few other pedagogical methods can approach. Future studies will include formalized implementations of some of the topics presented on freshmen level STEM courses and will document the successes and failures.

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