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Impact of Gamification on Student Engagement in Graduate Medical Studies

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Abstract

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Doctoral Study Submitted in Partial Fulfillment

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Abstract

Rapid technological advances have created major societal changes, transformed business sectors, and revolutionized enterprises. In contrast, the curricular structure of medical education has remained unchanged for the last 100 years, and, for the most part, medical education has been reluctant to embrace the use of technology. The prevalent pedagogical model is reliant on rote memorization. The conceptual framework that informed this study was the user-centered framework for meaningful gamification. This quantitative study focused on key research questions related to identifying whether significant increases occurred over time in cooperative learning, cognitive level, and personal skills—the dependent variables—when using a gamified learning method—the independent variable. The validated Student Engagement Survey was used to collect data from second-year medical students in a Southern California medical school, with $N = 64$. A repeated measures MANOVA with follow-up univariate ANOVAs was used, and statistical results indicated that there were significant differences over time in cooperative learning, cognitive level, and personal skills when using gamified learning methods. This research was conducted over a period of 3 months, divided into 3 Time Periods (TP). For all three variables, significant increases were noticed between TP 1 and TP 2, followed by significant decreases between TP 2 and TP 3. These findings pointed to the fact that more studies are needed to better understand whether certain types of gamification implementations are detrimental to student engagement in medical education, or whether more sound design principles ought to be explored to produce effective gamified learning components that could positively impact student engagement in medical education.

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Dedication

To the three most beautiful and wonderful women in my life: Kimberly, my wife and the love of my life—I am grateful for the sparkle of joy that she brings to my life; Sonia and Soraya, my most precious daughters whom I am so proud of and whom I deeply cherish and love.

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Section 1: The Problem

The Local Problem

The administrators at a college that is part of a Southern California graduate medical school find themselves caught in a struggle to deliver to their students a curriculum that meets the needs of a new generation of students. These administrators recognize that the infusion of technology into the course delivery system could help to leverage a learning modality that this new generation can relate to. With the vast majority of their students under the age of 30, the college administrators recognize a loss of opportunity in not fully leveraging technology, viewed as a way to enhance student engagement.

In the present context, technology is perceived as a means, not as an end in itself; it represents a vehicle used to construct pedagogical tools that can potentially influence the learning experience in a positive manner (C. Lin, Yu, Wang, & Ho, 2015). The college academic leaders do not identify technology as a panacea for resolving its academic struggles; rather, they try to identify technology affordances to address specific problems, such as student disengagement. In this study, gamification represented the technology channel through which college administrators sought to examine to which extent the use of gamified learning components could impact the level of student engagement.

Students' Perception

Every year, at the conclusion of each semester, the college instructors collect data from students through an annual survey to assess the effectiveness of its established curriculum (S. Franco, personal communication, May 17, 2016). Data analysis has shown that students wish to see more technology being integrated into the curriculum. Moreover, survey results have indicated that students feel the need to use technology more efficiently and more prominently, as well as to make technology a more integral part of the curriculum delivery process. In a national survey, these sentiments emerged as a major and predominant theme among several institutions (National Survey of Student Engagement [NSSE], 2013). Among some of the cases cited, students expressed the desire to use a digitized method of submitting their academic work, to receive feedback through an online communication system, to create e-portfolios through a computerized system designed for this purpose, and to access more learning materials and resources through an online platform.

With a student population predominantly composed of millennials, the college administrators have come to grips with the fact that digital communication must be greatly expanded, given that its students are part of a generation that has never known a world without computers (Crappell, 2015). As a result, the college administrators are making an effort to move away from the status quo and try to modify the curriculum structure to be more permeable to change, and in a special manner, change their attitude toward integrating technology to better meet the needs of its students and foster better engagement in the classroom.

Academic and Peer Influences

In addition to the abovementioned factors, the last decade has seen trends in education that compel faculty members to embrace new technologies in their teaching practices (Watty, McKay, & Ngo, 2016). Whether through exposure to current academic literature or while attending professional conferences, faculty members feel a wave of changes around them leading them to perceive that the time is ripe to adopt educational technologies and embrace them (Franklin, 2015). Many feel that suboptimal utilization of technology represents a disservice to their students (Watty et al., 2016). The abundance of literature that demonstrates the many advantages of using technology in the classroom may motivate faculty members to harness new and emerging technologies (C. C. Lin et al., 2015).

Furthermore, academic trends showing a growing interest in embracing other pedagogical models represent a catalytic influence inciting faculty members to consider incorporating innovative teaching methods in their practices (Ford, Polush, & Brooks, 2016). For example, it is not uncommon to hear buzzwords such as *flipped classroom* or *innovative learning spaces* on campus—these generate conversations that, to a certain extent, influence faculty members to move away from the status quo (T. Wood, personal communication, May 21, 2016). Faculty development programs touting the positive effects of adopting technological solutions in the classroom generate motivations for faculty members to consider curriculum delivery models that differ from traditional ones that are mainly lecture and teacher based.

Whether their influences are coming from peers, academic literature, faculty development programs, or professional conferences, faculty members find themselves confronting the inevitable fact that technology is around them and is here to stay; it will remain part of the modern classroom (Watty et al., 2016). This situation is triggering a mental shift in the college's faculty members who are acknowledging the need to make an effort to integrate technology solutions in the classroom. Instructors are inching toward wanting to give other pedagogical models a try to determine whether this move could positively impact the problem related to the engagement level of their students.

Faculty Constituency

The Association of American Medical Colleges (AAMC) released a report showing an alarming trend regarding an increasingly aging population among full-time faculty members teaching in medical schools across the United States (Daniels, 2015). To reverse this trend, in the last 5 years, the college administrators hired several faculty members who were in their 40s. As an unintended consequence of this move, the college administrators noticed a surprising cultural shift, marked by a strong inclination among these younger faculty members to embrace technology in the classroom (R. Hasel, personal communication, May 12, 2016). They requested the use of tablets as a means to effectively deliver the curriculum by using apps and specific medical software optimized for the mobile environment. The influence generated by this new group of instructors has motivated the college to explore technological venues to enhance its curriculum delivery method.

Another byproduct of this phenomenon was the fact that these new faculty members dispelled the idea that introducing technology in the classroom was more than just having distractive and frivolous "bells and whistles" in the panoply of educational tools at the disposition of the college. They demonstrated that a well-leveraged technology solution could constitute a major asset that could potentially enhance the learning process. For example, they demonstrated the effectiveness of mobile learning by implementing a rubric-based method of student evaluation, which greatly simplified the process of conducting formative and summative learning assessments within the college.

Among the unintended consequences of mingling faculty with different technological backgrounds was the formation of an informal mentoring environment (Laverick, 2016), where exchanges and dialogue took place. This resulted in the creation of a free-flowing information sharing process, leading to experimentation and usage of computer-based software tools by technologically noninclined faculty members in the college.

Thus, as a direct result of hiring a younger generation of instructors, the college is experiencing an attitudinal shift toward embracing technology. The younger faculty members conduct experimentation involving the use of technology in the classroom that shows positive impacts on student learning. As limited as these experiments might be, they demonstrate that technology can be a reasonably impactful factor toward creating a better learning environment for the college's student population, which is largely composed of millennials.

As a result, the college has experienced a shift that is leading faculty members, slowly but surely, toward the acceptance of a new paradigm in which technology is viewed as an instrument that could address the problem of lack of student engagement in the classroom.

Emerging Technologies

The college's faculty members are constantly subjected to a flood of marketing influences coming from various vendors taking advantage of advances in technology to create niches in the field of medical education. The incessant bombardment of advertising materials coming from vendors that have invested in technology products to influence the educational world greatly influences faculty members. Through this marketing exposure, faculty members are put in contact with tools that they view as potentially useful in their teaching. This phenomenon has greatly influenced faculty members to explore technology solutions that could assist them in their teaching practices (Information Resources Management Association, 2016). According to the group Transparency Market Research (2016), the value of the global medical education market will reach $38.4 billion by 2024, mainly driven by technological innovations and upgrades, with the rise of online medical education playing a major role in this analysis and trend.

As a result of marketing pressure exerted by vendors creating new software and education tools specifically tailored for medical education, faculty members at the local college where this study took place are discovering new educational tools and are leveraging technology to amplify certain dimensions of learning hitherto unavailable in medical education (Friedl & O'Neil, 2013). Not immune from the influence of this marketing force affecting the field of medical education, discussions within the college's faculty members are taking place regarding the place of technology in the curriculum. Some members of the curriculum committee (R. Hasel, personal communication, August 17, 2016) have highlighted the fact that the college administrators wished to put in place strategies that would involve the use of educational technologies as part of its curricular structure, with the hope that it would generate an increased level of engagement among the student population.

Consequently, the college administrators have created discussion venues and exchange forums to explore possible technological solutions that could be instrumental in changing a curriculum in need of change. Formal and informal discussions are taking place to address the problem labeled as *student disengagement*.

Rationale

Evidence of the Problem at the Local Level

The rationale for this study involved the need to probe a student cohort enrolled in a medical study course, with the goal of determining the impact of gamified learning exercises embedded as course components and used as learning tools. Using a survey instrument, a measurement process was conducted to assess to what extent students' level of engagement was impacted.

Some isolated research studies have been aimed at determining the effect of gamification in higher education, with a very few specifically targeted at medical education. Furthermore, existing studies on gamification have dealt with student academic efficiency and progress (Kayımbaşıoğlu, Oktekin, & Hacı, 2016), but practically none have dealt specifically with medical education and student engagement. Thus, this research conducted in the context of a graduate medical school and seeking to assess the impact of gamification on student engagement addressed a gap in the research.

The college administrators took the initiative to seek technological solutions to assist with revitalizing the curriculum delivery process by introducing haptic virtual reality medical simulation devices (J. Ywom, personal communication, September 16, 2016). Subsequently, 3D technology solutions were considered and evaluated. This included the use of 3D animation and 3D learning platforms that brought a better level of visualization into the student learning process. This string of quests led the college to seek and try other pedagogical approaches as well as investigate the potential benefits of using technology-driven learning tools such as gamification. The college administrators acknowledged the growing popularity of gamification in the classroom (Urh, Vukovic, Jereb, & Pintar, 2015) and wanted to explore its use, as well as assess its effectiveness in the classroom.

This study fell under the college's initiative to leverage technological means to meet students' needs in the hope of maximizing learning through affinity with technology-enabled devices and gaming environments. It represented a worthwhile endeavor to explore whether this could be achieved by studying the effects of infusing pedagogical components involving the use of gamification principles into the learning process of a Southern California graduate medical school.

Evidence of the Problem From the Professional Literature

The curricular structure of graduate medical education today is the same as it was more than 100 years ago when the very first medical education reform took place in 1910. Since then, the world has experienced dramatic societal changes, drastic changes in educational methods have taken place, and newer pedagogical models have emerged.

Most notably, explosive advances in technology have transformed education in unprecedented ways; such advances have included the introduction of simulation, 3D visualization and representation, augmented reality, and virtual reality, to name a few (Drake, 2014).

Given the predicament that leaders in medical education found themselves embroiled in, certain main factors, causes, and reasons explained the nature of the pedagogical and cultural dilemmas experienced by medical schools. These are described in detail in the sections that follow.

Generational factor. The status quo in graduate medical education has engendered several problems. Among them has been failure to meet the expectations of current and future generations of learners (Chretien, Yarris, & Lin, 2014)—a problem largely acknowledged in recent literature (Drake, 2014). One of the differential characteristics of the millennial generation is its members' high level of comfort with technology, hence their designation as the *digital generation* (Taipale, 2016). This idea resonates even more strongly with students enrolled in medical education (Erlam, 2014), who expect digital learning experiences that are interactive, adaptive, and who have been "reared on rapidly evolving technologies" and therefore "demonstrate decreased tolerance for lecture-style dissemination of course information" (Roehl, Reddy, & Shannon, 2013, p. 46).

The current generation of students has been characterized as having experienced a "specific technological socialization shaped by a distinct information and communication technology environment" (Hoffmann, Lutz, & Meckel, 2014, p. 144), which predisposes them to adopt certain attitudinal patterns. Among these is the fact that these students have a social networking tendency and are team oriented; they evolve optimally within engaging platforms that are socially oriented and conducive to both online and offline communications (DeVaney, 2015).

Students belonging to the millennial generation have had access to technology from a very young age and have more access to information, technology, and digital media than any previous generation. Furthermore, they have a propensity for experiential, group-based activities and collaborative learning experiences (Roehl et al., 2013). Instead of passively receiving information, millennials tend to be interactive and have a desire to be active while engaged in the learning process.

Taking these generational characteristics into consideration, one could safely assert that a major gap exists between a curriculum delivery model adopted by medical schools that relies heavily on teaching using a lecture-based format and the students' way of embracing the learning experience (Mitchell, 2012).

Preponderance of gaming. Games have pervasively permeated every aspect of contemporary life, and members of the current generation of students have spent their entire lives surrounded by video games (Vodanovich, Sundaram, & Myers, 2010). This phenomenon has been greatly amplified every year, as demonstrated by reports showing substantial growth of the global gaming market, which will reach $93 billion by 2019 (PwC US Entertainment & Media, 2016)—currently, the market is worth $71 billion. To put this figure in perspective, the video game industry will grow more rapidly than larger segments such as TV, cinema, and books.

Gaming, as a juggernaut of commercial and societal culture, also represents a major force shaping the world of education, as demonstrated by the fact that in recent years, several colleges and universities have offered video game degrees. Recognizing a major opportunity, the U.S. Department of Education took an unprecedented step to motivate and incentivize educational institutions to leverage gaming to enhance teaching and learning—it made the bold claim that the future of education included video games (U.S. Department of Education, 2016).

The abovementioned dynamics were among the factors that contributed to the emergence of game-based learning, perceived as conducive to the creation of a more interactive and engaging learning environment (Kayımbaşıoğlu et al., 2016). Shaped by societal influences marked by the prevalence of gaming, a distinctive characteristic of this new generation of students was their strong affinity with game-playing, which had given them the label “gamer generation” (Day-Black, 2015, p. 91). The increasing introduction of digital games and technologies into the educational arena has affected teaching and learning practices (Lynch, Mallon, & Nolan, 2014).

Being aware of the importance of gaming in education, the college administrators wanted to conduct an investigative process to evaluate whether leveraging educational components embedded within game-based learning could assist with its struggle to positively impact the level of engagement among the student population.

Learning disposition and preferences. Millennials have been characterized as having a short attention span and being unable to maintain concentration, especially during long, drawn-out lectures (Karakas, Manisaligil, & Sarigollu, 2015). However, the didactic part of medical education is structured around lectures and oral presentations. This situation reflects the disparity between medical schools' knowledge delivery method and millennials' approach to learning. Millennials have a tendency to be in control of activities surrounding their lives, including learning activities; they desire to take an active part in learning processes and benefit from being active participants rather than passive recipients (Procopie, Bumbac, Giusca, & Vasilcovschi, 2015).

For learning organizations, gamification is an innovative mechanism that makes it possible to adapt content to the needs of millennials, engaging this generation in a variety of learning activities that may include information on social wellness, societal regulations, financial responsibility, and life skills (Werbach, 2015). These learning initiatives have proven to have a positive impact by imparting knowledge and skills to millennials, thus implying that gamification tends to have a positive impact on millennials and lends itself to creating an environment conducive to learning.

In sharp contrast with millennials' learning dispositions, the commonly adopted medical school curriculum was tailored in such a way that memorization represented a major portion of the learning acquisition process and constituted the primary medium used to ingest learning materials—a process that was somewhat misaligned with millennials' approach to learning (Grey, 2011).

The purpose of this study was to determine whether the level of engagement of a student cohort enrolled in a Southern California graduate school was affected by the use of gamification principles embedded within course learning components. This study examined a problem related to the use of learning media that millennials could identify with and relate to. In conducting the study, I sought to highlight the problem related to the inadequacy of the current medical curriculum delivery method and identify to what extent gamification could be used to engage students. Gamification principles have been successfully used to impart learning to millennials for acquiring practical life skills. This study was an attempt to investigate whether these same gamification principles could have a similar positive impact in medical education and tackle the problem of student engagement among medical students.

Engagement in the classroom. In the most recent survey conducted by the Gallup Student Poll (2016), only half of the student population was engaged, and, most alarmingly, 10% were classified as both discouraged and disengaged, while 5% were actively disengaged.

The National Survey of Student Engagement (NSSE) is the largest organization in the nation focused on analyzing students' level of engagement; its main role is to establish standards for student engagement. It is composed of more than 1,500 participating educational institutions (NSSE, 2013). NSSE results have shown that participating institutions across the nation have been cognizant of the fact that engagement is a major factor in the learning experience. The derived analysis showed the importance and critical role of engagement in the academic experience; it represented a "make-or-break factor for learning to take place" (Dean & Jolly, 2012, p. 228).

The student disengagement problem is equally present in medical schools (McCoy, Pettit, et al., 2016), where institutions struggle to provide a learning environment that allows students to be participative and actively engaged in the learning process. Teaching faculty members at the college reported that medical students enrolled in their courses did not seem to be listening to their lectures or to be making an effort to participate during lectures (G. Thrush, personal communication, April 21, 2016). They noticed that a large majority of students had their laptops open but seemed to be engaged in parallel activities unrelated to the lecture or topic being covered. This rather disconcerting classroom reality had been noted for several years, and attempts were being made to curtail students' non-curriculum-related activities during lectures; however, the college administrators realized that there was no realistic, practical means to prevent students from engaging in activities other than the ones mandated by lecturers in the classroom.

This attitudinal discomfort displayed by medical students during lectures motivated college administrators to explore other pedagogical models. Among such possibilities was the use of gamification introduced as a curriculum component. The college's sister institution reported some promising results after implementing a gamification experiment, which influenced college administrators to explore and determine whether such an alternative way of delivering the curriculum could assist in creating a better level of engagement among its medical students.

Gamification of learning. The gamification of education is a relatively new phenomenon. Although prevalent in the commercial and advertisement world, gamification is perceived as a new methodology in higher education and represents a new pedagogical model for 21st-century educators (Taspinar, Schmidt, & Schuhbauer, 2016). Although there is ever-increasing interest in discovering its potential in educational settings, gamification is still an unknown quantity; educators and researchers are still seeking to understand the dynamism created by the use of gamification in the classroom to determine its positive or negative influence on the learning experience (Geelan et al., 2015).

As such, it was a worthwhile endeavor to further examine the inner workings of gamification and determine whether operationalizing the various game dynamics interjected in a gamified learning experience could positively impact the level of student engagement.

Definition of Terms

The following terms and concepts as they relate to the focus of this study are defined below with the goal of facilitating readers' comprehension of the study:

Game-based learning (GBL) or *digital game-based learning (DGBL)*: A byproduct of serious games, with a clear focus on achieving specific learning outcomes through the medium of play. It consists of leveraging the entertaining factor intrinsic to digital games to derive educational value and learning moments out of the gaming experience. Two critical components of DGBL are fun or entertainment, coupled with learning or education (Bellotti, Kapralos, Lee, Moreno-Ger, & Berta, 2013).

Game dynamics: Activities of a gaming experience involving the following: exploration, collection, competition, acquisition of status, collaboration, challenge, and progression. They constitute tools for allowing activities to progress and move the action forward. Three typical elements of game dynamics are constraints (rules and choices), emotions (ranging from enjoyment to unhappiness, from a sense of accomplishment to dissatisfaction), and narrative (underlying story behind the implementation; B. Kim, 2015b).

Game elements or *game-design elements*: Components of a game used to influence user behavior by generating motivation, creating excitement, fun, or engagement. Game elements consist of game mechanics and game dynamics (Deterding, Dixon, Dar, Khaled, & Nacke, 2011).

Game mechanics: All games make use of mechanics, which are the actions or methods present in the platform to create a compelling game experience. Mechanics dictate participants' behavior and generate interactions. Mechanics describe the various components of the game, determine how players interact with rules, and define the game's end goals (Reese, 2009).

Gamification: The use of game mechanics in traditionally nongame activities. In an educational setting, gamification is used to introduce game mechanics into learning components and learning activities, thus transforming traditional learning exercises into action-oriented and interactive activities (Jagoda, 2013).

Millennials or *Generation Y*: These terms encompass individuals born roughly between 1980 and 2000 who are likely to have been exposed to and immersed in a world of digital technology more than any previous generation, largely due to the fact that the world they have always known has been characterized by the pervasiveness of the Internet. As the most educated generation in western history, millennials tend to exhibit the following characteristics: creativity, independence, pragmatic idealism, diversity, solution focus, civic orientation, being socially conscious, and team orientation (Crappell, 2015).

Serious games: Games designed to contain instructional values and educational purposes, which are not specifically created to be played with amusement as a primary focus. They differ from entertainment games in placing emphasis on learning outcomes (Rooney, 2014).

Student assessment: Process used as a formative, diagnostic, or summative tool to make judgments about the progress, achievements, and performance of students over the course of a study. Different methods of assessment exist, such a self and peer assessment, as well as formal assessment (Stovall, 2015).

Student engagement: A construct that encompasses the following dimensions: emotive, cognitive, and behavioral. Given its multidimensional scope, engagement manifests itself in various forms, such as participative engagement, social engagement, and emotional engagement. The level of attendance and the mental effort expended during learning activities can represent a manifestation of the cognitive aspect of student engagement. Students' investments, presence level, and emotional reactions can be demonstrative of the emotive aspect. Students' level of participation, manifested level of interest, and active responses can be indicative of the behavioral aspect (Mandernach, 2015).

Significance of the Study

The importance of this study is described by the four factors below, namely technology integration in medical education, impact of gamification, gamification in medical education, and a new pedagogical model in medical education.

Technology Integration in Medical Education

According to a national survey involving more than 1,500 educational institutions (NSSE, 2013), the current generation of students demonstrates an inclination toward using new and cutting-edge technology in the classroom. Furthermore, the NSSE showed that there was a strong correlation between the use of technology and the level of student engagement—students were more engaged when technology was integrated into teaching and learning (NSSE, 2013).

Despite these facts outlining the importance of using technology in the classroom, medical education has a tendency to be reliant on traditional methods of curriculum delivery, which are lecture based and use technology to a minimal extent. As a matter of fact, researchers have shown that scholarly dialogue related to the use of educational technology within the field of medical education is on the decline (Han, Resch, & Kovach, 2013). This phenomenon has led some educators in medical education to consider revamping an antiquated medical education system through technology (Mahan & Clinchot, 2014).

In this study, I aimed at using technology in order to determine whether instilling learning components built around various types of technology could enhance students' learning experience and level of engagement. Among the technology components present in this study were the use of mobile learning, Web 2.0 technologies, software applications, and computer-based educational tools. Conducted within the context of a technology-rich environment, this study had the potential to shed light on how it may be possible to reshape medical education through technology-enhanced learning components.

Impact of Gamification

Game play has been touted as having considerable potential for developing various skills and abilities such as visualization, spatial and navigational abilities, reaction times, reflexes, psychomotor skills, and multitasking, as well as hand-eye coordination (Boyle et al., 2016). Other purported potential uses of game play involve the development of higher order cognitive skills that include critical and strategic thinking, analytical skills, and critical reasoning (Hainey, Connolly, Azadegan, & Gray, 2014).

Given such a large array of potential benefits of gamification, conducting this study was a worthwhile endeavor; it provided a means to evaluate to what extent the abovementioned learning potentials could be potent tools that could be leveraged in order to enhance teaching and learning.

Furthermore, gamification reflects an upward trend that impacts organizations, as highlighted by the fact that in 2015, 40% of the world’s largest 1,000 organizations were using some form of gamification with the goal of transforming their business operations and leveraging technological innovations (Blohm & Leimeister, 2013). Further, 87% of North American retailers plan on making use of gamification as a business strategy in the next 5 years to engage their customers (Convenience Store Decisions, 2015). In 2011, the gamification market was estimated at $100 million, and by 2016, phenomenal growth had resulted in this figure skyrocketing to $2.8 billion (Everson, 2015), with an even more impressive and explosive projected growth rate of 41.8% by 2022, when the market is projected to reach $22 billion (Research Markets, 2016). In contrast with the business world, in higher education, the adoption and integration of gamification are still in their burgeoning phase.

Gamification has been successfully used as an impactful and innovative technique to cater to the needs of millennials in social activities such as awareness, fundraising, advertising, and work environment processes (Procopie et al., 2015). This study was used to determine to what extent the level of success encountered in the business world by leveraging gamification could be replicated in an educational environment. In addition, this study shed some light on whether gamification could be used as an innovative pedagogical model in higher education to yield at least some of the many potential benefits outlined above.

Gamification in Medical Education

A search for literature related to game-based learning related to medical education or the use of educational games related to medical students' learning yielded very few results. This was due to the fact that very few studies have been conducted to determine the effects of game-based learning in medical education (Akl et al., 2010). Furthermore, the limited literature on this topic is composed of explorative essays rather than experimental studies, as well as reflection on purported potentials of gamification to assist medical educators (Ahmed et al., 2015).

Due to its newness, gamification is only sparsely used in educational milieus. This phenomenon is even more apparent in medical education—a system that is struggling to step into a modern era in which technology's presence and influence are nearly ubiquitous. Hence, if studies of the effects of gamification in higher education are scant, this reality is even more accentuated in medical education. This adds to the relevance and importance of exploratory studies such as this one. This study can be added to the body of limited research studies dealing with the effects of gamification in graduate medical education, and as such it contributes to the understanding of the influence of this new approach to learning in medical education.

A New Pedagogical Model in Medical Education

The teaching model that is predominant in medical education is currently the lecture-based model with a major emphasis on teaching in large amphitheaters. Ferris and O'Flynn (2015), talking specifically about medical education, asserted that "Universities are facing substantial challenges in meet[ing] the demands of 'Generation Y'" (p. 139). The pedagogical model that has been in place for decades in medical schools would benefit from being re-evaluated to discover other methods to impart learning to medical students. Models that have been suggested to improve medical education include problem-based learning, flipped classrooms, collaborative learning, and independent learning (Prober & Khan, 2013). A complementary approach that has been suggested for medical education involves innovation with technology integrated with innovation in pedagogy (Colbert & Chokshi, 2014).

This study was a small-scale realization of this idea; it stimulated interest in discovering new ways to use technology as a vehicle for delivering the curriculum in medical education. This was realized by exploring new pedagogical models, such as one using gamification principles that could influence teaching methods that were more student centered and could foster more engaging learning environments.

Research Questions and Hypotheses

The purpose of this study was to determine whether the use of gamification principles embedded within course-learning components would affect the level of engagement of a student cohort enrolled in a Southern California graduate school.

Three variables of the student engagement construct—cooperative learning, cognitive level, and personal skills—were considered in the following research questions:

Overall RQ: Was there a significant increase over time in cooperative learning, cognitive level, and personal skill when using gamified learning methods?

H_0: There was no significant increase over time in cooperative learning, cognitive level, and personal skill when using gamified learning methods.

H_A: There was a significant increase over time in cooperative learning, cognitive level, and personal skill when using gamified learning methods.

Sub RQ1: Was there a significant increase over time in cooperative learning when using gamified learning methods?

H_01: There was no significant increase over time in cooperative learning when using gamified learning methods.

H_A1: There was a significant increase over time in cooperative learning when using gamified learning methods.

Sub RQ2: Was there a significant increase over time in cognitive level when using gamified learning methods?

H_02: There was no significant increase over time in cognitive level when using gamified learning methods.

H_A2: There was a significant increase over time in cognitive level when using gamified learning methods.

Sub RQ3: Was there a significant increase over time in personal skills when using gamified learning methods?

H_03: There was no significant increase over time in personal skills when using gamified learning methods.

H_A3: There was a significant increase over time in personal skills when using gamified learning methods.

Review of Literature

Conceptual Framework

Several theoretical frameworks have been identified as informing foundational principles behind the use of gamification in various contexts (Mora, Riera, Gonzalez, & Arnedo-Moreno, 2015). The majority of these design frameworks apply to the business and corporate world, and a few have been identified as specifically applicable to the educational realm. Seaborn and Fels (2015) conducted a comprehensive multidisciplinary review of available theoretical frameworks related to gamification and distinguished a few that pertained to education. The user-centered framework for meaningful gamification (Nicholson, 2012) was used to serve as a foundation for this study. Among the core theories in this framework was one that was used to inform a gamified design strategy geared toward intrinsic motivation for meaningful engagement.

The four components of this framework are the following: (a) *organismic integration theory*, in which motivation intentionality is seen on a continuum from lack of user motivation to autonomous intrinsic motivation; (b) *situational relevance*, which stipulates that meaningfulness is a value judgment that is a prerogative of the user; (c) *situated motivational affordance*, which calls for alignment of the user's background and context with the gamified environment; and (d) *universal design for learning* (UDL), which acknowledges the nonhomogeneity of the user population and calls for a not-one-size-fits-all gamified design. Nicholson (2012) coalesced these four disparate theories to form the user-centered framework for gamification, arguing that they commonly embrace a user-centric view and approach—the framework that was used to inform the present study.

The principles behind the user-centered framework for meaningful gamification informed the design of this project, which involved creating a learning platform that, at its core, reflected concern about and an emphasis on users, represented by students in the context of this study. Various design components were integrated into the gamified learning platform to promote user centeredness.

Among these integrations was the incorporation of a learner-guided and learner-controlled assessment mechanism. Upon successful completion of a quiz or assessment section in each learning module, students received success acknowledgment in the form of a trophy; this signified that the students had met the requirements for the completion of that section of the module. Moreover, students were given the opportunity to pass quizzes multiple times and get an additional trophy each time. Because the quizzes were dynamically generated based on a random selection of questions, there was ample opportunity for students to explore and test their knowledge of different topics covered in the course. In this instance, students were given the freedom and opportunity to decide how much mastery of a given topic they wished to obtain. At this juncture, it is worth mentioning that the repetition and drilling mechanism seemed to be extrinsically motivating by rewarding students with trophies; however, the same mechanism motivated students intrinsically because students gained no further status or additional points for completing and passing quizzes multiple times. The loop mechanism was designed in such a way that the only motivation for repeating quizzes would be enjoyment of learning, using a platform that was designed to promote engagement.

Another concept surrounding user-centeredness was the notion of involving and engaging users—the learners, in this context—while designing a gamified platform. Applying sound design principles and following best practices, designers and instructional technologists devised a plan and executed it to create a learning product. However, students would ultimately be the best judges of whether the implementation successfully achieved the intended goal of creating an engaging learning platform. To this effect, third-year students who had already completed the course were asked to provide feedback on the design flow of the learning platform. These third-year students contributed to the evaluation of the product design to ensure that the various game mechanics achieved the desired learning outcome goals. Careful attention was paid to the evaluation of design components that needed to be adjusted in order to maximize engagement.

One of the premises behind the choice of gamification as a technology platform was that it would be beneficial to leverage this group of students' inclination toward gaming. This choice was guided by the choice to adopt a user-centered approach; instead of imposing a delivery method dictated by a traditional system, I chose a method that meshed well with millennials, who have been labeled as the "gamer generation" (Day-Black, 2015, p. 91). My aim was to adopt a vehicle for learning that students would find beneficial and that could lead to increased engagement.

Review of the Broader Problem

The review of literature synthesizes themes and ideas discovered in peer-reviewed research studies on topics related to the crisis in medical education vis-à-vis its use of technology or lack thereof. In conducting this review, I examined the state of medical education in order to understand that today's problems stem from historical antecedents. Further, I explored the evolution of digital game-based learning as a technology derivative applied to the educational realm. Moreover, I examined existing implementations of gamification within medical education while highlighting the various strengths, weaknesses, and contributions of these gamification experiments conducted in the context of medical education.

Search Strategies

The search strategies that I used consisted of investigation of peer-reviewed publications related to the topic of medical education, gamification, student engagement, and notions directly or indirectly related to the abovementioned themes. It involved a process of compiling available literature for a wide-ranging representation of current research related to this study. The search tools used that I used were Walden University's library and Google Scholar; I also used databases such as EBSCOhost, PubMed, AccessMedicine, McGraw-Hill Medical, ProQuest, and ERIC. Terms used in keyword and combined keyword searches included *gamification*, *gamified learning*, *game-based learning*, *gameful learning*, *game-based education*, *games and learning*, *gameplay education*, *gamification design*, *gamification education*, *gamification principles*, *gamification learning*, *Generation Y, millennials*, *medical education*, *medical education and technology*, *medical studies and technology*, *medical education reform*, *student engagement*, and *gamification student engagement*. Themes and patterns that emerged from this search process were used as scaffolding to construct and edify the structure of this study.

Websites and organizations focusing on the use of technology in higher education were consulted to discover trends and valuable information pertaining to the topic of gamification in education. Among such entities were Educause, Inside Higher Ed, International Society for Technology in Education, *Technological Horizons in Education (THE) Journal*, as well as sources more specific to medical education that deal with the use of technology to enhance teaching and learning, such as the *Journal of the American Medical Association* and the Association of American Medical Colleges.

To achieve saturation, recent dissertations related to the topic of gamification in education were consulted and their sources reviewed in order to gather comprehensive bibliographical information related to the research topic. Likewise, bibliographical sources of the most pertinent articles that closely relate to this study were examined to obtain references that could provide valuable leads and directions. This strategy was used to ensure that the body of research and articles pertaining to this study was as inclusive and as comprehensive as possible.

The State of Medical Education

For the last decade, medical education leaders have wrestled with the struggle to adapt to a changing world in which technology has infiltrated every aspect of modern life, including education, where it has offered the possibility of new pedagogical models. In the paragraphs that follow, I describe past research and factual information on the state of medical education.

Recognizing inherent problems related to medical education, several attempts were made to reform medical education, starting with the Flexnerian movement in 1910, which resulted in the writing of a comprehensive report outlining various aspects of medical education that were deficient (Flexner, 1910). This seminal work started the medical education revolution. Among the flaws of the medical educational system pointed out by Flexner (1910) was a lack of student centeredness and an inability to create an active learning environment conducive to critical thinking. More than a century later, the situation has yet to see any improvement.

To illustrate this fact, it becomes necessary to examine the graduate medical curriculum. Since 1910, the curriculum has been divided into a 2-year didactic phase consisting of lectures and presentations and a 2-year clinical skills phase encompassing laboratory studies and clinical rotations. This structure has remained unchanged since the early 1900s; medical schools still follow the same curricular construct more than 100 years later (O’Brien & Irby, 2013). This fact is illustrative of the status quo that prevails within medical education, which has prompted several medical educators and organizations to initiate a change process. Among those have been Christensen, Grossman, and Hwang (2016), who stated that medical education is currently in crisis and stuck in a rut, with a fundamental curricular design that is a century old.

New paradigms have been proposed to revamp the medical school system, and due to the obsolescence of the current traditional framework, calls were made not for evolution, but for a revolution of medical education (Benor, 2014). The new medical education was described as not reliant on classroom-based lectures; the role of the instructor would be to guide the acquisition, understanding, and synthesis of knowledge and to not be a mere disseminator of knowledge. Developing technologies, including mobile learning, wearable devices, and simulators, would render lectures delivered in auditoria obsolete, along with the practice of passively regurgitating information as a way to demonstrate knowledge mastery. Self-learning would become the predominant method of learning, and group-based structures would play a great role in knowledge sharing and assimilation. Rigorous summative assessments would be used to gauge knowledge acquired and maintain a high level of academic rigor.

Exactly 100 years after the Flexner report sponsored by the Carnegie Melon Foundation, that same organization published in 2010 an extensive report related to the state of modern medical education (Cooke, Irby, & O'Brien, 2010). Among other recommendations, it stipulated a lack of learner centeredness within medical education, as well as a need to leverage technology and a great need to put emphasis on critical thinking, particularly on linking factual and theoretical knowledge with clinical experiences. It emphasized the need to create a more engaging learning environment for a new generation of medical students.

The learning-teaching process needed to be revamped as indicated in the measures outlined by the American Medical Association (AMA), the largest association of medical doctors in the United States. The AMA released a comprehensive report calling medical schools to embrace change, innovate, leverage technology, and revamp an obsolete educational system that was based on a model more than a century old (AMA, 2015). The AMA's goal was to create a medical educational system that caters to the needs of a new generation of medical students, as well as to leverage technology and use its affordances to create new curricular models and learning experiences leading to deep learning. Among the objectives was the drafting of an educational roadmap to build a learning environment that would promote self-directedness and self-regulated learning. In a section dedicated to leveraging technology in the process of creating a new medical education system, the AMA's report highlighted the need to create technology-enabled teaching tools and to promote the innovative use of technology to create the medical school of the future.

Due to an educational system that is largely reliant on rote memorization and on a teacher-oriented model of teaching, student engagement is gravely lacking in medical education (Azzam, 2013). Reinforcing this idea, Fahnert (2017) suggested moving away from an overemphasis on didactic teaching in medical education to create a learning environment that is more conducive to student engagement. Poor student engagement is further exacerbated by the fact that a new generation of students is entering the medical field with modes of learning and expectations that differ from those of their predecessors. Current students, as members of the digital generation, have their existence empowered by technology-enabled devices. This situation is in dissonance with medical education's current stance of distancing itself from technology. The problem that medical education is confronted with stems from a lack of technology-enabled learning tools that could lead to the development of solutions to the problem of lack of student engagement. Assessing the state of medical education today, educators and researchers alike have acknowledged that technology should be made part of the medical school of the future, which should include, among other components, the use of educational games (Halperin, 2011).

The Game-Based-Learning Phenomenon

The massive influence of games as a mainstream entertainment and the social acceptance of games have greatly favored a move toward the adoption of digital games for educational purposes. McGonigal's (2011) work stands among that of popular evangelists and proponents of making games an integral part of human existence—

McGonigal went as far as to say that the power of games needs to be harnessed in order to boost global happiness. The popularity of games among millennials was demonstrated by figures published by the Pew Internet & American Life Project showing that 67% of the members of this age group claimed to be game players, with close to a quarter of them being self-proclaimed hardcore players (Duggan, 2015). Also compelling are the facts that 99% of boys and 94% of girls play digital games, with the number of hours youth spend playing games ranging from 7 to 10 or more hours per week (Homer, Hayward, Frye, & Plass, 2012). Furthermore, an average young person spends 10,000 hours playing video games by the age of 21, and 5 million people in the United States report playing video games 40 hours per week (Yunyongying, 2014).

The popularity of gaming has opened the way to capitalizing on this societal phenomenon to transfer gaming concepts in education and influence learning. However, adapting game concepts for learning is complex, in that this is a multifaceted endeavor; it necessitates a careful and measured approach to planning the design and implementation process to have a positive impact on learners. In this multifaceted approach, the dimensions that are foundational in game-based learning and that need to be taken into consideration are cognitive, motivational, affective, and sociocultural. These need to be among the design elements of games in order to facilitate learning and foster learners' engagement (Stewart et al., 2013). The cognitive aspect involves the use of imagination and conceptualization—a mental practice that players engage in while immersed in a game environment.

The motivational aspect entails engaging players in an immersive environment, providing experiences that captivate attention and motivate learners to persist and continue. The improvement of learning may come from extrinsic motivation or, preferably, intrinsic motivation that leads learners to reach levels of achievement, which in turn produce inner satisfaction. Such positive—if at times challenging—experiences provide an environment conducive to learning (Zusho, Anthony, Hashimoto, & Robertson, 2014).

The affective aspect focuses on players' experienced emotions, attitudes, and beliefs. Game elements such as aesthetic design, narrative, and game mechanics are used to induce emotions in players.

Taking the sociocultural aspect into consideration is an acknowledgment that learning is socially constructed and motivated (Wenger, 2000). Social environments are transformed into learning contexts and become platform enablers that facilitate collaborative work.

Consolidating the idea that games can contain intrinsic educational values, Stewart et al. (2013) conducted an extensive study outlining learning principles discovered in digital games. These learning principles and their description are displayed in Table 1.

In addition to the learning principles mentioned above, the following are among the arguments presented and listed as a by-product of relating game-based learning linked to education: increased motivation, learners' engagement, adaptivity, and graceful failure that consists of reframing the idea of failing during the learning process, and repurposing it as attempts and repetition—necessary steps needed as a way to reach subject mastery (Plass, Homer, & Kinzer, 2015). Based on these reported positive outcomes derived from using game principles that could potentially lead to the enhancement of learning, Squire (2011) posited that games represent an ideal medium for learning. Similarly, at the conclusion of a study conducted to assess the effect of gamification on health science learners, Fajiculay, Parikh, Wright, and Sheehan (2017) concluded that using game elements, such as digital badges, has the potential to positively influence millennial learners.

Among the reasons why game-based learning made its way into higher education was the fact that a number of studies demonstrated the effectiveness of game play on cognitive development, initially with younger learners, and subsequently reaching students in higher education (Kasimati, Mysirlaki, Bouta, & Paraskeva, 2015). This has led to research initiatives aimed at using game-based learning in order to inculcate learning abilities and skills such as problem solving, critical thinking, creativity, and digital literacy.

Another factor that contributed to the extension of game-based learning's scope to enter the boundaries of higher education was the proliferation of mobile devices—a phenomenon that displayed an explosive growth in the use of smartphones and tablets. Mobile learning affordances provided unprecedented opportunities to disseminate game-based learning components in the hands of learners and allowed for the introduction of innovative educational practices (Kasimati et al., 2015). Among these are the creation of flexible learning models, with an anywhere-and-anytime access to learning components;

personalized learning content; context-specific and context-sensitive learning approaches; and student-content interactive learning. Table 2 provides a more exhaustive listing of mobile device characteristics that facilitate the integration of game-based learning principles in education. Understanding mobile learning plays a role in this study since the gamified learning components will be accessible through mobile devices. A multi-year study concluded that “mobile technology is ubiquitous in the lives of today's college students” (Chen, Seilhamer, Bennett, & Bauer, 2015). Taking this reality into consideration, mobile accessibility can ensure that students will be given a choice to choose a medium of their choice to access the gamified learning components used in this study.

Table 1

Outlines of Learning Principles Found in Digital Games

Learning principles	Description
Identity	Taking on an identity in the game and thus making an extended commitment of self
Interaction	Interactive relationship between player and game space/world so that actions are situated
Production	Players coauthor their experiences, but can also participate in game creation through modification
Risk taking	Low consequences of failure encourage risk taking and exploration
Customization	Customization according to personal learning and play styles
Agency	All previously mentioned principles afford a sense of control and agency
Well-order problems	Finding solutions to earlier problems helps in solving later, more complex problems
Challenge and consolidation	New mastery of problems becomes consolidated through varied repetition
"Just in time" and "on demand"	Giving information just when the player needs it, or when he or she requests it.
Situated meanings	Situating the meaning of words in different contexts of use
Pleasantly frustrating	Given many of the previous principles, games manage to keep challenge to a doable level
System thinking	Games encourage players to think about relationships, processes, cause and consequence
Explore, think laterally, rethink goals	Encouraging to think about different alternatives to reach a goal, follow side-tracks
Smart tools and distributed knowledge	Knowledge is distributed across a player, nonplayer characters, and/or other players
Cross-functional tools	Knowing and making use of different resources within the team
Performance before competence	You don't have to know everything about a particular domain before you can participate in it, participation begins immediately

Note. From *The Potential of Digital Games for Empowerment and Social Inclusion of Groups at Risk of Social and Economic Exclusion: Evidence and Opportunity for Policy* (p. 77), by J. Stewart et al., 2013, Luxembourg: Publications Office of the European Union. Adapted with permission.

According to Epper, Derryberry, and Jackson (2012), a strong factor that propelled game-learning concepts into education was student expectations. One of the differential characteristics of the millennial generation was their high level of comfort with technology, hence their designation as the “digital generation” (Taipale, 2016). Another distinctive characteristic of this new generation of students was their strong affinity with game-playing, which gave them the label “gamer generation” (Day-Black, 2015, p. 91). As very apt consumers of digital content, current students thrive with sensory-rich stimulating learning environments; as such, game-based learning “must be an organic part of the student’s digital environment” (Epper et al., 2012, p. 9). Discussions surrounding the concept of game-based learning have led to debates and researches concerning which game elements are most effective in positively influencing learning practices. These inquiries have in many ways influenced the introduction of the gamification concept in education (Kapp, 2016). Thus, the debates have extended from discussing the value of game-based learning to the contemplation of the use of gamification in education.

Gamification in Education

One of the most commonly adopted definition of gamification is “the use of game design elements in non-game contexts” (Deterding, Khaled, Nacke, & Dixon, 2011, p. 3). Game design elements include game interface and design patterns such as badge, leaderboard, and level (Amir & Ralph, 2014). Other elements involve the inclusion of time constraints, limited resources and taking turns. Also, game mechanisms include challenge, curiosity, unpredictability, and surprises (B. Kim, 2015a).

Gamification has been characterized as well adapted to the learning style of a new generation of learners. The digital generation grew up around gaming and has great affinity with not just technology platforms, but also with game-like settings that provide, among other familiar generational components such as continuous challenges, captivating storylines, immediate rewards and feedback, and sometimes fun (Bruder, 2015).

Applied to an educational context, a gamified learning experience can positively influence student engagement by using gamification principles to affect the cognitive, emotional, and social aspects of the learning experience (Lee & Hammer, 2011). The cognitive aspect is stimulated through goal-oriented and learning objectives-based activities that challenge students within the gamified environment. Students engage in various learning exercises that can lead to knowledge acquisition and stimulate the decision-making process, because multiple learning alternatives and routes are created in order to lead towards achieving specific academic success goals (Kingsley & Grabner-Hagen, 2015). Also, students assess their level of mastery through built-in assessment tools; they are faced with challenges tailored to the level they reached. Students feel motivated and engaged in such an environment (Buckley & Doyle, 2016).

Table 2

Alignment of Indicative Mobile/Ubiquitous Devices Features With GBL Principles

Mobile/ubiquitous characteristics	Description	Game-based learning principle
Ubiquity	• The attribute of somebody being available and connected at any location and any given time. • Supports continuous information exchange.	• Allows the provision of both formal & informal learning. • Allows access to GBL from everywhere at any time. • Allows the provision of immediate feedback in response to student mistakes. • Enhances student's critical thinking and decision-making ability.
Localization	• Precise localization of a connected mobile device (when allowed by the user) • Precise information on the location of a person or a product.	• Provision of context-specific learning content. • Customized learning content
Interactivity	High level of interaction between • User-device • User-content • User-other users	• Supports social learning, collaboration, and collaborative decision-making • Supports increased interaction between students and students and learning content.
Identification/ personalization	• Users can be uniquely identified through their mobile device • Allows the monitoring and provision of data with regards to user's personal interaction with the mobile device	Allows the provision of personalized learning content.
Users have control over their devices	• Users are familiar with their mobile devices • Feel safe when using the devices • Can decide when, whether, and why they would use the device	• The game needs to allow players to track and manage their progress • Learner-centered learning • Learner is actively engaged • Minimization of technological barriers and technology adoption issues
Provides an immersive graphical interface	The provision of a camera, combined with online broadband supports the provision of 2D graphics and even virtual reality & augmented reality applications	The game must be immersive

Note. From "Ubiquitous Game-Based Learning in Higher Education: A Framework Towards the Effective Integration of Game-Based Learning in Higher Education Using Emerging Ubiquitous Technologies," by A. Kasimati, S. Mysirlaki, H. Bouta, and F. Paraskeva, 2015, in M. Khosrow-Pour (Ed.), *Gamification: Concepts, Methodologies, Tools, and Applications* (p. 1016), Hershey, PA: Information Science Reference. Copyright 2015, IGI Global, www.igi-global.com. Posted by permission of the publisher.

The emotional aspect plays an important part in a gamified learning platform. The design gamification involves the introduction of components and experiences that can lead to curiosity, frustration, or joy. It can also create feelings of optimism and pride (Plass et al., 2015). Most importantly, the experiences are designed to help students overcome their struggles through repetition as well as positive and encouraging feedback (Deterding, 2012). The loop mechanisms built into the activities help students repeat, rehearse, and persist without the fear of failure. A critical component of a gamified learning component is the reframing of failure (Kapp, 2013). The environment is built around the idea that failure is redefined as a necessary part of learning; feedback cycles reinforce the idea that repeated failures will eventually lead students to level completion and achieving learning goals. Thus, negative emotional experiences are replaced by positive ones and accompanied with a sense of accomplishment (Kapp, 2012).

The social aspect involves the participation of students within an environment where they interact with their peers and are part of a group. In this learning environment, students have new identities and roles (using avatars and role play), and, through branching mechanisms, they are asked to make choices and decisions. Also, gamification allows students to publicly identify themselves as “masters,” once they reach a higher level of mastery, and gain social credibility—for example, via a leaderboard (Mekler, Bruhlmann, Opwis, & Tuch, 2013)—as well as academic recognition by accumulating points (Kapp, 2016).

After exploring the use of gamification in education, the nature of this study necessitated the need to discover to what degree, and how, gamification has been applied to medical education.

Leveraging Gamification in Medical Education

Assessing the state of medical education today, educators and researchers alike acknowledged that technology should be made part of the medical school of the future, which should include, among other components, the use of educational games (Halperin, 2011).

Within the medical education community, a few attempts have been made to leverage the use of gamified learning components in medical curriculum to create an active learning environment that fosters student engagement. Gamification has been used in the business world, in marketing and promotions, in various areas of the enterprise such as training and employee incentivization (Alexe, Zaharescu, & Apostol, 2013). Only recently has it caught the attention of the world of education and only a few experimentations and studies have been conducted to assess its effectiveness.

Gamification is a new phenomenon in the world of education, and even newer in medical education. Several studies have been previously conducted in order to assess the effectiveness of gamification in medical schools. One such study aimed at supplementing traditional graduate medical education reliant on memorization as a means to promote knowledge retention with the incorporation of gamification elements into learners' study methods (Nevin et al., 2014). The game elements used were competition, badges, leaderboards, points, and levels. Also, immediate feedback, automated grading, and play styles, and loops were game mechanics used during the experiment. Among the motivating components of the gamified platform were peer and group competitions. Also, the study determined a positive impact on student engagement among medical students and statistical evidences pointed to a positive impact on learning using gamification strategies, specifically in the area of knowledge retention. Despite the positive outcomes of this research, its scope, restricted to the area of medical nomenclature memorization, does not fully validate the positive effect of gamification on the larger scale, such as a course component.

In medical education, projects were conducted in order to enhance learning experience, engage, and motivate students to learn. One such project was piloted with the goal to enhance a medical curriculum through the use of gamified learning components (Fleischmann & Ariel, 2016). The strength of this research resided in the fact that the results were collected over a long period of time—a one-year experiment. However, this gamified learning experience focused solely on improving a very small subset of the medical curriculum—namely, clinical skills designed to address students' laboratory test skills. It makes it difficult to generalize the results obtained in this research to other components of the medical curriculum. Also, since the sample was rather small (N = 30), making it difficult to interpolate the results and to assume that they will be similar for a larger student group. Interestingly enough, the statistical results showed a mixed response from students regarding the gamification experiment: students indicated a preference for lectures, while at the same time valuing the engaging nature of the gamified learning experience. Another deficiency of this research was a design lacking the integration of several of the game elements constituting a true gamification implementation—study limitations acknowledged by the authors.

Another study designed to improve clinical skills was conducted with the goal to boost medical students' engagement in surgical simulation training (Kerfoot & Kissane, 2014). Gamification was utilized to incite students to train periodically and the most critical game element used for this purpose was competition. A leaderboard was implemented in the form of regular email notifications reporting on teams' performance. Prizes were offered to winners in the form of monetary rewards and electronic gadget gifts. Results demonstrated a statistically significant gain in students' level of engagement and motivation. A gamification implementation reliant on external motivation, such as prize money, may not be a sustainable solution for keeping students motivated for a long period of time. Research conducted showed that extrinsic motivation (factors like prize money) do not tend to generate long-term commitment and prolonged motivation (B. Kim, 2015a). As a matter of fact, gamification designed to extrinsically motivate students had a tendency to have a long-term detrimental effect since it can undermine students' intrinsic motivation to learn (Deci & Ryan, 2013). The authors conducting this research acknowledged this phenomenon and called for further studies into conducting a similar study longitudinally in order to do a study comparison between the two approaches—a short term, versus a multi-year research.

One area where gamification was used in medical education with the purpose of improving surgical skills. An experiment was conducted to increase medical skills and designed to train on improving skills to perform laparoscopic procedures (Giannotti et al., 2013)—a minimally invasive surgery that is a modern surgical technique where operations are being conducted using only a small incision in the body. Control and experimental groups were created, and performance metrics were analyzed using a validated simulator. The experimental group demonstrated a significant improvement in performance, demonstrating a highly positive research outcome. Although this study was designed to be gameful, it would be a stretch to qualify this research as a typical gamification experience. The important distinction between game and gamification needs to be made in order to delineate the scope of evaluation of the laparoscopy training experiment. Using a Wii device, this study falls more within the game category than the realm of gamification, which uses game mechanics within a non-gaming context (Shernoff, Hamari, & Rowe, 2014). Thus, despite the highly encouraging results obtained from the laparoscopy study, it would be methodologically unsound to infer that the conclusions obtained would apply to a gamified learning experience.

Gamification projects were also used to determine the impact of gamification on medical students' learning and engagement. This was illustrated by a study designed to assist medical students in learning about the structure and functions of body systems (Geelan et al., 2015). The challenge was associated with the vast amount of materials to be covered within a very compressed amount of time, as well as the challenge linked to knowing the numerous links between body systems. Among the game elements used was the categorization of the learning content into levels—students were exposed with a learning platform that presented the learning content with a gradual increase in the level of difficulty. Mechanisms, such as immediate feedback and progress tracking, were integrated in the gamified learning platform. In addition to having a good sample (*N*=700), one of the strengths of this experiment was the level of attention given to the design of the gamified learning platform. During the design process, special attention was given to ensure that any extraneous game elements that could lead to distraction were eliminated from the design. One challenging aspect of this implementation resided with the fact that several technical problems caused some disruptions of the learning process and created a negative attitude in students who expressed frustrations while interacting with the gamified platform. This experience is a reminder of the critical importance of designing a gamified learning platform that is fully tested, technically sound, and well-engineered.

The gamification of medical education has been evaluated through the use of competition as a means to generate a higher level of motivation among medical students and improve their technical and cognitive skills. A research design to teach thoracic surgery to medical students (Mokadam et al., 2015) was used to demonstrate these concepts. The strength of this research lied in the methodical data gathering process that spanned 3 years. Results showed an increase in the level of student motivation, the gamification implementation impacted students' participation in learning activities and demonstrated great enthusiasm. However, the methodological approach selected may not be adequate since participation was voluntary and the students choosing to participate could very well have been the most competitive ones of the group in the first place. As such, confounding factors compromised the measure of the level of competitiveness from the very beginning. Considering students' level of competitiveness as a covariate to be controlled could have mitigated this problem. Also, participation in the research was voluntary and there was no comparison group, which represented a methodological shortcoming and considerably weakened this research study.

Gamification was used to create an active learning environment where medical concepts were disseminated through a game-based platform, instead of a purely lecture-driven teaching approach (Day-Black, 2015). In the experimentation conducted, learners were provided with a game-based learning platform through which they would gain skills, such as identifying health problems caused by environmental hazards and evaluating the effects of a chemical toxin on patients' health. The learning platform had a built-in assessment mechanism. The outcomes of this experiment pointed toward a positive impact on reinforcing engagement toward learning, as well as improving student learning outcomes. Since students received a grade incentive to participate in this research, the author expressed some reticence in claiming positive impact originating uniquely from the gamification experience. Although the grade percentage allotted to the gamification was low (2%), it was still an influencing factor in evaluating the full impact of the gamified learning experience.

A research study designed to assess the effect of gamification on student engagement using game elements revealed that students' desire to interact with a gamified learning environment was directly correlated with the incorporation of activities not tied to academic grades (Armier, Shepherd, & Skrabut, 2016). In essence, gamification did not contribute to motivating student learning when it was linked to summative assessments (Ferris & O'Flynn, 2015).

As demonstrated above, most existing gamification experiments were designed to address highly specific problems, hence limited in scope (Day-Black, 2015). Also, they were integrating critical gamification components—abstraction, mechanics, and interfaces—in a partial manner (Yunyongying, 2014). Finally, these studies did not involve the use of a control group in order to comparatively examine and quantitatively assess the measurable effect of gamification. This led Hamari, Koivisto, and Sarsa (2014) to state that "empirical results on the effectiveness of gamification are in demand" (p. 3027). An endeavor worth pursuing is to address the above limitations and thrive to bring an understanding of the effectiveness of gamification in graduate medical studies, based on the integration of critical gamification principles, which are abstraction, mechanics, and interfaces. This, in turn, would suggest how to integrate these strategies into a medical school curriculum in order to create a more engaging learning environment.

Gamification and the Student Engagement Construct

Since this study's major emphasis focuses on measuring the level of student engagement, it was important to further explore the intricacies of the student engagement construct and gain a better understanding of its various facets.

A problem faced by educators is the lack of a unified definition of student engagement (Mandernach, 2015). A lack of consensus exists in defining the characteristics and parameters of engagement. Furthermore, engagement has traditionally been understood as time-on-task vis-à-vis completion of course activities. Progressively, more complex aspects of the engagement concept were taken into consideration, leading to the emphasis on certain characteristics, such as learners' behavior. From this germinated the notion of behavioral engagement, as posited by Skinner and Pitzer (2012) who defined engagement as “the behavioral manifestation of motivation” (p. 22).

Current understanding and definitions of the engagement construct are more holistic and embrace a multidimensional approach; move diverse facets are taken into consideration, such as the cognitive, behavioral, affective, and sociocultural aspects (Plass et al., 2015). From this perspective, movements and gestures illustrate behavioral engagement, and so does initiatives taken to invite other learners to be part of the experience. Various game elements place learners in challenging contexts where they can fail a level or achieve a goal; these experiences illustrate the emotional engagement. Collaborative work done while attempting to solve problems during a gamification exercise leads to a sociocultural engagement. In turn, these types of engagement fusion to create motivational elements, which promote cognitive engagement. Optimally, a well-designed gamification platform should have the potential to trigger these four types of engagement.

Of interest to this study is Barkley’s (2010) emphasis on the fact that “. . . engaging students doesn’t mean they’re being entertained. It means they are thinking” (p. xii). Linking the notion of gamification with the engagement concept does not necessarily mean that the gamified learning activities are going to be fun. It would be a misunderstood fact of game-based learning to assume that the fun component is a *de facto* assumed ingredient of the educational experience.

At this juncture, it is worth mentioning that engagement does not equate motivation. When students are motivated, it does not mean that they are engaged in learning (Kim, Park, Cozart, & Lee, 2015). Motivation related to learning implies a desire to be involved in learning activities; the “mindful engagement” into learning activities is what actually drives learning (Martin, 2012). Reinforcing this notion, Skinner and Pitzer (2012) stated that motivation precedes engagement; motivation serves as a trigger mechanism that leads to learners to an engaged state.

Implications

The proposed project derived from this study would be an evaluation report, aimed at designing a guide to assist faculty members in general and medical educators in particular, with understanding and assessing the use of gamification in their learning practices. The project deliverable would be a short guide designed to inform faculty members involved in teaching medical students about the results summary of the research study; it would outline the guiding principles upon which gamification is reliant upon from a pedagogical standpoint. The goal would be to provide an informational report that could be used to orient faculty members in their quest to assess various technology-based pedagogical models, specifically in the area of applying gamification in medical education.

Given the fact that gamification as an education tool is a rather new and uncommon approach to teaching medical curriculum, one would hope that the creation of a short guide to using gamification in medical education would be of value and would contribute towards informing and guiding medical educators towards evaluating the potential merits of using gamification in teaching a medical curriculum.

Also, since engagement is the notion closely associated with the use of gamification, the project would aim at describing the linkage between these two concepts and highlight how embracing them could result in potentially beneficial effects towards improving student learning outcomes. Given the fact that student engagement is known as having a positive impact on student's academic life (Tendhar, Culver, & Burge, 2013), it would be a worthwhile endeavor to share with faculty members through the evaluation report how gamification could be used to foster student engagement in medical education.

Summary

In the course of this study, a historical perspective on the evolution of medical education revealed that for the last 100 years, its curriculum structure, its pedagogical approach, as well as its knowledge delivery system have for the most part stayed the same. Medical studies have largely remained reliant on a teacher-oriented and lecture-based method of teaching. In a rapidly changing world that has undergone major societal transformation and where technology has infiltrated all major aspects of daily life—including the educational world—a reconsideration of medical education was needed.

There is an explosion of information in the medical field and, more critically, a population shift is taking place as evidenced by the increasing numbers of medical students belonging to the millennial generation entering the field. These factors call for an evaluation of medical education's relationship with technology, which needs to be evaluated in order to determine to what extent technology affordances could foster the creation of more agile pedagogical models and adapted to the new reality that settled in the educational arena.

There is a dissonance between the way millennials approach learning and the way medical schools impart knowledge to its students. With a heavy emphasis on using traditional lectures as a way to handle the didactic phase of the curriculum and with a reluctance to leverage technology, medical schools find themselves at odd with the student population that they intend to serve. A realization of such a problem prompted several medical educators, and most notably major organizations in charge of medical education, to propose new approaches in medical education that are inclusive of technological means in order to innovate a stagnant and very traditional medical education.

Remaining in a traditional and lecture-based method of curriculum delivery has been attributed to be one of the causes for fostering student disengagement in medical education, where students feel disconnected from an educational system that does not meet their needs. As digital natives, these students are technology oriented and their inclination to turn to the digital world is in sharp contrast with a medical education system that is reluctant to leverage technology. A posture leaning towards embracing and leveraging technology could lead to the exploration of innovative ways to deliver the medical curriculum and create a learning environment conducive to behavioral, sociocultural, affective, and cognitive engagement.

In the context of this study, the use of gamification was the adopted channel to incorporate technology into the medical curriculum with the goal to determine whether principles borrowed from game-based learning could be instrumental in creating innovative learning methods that could impact the level of student engagement in medical education. The next section describes the methodology used to evaluate, assess, and measure the level of this impact. Also, it describes an analysis of the research data in order to evaluate the stipulated hypotheses and attempts to formulate some conclusions and recommendations.

Section 2: The Methodology

Research Design and Approach

This study consisted of measuring and quantifying the impact of a pedagogical approach upon attitudinal variables that are components of the student engagement construct. As such, it used a quantitative research method characterized by its reliance on measurements that needed to be performed as objectively as possible, and it emphasized the statistical or numerical analysis of data collected using tools such as polls, questionnaires, and surveys (Creswell, 2014). To ensure a greater level of reliability and validity of data, standardized and validated instruments are preferred. The importance of using a validated instrument lies in the fact that the reliability and validity of that instrument can be applied to the study being conducted. Reliability refers to the level of consistency yielded by an instrument when comparing results obtained from different test iterations. The reliability factor ensures that an instrument measures a given variable consistently; it determines the instrument's accuracy. Reliability cannot be measured; rather, it is estimated. Validity, on the other hand, refers to the level of accuracy with which an instrument measures a variable; it determines the strength of conclusions and inferences (Mohamad, Sulaimanb, Sern, & Sallehd, 2015).

One possible approach to conducting this study involved the use of a quasi-experimental design with a control group and an experimental group. Such a design entails running a pretest and a posttest applied to an experimental and a comparison group; it aims toward demonstrating causality between an intervention and an outcome. Another characteristic of quasi-experimental design is its lack of random assignment, which is a limitation—randomized controlled experiments are generally considered to yield the highest level of credibility when assessing causality.

Quasi-experimental studies lend themselves to research contexts where logistically it is not feasible or ethical to conduct a randomized controlled experiment. In the present study, a preexisting group of medical students enrolled in a course was used. It was possible to create a control group (nonparticipating students) and an experimental group (participating students); however, it was highly impractical, if not impossible, to use randomization (Scher, Kisker, & Dynarski, 2015). Furthermore, using a quasi-experimental design is fraught with ethical problems due to the inequality and disparity in the dissemination of knowledge and learning experience between the treated and comparison groups (Steiner, Cook, Li, & Clark, 2015). Due to the aforementioned limitations and problems associated with a quasi-experimental design, a different approach needed to be considered; as described below, a repeated measures multivariate analysis of variance (MANOVA) statistical analysis test was deemed appropriate for this study.

This study used MANOVA, an inferential statistics tool, to investigate the hypotheses. MANOVA provides a way to measure differences between multiple variables and test two or more variables at once. A repeated measures MANOVA is not limited to one dependent variable; hence, a MANOVA was used to measure the level of student engagement across three variables.

Within the scope of this study, the use of repeated measures MANOVA allowed for the study of the three dependent variables constituent of the student engagement construct, namely cooperative learning, cognitive level, and personal skills variables.

Figure 1 illustrates the design approach, which consisted of using repeated measures MANOVA for three time periods.

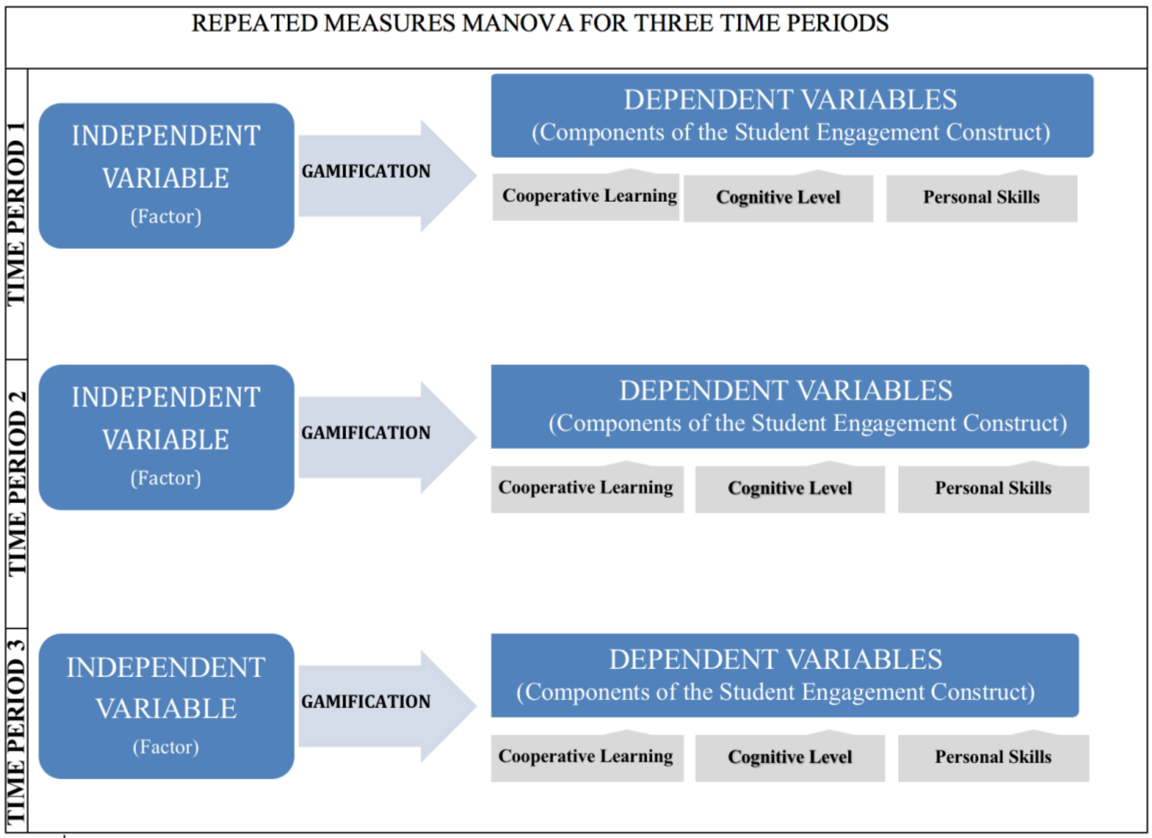

Figure 1. Repeated measures MANOVA design. The factor and its relationship with the responses, using a repeated measures MANOVA during gamification session.

Setting and Sample

This study was conducted within the context of a course that was part of the medical curriculum, with an enrollment of 70 students. In this 3-month course, the instructor included the gamification exercises as part of the course components. A lecture-based approach was adopted to disseminate knowledge to students during the first part of this course. Following the lecture phase, a gamified learning component was introduced and presented to students enrolled in the course as a voluntary exercise.

The research endeavor leading to the creation of this gamification project was not divulged to students in order to avoid the Hawthorne effect, which could have skewed the results obtained from the data gathering process. The Hawthorne effect (Benedetti, Carlino, & Piedimonte, 2016) involves the alteration of participants' behavior due to the fact that they are being studied or observed.

The instructor predicted a high level of participation, stating that in the past, students had consistently demonstrated eagerness to use new methods of teaching (J. Ywom, personal communication, October 25, 2016). Nonetheless, to encourage participation, at the beginning of the course the instructor gave students a chance to win a gift card should they decide to participate. A random drawing determined a handful of students who were the recipients of a gift card.

The average age of the graduate medical students who participated in this study was 28 years, meaning that this group of students belonged to a generation labeled as *millennials*. On average, students of this generation have two devices that are Internet enabled, and 90% of them own a tablet. Instructors described this group of students as technology savvy, with a strong inclination to use technology in their academic activities (A. Lee, personal communication, October 21, 2016). A large majority of students were single (77%), with a gender distribution of 51% males and 49% females. Out of the 70 students enrolled, 40% were Asian, 32% were White, 9% were of unspecified race, 12% were Hispanic, and the remaining 7% were from various ethnic groups.

The repeated measures MANOVA proposed for this study required an adequate number of participants to ensure valid interpretation of the findings. A medium effect size (f = .25) was expected. In addition, a generally accepted power of .80 and a significant alpha level of .05 were applied (Cohen, 1992). With measurements made at three separate time periods, G*Power 3.1.7 was used to calculate that a minimum sample of 55 participants would be sufficient for data collection (Faul, Erdfelder, Buchner, & Lang, 2014).

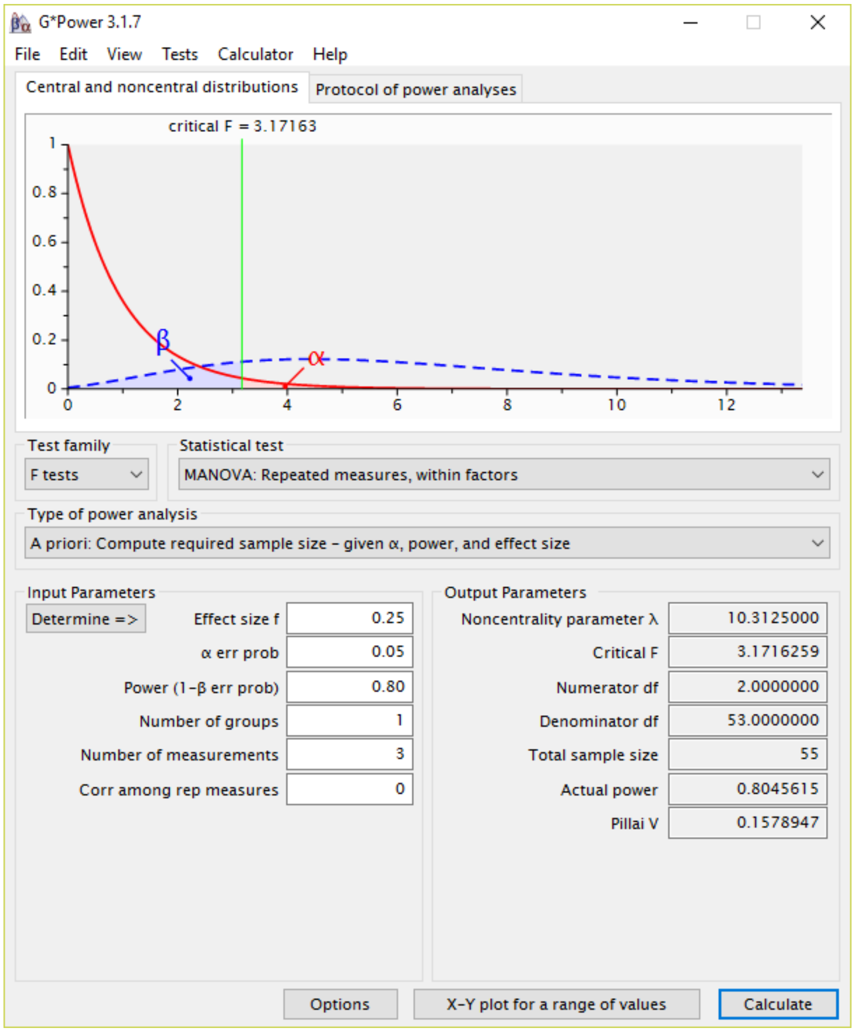

Figure 2. G*Power application. This figure shows the calculation of the minimum sample needed for data collection.

Instrumentation and Materials

This quantitative research study used a survey as its data-gathering instrument. The survey used was the Student Engagement Survey (SES), which is a 14-item validated instrument using a 4-point Likert scale (4: *very often*; 3: *often*; 2: *occasionally*; 1: *never*).

The SES is a subset of the National Survey of Student Engagement (NSSE). The NSSE is a survey instrument used at more than 1,500 universities across the United

States and Canada to gather data about quality of engagement for students in higher education (Tendhar et al., 2013). It represents the most frequently used instrument to measure students' perception of engagement in the nation—more than 2 million students take this survey every year. This survey was built with the assumption that more engagement is correlated with more learning. Studies supporting this assumption have demonstrated that academic engagement translates into degree completion, on-time and faster graduation, as well as higher academic performance (Fiorini, Liu, Shepard, & Ouimet, 2014). At the foundation of the NSSE are five benchmarks, which are level of academic challenge, active and collaborative learning, enriching educational experiences, student-faculty interaction, and supportive campus environment. The NSSE grants researchers permission to use the survey for research purposes.

The SES was created through a research grant and uses 14 of the 40 survey questions contained in the NSSE (Ahlfeldt, Mehta, & Sellnow, 2005). Appendix B contains the complete SES survey form. The smaller survey was created as a portable and quickly distributable survey form to be used at the course level. The selection of questions was based on their ability to measure student engagement at a course level in relation to level of cooperative learning, cognitive level, and personal skills development. An analysis of the SES determined that the alpha reliability of this 14-item instrument was 0.84 (Ahlfeldt et al., 2005).

To accommodate future research projects, additional questions unrelated to the student engagement construct were added to the last SES survey. The purpose was to gather data about students' experience using the gamification platform—user interface, navigation, instructions, and clarity of design and purpose. Additionally, questions regarding students' prior exposure to and experience with other gaming platforms were included. Other survey questions addressed topics such as which game mechanics students found most engaging.

The SES measures the following components of the student engagement construct: cooperative learning, cognitive level, and personal skills. The cooperative learning variable is constructed using the results obtained from *Questions 1 through 4*; the cognitive level variable is obtained from *Questions 5 through 9*; and the personal skills variable is constructed from *Questions 10 through 14*.

ANOVA was used to make an overall comparison indicating whether mean differences existed in each of the three subscales of the SES after use of the lecture-based and gamified learning methods. The first four questions upon which the cooperative learning variable is constructed were as follows:

During your class, about how often have you done each of the following?

1. Asked questions during class or contributed to class discussions
2. Worked with other students on projects during class time
3. Worked with classmates outside of class to complete class assignments
4. Tutored or taught the class materials to other students in the class

Respondents answered the questions using the following scale: 4: *very often*, 3: *often*, 2: *occasionally*, and 1: *never*. Appendix B shows the complete survey.

To assess the instrument's reliability, Cronbach's alpha values were examined for the series of items comprising each of the three scales. Cronbach's alpha is a measure of internal consistency; it is used to determine how closely related the members of a set of items are as a group and is used as a measure of scale reliability (Vaske, Beaman, & Sponarski, 2017). The value of the coefficients was interpreted through incremental thresholds described by George and Mallery (2016), in which $\alpha \geq .9$ = excellent, $\alpha \geq .8$ = good, $\alpha \geq .7$ = acceptable, $\alpha \geq .6$ = questionable, $\alpha \geq .5$ = poor, and $\alpha < .5$ = unacceptable. As evidenced by Table 3, the reliability of the scales was acceptable.

Table 3

Cronbach's Alpha Reliability Statistics for Scales

Scale	No. of items	α
Cooperative learning		
TP1	4	.393
TP2	5	.725
TP3	5	.790
Cognitive level		
TP1	4	.430
TP2	5	.711
TP3	5	.702
Personal skills		
TP1	4	.703
TP2	5	.822
TP3	5	.881

Students were provided with a web link to the online survey. The instructor administered the survey in class during different time periods. The process of completing the survey required the students to fill out the survey in its entirety. Moreover, students had to be full participants during the three survey periods. If either of these conditions was not met, the entries made by participants would be excluded from the data set to be considered for final analysis. Students used their computing devices (laptops or smartphones) in order to access the form and complete the survey.

The survey data was captured using an online form represented in Appendix B and tied to a secure backend database used to store the raw data.

Data Collection and Analysis

To address the research questions outlined in this study, a repeated measures MANOVA, also known as within-subjects MANOVA, was conducted to assess if over the course of the semester significant increases existed in cooperative learning, cognitive level, and personal skills by use of lecture-based and gamified learning methods. A repeated measures MANOVA is an appropriate statistical analysis when the goal of the research is to analyze for differences in multiple continuous dependent variables through different points in time (Howell, 2013). In this study, it is used to determine the variances in students' level of engagement over time following the use of various learning exercises that include the integration of gamified learning components into a medical course. In this research, the within-subjects effect corresponded to the following three testing periods: pretest, post lecture-based method, and post gamified learning method. The three dependent variables corresponded to the components of the student engagement construct: cooperative learning, cognitive level, and personal skills.

Thus, the variables used for this study include the following: the independent variable is the gamification process applied to learning components embedded in a course; the dependent variables are components of the student engagement construct and consist of the cooperative learning, the cognitive level, and personal skills.

The SES is validated instrument using a four-point Likert scale, providing nominal data sets. The students have to select an answer from a range of options ranging from 1 to 4. In the case of the first sets of questions related to cooperative learning, students had to answer to a question related to their participation during class activities. The available answers were limited to the following four options: very often, often, occasionally, or never. Table 3 describes the question and plausible answers related to cooperative learning.

The SES was administered during a class session by the instructor using an online survey that was designed to be responsive—the form design provided optimal viewing experience of the survey within a web browser and minimized the need for scaling and panning. It was also designed to be mobile friendly, allowing students to fill out the survey using their smartphones or tablets if they so desire. Also, this online survey was designed and tested to ensure accessibility as well as cross-browser compatibility. To prevent any eventual or unforeseen technical problems that could encroach on the SES survey completion, tablets, serving as backup devices were distributed to students running into technical problems.

This research was conducted over a period of 3 months, during which the survey was used on three occasions, according to the survey time periods described below.

Survey Time Periods

The sequence of the data gathering process was as follows:

Time Period 1: Beginning session. At the beginning of the semester as part of the course activities, the SES survey was administered to students. This beginning phase of the course used a lecture-based learning delivery method. This iteration of administering the SES survey was the first in a series of three instances where students were asked to complete the SES survey. This first instance was used as a pre-test.

Time Period 2: End of lecture-based session. At the end of the course period during which students were given in-class lectures, students were asked to complete the SES survey. This was the second occurrence of filling out the SES survey.

Time Period 3: Gamification session. At the end of the lecture-based session, students were given 4 weeks to experiment and learn the course material using the gamified learning platform. At the end of this 4-week period, students were asked to fill out the SES survey for the third and last time to gather what would be considered the post-test data.

Data Analysis Procedure

Given the fact that this study used a repeated measures MANOVA, different measurements were taken over a period of time to quantify and assess variances over the course of the study. Survey responses from the SES were entered into SPSS version 23.0. Descriptive statistics were used to examine the trends in the nominal and continuous variables. Frequencies and percentages were examined for the nominal level variables. Means and standard deviations were calculated for the continuous level data. Moreover, a major step taken during the data analysis process was to conduct an exploratory factor analysis.

Factor analysis is a valuable statistical tool that can be used to investigate variable relationships for intricate concepts such as operations research, socioeconomic status, psychometrics personality theories, dietary patterns, marketing, psychological scales, as well as constructs such as intelligence and engagement (Norm O'Rourke & Hatcher, 2013). Factor analysis allows researchers to investigate concepts that are not easily measured directly by collapsing a large number of variables into a few interpretable underlying factors. As a simplification method, it extracts maximum common variance from all variables and summarizes them into a common score. Factor analysis is reliant on two core concepts, which are factor and factor loadings. According to Kline (1994), a factor is defined as “a dimension or construct which is a condensed statement of the relationships between a set of variables” (p. 5). Factor loading, on the other hand, is the correlation between a variable and a factor.

To calculate the number of factors that were optimal for the SES survey instrument, an exploratory factor analysis (EFA) was performed. EFA has six steps (Osborne, 2015, p. 2):

1. Data cleaning
2. Deciding on extraction method to use
3. Deciding how many factors to retain
4. Deciding on a method of rotation
5. Interpretation of results (return to Step 3 if solution is not ideal)
6. Replication

Applied in the context of multivariate statistics, EFA represents a statistical technique that is used to reduce data to a smaller set of summary variables, with the goal to identify the underlying relationships between measured variables (McNeish, 2017). In this study, cooperative learning, cognitive level, and personal skills represent these measured variables.

Used as a method of data reduction, the EFA was run on each of the proposed variables to explore the factor structure, using a promax rotation. To calculate the optimal number of factors for each scale, the eigenvalues were calculated in a correlation matrix with every corresponding survey item. Eigenvalues represent the variances of the factors (J. Fan, Shu, Zhao, & Yeung, 2017) and each eigenvalue measures how much of the variance of the observed variables a factor explains. The Kaiser criterion (Braeken & van Assen, 2017) states that the optimal number of factors is determined by the number of eigenvalues greater than 1 (A. B. Costello & Osborne, 2005). Based on prior validity testing, it was determined that the three factors were an optimal solution corresponding to: cooperative learning, cognitive level, and personal skills. Each EFA demonstrated strong factor loadings onto the individual constructs, as presented in Tables 4-6.

Table 4

Factor Loadings for Cooperative Learning

Item	Factor loading
Q1	.446
Q2	.692
Q3	.560
Q4	.698

Table 5

Factor Loadings for Cognitive Level

Item	Factor loading
Q5	.907
Q6	.743
Q7	.624
Q8	.717
Q9	.687

Table 6

Factor Loadings for Personal Skills

Item	Factor loading
Q10	.702
Q11	.669
Q12	.846
Q13	.868
Q14	.747

Once the EFA process and the optimal number of factors determined, the MANOVA would be used to make the overall comparison on whether mean differences existed between the three variables after use of the lecture-based and gamified learning methods. If the *p*-value was less than the significant alpha level ($\alpha = .05$), then a statistically significant result would be noted (Tabachnick & Fidell, 2013). If significance was found, an additional and investigative step involving the use of Bonferroni post-hoc test would be conducted through use of a pairwise comparison to determine exactly where the differences occurred. To this effect, descriptive statistical data would be used to summarize the computed data. Accordingly, a table would be designed to display the mean values and standard deviations for the cooperative learning, cognitive level, and personal skills variables. Since the data gathering process took place during three separate time points, the mean values and standard deviations for each time point corresponding to each variable would be displayed.

Assumptions, Limitations, Scope, and Delimitations

This study makes several assumptions and contains certain limitations. Also, it has a well-defined, albeit limited scope. These essential elements are described below.

According to a study conducted by Hurwitz, Kelly, Powis, Smyth, and Lewin (2013), medical students tended to have a higher than average cognitive capacity and a more pronounced level of motivation towards academic endeavors. However, an assumption made during the course of this study was that the medical students being studied truly fell under the gamer generation group, and that they were for the most part exposed to gaming during the early stage of their growth development process. These students were assumed to be typical millennials, sharing the same attributes of having a propensity to gaming.

In a study designed to use gamification to motivate people to exercise, Koivisto and Hamari (2014) argued that age and gender had an effect on the effectiveness of using gamification. The authors reported that women received greater benefits from a gamified physical exercise. This study does not take into consideration students' gender and age while assessing the impact of using gamification in medical education.

Using gamification in an educational setting has ramifications that can extend to influence the cognitive, emotional, and mental aspects of the student learning experience.

Hence, many facets of learning can be affected. However, this study limits its scope to focusing solely on the impact of gamification on engagement. Mekler, Brühlmann, Opwis, and Tuch (2015) conducted a gamification experiment and concluded that gamification can affect participants' feelings. Taking into consideration such emotional components is beyond the scope of this study, which does not address questions related to how gamification affects participants' emotional state.

According to the Bartle Test of Psychology (Shelley Navari, Fernando Chade De, & Marcos, 2016), each person has a dominant trait that determines how that person interacts with a gaming platform, including participation in a gamification activity. Bartle identifies four dominant traits, which are: the achievers who are motivated by points and status; the explorers who are mostly eager to experience new things and are motivated by the discovery process; the socializers who are mostly interested in interacting with others while engaged in a gaming activity; and the killers who are motivated by competition and concerned about getting ahead of others, as well as mostly primarily focused on winning. This study has a limitation in that it does not take into account Bartle Player Types, which is mostly used to craft the gamification design to cater for the needs of users.

In an interesting study in the area of health education examining learning components similar to the ones explored in the current study, Fan, Xiao, and Su (2015) concluded that students' learning styles made a difference in attaining different degrees of learning achievement while gamifying the curriculum. Taking students' learning styles into consideration was not part of the scope of this study.

Sailer et al. (2017) conducted an experimental gamification study demonstrating the importance of a research design involving a control group and an experimental group. Such a design would yield a better certainty that no other factors are influencing the outcomes of the experiment. One of the limitations of the present study is the lack of a control group. As previously stated, the legal ramifications for using such a research design would not allow using such an approach.

The boundaries of this study remain within the constraint of a single course that is part of the larger curriculum and in which a gamified learning component was incorporated. This implies that the conclusions drawn in the course of this study pertains to the impact of gamification within a course and, therefore, cannot be generalized for the entire curriculum.

Protection of Participants' Rights

This gamification project was part of an academic initiative designed to evaluate the impact of a technology-driven learning tool using a gamified learning component within a college that is part of a graduate medical school in Southern California. Since this represented a new pedagogical approach for the college and being uncertain about possible outcomes for using such an innovative platform, students were not required to participate in this study. They were incentivized and offered course bonus points but were not penalized for not participating in the gamification activities. The newness of this gamification platform could have potentially created undue stress on some students if it was a mandated exercise, thus the decision was made to make it an optional activity.

The gamified learning components were introduced and presented to students enrolled in the course as a voluntary exercise. The instructor structured the course grading system in such a manner that participation to the gamification practices resulted in receiving bonus points. The goal was to be non-intrusive and avoid imposing on students a method of learning that was new to them and could potentially be detrimental to their learning outcomes. One of the reasons behind not making the gamification activities part of the main grading process was to avoid any ethical issues. Given the fact that this was the first time this type of learning exercise was conducted within the college, it remained to be seen whether this pedagogical tool would positively or negatively influence student learning. Thus, the students' participation or abstention in the gamification practices would not adversely affect students' grade for the course, making it a low risk learning exercise prevented any potential ethical problems.

It should be noted that this gamified learning implementation was built as an integral part of the course; therefore, there was no need to get an informed consent from students to conduct this research. Gathering survey data is a process that is fully integrated as part of curricular activities, and any data gathered, including the ones obtained through conducting this research, are protected and secured following institutional privacy policy and in conformity with FERPA regulations.

Data Analysis Results

The purpose of this study was to determine whether the level of engagement of a student cohort enrolled in a Southern California graduate school was affected by the use of gamification principles embedded within course learning components. This section presents the findings of the statistical analysis. A repeated measures MANOVA was used to assess the research questions. Statistical significance for the assumption tests and inferential analyses were evaluated at the conventional level, $\alpha = .05$.

Preanalysis Data Screening

A total of 68 subjects participated in the study. Four participants were removed for not completing an entire testing period (TP1, TP2, or TP3). Prior to conducting inferential analyses, univariate outliers were examined through a calculation of standardized values, or *z*-scores, where values outside of the range ± 3.29 are considered outliers (Tabachnick & Fidell, 2013). No outliers were present in the data set.

Multivariate outliers were examined using Mahalanobis distances, which consisted of calculating the distances between the data set points and the data distribution. As noted above, when dealing with univariate data, the distance between points or observations is determined by their position vis-à-vis the standard deviation. When dealing with multivariate data, the same principle can be extrapolated to consider distances between a point and the normal distribution—the principle behind using the Mahalanobis distance (Zhao, Lu, Yun, & Wang, 2017). Mahalanobis distance is an effective method for determining multivariate outliers, due to the fact that it provides a more sensitive and accurate measure than checking individual distances between data set points and data distribution (Todeschini, Ballabio, Consonni, Sahigara, & Filzmoser, 2013). After calculating the Mahalanobis distances, it was determined that no multivariate outliers existed in the data set.

Hence after evaluating both univariate and multivariate outliers, 64 out of 68 participants were utilized in final analyses, with four incomplete responses.

Assumptions

Prior to conducting the repeated measures MANOVA, the following assumptions related to the parametric assumptions of the analysis were tested and considered: independence of observations; assumption of normality; sphericity; absence of multicollinearity; linearity, equality of variance; homogeneity of regression, and reliability of covariates (Liu, 2016). After consideration and conducting a treatment for each of these assumptions, below are the results.

The independence of observations assumption was met as each participant provided an independent response for each of the three testing time periods. The assumption of normality was meant to check that the dependent variables resembled an empirical bell-shaped distribution (Field, 2009). The assumption of normality was tested with Kolmogorov-Smirnov (KS) tests. A KS test is used to determine if two datasets differ significantly; it does so by comparing the cumulative distributions of two datasets (Corder & Foreman, 2014). The normality assumption was assessed with nine KS tests (three dependent variables compared at three different time periods, TP1, TP2, and TP3). As presented in Table 13, results for all the KS Results of each KS test indicated significance (all $p < .05$); thus the assumption of normality was not met. Stevens (2009) suggested that samples with sums of 30 or more observations approximate to normality, even if the distribution appears to deviate from normality. The absence of normality could potentially be attributed to the relatively low sample size for the research.

The assumption of sphericity assesses that the differences in the dependent variables are approximately equal among the three time periods. Sphericity was used to check if there was equal variance and covariance for each level of the within-subjects effect (Leech, Barrett, & Morgan, 2012). Mauchly's test of sphericity was used to test the assumption—a test used to determine concurrently whether or not two assumptions are met (Meyers, Gamst, & Guarino, 2012). Results of Mauchly's test of sphericity indicated significance ($p < .05$), which is indicative of a heterogeneity of covariance (Yockey, 2016). Thus, the assumption of sphericity was not met. Since the assumption of sphericity was violated, this could result in having an F statistic value that could produce severely biased results. Due to the parametric assumptions not being met, SPSS generates adjustment procedures or correction options; one of them being the Greenhouse-Geisser method, which is needed to be used in order to overcome the effect of the violation (Yockey, 2016).

The absence of multicollinearity was tested by variance inflation factors (VIFs) to ensure the subscales for student engagement were not too closely related (Howell, 2013). Due to all the correlations being below .90, this suggests that there was not a high association among the variables of interest and the assumption was met.

The assumptions for linearity, equality of variance, and equality of covariance did not apply due to independent groups not being examined. Also, homogeneity of regression and reliability of covariates were not assessed because control variables were not examined in the analysis.

To address the research questions, a repeated measures MANOVA was conducted to determine whether there were significant differences over time in cooperative learning, cognitive level, and personal skills when using gamified learning methods.

The *F* test was used to make the overall comparison on whether mean differences existed in each the three subscales of the SES after use of the lecture-based and gamified learning methods. If the *p*-value was less than the significant alpha level ($\alpha = .05$), then a statistically significant result would be noted (Tabachnick & Fidell, 2013). If significance was found, then a Bonferroni post-hoc test would be conducted through use of pairwise comparison to determine exactly where the differences occurred.

Analysis of Research Questions

Results of the multivariate *F* test indicated significance, Pillai's Trace = .031, $F(6, 250) = 7.52$, $p < .001$, partial $\eta^2 = .153$, suggesting that there are significant differences in the student engagement constructs over time. Three univariate tests were examined for the findings of each student engagement construct evaluated in each research question.

Based on the analyses conducted, the results of a series of follow-up repeated measures ANOVAs are provided below.

Sub RQ1: Was there a significant increase over time in cooperative learning when using gamified learning methods?

H_01: There was no significant increase over time in cooperative learning when using gamified learning methods.

H_A1: There was a significant increase over time in cooperative learning when using gamified learning methods.

To address Sub RQ1, a repeated measures ANOVA was conducted to determine whether there were significant differences over time in cooperative learning when using gamified learning methods. The results of the repeated measures ANOVA for cooperative learning indicated significance, $F(1.72, 108.41) = 13.21$, $p < .001$, partial $\eta^2 = .173$. The time periods were further examined for potential differences in cooperative learning by each time period. It was evident that there were significant differences for cooperative learning between the initial time periods TP1 ($M = 2.62$) and TP2 ($M = 3.00$), with $p < .001$ and between TP2 ($M = 3.00$) and TP3 ($M = 2.79$), with $p = .038$. It was also evident that there was no significant difference for cooperative learning between TP1 ($M = 2.62$) and TP3 ($M = 2.79$), with $p = 0.114$. There was a 0.38 point mean increase in cooperative learning scores between TP1 and TP2, then a subsequent 0.21 point mean decrease in scores between TP2 and TP3. This significant decrease lead to a failure to reject the null hypothesis ($H_0 1$), suggesting that there was no significant increase in cooperative learning when using gamified learning methods. Table 7 presents the findings of the repeated measures ANOVA.

Table 7

Repeated Measures ANOVA for Cooperative Learning

	TP1		TP2		TP3		*F*	*p*	*η*
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*			
Cooperative learning	2.62	0.52	3.00	0.56	2.79	0.62	13.21	<.001	.173

The pairwise comparisons are displayed in Table 8.

Table 8

Cooperative Learning (CL): Pairwise Comparisons Through Time Periods TP1, TP2, and TP3

(I) CL	(J) CL	Mean difference (I-J)	Std. error	*p*
TP1	TP2	-.379	.057	.000
	TP3	-.172	.081	.114
TP2	TP1	.379	.057	.000
	TP3	.207	.081	.038
TP3	TP1	.172	.081	.114
	TP2	-.207	.081	.038

Sub RQ2: Was there a significant increase over time in cognitive level when using gamified learning methods?

$H_0 2$: There was no significant increase over time in cognitive level when using gamified learning methods.

$H_A 2$: There was a significant increase over time in cognitive level when using gamified learning methods.

To address Sub RQ2, a repeated measures ANOVA was conducted to determine whether there were significant differences over time in cognitive level when using gamified learning methods. The results of the repeated measures ANOVA for cognitive level indicated significance, $F(1.72, 108.12) = 15.29$, $p < .001$, partial η^2=.195. The time periods were further examined for potential differences in cognitive level by each time period. It was evident that there were significant differences for cognitive level between the initial time periods TP1 (M = 3.28) and TP2 (M = 3.59), with $p < .001$ and between

TP2 (*M* = 3.59) and TP3 (*M* = 3.42), with *p* = .021. It was also evident that there were no significant differences for cognitive level between TP1 (*M* = 3.28) and TP3 (*M* = 3.42), with *p* = .084. There was a 0.31 point mean increase in cognitive level scores between TP1 and TP2, then a subsequent 0.17 point mean decrease in scores between TP2 and TP3. This significant decrease lead to a failure to reject the null hypothesis ($H_0 2$), suggesting that there was no significant increase in cognitive level when using gamified learning methods. Table 9 presents the findings of the repeated measures ANOVA.

Table 9

Repeated Measures ANOVA for Cognitive Level

	TP1		TP2		TP3		*F*	*p*	*η*
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*			
Cognitive level	3.28	0.47	3.59	0.42	3.42	0.48	15.29	<.001	.195

The pairwise comparisons are displayed in Table 10.

Table 10

Cognitive Level (CL): Pairwise Comparisons Through Time Periods TP1, TP2, and TP3

(I) CL	(J) CL	Mean difference (I-J)	Std. error	*p*
TP1	TP2	-.313	.044	.000
	TP3	-.141	.062	.084
TP2	TP1	.313	.044	.000
	TP3	.172	.062	.021
TP3	TP1	.141	.062	.084
	TP2	-.172	.062	.021

Sub RQ3: Was there a significant increase over time in personal skills when using gamified learning methods?

$H_0$3: There was no significant increase over time in personal skills when using gamified learning methods.

H_A3: There was a significant increase over time in personal skills when using gamified learning methods.

To address Sub RQ3, a repeated measures ANOVA was conducted to determine whether there were significant differences over time in personal skills when using gamified learning methods. The results of the repeated measures ANOVA for personal skills indicated significance, $F(1.70, 109.54) = 8.00$, $p = .001$, partial $\eta^2 = .113$. The time periods were further examined for potential differences in personal skills by each time period. It was evident that there were significant differences for personal skills between the initial time periods TP1 ($M = 3.36$) and TP2 ($M = 3.57$), with $p < .001$ and between TP2 ($M = 3.57$) and TP3 ($M = 3.33$), with $p = .003$. There was a 0.21 point mean increase in personal skills scores between TP1 and TP2, then a subsequent 0.24 point mean decrease in scores between TP2 and TP3. This significant decrease lead to a failure to reject the null hypothesis (*$H_0$3*), suggesting that there was no significant increase in personal skills when using gamified learning methods. Table 11 presents the findings of the repeated measures ANOVA.

Table 11

Repeated Measures ANOVA for Personal Skills

	TP1		TP2		TP3		*F*	*p*	*η*
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*			
Personal skills	3.36	0.52	3.57	0.45	3.33	0.59	8.00	.001	.113

The pairwise comparisons are displayed in Table 12.

Table 12

Personal Skills (PS): Pairwise Comparisons Through Time Periods TP1, TP2, and TP3

(I) PS	(J) PS	Mean difference (I-J)	Std. error	*p*
TP1	TP2	-.203	.048	.000
	TP3	.028	.071	1.000
TP2	TP1	.203	.048	.000
	TP3	.231	.067	.003
TP3	TP1	-.028	.071	1.000
	TP2	-.231	.067	.003

In summary, there were significant increases in cooperative learning, cognitive level, and personal skills between TP1 and TP2 and significant decreases between TP2 and TP 3. Due to the fact that the hypotheses are directional and address increases over time, the null hypotheses (H_0, H_01, H_02, and H_03) were accepted, suggesting that the gamified learning methods did not increase the level of student engagement. Table 13 presents a consolidated view of the findings for the cooperative learning, cognitive level, and personal skills variables across the three time periods.

Table 13

Repeated Measures MANOVA for Student Engagement Variables

	TP1		TP2		TP3		*F*	*p*	*η*
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*			
Cooperative learning	2.62	0.52	3.00	0.56	2.79	0.62	13.21	<.001	.173
Cognitive level	3.28	0.47	3.59	0.42	3.42	0.48	15.29	<.001	.195
Personal skills	3.36	0.52	3.57	0.45	3.33	0.59	8.00	.001	.113

The display of the variables' mean values when comparing TP1 and TP2, as well as TP2 and TP3, is represented in Figure 3.

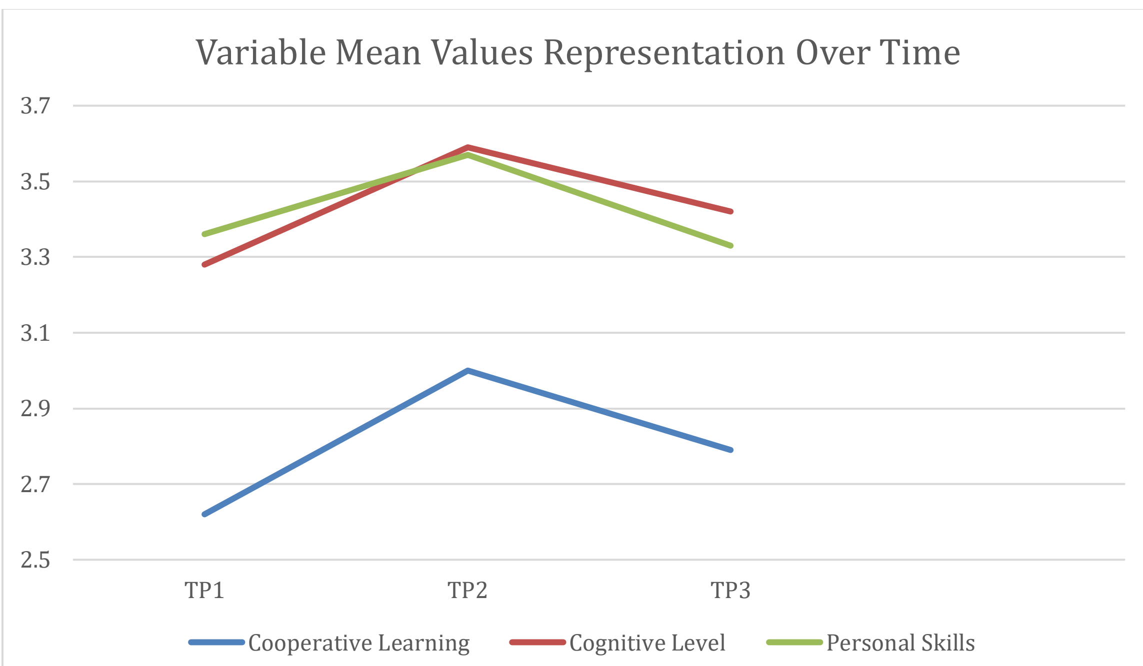

Figure 3. Variables' mean values showing increases and decreases over time.

The college administrators’ realization of the need to integrate technology in the curriculum through the use of gamification and the need to formalize the process of conducting gamified learning components led to the creation of a project consisting of creating a short guide to using gamification in medical education. The next section describes the details of the project and continues to explore the statistical findings and concepts in connection with the literature and theoretical foundation related to the project. It provides a rationale for the selection of the project, as well as outlines a project evaluation plan and discusses the project implications.

Section 3. The Project

Introduction

This study was conducted as an exploration of a technology solution designed to measure the level of student engagement using a gamified learning platform. The project derived from this study was an evaluation report, presented as a short guide to using gamification in medical education. This section contains the rationale for creating the project, along with a review of literature used to support the adopted practices for creating the project components. A practical description of the project is also provided, along with the project evaluation plan and the project implications.

Rationale

A comprehensive treatment and review of existing gamification projects and implementations in medical education was presented by McCoy, Lewis, and Dalton (2016). To my knowledge based on the research that I conducted, this is the most comprehensive treatment to date of the use of gamification in medical education. The authors compiled existing peer-reviewed literature, commercially available media related to gamification, and grey literature to build a library of recently published and research-oriented evaluations of gamified training platforms specifically used in the realm of medical education. Beyond this well-put-together body of literature, and apart from scattered gamification projects conducted to evaluate the effect of using gamified learning tools within medical education (Lin, Park, Liebert, & Lau, 2014; Pettit, McCoy, Kinney, & Schwartz, 2015; Snyder & Hartig, 2013), no practical guide currently exists that could assist medical schools and teaching faculty members wanting to venture into building gamified learning components to be used in a classroom setting in the context of didactic medical education.

A short guide, such as the one designed to represent the current project, would be a great resource and would play a vital role in guiding medical institutions and faculty interested in using gamification as a component of their teaching and learning repertoire.

A panoply of technology-related solutions emerged on the market to assist medical education. Among these were 3D technologies designed to assess the feasibility of high-fidelity synthetic ventricular septal defect (J. P. Costello et al., 2014), point-of-care ultrasound educational tools (Solomon & Saldana, 2014), and advanced simulation programs for instructional purposes (Maddox & Schmid, 2014), to name just a few. It would be advantageous for the medical education community to have at its disposal a guide that would assist educators and administrators in navigating the intricate maze of implementing a gamification project. The practice of using practical guides has proved to be useful and efficient when it comes to making use of newly introduced tools and technologies, as in the case of simulation-based medical education (Y. Lin, Cheng, Hecker, Grant, & Currie, 2018). That practice was extended to the current project, in which it was applied to gamifying medical education.

Additionally, teaching faculty members have great familiarity with diverse training venues whenever new technology tools are introduced to aid with curriculum delivery. Such training methods include the use of workshops, self-directed programs, multimedia tools, in-person and web-based learning, and short, concise guides (Gupta et al., 2017). Components from the abovementioned resources and elements constitute one of the contributing factors for constructing the current project as a short guide to using gamification in medical education.

Another impetus for this project was the need to create promotional and informational literature to motivate faculty members to adopt the use of gamification. Gamification is among the digital strategies used in higher education to create a culture of innovation and provide students with a stimulating learning environment (Adams Becker et al., 2017). In recent years, gamification has emerged in the field of medical education as a viable tool that could revitalize a learning and teaching culture dominated thus far by a pedagogy reliant on lectures. This is illustrated by the initiative to create a gamification platform to prepare medical students for board review (Snyder & Hartig, 2013). Such an unexpected learning tool piqued the interest of medical educators wanting to innovate and explore alternative methods of teaching. Furthermore, this gamification experimentation yielded positive results and demonstrated that this pedagogical approach was more than just a fad. Unexpected but real potentials were revealed, leading to a hope that the use of gamification in other areas of medical education could have a positive impact on medical students. Given such potential, it was a worthwhile endeavor to create a guide to motivate faculty members to embrace gamification.

Yet another element that served as an impetus for embarking on this project was the fact that it outlined a highly interdisciplinary and collaborative environment. A common perception is that silos are prevalent in higher education (Trust, Carpenter, & Krutka, 2017)—and medical education is not immune to this reality. This is manifested in a lack of collaborative initiatives between academic and technical teams. This project embraced a team-based approach for incorporating expertise drawn from both sides (academic and technical) and described a successful outcome that demonstrated a positive impact of using technological means to positively influence teaching and learning.

Furthermore, the university had at its disposition a variety of resources needed to create a gamification project that included 3D components, a database backend, application builders, content experts, and designers. Hence, at a local level, it was a worthwhile endeavor to create this project to let colleges and faculty know about the availability of these skill sets, and to allow for the creation of a gamification project that would require the participation of technical, creative, and academic participants and contributors.

Review of the Literature

This review represents a thorough and critical analysis of existing peer-reviewed literature pertaining to the elements outlined as being part of the project's components and their proposed design principles. The project document includes content describing the implementation of a digital gamification project through the use of technology solutions, along with the description of design principles placed in the forefront of such a gamification implementation. Understanding gamification principles and design is of paramount importance in creating a sound pedagogical learning tool that can impact students' learning experience—hence the inclusion of a section dedicated to defining gamification and its components in the project. Additionally, various gamification design components could promote various types of motivation—extrinsic or intrinsic—hence the need to explore the theory that touches upon motivating factors embedded within gamified learning platforms.

Furthermore, a deliberate approach needs to be taken to obtain desired outcomes while designing a gamified learning component. Diving into the student engagement construct, it is important to move toward achieving not just cognitive, but also attitudinal outcomes. This could be accomplished by exploring the concept of and applying principles related to operationalizing gamification, which will be discussed in this section.

Another critical component of this research study was the design framework that served as the theoretical underpinning of a gamified learning component. This framework layered the various building blocks of a gamification design and served as scaffolding to construct a sound gamified learning platform.

The search tools that I used included Walden University's library and Google Scholar. Other resources included databases such as EBSCOhost, Pubmed, ProQuest, and ERIC. Terms used in keyword and combined keyword searches included *gamification framework*, *self-determination theory*, *gamification design*, *operationalizing gamification*, *gamification assessment*, *gamification and motivation*, *gamification and engagement*, *gamification and learning*, and *gamification in medical education*.

Gamification Design

According to Burke (2014), a plethora of gamification projects fail due to poor design. These projects fail to achieve their intended objectives not because of the gamification process, but because their design is simply not adapted to the context in which they are applied. This can be illustrated by the fact that some gamified applications aimlessly overlay points and badges in various activities, without any obvious motivating and clear objectives. In addition, beyond gamification design deficiency, poor choice and implementation of gamification mechanics are major culprits in failed gamification applications (Chang & Wei, 2016).

Gamification designers must carefully craft learning components that truly foster engagement; poor design can lead to frustration and loss of interest (Mekler et al., 2015). There is no one-size-fits-all template for implementing a gamification project that will be deemed effective; however, there are guidelines that can serve as scaffolding for a sound design, leading to the creation of an engaging gamified learning platform (B. Kim, 2015b).

A carefully crafted reward system needs to be implemented in a gamified learning platform to give learners a sense of satisfaction (Mekler, Brühlmann, Opwis, & Tuch, 2013). If the ratio between difficulty and reward leans more toward struggle than toward joy, the learning experience may be hampered. On the other end, if there is too little challenge, loss of interest can occur. This principle is reflected in the concept of the *zone of proximal development* (Shernoff et al., 2014).

The section of the project entitled “Learning Design Structure” describes the gamification design process. This process needs careful consideration to ensure that the gamified learning platform is not merely designed to assist students in being able to regurgitate factual components of the learning module. Promoting deeper conceptual learning is a concern that needs to be addressed during the design phase of any gamification implementation (Landers & Armstrong, 2015). This can be achieved by leading students to reflect about how disparate ideas and knowledge components relate to each other, and how grasping individual fragments of knowledge contributes to an understanding of a bigger concept and principle (Muntasir et al., 2015).

Progression is a game design element that plays a role in incrementally building core knowledge acquired by students (Hanus & Fox, 2015). Also known as “scaffolded instruction” (Chien, Ya-Fei, & Shin-Yi, 2016), the method consists of organizing and categorizing knowledge blocks such that learning happens incrementally. This helps mitigate the feeling of helplessness experienced by students when they feel overwhelmed and disoriented. This, in turn, leads to the creation of a learning environment that is more engaging for learners.

Building a gamification application that focuses on competition and performance, especially in an educational setting, can result in the creation of an environment that is not conducive to learning. Understanding self-determination theory and applying its guiding principles can mitigate this problem.

Self-Determination Theory

The project contains an outline of self-determination theory (SDT). Ryan and Deci (2000) designed SDT, which involves the notion that intrinsic motivation leads to higher quality learning. Intrinsic motivation prompts an individual to engage in a task or action because it is inherently satisfying or enjoyable; it refers to the impetus to thrive without the need for external incentives. Intrinsic motivation emanates from the basic aspiration for autonomy and competence. The inner desire for autonomy refers to “the experience of behavior as volitional and reflectively self-endorsed" (Niemiec & Ryan, 2009, p. 135). Students display autonomy when they exercise discipline and dedicate time to study of their own volition. A feeling of competence is experienced when students feel that they are able to successfully meet the requirements of academic challenges. In order to be intrinsically motivated, it is essential that students feel both competent and autonomous (Ryan & Deci, 2013). Learning tasks that promote autonomy are conducive to students' intrinsic motivation, whereas controlling educational environments tend to undermine intrinsic motivation. Students' level of interest in learning diminishes when they are put in controlling learning environments (Deci & Ryan, 2013).

SDT stipulates that humans thrive when they feel that they can reach competency and autonomy while feeling a sense of relatedness.

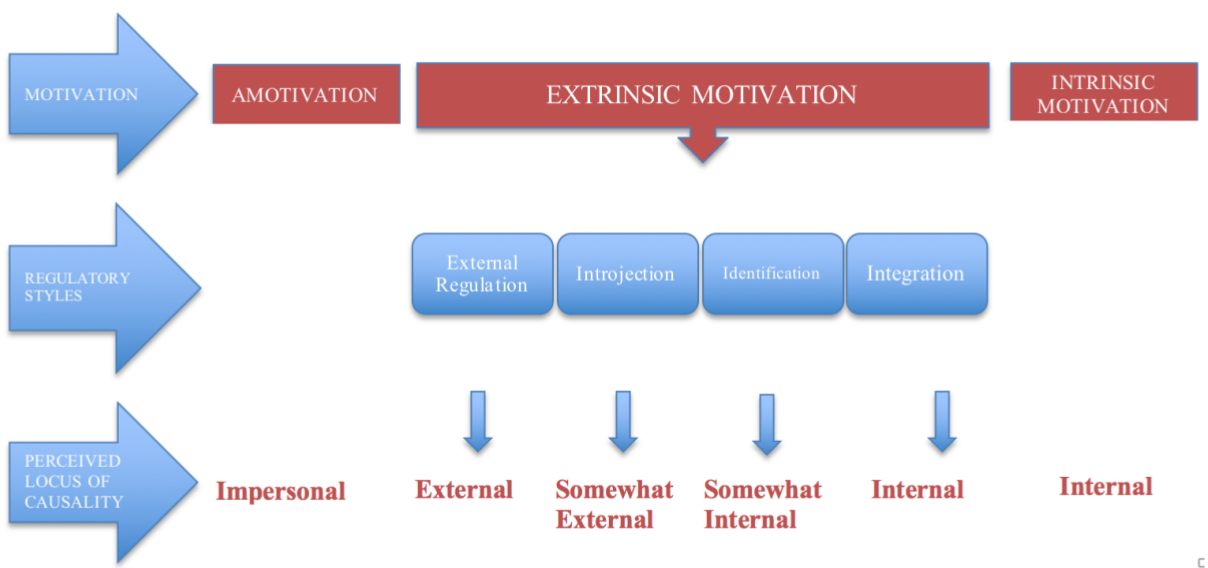

Figure 4. Self-determination theory. This figure illustrates the SDT continuum. Adapted from "Intrinsic and Extrinsic Motivations: Classic Definitions and New Directions," by R. Ryan and E. Deci, 2011, *Contemporary Educational Psychology, 25*, p. 61. Copyright 2000 by Elsevier.

When students need to engage in learning and encounter topics or subjects that they do not find appealing or interesting, other reasons need to be introduced to incentivize them; these could involve extrinsic motivation. Ryan and Deci (2000) identified four types of extrinsic motivation: external regulation, introjection, identification, and integration. *External regulation* represents the least autonomous type of extrinsic motivation and exerts the most pressure on the learner to either focus on reward or avoid punishments. This type of motivation is very transitory and tends to dissipate once the controlling contingencies no longer exist. For example, a student purely motivated by good grades (reward) or by the fear of being judged by peers (punishment) will most certainly seek breadth but not depth of knowledge on a given topic, in that the goal is to pass a test to obtain good grades and not to reach deep learning.

Introjected regulation, the next type of extrinsic motivation, refers to behaviors enacted to satisfy internal contingencies. It originates from an internal voice (Buckley & Doyle, 2016). Guilt, worry, or shame becomes the motivating factor; students are inspired to exhibit a certain level of motivation based on avoidance of self-derogation. Students succumbing to this type of motivation struggle to find learning a rewarding activity and lack confidence about their abilities to perform (Johnmarshall, 2013).

The next type of extrinsic motivation is *identified regulation*, whereby a learner has internalized and accepted the importance of a given behavior and chooses to be subjected to the discipline and constraints imposed by personal choice. This type of motivation is more self-determined and originates more as a self-imposed pressure

(Kusurkar, Ten Cate, Vos, Westers, & Croiset, 2013). For instance, a medical student might decide to be subjected to the discipline of studying human anatomy and dealing with human cadavers because of a strong desire to develop professional competency to become a successful doctor in the future.

The last type of extrinsic motivation is *integrated regulation*, whereby the learner has fully integrated a form of motivation from within. The learner finds congruency between external factors that exert pressure to perform and internal motivation that is in accord with inner values and beliefs. The student is reconciled with the idea that external academic demands are aligned with the inner desire to be academically responsible (Bailey & Phillips, 2015). Integrated regulation represents the most autonomous type of extrinsic motivation.

Given the importance of fostering autonomous types of extrinsic motivation that impact student learning positively, fostering a learning environment that facilitates internalization needs to become an academic preoccupation. The salience of evaluative pressure needs to be re-contextualized to convey an academic orientation that fosters internalization of the learning process. The gamification of learning could be a way to achieve such a goal.

Applying the enunciated principles above, gamified learning components need to balance the elements that promote extrinsic motivation with the ones that foster intrinsic motivation. The extrinsic components of the gamification implementation used in this research study are the progress indicator, trophies, and completion rates. The intrinsic motivation factors are the students' motivation to learn in order to acquire competence and foster engagement. As a related effect, this can generate collaborative learning and achieve a sense of satisfaction and achievement in students as they overcome the identified and measurable challenges embedded within the gamified learning component. The project contains a graphical representation showing elements depicting the intrinsic and extrinsic motivating factors.

Understanding SDT's driving principles is paramount since the theory is tightly related with the notion of engagement in the classroom. Game elements integrated within the gamified learning component need to carefully account for the type of motivation that these elements engender. Design considerations need to be taken into consideration the fact that extrinsic motivating factors lead to learning that does not necessarily constitute deep learning, thus the need to focus on a design that fosters intrinsic motivation.

Evaluation Framework

Measuring, assessing, and quantifying educational outcomes have become a predominant theme in higher education, due in large part to accreditation regulations, motivated by the idea to hold institutions accountable for student learning (Hazelkorn, 2016). This trend influenced and led into the assessment of various areas of educational practices, including the effectiveness of game-based learning in education (All, Nuñez Castellar, & Van Looy, 2015).

Stewart et al. (2013) identified two types of digital game-based learning (DGBL): special purpose games, which have been developed for educational purposes, and commercial off-the-shelf games, developed for entertainment purposes. The gamified learning component described in the project falls under the former categorization.

Furthermore, three types of special purpose games have been identified (Stewart et al., 2013): the first type is designed for the purpose of knowledge transfer and aims at achieving cognitive learning outcomes; the second type is meant for skill acquisition and designed for skill-based learning outcomes; the third type is primarily geared towards fostering an attitudinal/behavioral change, thus impacting affective learning outcomes. The various outcomes of these special purpose games are not mutually exclusive and can sometimes overlap. Thus, it is not unusual that a game designed with a behavioral change intention can also produce a cognitive learning outcome. Such is the case for the gamified learning component described in the project, which is designed to produce cognitive (knowledge acquisition) and attitudinal (in the form of student engagement) outcomes.

Operationalizing Gamification

In the context of the created project that focuses on gamification and student engagement, operationalization implies identifying the gamification variables and turning them into tangible and impactful factors that lead to student engagement (Reiners et al., 2012). The concept of operationalizing gamification encapsulates the idea of utilizing gaming mechanisms to create an authentic and immersive learning environment. Also, Reiners et al. (2012) placed an emphasis on the necessity to create an authentic environment when creating a gamification platform. The platform's authenticity referred to the usage of pedagogical strategies designed to simulate a real environment as closely as possible. Among these strategies would be the creation of authentic tasks and challenges that are as demanding as they would be in a real-world setting, providing means and resources to students to allow them to view a given problem or learning scenario from multiple perspectives. Also, this approach would facilitate collaborative learning opportunities where students could work together to solve problems and design solutions together, provide communication venues where students could exchange ideas and articulate their growing understanding, and use contextualized and meaningful assessments that gaged, not just factual knowledge but more importantly, understanding and subject mastery.

Another aspect of the authentic learning paradigm was to give students permission to fail. In real-life, students would be confronted with life's reality of making mistakes, misjudging, and making wrong decisions. To reduce risks, the education system rendered the learning activities abstract and detached students from these risks by presenting videos and reading case studies, leading to passive learning. Such approach would lead to a massive reduction in retention of knowledge (Reiners et al., 2012). Several game mechanics are preconized to preserve the authenticity of the learning experience, such as non-player characters (NPCs) that are scripted and programmed bots taking the place of non-person-controlled characters that students interact with inside the learning platform. Another proposed game mechanic was the rewinding process, which consisted of repeating crucial learning moments with the goal to build confidence. Resetting the scenario did not necessarily mean restarting it from the beginning, rather it involved going back to a point that proved challenging for the learner and needed to be repeated as a reinforcing learning tool.

The operationalization of gamification is an extremely enticing concept; it is replete with original ideas and mechanisms that could lead to high quality and very engaging learning tools. The concept lends itself to creating a solid framework for developing gamified learning components that are immersive and well adapted to realities that students have to encounter. The downside of this concept is twofold: first, defining authenticity could be an elusive pursuit and can tend to be subjective; outlining authentic experiences to be integrated within the gamification implementation can prove more challenging that it seems. Second, given the intricate nature of this approach, it could be very hard to actually implement a gamification project that embraces the defined principles upon which this theory is built. For example, creating and using NPC's in an effective way requires a great level of sophistication, from a project planning, design, and implementation standpoint. The design component can become quite an intricate process and would necessitate a long iterative process in order to make the necessary adjustment and perform some fine-tuning—a critical process in endeavors of this nature.

MDA Framework

As a way to assist the reader with understanding gamification principles, the project includes content describing fundamental notions such mechanics, dynamics, and aesthetics. These are design principles borrowed from the mechanics, dynamics, aesthetics (MDA) framework, originally conceived by Hunicke, LeBlanc, and Zubek (2004). Mora et al. (2015) stated: "a clear design strategy is the key to success in gamification" (p. 2). This calls for a thorough investigation and analysis of a design strategy prior to adoption in order to ensure a successful gamification implementation. In this regard, MDA helps in grasping how gamification works.

According to the MDA framework, mechanics describe the particular components of the game, such as actions, behaviors, and control mechanisms; they represent the agents, objects, elements and their relationships in the game. Also, they define the game as a rule-based system, stipulating what the elements are, how the various components relate to each other, and how the player or learner interacts with the platform. A large part of the mechanics is to specify the rules of the game; these are the constraints under which the platform operates. The mechanics define how the game is set up, what actions players need to take and how those actions transform the game state, how to end the game, and what constitutes a final resolution.

Dynamics describes the run-time behavior of the mechanics acting on player inputs and each other's outputs over time. They are the emergent behavior that arises from gameplay, when the mechanics are put into use; hence they represent the play of the game when the rules are set in motion.

Aesthetics describes the sensations and emotional responses received when the player interacts with the game platform. They allow designers to determine if they game is fun, if the platform is frustrating, interesting, and whether the experience is emotionally or intellectually stimulating and engaging.

Figure 5 represents the different aspects of the MDA framework, categorizing mechanics as the embedded narrative, dynamics as the emergent narrative, and aesthetics as the interpreted narrative.

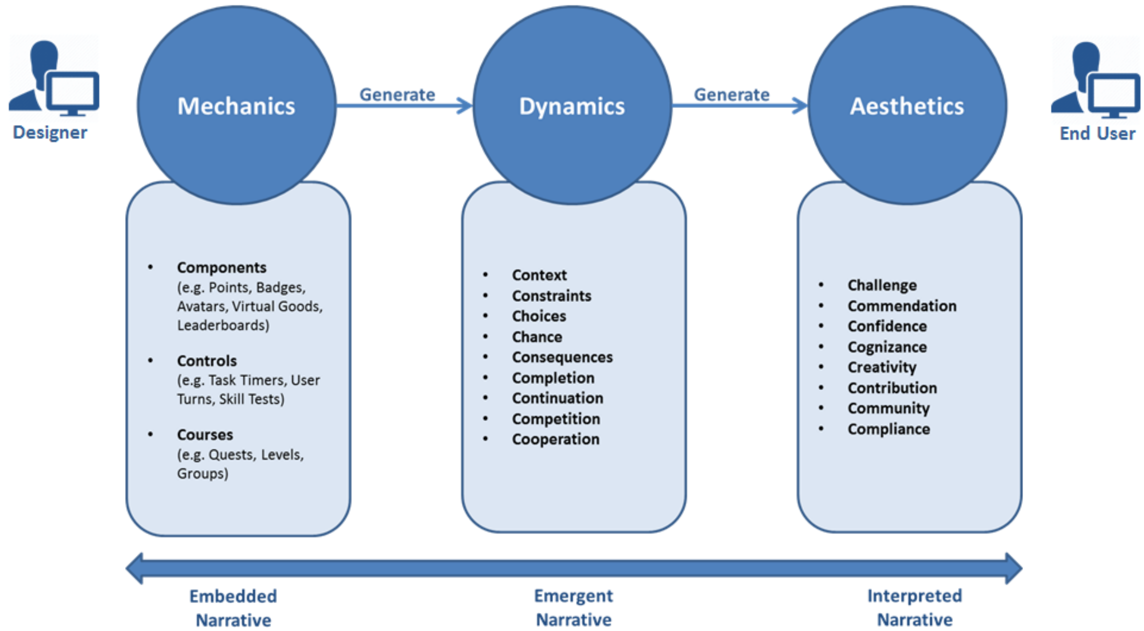

Figure 5. A representation of the MDA framework. From "Level Up Your Strategy: Towards a Descriptive Framework for Meaningful Enterprise Gamification," by U. Ruhi, 2015, *Technology Innovation Management Review, 5*(8), p. 8. Reprinted courtesy of the Copyright Holder under a Creative Commons License CC BY 3.0 (https://creativecommons.org/licenses/by/3.0/)

Subsequently, different game strategists further expanded the MDA framework and added components they felt were congruent with the original framing of game mechanics, game dynamics, and game aesthetics. Table 14 is a compilation of how various authors contributed to include narrative elements to the MDA framework.

One key importance of MDA is that it describes a multifaceted aspect of gamification and presents the game designer's perspective, as well as that of the game player. The latter engages with the platform viewing game mechanics as the game rules, whereas the former considers them as player actions and control mechanisms. Equipped with an understanding of game mechanics, dynamics, and aesthetics, the designers involved in this project can identify the various elements that would be part of the newly developed gamified learning platform.

Project Description

The project was created within the context of gamifying a course component to be used by graduate medical students, part of a technology implementation designed to determine the impact of gamification on student engagement. This medical course has always been taught in a traditional manner—through lectures and PowerPoint presentations. This gamified learning platform is a first in its kind since it represents the first gamification project that the college is experimenting with to assess how impactful such a project can be on its students' level of engagement.

Table 14

Compilation of Various Narrative Elements Contributing to the MDA Framework

Game mechanics	Game dynamics	Game aesthetics
Werbach (2015): • Challenges • Chance • Competition • Cooperation • Feedback • Resource acquisition • Rewards • Transactions • Turns • Win states B. Kim (2015c): • Points • Badges • Leaderboards • Statuses • Levels • Quests • Countdowns • Mission	Hunicke et al. (2004): • Challenge: time constraints, pressure from opponents • Fellowship: information sharing among members, collaboration to solve problems • Expression: derived from dynamics, encouraging participants to personalize their character and constructing their worlds or levels • Dramatic tension: increasingly higher level of tension, release, and a finalization	Hunicke et al. (2004): • Sensation – Game as sense-pleasure • Fantasy – Game as make-believe • Narrative – Game as drama • Challenge – Game as obstacle course • Fellowship – Game as social framework • Discovery – Game as uncharted territory • Expression – Game as self-discovery • Submission – Game as pastime • Achievement • Epic meaning • Blissful productivity

The project provides a brief introduction to concepts related to gamification and explains the meaning of these concepts. Next, it outlines a learning design structure that provides a scaffolding assembly for building gamified learning tools. Also, a description of the research study is presented, along with the research findings. The project outlines the various types of resources required to conduct gamification projects of this nature. The gamification project execution phases are described, outlining the sequence in which each stage of the project is implemented, adopting systems design and analysis best-practices for a software development project, contextualized to accommodate the need for a gamified learning project. A section of the project consists of delineating notions related to game mechanics and their impact on motivation, game dynamics, and game aesthetics, which represent critical game design elements lying at the heart of any gamification project.

Graphical components and illustrations were used throughout the project to enhance readability and aesthetic of the overall document.

Resources and Supports

The successful implementation of this project necessitated the participation and involvement of a diverse set of expertise. Several participants, qualified in various fields, needed to be brought together to make this project a reality. Given the multi-faceted nature of this project, the skills required range from academic content experts specialized in pedagogy and medical field to programmers versed in code writing and applications design—they contributed to the technical content of the project.

The needed resources can be categorized as follows: pedagogical resources, technology resources, creative resources, technical resources, and system support resources. Below is a detailed inventory of what each category of resources entails.

Pedagogical resources. A faculty member needed to be part of this project and played the critical role of content expert. This instructor needed to be involved at every step of the way to ensure that the pedagogical components were described and constructed to form the content found in the section dedicated to the learning design structure. As far as the design of the gamified learning component was concerned, the faculty member along with the instructional designer needed to soundly structure the course material, with clearly defined learning goals and objectives, a logical outline, and embedding a level of assessment that matched the course content and aligned with the objectives. This was paramount because there was no technology solution that could salvage a poorly designed and weakly structured course.

Technology resources. The gamified learning component, described in the project, made use of 3D elements that were integrated in the learning interface. To this effect, key resources specialized in the field of 3D technologies needed to be involved to provide content and information related to 3D scanners and 3D software used as capture and rendering applications, but also as a software manipulation, editing and optimization applications. Members from the 3D team described 3D design software that were used to manipulate and transform 3D files obtained either from scanning or from acquired 3D assets. Also, they described the 3D programming software used as a programming and development software, which was the main platform used to code software logic and create development as well as production builds. The 3D technology team came up with the list of software in Table 15, which were used to build the gamified learning platform.

Table 15

Listing of 3D Tools and Software Used in Project

3D tools	Usage
Autodesk 3DS Max	Modeling, animation, and rendering
Unity 3D	Cross-platform game engine, using C# programming language
Agisoft Photoscan	Photogrammetric processing of digital images to generate 3D spatial data, using computer vision methods
Autodesk Maya	Creation of interactive 3D applications, including video games, animation, and visual effects
Artec Studio	Software for professional 3D scanning and data processing
Artec Eva	Structured light 3D scanner for making textured 3D model of medium sized objects

Members of the technical team provided the needed content to describe the application hosting and rendering server used. The rendering server was used to process the resource-intensive computing task of compiling and rendering the 3D files. Also, they were used to create the computing power-hungry process of creating application builds once the development process reached a phase where software versions could be created.

Among the role played by the technical team was to provide the necessary content for the project in order to document the main development process using Unity 3D software—a game engine specifically designed to architect and produce 3D entertainment games as well as game-based learning applications (Ma, Bale, & Rea, 2012).

Creative resources. This project necessitated the use of several graphical components (buttons, graphical box and text containers, navigational components, graphic files to create interface particles), interface elements, 3D models, and sounds effects. The creative resource team was tasked with downloading these elements from online repositories and ensured that the proper copyright and usage rights were taken into consideration. Also, members of the creative resource team provided the content related to describing the needed 3D model components acquired through various means—for the most part, online.

Technical resources. Several key resources were required to handle various technical aspects for creating the gamified learning platform. A database administrator was required to handle to creation and maintenance of the various database tables and objects required to hold information related to the gamified learning component. An application developer was required to create application program interface (API) to obfuscate the complexity of database queries and provide easy-to-use programming methods to the 3D programmer. A 3D programmer played a central role since this role implied coalescing all project components into a whole that would eventually become the finalized product. This was made possible by creating the underlying codes that formed the logic behind the graphical and 3D components and making them part of the interactive functionality, thus providing a user interface through which the user experienced the learning platform's features and capabilities. All the enunciated technical resources above provided content related to their respective field of expertise; these contents were consolidated to form a unified and condensed narrative that was included as part of the project.

System support resources. Beyond building the actual learning platform, several resources were required to organize the project development process. Among those are resources required to test the learning platform for quality check purposes and for releasing the actual polished version of the learning platform. Also, a project manager was required to coordinate group efforts and ensure that specific project milestones were clearly delineated, as well as manage the collaboration with content experts and stakeholders. All these resources described above provided narratives that were included as part of the project.

Potential Barriers and Solutions

The potential barriers that could emerge from the onset of this project could stem from the following four factors: resistance to change, content volume and selection, content diversity, and local versus generalized needs and requirements. These factors are described below.

Resistance to change. A recurring theme in medical education is its slow adoption of change and inability to quickly adjust to meet the challenges of an ever changing educational landscape and fast-evolving technology world (Shelton, Corral, & Kyle, 2017). Based on this reality, a reluctance to embrace the project content and its premises could arise. Presenting innovative teaching methods to certain groups of medical educators could prove to be a challenging task (Hopkins et al., 2018). As such, openness and receptiveness to the project, which describes the utilization of a new approach to teaching and learning, could be a challenge.

Content volume and selection. With the large and diverse set of resources and participants, the amount of material collected was bound to be voluminous. Since the scope of this project was meant to be relatively small, the volume of materials gathered represented a challenge in creating a short and concise guide to a gamification implementation project. Creating the impression of emphasizing the importance of one section over another could pose a problem. Balancing the amount of coverage between the academic, technical, and procedural sections could lead to a balanced project content conundrum. A lopsided coverage of one aspect of the project over another would result in either a misrepresentation or an incomplete portrayal of what the overall endeavor of creating a gamified learning platform would truly entail.

Content diversity. The project content was an amalgam of pedagogical theory, research design method, technical and technological implementation and tools, administrative concepts, and specialized knowledge. A large mixture of expertise was required to populate the content of the various sections in the project, which contributed to the richness but also the complexity of the document. Such a large diversity of content would make it difficult to coalesce the highly diverse content and form a cohesive narrative.

Local versus generalized needs and requirements. This research study was conducted to address a very specific need within the college. Delineating the design scope of the gamified learning platform was done for building a specific application meant to be used for and by the college. Therefore, the challenge of differentiating between what features and requirements, applied to specific and local needs, as opposed to what would be applicable to a larger audience could be quite a conundrum.

To address the content volume and selection dilemma, a process of elimination and a content filtering process could be used to retain only necessary information that would be inclusive of a quick guide document. Content contributors could be asked to categorize their materials as primary and secondary—layered as or numbered in level of importance. Should any challenge arise, the group's self-rating of their content would be used to filter content to be included as part of the project. This could be an iterative process that would necessitate a few passes at further condensing and prioritizing content, until the essential core was identified, which in the end would constitute the finalized project.

A solution that could address the content diversity would be to create addendums to the project. These additional documents could explain in greater details any section that a group content provider may deem appropriate and would merit a larger coverage of topics needing more explanations. Another way to address this content issues would be to create a two-volume document, with one section dedicated to the pedagogical part and a separate one dedicated to technical content. This idea had its merit, however it would defeat the purpose of creating a short guide. The initial and proposed scope of the project was to create a concise document, however a future version could result in the creation of a multi-volume document, given room for ample coverage of all sections.

The solution applied to address the dilemma related to the local versus generalized needs could be framed as a selection and content filtering by carefully omitting any parts or solutions that might vary from one context to the other, or it might be inappropriate or not applicable in a different institution. For example, the list of 3D software listed in the project differs from what the 3D team provided. The team listed the Agisoft Photoscan and Artec Sofia software, however these are not industry standard software and different institutions may use a completely different set of software. Therefore, these software were omitted from the list included in the project. The Autodesk 3DS Max and Maya software are mainstream software that are widely used in 3D design and animations, making them good candidates to be included in the list of suggested software. They were retained and included as part of the project content.

Proposal for Implementation

The short guide document was designed to provide a starting point for any faculty or medical college wanting to start or envision launching a gamification project. The first group to be exposed to the project document will be the college faculty group. A gamification group, led by the faculty who served as the content expert to create the gamified learning platform, will be formed to discuss, evaluate, and critic the document and provide feedback. The feedback received will be used to enhance the existing content and create a new version of the document. This phase is slated to last 3 months.

The revised version will then be brought to the Curriculum Committee for a discussion involving the inclusion of gamified learning components to be an integral part of the curriculum. The Committee’s response would be expected within 4 months of the document’s submission to the group. The expectations from the Curriculum Committee would be to provide recommendations regarding the inclusion of gamification as part of the medical curriculum. Including these recommendations, presented along with the project document, a faculty development program will be put in place to organize a training effort to expose faculty members to concepts related to gamification and how to integrate them to be part of faculty teaching's arsenal.

In order to disseminate the idea of using gamification at the university level, the Office of Academic Affairs will be a leading voice to provide a strategic approach for adopting innovative teaching methods—illustrated by the use of pedagogical approaches through the gamification of the learning experience.

The last phase involves reaching out to medical schools that had previous joint initiatives in the past with the college on other projects related to exploring innovative ways to improve the medical curriculum. The goal would be to exchange ideas and resources to collaborate and jointly work on a gamification project that would mutually benefit both institutions.

The complete project dissemination phases are provided in Table 16. This table provides also a description of each entity's role in the creation, refining, and dissemination of the project document.

Roles and Responsibilities

Along with listing the entities involved and showing the timeline, Table 16 displays also the various roles played by all groups involved. Additionally, a group of students will be asked to provide feedback, suggestions, and report any non-working features, as well as report any navigational or technical difficulties while navigating through the gamified learning platform. Feedback received from students will play a major role in solidifying and improving the platform. To facilitate the gathering of feedback from students, a form found in Appendix B was created as a data collection tool.

My role would be primarily that of a facilitator and a liaison officer. I will coordinate the various efforts needed to get the evaluation project moving forward, remind entities about deadlines and timelines, as well as assist with any additional information or clarification needed for any group needing to discuss various points that may need to be addressed. I will work with the college administrators and faculty members to shed some lights on the project as a whole, as well as provide details related to the research study and the gamified learning platform as necessary. Also, I will be a liaison between the college and the faculty development office to put together a training plan or a demonstration session to provide a venue to provide faculty members with a learning opportunity to discover the potential behind the use of gamification in medical education.

Also, I will work with university administrators to use the short guide as a supplementary document to be used as a support document for the larger strategic vision of embracing new pedagogical models within the institution.

Table 16

Project Dissemination Phases

Phase	Entity/Group	Timeline
Phase I	College faculty group *Role*: Provide feedback *Action*: Create a newly revised version of current project document description	3 months
Phase II	College curriculum committee *Role*: Provide recommendations *Action*: Submit written document outlining recommendations	4 months
Phase III	Faculty development program *Role*: Provide a venue to disseminate information about using gamification in medical education *Action*: Schedule training or gathering events to expose faculty to the notion of using gamification in the curriculum	3 months
Phase IV	University academic affairs *Role*: Officially adopt gamification as an innovative teaching tool with the university *Action*: Write communiqués to various colleges regarding the use of gamification as an innovative teaching approach	3 months
Phase V:	Medical school partners *Role*: Join forces with medical school partners and collaborate at the level of exchanging ideas regarding the use of gamification, using project document as a reference *Action*: Formalize partnership and work towards starting a joint venture to start a gamification project	6 months

Project Evaluation Plan

The type of project evaluation plan will be goals based. Designing a project evaluation plan is a critical process since it can provide data that highlight successes, but also improvement measures viewed as opportunities (Lubejko, 2016). A goals-based evaluation plan is defined as “a type of evaluation used to determine the extent to which programs are achieving their overall, predetermined objectives” (Nelson, 2009, p. 1438). The main underlying objective behind the creation of the documented project was that of a dissemination, knowledge sharing, awareness development, and motivation to use gamifying learning components in medical education.

Specific goals related to each phase will be developed, each requiring a different type of evaluation to be conducted. Thus, these goals are linked to each one of the dissemination phases as outlined in Table 6. Phase I consists of involving the faculty group and getting feedback. The lead faculty will generate a survey, as well as gather verbal assessment from faculty members. Phase II involves the Curriculum Committee members and since the committee already has its internal program evaluation procedure in place, this will be used to assess and receive feedback regarding the members’ views and assessment of the project. Phase III involves the Faculty Development Program, which also has a standard survey for assessing activities conducted within the realm of faculty development. Their data gathering system will be used as the evaluation tool. Phase IV represents an initiative led by Office of Academic Affairs and the strategic plan document, which will contain a section dedicated to innovative teaching, already contains key performance indicators, with specific and detailed measurement of goals and objectives. The last phase includes the involvement of medical school partners, with the end goal to establish a successful partnership and collaborate on building gamified learning components to be included as part of the curriculum.

The key stakeholders who will have dealings with the project document are the faculty members as major key players when it comes to discussions and decisions related to the pedagogical aspect linked to the use of gamification; college administrators who are interested in the project content and establish how it fits within the university's larger strategic plan; students who are the actual population impacted by any gamification implementation project; and the technical teams who contribute to drafting the technical aspects of the project document.

Project Implications

This research study was designed to explore the impact of gamification on student engagement, thus contributing, to a certain extent, to a better understanding of how gamification works and how it can be leveraged in higher education in general and in medical education in particular. One deliverable derived from this research study was the creation of a project, which is a short guide related to the use of gamification in medical education. The implications as a result of implementing this project are discussed below, first at the level of the local community and then for medical education at large.

Local Community

The initiative to explore the impact of gamification on student engagement originated from a college administrators' desire to explore technological venues to address a problem related to student disengagement, partly rooted in the fact that the curriculum delivery method was not fully in line with learning modalities expected from a group of students who are in large majority millennials.

At the college level, the creation of the project document could foster a collaborative spirit between faculty members, instructional technologists, programmers, and designers; it could generate a new dynamic and a new approach to collaborate in order to achieve the common goal of catering to the needs of students. A certain level of collaboration already exists between the technical group and the academic group through the usage and delivery of computing and networking services. However, during this process, one possible outcome would be to see an increase in the depth of involvement from both, creating a synergy that could result in the creation of an efficient workflow, as well as a tighter working relationship and a greater respect between participants with different types of expertise. It is not uncommon to witness an adversarial attitude and relationship between the technical and academic sides in academia (Reid, 2017). The development of this project could be demonstrative of the fact that the coalition of the technical team and the academic side is a potent force that could play a transformative role in shaping an educational environment and culture. Having faculty members working side by side with technology staff could allow them to see the human side of technology; it could demystify the notion of technology being impersonal and a cold entity.

As a result of disseminating this project, which will be used as an informational tool, some faculty's perceptions about gamification could evolve from being a technological fad that could cause the demise of the college, to being perceived as a pedagogical tool that could bring value to education. This shift could derive from dialogues, exchanges, and inquiries from all sides involved in this project. A lack of understanding about what gamification is at its core leads people to believe that it dilutes the importance and rigor of the academic endeavor. The academic group working closely with the technical team could prove that it could be quite the contrary. As highlighted by the project document, the integration of gamification components embedded within the gamified course content was the result of a careful evaluation of pedagogical principles and how they could be used to promote learning. Faculty members could become aware that pedagogical principles informed and guided the use of gamification components; meshing the two required a careful and at times difficult evaluative and implementation process.

As a result of the dissemination of this project, some reluctant faculty members could start to view technology no longer as a necessary evil but as a potent instrument that could bring value to medical education. In the current societal context, technology and education have become tightly interwoven and inseparable (Caplan, Myrick, Smitten, & Kelly, 2014), with great possibilities and potential towards enhancing teaching and learning when used appropriately and adequately. The hope is that this dissemination effort could lead to unleashing these possibilities and potentials towards the betterment of medical education.

In summary, within the context of this project, social change could be framed on one hand as a possible change of the college administrators' posture vis-à-vis the role of technology in medical education. Through an exposure to a gamification process, the college administrators could perceive technology as instrumental in promoting new pedagogical models that could enhance its curriculum. On the other hand, social change could be expressed as the faculty's attitudinal change regarding their understanding and perception of the role of technology in medical education. After being made aware and being exposed to literature related to gamification, they could display a level of openness and become more inclined to venture in trying technology tools as part of their teaching arsenal.

Implications for the Larger Context

Groh (2012) stated that rigorous and systematic studies about the benefits of gamification and its side effects must be conducted to better understand how to efficiently utilize gamification in education. Discussing medical education, Sera and Wheeler (2017) further reinforced the fact the body of literature related to the gamification of learning is still rather scant. To a very small extent and at a very practical level, the hopes are that the introductory level to gamification represented by the project could contribute to piquing the interest of medical educators and motivate them to take it one step further in their teaching practices.

Gamification initiatives as described in the project, necessitate the involvement of multiple talents, ranging from a content expert in the academic field to skilled designers and programmers experienced in the area of information technology. Also, it calls for the involvement learners in the design process. As such, building a gamified learning platform in medical education could be instrumental in breaking the silo mentality. The collaborative nature of gamification project could stimulate a synergy among various entities in an educational institutional.

Conclusion

This section dealt with the development of a short guide to the use of gamification in medical education as the selected project. One of intended goals was to disseminate practical knowledge and understanding regarding notions and principles related to gamifying learning in medical education. A review of literature was conducted to investigate and explore the various concepts related to gamification covered in the project document, as well as covering scholarly treatments of literature related to research findings. Additionally, a project description was provided, along with an outline of needed resources to complete the project. Also, a descriptive summary of the roles and responsibilities of all parties involved in the making of the project was provided. A goals-based evaluation plan was outlined, along with enumerating the various expected outcomes from the set goals. Finally, a summary for possible social change implications was provided both at the local level and the broader context.

The next section presents a professional reflection and provides an evaluation of the project's strengths and limitations, as well as implications and directions of future research.

Section 4: Reflections and Conclusions

The final section of this study presents reflections on the strengths and limitations of the project and a discussion of how the research and project development had an impact on me as a scholar, practitioner, and project developer. Additionally, I discuss the implications and importance of the work involved in this final study. Finally, I suggest proposed and potential directions for future research.

Project Strengths and Limitations

From its inception, this project, presented in Appendix A, was embraced and backed by my institution, which catapulted innovative teaching and learning to the forefront of its core cultural values. Strategic plans were designed to advance the use of technology in education, resulting in several technology projects that were administratively and financially supported. This institutional acknowledgment of the importance of promoting and using technology in medical education provided an opportune occasion to create a documentation project related to gamification with the hope of gaining traction at the institutional level in disseminating such a pedagogical approach. Without this momentum, it would have proven a bigger challenge to propose the use of what is considered a quasi-obscure educational tool such as gamification. This institutional support allowed for the participation of the academic team, the instructional design group, and the technical team.

As a result, the various institutional entities were eager to allocate resources to bring this project to fruition. The many talents involved contributed their highly diverse skill sets to build the varied content types in this project. It would have been impossible to build a project of this nature without their expertise in producing content covering the pedagogical, technical, design, and creative aspects. The contributing talents involved in the making of this project represented a major asset for its implementation.

The nature of the selected content used to describe the gamification principles also constituted one of the strengths of this project. As gamification begins to gain ground and take root in enterprise and educational milieus (Awwal, Alom, & Care, 2016), guides and infographics have been created to popularize the use of gamification (Çeker & Özdamlı, 2017). However, a pitfall to avoid was that of sharing principles that could lead to “superficial gamification” (Cook, 2013)—a practice involving the use of extrinsic motivators that are not aligned with the intended objectives. Efforts were made to ensure that the project content differentiated approaches to gamification, bringing awareness of the types of motivating factors that should be aligned with the intended goals of the learning material and objectives. Among the project contents that were used to achieve a better understanding of impactful gamification implementation were notions related to mechanics, dynamics, and emotions—design components that could lead to the production of engaging gamified platforms (Robson, Plangger, Kietzmann, McCarthy, & Pitt, 2015).

Another strength of this project is its portability—presented as a guide document, it concisely covers topics related to gamification and provides a broad overview of most critical notions related to the concept. As literature covering the use of gamification in education begins to proliferate (S. Kim, Song, Lockee, & Burton, 2018), it is important for educational institutions to have a concise document, such as this project, which makes gamification a less daunting subject to grasp and less intimidating (Yunyongying, 2014).

Last but not least, the great dedication of everybody involved in the making of this project constituted one of its greatest strengths. Without their tireless efforts and countless hours spent to make sure that all details were meticulously inspected, as well as to write down any needed content, the realization and completion of this project would not have been possible.

As much as the conciseness of the project constituted one of its strengths, it also represented its Achilles heel. Many integral gamification principles were left out; many critical elements and best-practice principles could not be covered because the intention was to produce a short, concise document. The condensed content of this project is of informational value; it does not provide the needed information to get a gamification project off the ground. To illustrate this point, it is worth mentioning that the decision to select and include rewards necessitates an investigation related to the reward mechanism that requires information such as type, recipient, vehicle, rationale, access, and representation, to name just a few. In that the reward mechanism represents a very small fraction of the overall project implementation plan, it would require a lot of documentation to cover the full scope of gamification implementation. A precipitated and uninformed gamification implementation could lead to a project that would be labeled “shallow gamification” (Andreas, 2014).

Recommendations for Alternative Approaches

The nature of the problem described in this research study is related to addressing lack of engagement among medical students. The recommended approach to address this problem was to inject a new pedagogical model, driven by technological means and implemented through the use of gamification embedded as a learning platform.

Other means exist to address the problem of lack of student engagement. One of them involves transforming the learning modality from a lecture-based to a problem-based format. Within the realm of medical education, problem-based learning (PBL) has been touted as an educational approach that increases knowledge retention, improves critical decision-making process, and promotes quality communication among students (Murgu, Kurman, & Hasan, 2018). According to Jindal, Mahajan, Srivastav, and Baro (2016), who studied the use of PBL in medical education, students favored the use of PBL because of its group-based structure and its enhancement of their ability to address real-world health problems. Based on such research, PBL could address the problem of lack of student engagement in medical education.

Going beyond PBL, Nadiia (2016) proposed the introduction of several teaching methods that could transform medical education. Among these were team-based learning (TBL), interactive lectures (using a student response system and interactive engagement), group discussion, collaborative learning, and cooperative learning. These methods of teaching have the potential to address the problem of lack of student engagement.

Emanuel (2017) proposed an interesting approach to reforming American medical education. He posited that the problems encountered in medical education stemmed from its core structure—not from the lack of use of technology or from sticking with obsolete pedagogical models. He proposed that medical students should spend more time learning in clinical settings and that preclinical training should be reduced, implying that there should be less lecture time. Addressing the problem of student engagement from the standpoint of augmenting practical training could be a way to bring change to medical education.

Alternative definitions of the problem could be framed by a conjecture that lack of student engagement (a) is a manifestation of a problem of a different nature or (b) has root causes elsewhere. Assuming that a problem of a different nature needed to be investigated, one could presume that what appears to be lack of engagement is instead a multitasked learning modality. Lack of interaction and participation in class could be due not to apathy and disinterest, but to students branching out to parallel undertakings, which might be related or unrelated to current class activities. In fact, due to the massive amount of knowledge found on the Internet, students could be searching for materials related to topics that the teacher is covering during class time. In this instance, what was being perceived as a lack of engagement was the adoption of a parallel learning method—branching out to find complementary learning resources online. This corroborated the theory that millennials were resourceful and had a strong propensity for multitasking (DeVaney, 2015).

One alternative solution to the problem stated above is to break the monotony of hours-long lectures with probing questions posed through a student response system. In a study conducted within the context of health sciences, Benson, Szucs, DeIuliis, and Leri

(2017) demonstrated the effectiveness of a student response system in enhancing long-term retention of course content. This approach could be a viable teaching strategy.

The problem, initially defined as a lack of engagement, could also be defined as nonreliance on classroom lectures. Currently, the college mandates the recording of all lectures, negating the need to rely solely on classroom time to access learning content. At their leisure, students can listen to recorded lectures, replay portions of lectures that they deem essential or important, add annotations to lectures digitally, exchange notes with other students through video interface, and take advantage of many other flexible and social options within the lecture capture system. They feel no pressure to be focused or engaged in class because other means exist—the video lectures—to study the course material.

An alternative solution to the problem enunciated above would be to combine lectures and videos through the use of interactive video lectures (IVLs). According to Hung, Kinshuk, and Chen (2018), IVLs have the unique ability to create an educational environment that provides interactive learning activities. IVLs require instructors to create courses with built-in interactive mechanisms and necessitate a more thoughtful course design process. However, faculty using IVLs could be rewarded by teaching in a dynamic learning environment where, according to Hung et al., students' comprehension and retention of learning content are increased.

Scholarship, Project Development, and Leadership and Change

The making of this project deepened my understanding of the scholarship of teaching and learning. Creating the final project incited me to exercise academic rigor and use critical thinking throughout the various stages from project inception through completion. Logically developing a project outline that would produce a coherent and persuasive flow required a great deal of analysis and reflection, with lots of trial and error along the way. Building the project according to a predetermined and predefined structure was a challenging exercise. I tend to be a freethinker and creative, with a tendency to take liberties and deviate from established guidelines and norms.

Throughout the process of conducting research and developing the project, I learned about the immense advantage of collaborative scholarship. Collaborative scholarship entails a coming-together of the academic community to undertake the common task of creating a body of knowledge, a new process, an enhanced or revised understanding, or a project. This process also produced an experience of implicit and explicit mentoring and knowledge acquisition that took place both naturally and purposefully. By mingling and collaborating, participants enriched each other's knowledge and understanding of other fields of expertise. Interacting and collaborating with members of various academic branches allowed me to acquire a better understanding of the struggles and challenges encountered by faculty members who are deeply committed to scholarship, education, and their teaching practices. Likewise, faculty members developed a better understanding of educational technologies and their many ramifications. The reciprocity of the learning experience gave me a great sense of satisfaction in experiencing how transformative the encounters were by dialoguing and collaborating with scholars and experts in areas different from mine. I developed the greatest appreciation for the work, dedication, and contributions of my peers and colleagues. Further, this experience allowed me to truly value synergy in an educational setting. The university is replete with experts in many areas; combining forces truly produced quantitatively and qualitatively better outcomes.

Through the development of this project, I had the opportunity to discover the many resources available at the institution—academic, technical, creative, and technological resources. Managing and prioritizing were among my responsibilities as the project owner. Because this project was a rich and complex amalgamation of scholarly content, technical components, creative modules, instructional segments, and technological elements, it gave me a tremendous opportunity to exercise organizational, directional, and communication skills—an experience that stretched me personally and professionally. Most importantly, the complexity of this project gave me the opportunity to benefit from the power of delegation. Discerning individuals' existing talents and benefiting from their strengths allowed me to dissect the project, prioritize tasks, define milestones, and hand over the implementation of specific project segments to identified team members. Team members felt empowered and took ownership of their assigned work. Delegating represents a powerful and winning strategy.

Reflection on the Importance of the Work

There is a scarcity of gamification studies in medical education. This project contributes to the body of literature addressing the questions surrounding the appropriateness and efficacy, as well as educational impact and contribution, of gamification for medical education. Within this larger context, this study could shed some light on the impact of gamification in medical school settings.

Engagement was another predominant theme of this study. The discussions surrounding that topic could help in understanding and bringing to the forefront of medical education the importance of an educational system dedicated to and concerned about knowledge delivery. At the same time, it is necessary to pay attention to the recipients of delivered content—medical students. At the core of this study was a great emphasis on the learning experience, as well as the impact of the knowledge delivery format and delivery mechanism on learners—in this case, a gamified-learning platform.

Medical education remains intrinsically a lecture-based system, and the hope is that in the future changes could include embracing technological solutions and pedagogical approaches involving the use of gamification. In a very small way, this research study brought to light the fact that more studies need to be conducted to determine the impact (positive or negative) of gamification on medical education in general and student engagement in particular.

Bruner (1997) made the following profound remark regarding the nature of education:

> Education is not simply a technical business of well-managed information processing, nor even simply a matter of applying “learning theories”… It is a complex pursuit of fitting a culture to the needs of its members and their ways of knowing to the needs of the culture. (p. 43).

Subsequently, Swanwick (2005) linked these thoughts to medical education; they pointedly express the importance of moving the educational system beyond being a knowledge-sharing and delivery process. By emphasizing the importance of student engagement in medical education, this research study may start a dialogue that emphasizes how students, as recipients of a lecture-based system, react to the adopted mode of delivery. In essence, this research study points to the consideration of a student-centered approach to teaching and learning in medical education.

Implications, Applications, and Directions for Future Research

During the course of this study, several noteworthy attitudinal and cultural changes took place at the following three levels: faculty perceptions of technology, college administrators' understanding of the importance of integrating technology in the curriculum, and the supporting team members' understanding of their role in supporting academic endeavors.

Implications and Applications

The faculty members' involvement in the study and in the making of the project was crucial. Without their willingness to lend their expertise, this study could not have been conceived. Through their participation, faculty members developed a better understanding of how teaching and technology could be meshed to create a type of learning platform that was unique and could be a potent instrument for imparting knowledge to medical students. As a by-product of the building process of a game-based learning platform, the experience gave an opportunity for faculty members to demystify technology. They came to the realization that building a gamified learning component was similar to any multidisciplinary project where experts from different fields come together to synergize and collaborate to create a unique product. According to Reid (2017), one of the barriers to faculty technology adoption is self-efficacy, defined as a faculty member’s belief or confidence in his or her ability to succeed. Throughout the implementation phase of this study, the modular approach in building the gamified learning platform allowed faculty members to see the project come to fruition while working with one learning block at a time. Instead of having an overwhelming experience, faculty members gained confidence in their contribution and their belief in a positive outcome.

At the college level, the building process of a gamified learning platform reverberated as a materialization of a strategic approach and commitment to using technology as a means to cater to the needs of their millennial learners. This was a practical demonstration of the college administrators’ desire to leverage technology and to showcase embracing a different pedagogical model to explore technological means within the context of medical education. It allowed the college administrators to revisit their approach to technology integration practices in general and, in particular, examine future projects to further explore gamification as a pedagogical instrument. It gave the college administrators the opportunity to reflect on their technology integration knowledge and practices and strategize for future initiatives involving the revision of the program curriculum to incorporate in its structure a more systematic and in-depth inclusion of technology.

As far as the educational designer and technology groups were concerned, one key realization was the fact that to have a strong design framework when building game-based learning components was paramount. Among the pitfalls to avoid was the reliance (or overreliance) on the gaming elements to teach content instead of crafting the course such that strong instructional design and sound pedagogical principles constituted the engines and foundations driving learning. The gaming platform should not be used as just a container and a vehicle to drive content; it should be used to allow learners to experience game play in order to inform the educational process. Researchers, instructional technologists, and faculty alike who wish to be involved in experimenting with gamification in education would greatly benefit from applying the principle of emphasizing the need to use strong instructional design best practices from the inception phase of building game-based learning modules or products.

Directions for Future Research

Reflecting on the history of medical education, Bligh and Parsell (2000) made the following recommendation: “It is important that we take control, harness what has already been achieved and create a clear direction for medical education in the future” (p. 416). Since the first revolution in medical education ignited by the Flexnerian movement, the history of medical education is replete with instances of transformational changes being proposed and advanced as an agenda for the future of medical education (Quintero et al., 2016). The quest for educational efficiency in the medical field has been a recurring theme and rapid advances in technology makes the task even more challenging (Rangel, Cartmill, Martimianakis, Kuper, & Whitehead, 2017).

These are all indicative of the fact that more needs to be done in order to improve medical education. Hopefully, this study gave a small glimpse of the range of possibilities within the medical curriculum, showing various pedagogical alternatives that needed to be researched with the goal to enhance teaching and learning. Beyond the scope and intent of this study, it would be highly advantageous to conduct a gamification project study that would adopt a research method involving the use of a control group. Such a research would prove to be highly instrumental in elucidating some of the contradicting results obtained while using gamification in teaching and learning. Landers and Armstrong (2017) conducted a research and concluded that (1) confounding variables could skew research results and (2) there were cases where gamification had a negative impact on student learning. Focusing on the use of gamification in medical education and acknowledging the mixed results obtained while assessing its effectiveness, Maroof et al. (2015) argued that further research needed to be conducted for more definitive answers. According to All et al. (2015), one way to potently assess the effectiveness of using gamification in the classroom was to adopt a research method that involved the use of a control group, which would give a reliable baseline data to compare results with. To this extent, a future research using the gamified learning components developed during the course of this study designed to assess the effectiveness of using gamification in medical education could make use of such a quantitative research method.

Another direction for future research should include a study that would be larger in scope—one that would be integrally embedded in the medical education curriculum and inclusive of the multiple disciplines taught through various courses during the didactic years—the 1st and 2nd years. Addressing the topic related to the use of gamification in medical education, Yunyongying (2014) argued that a fully integrated gamification program into the curriculum would yield the best results to achieve a higher level of engagement among medical students.

Conclusion

This research study placed the emphasis on studying the impact of gamification on student engagement in medical education. The findings pointed to a decreased level of engagement among medical students. Since engagement is a complex construct, it would be irrational to believe that the conclusive results obtained through the course of this study constitute the final word on this discussion topic. If only this study contributed to fuel more dialogues to the already lively exchanges surrounding the use of gamification in medical education, it would have been a worthwhile endeavor. And, thus, it would have succeeded in dropping a spark of idea in the vast ocean of an educational world fueled by digital innovation—a phenomenon that is having an impact on medical education.

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Appendix A: Project Design

The project design content and description are presented on the next page.

A SHORT GUIDE TO GAMIFICATION IMPLEMENTATION IN MEDICAL EDUCATION

BY RALAI ANDRIAMIARISOA

June 2018

OUTLINE

PREAMBLE

This short guide is intended to be used by any medical school interested in conducting a gamification project. The intent of this document is to briefly give the reader an overall understanding of the development process as well as what a project related to building a 3D-based gamified learning component entails.

This document contains a brief overview describing the various components of a gamified learning component. It is intended to inform the reader about the necessary requirements and needed resources in order to bring a 3D-based gamification project to fruition.

A condensed learning design structure is provided in order to provide a structure to the gamified learning tool. A given institution can opt to use a different learning sequence or adapt the existing one. The included learning design structure proved to be effective, as indicated in the findings section.

As demonstrated by the amount of resources needed and the level of coordination required to build a 3D-based gamified learning platform, hopefully this short guide can help the reader make a determination and an informed evaluation of the approximate level of effort needed to successfully conduct a project involving the creation of a course-level gamification project.

This short guide can be used as a starting point by faculty, curriculum designers, as well as IT personnel in order to draft an implementation plan for designing a gamified learning tool.

INTRODUCTION

Gamification has been defined as the use of game mechanics in traditionally non-game activities (Hamari et al., 2016). In an educational setting, it is used to introduce game mechanics into learning components and learning activities, thus transforming traditional learning exercises into action-oriented and interactive activities (Jagoda, 2013).

Gamification is a new phenomenon in the world of education, and it is even more so in medical education. Even though several studies have been previously conducted in order to assess the effectiveness of gamification in medical education (Nevin et al., 2014), there has been no consensus and definite conclusion regarding the role and impact of gamification on the medical curriculum.

A gamification exercise conducted with medical students concluded that a significant majority of the respondents agreed or strongly agreed that the gamified exercises were engaging and perceived as effective learning tools (Pettit, McCoy, Kinney, & Schwartz, 2015). Experimentations of this nature tend to indicate that exploring the use of gamification in medical education is a worthwhile endeavor.

LEARNING DESIGN STRUCTURE

Learners' interaction with the gamified learning platform is a structured experience governed by the following components:

(1) A learning progression that is determined by the level of mastery attained by the students. As a self-paced learning platform, the gamified learning platform will unlock different levels to the learner who will be moving from a higher level of difficulty in learning materials covered as the learner demonstrates the ability to handle and succeed at every step of way.

(2) A study-practice-assess learning construct, which allows the student to acquire an understanding of the learning content, build a mastery of the knowledge acquired through practice, and measure the level of knowledge acquired through an assessment.

The illustration above displays the three categories of learning activities used to structure learners' interaction with the learning platform. These three categories embedded within the study-practice-assess learning construct are:

(1) THE STUDY COMPONENT
Designed to provide an interface to allow students to learn the course material. This component can be inclusive of all learning materials or can be used to serve as a supplement to the learning material provided by the instructor. This component can be used as a study material and a reference.

(2) THE PRACTICE COMPONENT
Used as a knowledge reinforcement tool, where students use repetition to reach a mastery level for each learning module. Among the underlying principles supporting the design of the practice component are: permission to fail and rapid feedback (Information Resources Management Association, 2015).

a. Permission to Fail: Refers to a principle that separates achievements from performance; it fosters risk taking and exploration, and capitalizes on students venturing to try and attempt tackling challenges encountered through the practice exercises (Reiners et al., 2012).

b. Rapid Feedback: When students answers a quiz question incorrectly, a feedback is provided that serves as a learning guide pointing them in the right direction and giving them clues—as opposed to punishing them.

THE ASSESSMENT COMPONENT
The assessment component is also replete with rapid feedback—students receive a feedback from the system notifying them the part of their answer where they missed the question.

As opposed to the practice area, the assessment component requires more persistence and perseverance due to the fact that rules govern whether student pass or miss the quiz. In order to pass, students must correctly respond to a given number of questions in a sequence where they get the right answer to these questions back to back.

This exercise is meant to build resilience in students' learning abilities. Passing a quiz will result in obtaining a trophy, with the added bonus of receiving additional trophies for passing a quiz multiple time. The large pool of quiz questions provides students with the opportunity to test the breadth and depth of their knowledge.

RESEARCH FINDINGS

A study involving 64 medical students was conducted to determine whether the level of engagement of a student cohort who participated in this gamified learning experience was affected by the use of gamification principles embedded within course learning components.

The Student Engagement Survey (SES) is a validated instrument (Ahlfeldt, Mehta, & Sellnow, 2005) and was used as the data-gathering instrument. This survey was designed to measure three components of the student engagement construct: Collaborative learning, cognitive development, and personal skills.

A repeated measures MANOVA was used to assess the research questions. Students filled out the survey form on three different occasions.

- *Time Period I: Beginning session.* At the beginning of the semester as part of the course activities, the SES survey was administered to students. This beginning phase of the course used a lecture-based learning delivery method
- *Time Period II: End of lecture-based session.* At the end of the course period during which students were given in-class lectures, students were asked to complete the SES survey. This was the second occurrence of filling out the SES survey.
- *Time Period III: Gamification session.* At the end of the lecture-based session, students were given 4 weeks to experiment and learn the course material using the gamified learning platform. At the end of this 4-week period, students were asked to fill out the SES survey.

RESEARCH QUESTIONS

- **Overall RQ**: Was there a significant increase over time in cooperative learning, cognitive level, and personal skill when using gamified learning methods?
- **Sub RQ1**: Was there a significant increase over time in cooperative learning when using gamified learning methods?
- **Sub RQ2**: Was there a significant increase over time in cognitive level when using gamified learning methods?
- **Sub RQ3**: Was there a significant increase over time in personal skills when using gamified learning methods?

RESULTS

- Results of the multivariate *F* test indicated significance, Pillai's Trace = .031, $F(6, 250) = 7.52$, $p < .001$, partial η^2=.153, suggesting that there are significant differences in the student engagement constructs over time. Three univariate tests were examined for the findings of each student engagement construct evaluated in each research question.
- The results of the follow-up repeated measures ANOVA for cooperative learning indicated significance, $F(1.72, 108.41) = 13.21$, $p < .001$, partial η^2=.173.
- The results of the repeated measures ANOVA for cognitive level indicated significance, $F(1.72, 108.12) = 15.29$, $p < .001$, partial η^2=.195
- The results of the repeated measures ANOVA for personal skills indicated significance, $F(1.70, 109.54) = 8.00$, $p = .001$, partial η^2=.113.

Bonferroni post-hoc test was used to further examine the differences in the level of student engagement by each time period. It was evident that there were significant differences for collaborative learning between the initial time periods TP1 and TP2 and between TP2 and TP3. It was also evident that there were no significant differences between TP1and TP3.

There were significant increases for collaborative learning, cognitive level, and personal skills between TP1 and TP2 and significant decreases between TP2 and TP3.

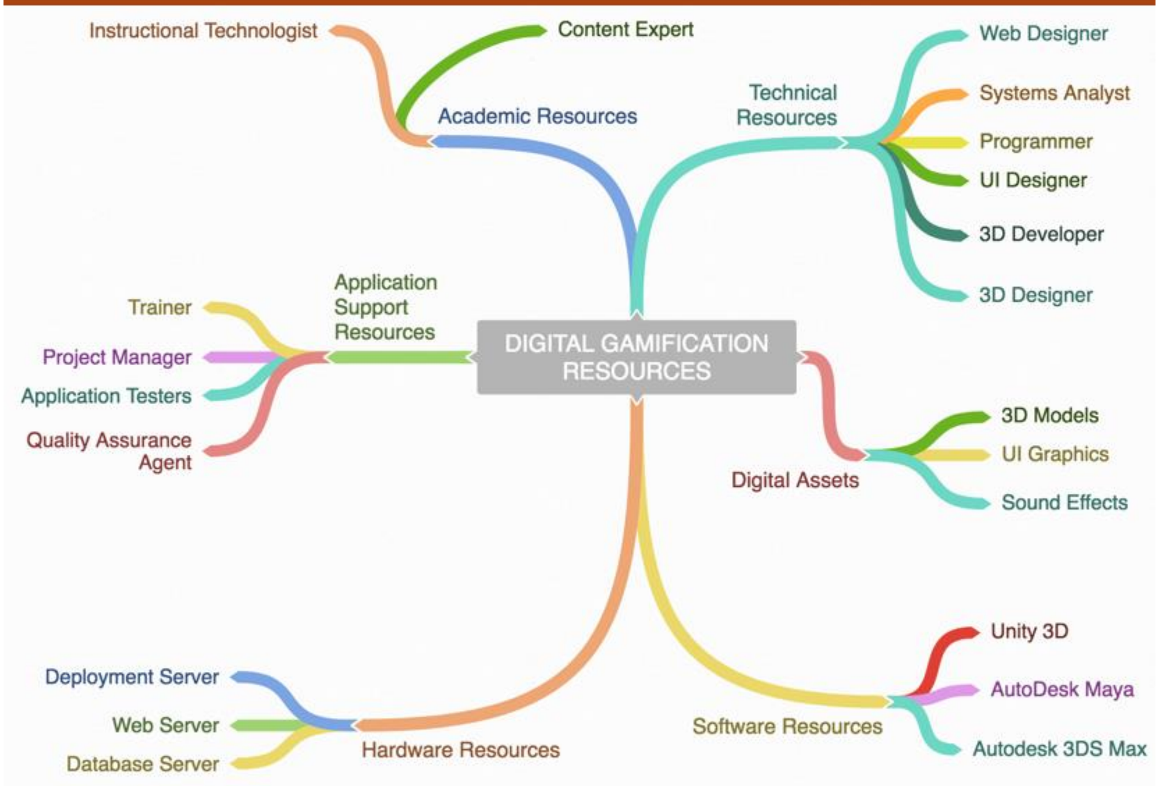
Due to the fact that the hypotheses were directional and evaluating increases, the null hypotheses (H_0, H_01, H_02, and H_03) were accepted, suggesting that there were no significant increases over time in student engagement when using gamified learning methods.

Follow-up Repeated Measures ANOVAs for Student Engagement

	TP1		TP2		TP3		*F*	*p*	η
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*			
Cooperative learning	2.62	0.52	3.00	0.56	2.79	0.62	13.21	<.001	.173
Cognitive level	3.28	0.47	3.59	0.42	3.42	0.48	15.29	<.001	.195
Personal skills	3.36	0.52	3.57	0.45	3.33	0.59	8.00	.001	.113

PROJECT RESOURCES

One distinct characteristic of 3D-based gamified learning projects is the fact that they tend to be relatively resource intensive endeavors. The illustration below categorizes the resource types needed to complete a 3D-based gamified learning component.



The resource types can be categorized as follows:

- Academic resources
- Technical resources
- Application support resources
- Digital assets resources
- Software resources
- Hardware resources

ACADEMIC RESOURCES

(1) CONTENT EXPERT:

One or more faculty members needs to be involved at every step of the way and needs to ensure that the pedagogical requirements are preserved through the design phases that transform the learning requirements into a product encapsulating the project requirements. The faculty member needs to soundly structure the course material, with clearly defined learning goals and objectives, a logical outline, and contains a level of assessment that matches the course content and aligned with the objectives. This is paramount because there is no technology solution that can salvage a poorly designed and weakly structured course (Salas, 2016).

(2) INSTRUCTIONAL DESIGNER:

Once the writing of course content is complete, the faculty needs to hand over the material (usually a PowerPoint presentation) to the instructional technologist who repurposes the course document into a newly designed requirement document. A modularized and sectioned format of the original document will be designed—one that the project manager and the technical team can use to understand the logic of the application and determine which blocks need to be integrated in which gamified module. This document will be organized in such as a way that it can serve as a road map to developers, thus allowing them to get a firm grasp of the program structure, logic, and flow.

NOTE:

At the time of the application rollout, the instructor needs to provide students with the necessary instructions on how to access, use, navigate, and take advantage of features embedded with the gamified learning components. Thus, the instructor needs to have a good command of the various functions of the application and be familiar with its features in order to be able to provide adequate information and instructions to students. The instructor will work closely with the development team and the instructional technologist in order to ensure that the features implemented achieve the pedagogical goals intended for the course module being gamified. Alternatively, a trainer could be asked to provide in-class instructions to students.

TECHNICAL RESOURCES

EXPERTISE	RESPONSIBILITIES
3D Designer	▪ Create all necessary 3D assets to be used in the application, which necessitates scanning and optimizing required 3D objects ▪ Optimize raw 3D objects in order to enable usability inside the 3D application and improve performance ▪ Identify and acquire any other 3D assets required by the project ▪ Create 3D components that need to be created as part of the application (such as colliders)
3D Programmer	▪ Create frontend logics through coding ▪ Implement all program logic and flow through programming ▪ Create optimized codes that will make application run optimally ▪ Create prototype and live builds ▪ Implement program logic and flow using programming constructs
Web Designer	▪ Ensure that the Web interface is user-friendly and conducive to a user experience focused on using the platform and not on how to use it. ▪ Ensure that graphical and navigational components are optimized and optimal.
Application Testers	▪ Run all possible scenarios of using the various features of the learning platform. ▪ Identify bugs, inconsistencies, and technical flaws ▪ Assess and report all necessary fixes and adjustments
User Interface Designer	▪ Produce an overall design that matches and fits the overall application. ▪ Create a general theme that will be used throughout the application for design consistency.
Systems Analyst	▪ Ensure conformity to requirements and conduct test. ▪ Produce quality assurance and report documents
Programmer	▪ Create technology bridge between application and backend systems and database server ▪ Create application program interface to receive and send data to the learning module ▪ Create underlying program logic to accommodate the needs of 3D programmer

APPLICATION SUPPORT RESOURCES

(1) TRAINER:

A person in charge of showing users how to use the application and who is familiar of the ins and outs, as well as the many facets of the platform. This person could also be in charge of creating training documents, as well as short videos to be used for training purposes.

(2) PROJECT MANAGER:

This person is responsible for defining the project scope, keeping a timeline of the project development, communicating with the various stakeholders and ensuring that all parties are working in a coordinated manner. The project manager is in charge of creating a detailed and functional document requirements.

(3) APPLICATION TESTERS:

Testers are responsible for running all possible scenarios of using the various features of the gamified platform. Their goal is to identify bugs, technical flaws, logic errors, or design inconsistencies. They are responsible for documenting and reporting their findings and communicate with the technical team.

(4) QUALITY ASSURANCE AGENT:

At least one person needs to be in charge of ensuring that the gamified learning platform is running in a stable manner on the production environment. Among the goals to be achieved is to ensure that the product launch will be a successful one. This person needs to identify any plausible improvements after a thorough analysis of the entire platform. Also, this agent needs to conduct iterative review and create a document containing any product future enhancements.

DIGITAL ASSETS RESOURCES

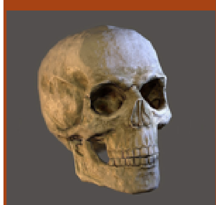
The creation of gamified learning platform involves the use of 3D components and high quality digital assets for maximum efficiency, for delivering a quality-learning tool, and for creating a product that is appealing to millennial students.

A project of this nature requires several graphical components (buttons, graphical box and text containers, navigational components, graphic files to create interface particles), interface elements, 3D models, and sounds effects.

Some of these elements can be downloaded through online repositories, while ensuring that the proper copyright and usage rights are taken into consideration. Other components will be created by the design team using design software and optimized for speed and efficiency.

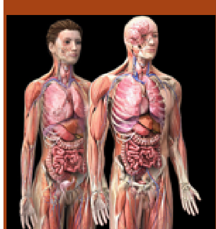
The needed 3D model components can be purchased through online libraries and rights of use will be acquired. Specific 3D models needed for this project had to be scanned, optimized, and exported, in order to be integrated as project components for this project. This 3D model acquisition method is tedious and resource intensive, however it represents a required step for this study.

Below are some popular sources where digital assets can be acquired and downloaded from.



3D assets suitable for 3D applications can be acquired from TurboSquid.com. Most of the time, they are appropriate for use as embedded in an application, but not suitable for printing due to their low resolution. Usage rights must be carefully examined when acquiring digital assets from a seller.

A rich set of graphical components (with a medical theme or generic) can be found at freepik.com. The vast array of available digital assets makes it easier to build graphic-rich user interface, as well as design attractive and appealing learning applications.

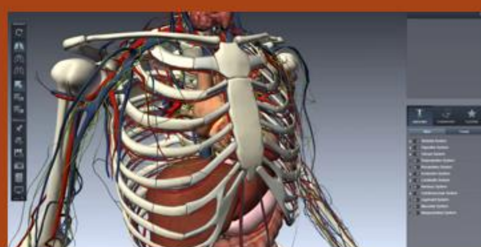


Zygote.com produces the best quality and most complete human anatomical 3D structure on the market today. Any medical school that is serious about producing the highest level of quality 3D applications for medical students ought to consider licensing Zygote's 3D models.

SOFTWARE RESOURCES

- UNITY 3D:
  The main development process where the majority of the programming effort takes place is within the Unity 3D software—a game engine specifically designed to architect and produce 3D entertainment games, as well as game-based learning applications (Ma, Bale, & Rea, 2012). Unity 3D is a dominant game engine development platform, with rich and powerful capabilities, enabling the creation of highly sophisticated and graphic-rich gaming and learning environments. One of its major advantages is the creation of multi-platform applications, including iOS, Android, and Web.

- AUTODESK 3D SOFTWARE:
  3DS Max is used as a modeling, animation, and rendering, whereas Maya is used for creating interactive 3D applications, including video games, animations, and visual effects.



Unity 3D is used to create dazzling 3D games, as well as highly sophisticated 3D medical learning components.

3DS Max is a powerful 3D animation tool to create visually stunning and instructive learning materials.

Medical schools can benefit from using 3D technologies, including 3D scanners along with their accompanying software for capturing assets needed for specific implementations (Furlow, 2016). As an example, a bone with anatomical abnormalities would be difficult to find online. The balance would be to consider and make a decision that weights cost versus acceptance of a lower quality and less accurate representation of a given anatomical structure.

HARDWARE RESOURCES

Several hardware types are required for a successful implementation of a gamification project. These hardware types are:

- Development desktops: 3D software require powerful computing resources to process 3D files and 3D components. High-end desktops are required for 3D developers and 3D designers.

- Backend servers:
  - Database server: Usage data, access logs, assessment results, status, and achievements are among some of the data stored on the database server
  - Web server: Used for a Web deployment of the application, also known as WebGL.
  - Deployment server: A repository used to allow students to download assets, documentations, software, and apps for different platforms when using Enterprise deployment.

- Testing hardware:
  - iOS and Android devices
  - Tablets and smartphones from different manufacturers for testing different screen sizes and computing environments.
  - PC and Mac Laptops

Due to the unique challenges presented by running games and 3D applications, a niche market was created for users requiring high-end computing resources. Vendors created a special type of hardware called ‘gaming laptops.’

As an alternative to hosting on-premise hardware, medical schools have the option of purchasing on-demand computing resources using a cloud service, such as the Amazon Web Services (AWS). Fees are based on usage, hence depending on the institution’s needs, AWS could be a more viable solution.

PROJECT PHASES

Using project management principles (Satzinger, Jackson, & Burd, 2015), coupled with academic requirements and gamification implementation steps, the table below was created in order to represent the various phases to conduct a gamification project.

PHASES	ACTIVITIES	OUTCOMES
Requirements Gathering	Collaborate with College and content experts and identify opportunities	Create a concept proposal
Concept Development	Define scope and assess required resources. Determine suitable course	Create a plan & feasibility study document
Requirement Analysis	Analyze needs and develop user requirements. Align with learning objectives	Create a detailed functional document requirements
Design	Transform requirements into design specifications. Align with pedagogical model	Create systems design document
Development	Create backend and frontend systems, perform coding, building, testing, optimizing, and refining	Create a testable, runnable, and optimized application
Integration	Ensure conformity to requirements and conduct test	Quality assurance and report documents
Implementation	Resolve identified problems and rollout to production environment	Push to live production
Maintenance	Ensure a stable production environment and identify improvements	Create in-process review and future enhancements document

GAME MECHANICS

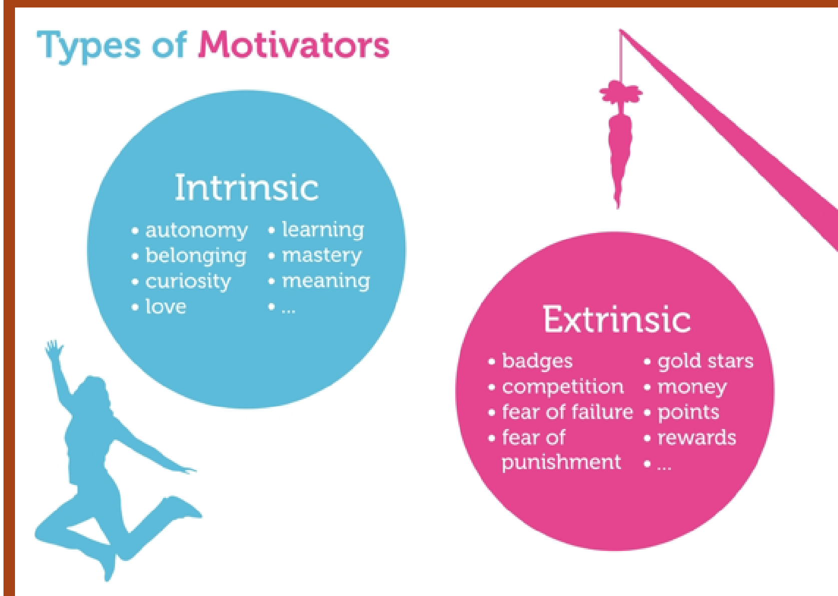
Game mechanics are the actions or methods present in the platform in order to create a compelling game experience. They dictate participants' behavior and generate interactions. Mechanics describe the various components of the game, determine how players interact with rules and define the game's end goals (Shernoff, Hamari, & Rowe, 2014).

Game mechanics must be judiciously selected in order to create the desired effect—in our case, generate student engagement. Below is a table representing game mechanics and their contributing roles as engagement factors.

MECHANICS	*ENGAGEMENT FACTORS*
Leaderboard	Social feature to foster a level of competition. Ranking adds a game play element to learning. It represents a highly motivating feature for students who are achievers
Trophy	Representative of earned awards as a result of effort put into studying and demonstrating knowledge acquisition
Progress Indicator	This feature is inherently rewarding—seeing that efforts exerted are paying off appeals to basic human satisfaction. At any given moment, students know where they stand in the learning continuum.
Performance Summary	It provides students with an overview of their overall performance. This represents a big-picture learning tool
User-defined Identity	Besides providing a protection against FERPA, it allows students to embrace a playful character while engaged in the learning process
Immediate Feedback	It contextualizes students' knowledge level and provides an assessment of students' knowledge of study material. It helps students assess the gap between their perceived and assessed knowledge (Dicheva, Dichev, Agre, & Angelova, 2015)
Loop	The multiple iterations and repetitive nature of the gamified learning platform are created through a looping mechanism. This process can lead to subject mastery. The loop process: repeat, rehearse, and persist without the fear of failure
Success Indicator	It serves the role of reinforcing positive behavior and outcome. Positive feedback represents an affirmation of progress made by students.
Settings Customization	It gives students the opportunity to customize certain platform features according to their taste and preferences. Providing students control is in and of itself a form respect of their learning style and study mode

MOTIVATIONAL FACTORS

Depending on how game mechanics are devised and integrated within the gamification project, the design process can lead to a learning experience that is either intrinsically or extrinsically motivating.



The core of the self-determination theory (SDT) designed by Ryan and Deci (2000) consists of the notion that intrinsic motivation leads to higher quality learning. Intrinsic motivation consists of engaging in a task or action because it is inherently satisfying or enjoyable; it refers to the impetus to thrive without the need to interject external incentives (Banfield & Wilkerson, 2014).

Extrinsic motivation exerts the most pressure on the learner to either focus on reward or avoid punishments. This type of motivation is very transitory and tends to dissipate once the controlling contingencies no longer exist. For example, a student purely motivated by good grades (reward) or by the fear of being judged by peers (punishment) will most certainly seek a breadth but not a depth of knowledge on a given topic, since the goal is to pass a test to obtain good grades and not to aim for deep learning.

It is important to mention that repetition and drilling mechanisms seem to be extrinsically motivating by rewarding students with trophies, however these same mechanisms can motivate students intrinsically since there is no further status gained or additional points awarded for completing and passing quizzes multiple times.

GAME AESTHETICS

As students interact with the gamified learning platform, they experience a range of emotions, labeled as the game aesthetics. Below is a table showing some of the desired or provoked emotions that students may feel.

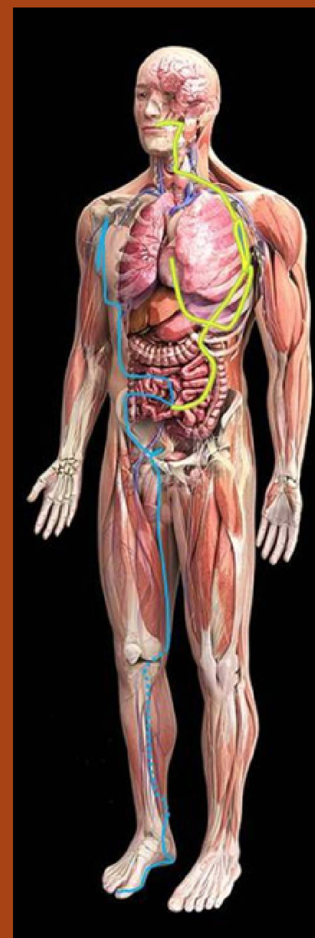
DYNAMICS	DESCRIPTION
Excitement	The newness of the platform and the thrill of using a new learning environment will generate a level of excitement among students
Frustration	Students will have to respond to several questions correctly in a row in order to pass the quizzes. Providing a wrong answer close to reaching the threshold question will result in a sense of frustration
Relief	Conversely, getting passed the threshold question and successfully passing the quiz will result in a sense of escape and relief
Satisfaction	Completing all levels and covering all learning components will give students a sense of satisfaction and accomplishment
Surprise	Quiz questions are generated randomly from a large pool of questions. Students will experience a sense of anticipation and surprise, not knowing what questions will be presented to them
Challenge	The level of difficulty will gradually increase, challenging students to perform at a higher level at each iteration
Joy	After completion of each quiz, the interface will display a series of congratulatory messages and graphical acknowledgment of students' achievement. The celebratory nature of these displays will bring a joy and smile to students' face
Discovery	The learning platform contains several features and a set of rules governs how students will interact with this platform. Students will experience a sense of discovery while navigating through the various parts of the gamified learning component

GAME DYNAMICS

Game dynamics are tools for allowing activities to progress and move the action forward (Kim, 2015).

DYNAMICS	DESCRIPTION
Exploration	Learning areas were created in order to allow students to study material. These areas were designed in order to provide students with learning tools, but also practice sessions where they can assimilate didactic content and build confidence in content knowledge mastery.
Collection	Throughout their experience interacting with the gamified content, student will accumulate points as they engage with the learning modules. Also, they collect trophies as they progress from one stage to the other.
Competition	A two-layer leaderboard was created for progress checking. The first layer was designed to view students' personal level of achievement and their progress. The second layer is the general leaderboard that provides students with a way to situate their learning progress vis-à-vis other students.
Acquisition of status	Assessment tools are interwoven as part of the gamified learning component. The students' level of performance as demonstrated by their score while taking the assessments gives them the opportunity to earn trophies (bronze, silver, and gold). The goal is to instill a sense of pride in students who study diligently and are performing well (Landers & Armstrong, 2015).
Collaboration	During the learning process, students are strongly encouraged to study in groups, help and assist each other, exchange ideas, and discuss their challenges and progress. The collaborative nature of this learning environment takes into consideration the mode of learning of millennials.
Challenge	Challenges are embedded throughout the learning component. The first challenge encountered by students is to achieve a mastery level by learning repetitively the sections where they struggle the most. The other challenge students have to face is to actually succeed during the various assessments embedded in each level of learning.
Progression	Different levels are built into the learning platform. Two layers of progression exist: the first layer allows students to move from an introductory level of course content to more advanced topics. The second layer of progression is built into each course level where students move from learning to practicing and when they feel

CONCLUSION



This brief guide was created with the hope that it can assist other medical schools that aspire to integrate gamification within their curriculum. Its intent was to provide an understanding of the various components involved in a gamification project, as well as the commitment needed in order to succeed.

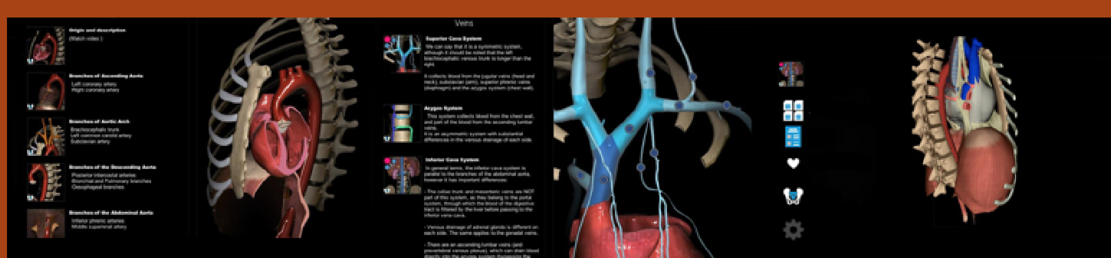
During the course of this project, the learning design structure played a vital role in providing a guided learning environment to students. The self-paced learning environment gave students the liberty to navigate through the gamified learning platform in a non-linear fashion and move to a level of mastery corresponding to their measured and quantified knowledge of the course material.

The research conducted pointed to the fact that gamification of medical education did not lead to an increase in the level of student engagement. Other studies related to medical education point to the contrary (McCoy, Lewis, Dalton, 2016), hence more research is needed to further understand the role of gamification in medical education (Maroof et al., 2017).

This document highlighted the fact that using gamification incorporated with 3D technologies can be resource intensive. The needed resources range from academic and technical, to the need for applications support systems, as well as specialized software and hardware.

A project plan, specifically adapted to education in general and medical school in particular, can greatly assist with a smooth implementation of a gamification project.

Game mechanics, game aesthetics, and game dynamics are critical components of a gamification implementation and they need to be used judiciously.



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Appendix B: Student Engagement Survey

A. During your class, about how often have you done each of the following?

Scale: 4: very often; 3: often; 2: occasionally; 1:never

1. Asked questions during class or contributed to class discussions	4	3	2	1
2. Worked with other students on projects during class time	4	3	2	1
3. Worked with classmates outside of class to complete class assignments	4	3	2	1
4. Tutored or taught the class materials to other students in the class	4	3	2	1

B. To what extent has this course emphasized the mental activities listed below?

Scale: 4: very much; 3: quite a bit; 2: some; 1: very little

5. Memorizing facts, ideas or methods from your course and readings so you can repeat them in almost the same form	4	3	2	1
6. Analyzing the basic elements of an idea, experience or theory such as examining a specific case or situation in depth and considering its components	4	3	2	1
7. Synthesizing and organizing ideas, information, or experiences into new, more complicated interpretations and relationships	4	3	2	1
8. Evaluating the value of information, arguments, or methods such as examining how others gathered and interpreted data and assessing and accuracy of their conclusions	4	3	2	1
9. Applying theories and/or concepts to practical problems or in new situations	4	3	2	1

C. To what extent has this course contributed to your knowledge, skills, and personal development in the following ways?

Scale: 4: very much; 3: quite a bit; 2: some; 1: very little

10. Acquiring job or career related knowledge and skills	4	3	2	1
11. Writing clearly, accurately, and effectively	4	3	2	1
12. Thinking critically and/or analytically	4	3	2	1
13. Learning effectively on your own, so you can identify, research, and complete a given task	4	3	2	1
14. Working effectively with other individuals	4	3	2	1

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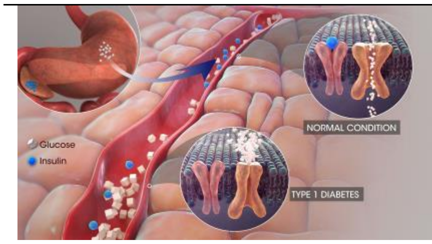

Description: 3D medical animation still of Type 1 Diabetes showing lower amount of insulin production in a diabetic patient.
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Description: 3d Human Anatomy Model

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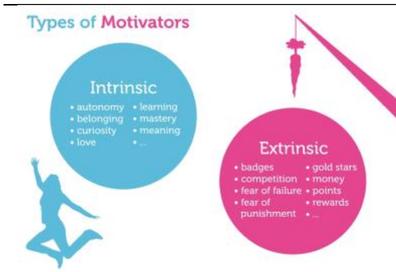

Description: Intrinsic and extrinsic motivation

Copyright: Interaction Design Foundation

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Description: Human Heart Model

Artist: Tamarar Stock

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Appendix D: Copyright Information

Table 2. Alignment of indicative mobile/ubiquitous devices features with GBL principles

Mobile/Ubiquitous Characteristics	Description	GBL Principle
Ubiquity	• The attribute of somebody being available and connected at any location and any given time. • Supports Continuous information exchange.	• Allows the provision of both Formal & informal learning. • Allows access to GBL from everywhere at any time. • Allows the provision of immediate feedback in response to student mistakes. • Enhances student's critical thinking and decision-making ability.
Localization	• Precise localization of a connected mobile device (when allowed by the user) • Precise information on the location of a person or a product.	• Provision of Context-specific learning content. • Customized learning content
Interactivity	High level of interaction between • User-device • User-content • User-other users	• Supports social learning, collaboration, and collaborative decision-making. • Supports increased interaction between students and students and learning content.
Identification/ Personalization	• Users can be uniquely identified through their mobile device • Allows the monitoring and provision of data with regards to user's personal interaction with the mobile device	Allows the provision of personalized learning content.
Users have control over their devices	• Users are familiar with their mobile devices • Feel safe when using the devices • Can decide when, whether and why they would use the device	• The game needs to allow players to track and manage their progress • Learner-centered learning • Learner is actively engaged • Minimization of technological barriers and technology adoption issues
Provides an immersive graphical interface	The provision of a camera, combined with online broadband supports the provision of 2D graphics and even Virtual Reality & Augmented reality applications	The game must be immersive

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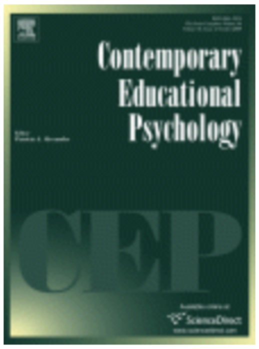

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