ERASMUS UNIVERSITY ROTTERDAM - 2013

Gamified Education

Introducing Game Elements into the School Environment to Enhance Student Motivation and Performance

Alexandre Chevtchenko
Student number: 370954
Supervisor: Dr. Julia Müller

Abstract

This thesis discusses gamification, or the use of game elements in non-game contexts, and its potential application in education in order to enhance student motivation and engagement. After presenting a number of arguments in favor of using this method in schools, the paper presents an overview of game elements and techniques that can be used to trigger motivation, supported by an analysis of the psychological and behavioral mechanisms in play. Finally, an experiment is proposed that investigates the relationship between gamification and academic performance in elementary school students.

Table of Contents

1. Introduction: a definition of gamification

Games have been a part of human societies throughout recorded history. They take on a multitude of forms: card games, board games, dice games, various sports, and many others. Archeologists have found board games dating as far back as 3000 BCE in Egypt and Iran; yet attempts to understand games with a formal, systematic approach are relatively recent.

The Austrian philosopher Ludwig Wittgenstein was one of the first academics to attempt this. In his *Philosophical Investigations* (1958), he famously used games as an example illustrating the inadequacy of language for defining abstract concepts. According to Wittgenstein, one can easily say whether something is or isn't a game; however, a general definition is impossible because the word "game" encompasses such a variety of disparate activities. Fortunately, the task is not as insurmountable as Wittgenstein believed, and other academics have since been able to make progress on the subject of games.

With the advent of computers and the Internet, games are becoming increasingly common in the modern world. Indeed, it can be surmised that virtually everyone born in a developed country after 1980 plays or has played video games. It goes without saying that for this multi-billion industry, understanding and promoting games is essential. However, understanding games – in particular, their exceptional motivational power – can be useful in a variety of other fields and applications.

Gamification, or the incorporation of game elements into non-game settings, attempts to harness this motivational power in order to influence behavior. Although the process can work with elements of traditional games, this analysis will primarily concentrate on digital games due to the higher pliability and interactivity of this medium, as well as its accessibility and low

reproduction costs. Currently, gamification is primarily applied by companies as a marketing tool to promote a product or service. But the approach also has promising applications in other domains, such as employee motivation in the workplace, government, social and environmental action, and education, which is the focus of this thesis.

2. Games in the modern world

2.1. Ubiquity of digital games

The demographics of gaming have changed dramatically since the early days of digital games and the stereotype of the teenage boy gamer. A 2011 study by the Entertainment Software Association showed that 72% of the population of the United States plays video games (Entertainment Software Association, 2011). The gender ratio has become more balanced, with 42% of game players being female. Video games have become a part of everyday life for children, adolescents, and adults alike: indeed, the same study shows that the average age of players is 37. These trends can also be observed in the European Union (Interactive Software Federation of Europe, 2012), and it is reasonable to expect similar numbers in other developed countries.

This proliferation of games is due in part to technological progress. Thanks to increased processing power, improved visual quality and battery life, playing a video game no longer requires a dedicated platform such as a computer or a television set with a gaming console; in fact, 55% of gamers play on a phone or other mobile device (Entertainment Software Association, 2011).

2.2.Familiarity of children with games

One of the consequences of this ubiquity of games is that children become familiar with games from a very young age. The gaming industry, in an effort to reach diverse demographics and age groups, has brought forth a multitude of genres. Puzzle, board, and trivia games are by far the most popular group, being the type of game preferred by 47% of players. Furthermore, game designers see the value of challenges and problem-solving in making a game successful by keeping the players interested and these elements are present in all games to some degree. Through play, gamers cultivate useful personal qualities such as creativity and perseverance (McGonigal, 2011). As a result, 68% of parents believe that game play in general provides education or mental stimulation, making them likely to allow or encourage their children to play.

In these circumstances, it comes as no surprise that children are highly familiar with the medium of games from the youngest age. In the United States, 97% of teenagers play some kind of digital game on a regular basis (Lenhart, et al., 2008). Bing Gordon, a prominent executive in the video game industry, stated in an interview that it is "*the new norm for people born after 1971*": people are so accustomed to the rules and interfaces of video games that they adopt a game-like mindset to various everyday situations and "*see the world through the lattice of games*" (Gordon, 2013). Designing systems that resonate with these principles will be instrumental in engaging young people in school and, later on, in the workplace.

3. Games as a medium for education

3.1. Similarities and differences between games and school

At first glance, the school environment does not seem so different from a game: there are levels, rewards, points and leaderboards. However, the majority of students do not perceive the experience as playful – or even interesting for some – and schools find themselves facing major issues with student motivation and engagement which often result in undesirable outcomes. Indeed, lack of interest can lead to poor performance, cheating, learned helplessness (repeated failure and perceived lack of control over outcomes can cause some to actively sabotage themselves by refusing to study) and ultimately, dropping out of school.

Games, on the other hand, are able to create an environment in which players accomplish tasks for intangible rewards that are clearly less valuable than an education to any rational outside observer. Some of these tasks can be difficult or tedious: for instance, the online-gaming community has dubbed “grinding” the process of repeating an action (such as completing a quest or defeating a computer-controlled enemy) many times in order to increase their character’s power or wealth within the persistent world of the game. This choice of word suggests that, while completing the task once or a handful of times might be entertaining, the effect wears off after a few repetitions. Yet players continue to voluntarily invest time and mental effort in these tasks in order to achieve longer-term objectives within the game.

This type of behavior is similar to what schools implicitly expect from students: a commitment to immediate and medium-term labor that can be perceived as unpleasant but has the potential to yield vast benefits in the long-term (e.g. a career, social status, etc.). However, it would be a stretch to imagine that many elementary school students have already set lifelong goals for

themselves (such as a future career) and are actively pursuing them at such a young age. These life goals are perceived by students as very abstract, since the temporal, spatial, and social distance separating them is so large (Trope & Liberman, 2010). Furthermore, when dealing with intertemporal choice situations, people in general tend to exhibit a short-term bias (Thaler, 1981). So children naturally prefer to dedicate their time to leisure and play; they sometimes perceive studying as a pointless chore, and often will not study unless they are pressured to do so by a parent or a teacher. On the other hand, students tend to be more engaged when they have a clear short-term objective. While the school environment typically fails to take this into account, games are able to counter the short-term bias by breaking down the path to the final objective into smaller tasks and offering intermediary rewards all along the way (Gee, 2008).

When considering the matter of engagement, it is important to recognize the importance of the issue of failure. Trial-and-error is a natural element of any learning process, because it lets learners practice and figure things out through repetition. Yet games and schools differ significantly in their approach on this issue. Games encourage players to learn through experimentation by keeping the stakes relatively low and providing feedback in short cycles (Gee, 2008). For example, in the game *Angry Birds* the player must earn points by destroying structures with birds launched from a slingshot. The structures are made up of blocks of various materials, and the birds have different properties and special abilities. In essence, the player takes on the role of an experimental physicist and has to work out the optimal way to destroy a structure. In order to move on to the next level, the player must beat a minimum requirement of points; if the threshold is not reached, the player can restart the level with one button press. This enables players to monitor their performance and progress and helps avoid frustration. On the

contrary, in the school environment feedback cycles are long and the stakes of failure are high, which fosters frustration, anxiety, and disengagement (Pope, 2003).

3.2.Arguments for the use games in education

Researchers and industry professionals alike make a number of arguments in favor of using games in education, some of which will be presented in the following paragraphs.

3.2.1. Games are built on sound educational principles

Firstly, games inherently incorporate sound learning principles established by cognitive sciences. For instance, digital games make it possible for students to project themselves into a situation, which enhances their ability to understand it (Gee, 2003). Learning through repetition and extended practice is encouraged by keeping the stakes low and minimizing the consequences of failure, which is seen as an inherent part of the learning process (Ke, 2009; Klopfer, Osterweil, & Salen, 2009). Games give the player clear objectives and provide feedback in rapid cycles (Dickey, 2005), both of which make learners more responsive and lead to a higher performance.

3.2.2. Games provide a personalized learning experience

Secondly, digital games are capable of delivering a fine-tuned, tailored learning experience to students. A personalized approach to education is instrumental in ensuring that students realize their full potential. Games adapt to the needs of the learner by providing relevant information when it is needed, along with immediate opportunities to put it into practice (Gee, 2008). An essential mechanic of many games is a logical learning progression, whereby mastery of a skill or concept is required in order to advance. Scaffolding – guidance provided in the initial stages of the game (Ash, 2011), and a steady, adaptable learning curve (Gee, 2008) also contribute to

the personalized aspect of the experience. Difficulty increases as the player progresses, but the gap between the player's skill and what is needed for a task must never be so large as to become discouraging. Close monitoring of each player's performance yields more constructive feedback and relevant assessments. The player adapts to the game (by trying new strategies and starting over when he fails) and the game adapts to the player (by providing hints or adjusting the difficulty level). This constant feedback loop that exists between the player and the game easily lends itself to data collection and analysis for the purpose of assessment (Schwartz & Arena, 2013; Shute & Ventura, 2013).

3.2.3. Games foster engagement

Lastly, games have vast potential for making the learning process more engaging for the students. Students' expectations of learning environments are affected by exposure to gaming: they prefer visually rich, dynamic interfaces designed for multitasking (Prensky, 2001). Using narrative to combine separate tasks and pieces of information in a coherent manner (Dickey, 2005) further increases engagement. In addition, games excel at triggering motivation through different types of fun (Gee, 2008; Olson, 2010); this will be expounded in the next section of this paper.

3.3.Importance of design

It is clear that the mere presence of game-like elements and dynamics in the school environment is not sufficient to produce an engaging experience for the learners. In order to be successful, a gamified environment needs to be designed; it is crucial to understand which game elements are most effective for use in education, as well as how they should be implemented, and how they should tie in to rewards and objectives both inside and outside the context of the game. Some

insights into the motivational power of games and the behavioral mechanisms in play will be presented in section 4.

A major shortcoming of the existing literature is that it is predominantly descriptive and theoretical in nature: a qualitative meta-analysis of 89 instructional gaming studies by Ke (2009) finds that there is only little insight into the relationship between games and actual academic performance. Although many projects already exist that apply gamification to education in various forms (some of which will be discussed in section 5), advancement of the theory is not their primary objective. Consequently, one of the objectives of this paper is to propose an experiment that can be used in order to analyze this relationship and quantify the impact gamification can have on students' performance.

4. Motivational power of games

4.1. Extrinsic and intrinsic motivation

Understanding motivation, the psychological causes of people's actions, is a task as complex as it is crucial. Psychologists have developed a multitude of theories of motivation in order to achieve this, but this analysis focuses on one approach in particular. Grounded in cognitivism, this model distinguishes between two broad categories of motivation: intrinsic and extrinsic (Ryan & Deci, 2000).

Intrinsic motivation is not dependent on external rewards or influences and exists within the individual. It is the interest or enjoyment inherent to the action itself and is, in the field of education, potentially more powerful than its extrinsic counterparts. Indeed, research shows that

students who are motivated intrinsically are more eager to learn and improve their skills (Wigfield, Guthrie, Tonks, & Perencevich, 2004).

Extrinsic motivation, on the other hand, comes from outside the individual. It refers to actions performed in order to obtain an outcome or reward that is external to the task, money being the most common example. In the context of gamification, the SAPS framework separates extrinsic rewards into four categories: *status*, *access*, *power*, and *stuff* (Zichermann & Linder, 2010). *Status* refers to how one is seen by others and rewards include things like recognition, respect, and admiration. *Access* designates rewards with an exclusivity component, things or content that cannot be unlocked other than by doing the task. *Power* refers to rewards that give the player new abilities within the gamified environment. *Stuff* designates objects, either real or virtual, such as items, currency, and so on. As will be show in subsection 4.3., digital games provide an ideal setting for implementing extrinsic reward structures.

One must be wary of the drawbacks of extrinsic motivators when designing these systems. Research by Gneezy and Rustichini (2000) has shown that their effect on performance is not monotonic, and inappropriate use of extrinsic rewards can demotivate. In their experiment, subjects split into four treatment groups received a fixed amount for answering 50 questions taking out of an IQ test; in addition, subjects in the second, third, and fourth groups received respectively 0.1 NIS (New Israeli Shekel), 1 NIS, and 3 NIS per correct answer. The average number of correct answers went down from 28 for the first group to 23 for the second group, and remained stable at 34 for the third and fourth groups. These results indicate that low-value monetary rewards can have detrimental effects on performance. The authors attributed this phenomenon to the fact that a reward that is too small can be seen as insulting by the subject. Furthermore, there is evidence of an overjustification effect, whereby extrinsic rewards crowd

out intrinsic motivation (Lepper, Greene, & Nisbett, 1973). The researchers found that children who showed an inherent interest in an activity (such as drawing) exhibited a lower level of intrinsic motivation after receiving expected rewards, i.e. when they had prior knowledge of the reward. However, this effect does not seem to be triggered by intangible (such as verbal praise) and unexpected rewards.

Both types of motivators are inherently present in the school environment. External motivators range from grade reports and the threat of punishment to the prospect of a better career and social status achieved through education, while things like the pleasure of learning and bettering oneself refer to intrinsic motivation. However, as discussed in section 2, it is difficult to imagine that many children attach a lot of importance to long-term objectives such as a career (at least up to a certain age). This makes young students less likely to respond to external motivators, unless they are framed in a way that ties in to more immediate and concrete objectives. Moreover, repeated failure can erode intrinsic motivation, which means that students who underperform are even less motivated. In the end, the motivators present in the school system are often trumped by the fact that studying is just “not fun”.

4.2.The nature of fun

Fun, despite being known to and understood by virtually everyone, is quite hard to define as a concept. Most dictionaries mention enjoyment or amusement in their definitions, but that is hardly enough to go by when applying a rigorous and systematic analysis. As with games, this has to do with the breadth of the concept and the difficulty of encompassing all the activities that can be perceived as fun in one general definition. Fun can be very personal and subjective, which complicates things even further. Indeed, different people find fun in different things: for

example, collecting stamps or other memorabilia is fun for some, while others find this type of activity boring; some enjoy challenges and problem-solving, while others are more inclined towards leisure and favorable odds.

One way to further understand the concept of fun is to break it down into categories. One attempt at such a classification is the *Four Keys to Fun* approach created by XEODesign, a consultancy and game design firm (XEODesign, 2004). This approach identifies four categories of fun associated with different emotions. *Easy fun* is associated with a relaxed setting, curiosity, and surprise; it sparks players' imagination, inspires them to explore and be creative. On the other hand, *hard fun* is about overcoming obstacles, learning, achievement, and problem-solving; it is associated with feelings of accomplishment and pride, as well as frustration. *People fun* involves various forms of social interaction, from competition to communication and teamwork. The final category is the seemingly contradictory *serious fun*: the fun in doing things that have purpose and meaning outside the context of the game, for oneself or for others (e.g. environmental action, helping one's community, etc.). Other researchers have also come up with similar taxonomies of fun; for instance, Hunicke, LeBlanc, and Zubek (2004) produced one divided into eight categories: *sensation*, *fantasy*, *narrative*, *challenge*, *fellowship*, *discovery*, *expression*, and *submission*. The important thing is to recognize that there exist different types of fun, some of which may be more appropriate and effective than others in an educational environment.

It is crucial to keep in mind that these categories are not mutually exclusive, and an activity or game may involve several of them to some extent. In fact, too much focus on one particular aspect of fun is undesirable, since it can result in missed opportunities for engagement. Sometimes, fun can just happen spontaneously; but in order to consistently provide fun as a

motivator, games should be designed in a way that taps a broad spectrum of emotions, which will also enable them to trigger different kinds of motivation.

4.3.Game elements that trigger motivation

Werbach (2012) has developed a framework that is very helpful in visualizing what game elements actually are. The pyramidal structure is composed, from top to bottom, of *dynamics*, *mechanics*, and *components* (aesthetic elements such as visuals and sound are left out, since they are more relevant to the player's *experience* rather than the actual game). Elements found on lower levels are representations or implementations of the more abstract elements found higher up. Thus, *dynamics* are the overarching conceptual elements of the game, such as constraints, relationships, narrative, and progression. *Mechanics* are the elements that move the action forward, such as uncertainty and challenges, competition and cooperation, feedback and rewards. Finally, *components* are specific manifestations of dynamics and mechanics, with which the players interact directly. For instance, a game might utilize mechanics such as challenges and feedback, in order to convey a sense of progression. In turn, these mechanics can be implemented by deploying within the game components such as points, levels, content unlocking, achievements and badges (rewards offered for completing a specific set of tasks), and so on. It should be noted that a given element can be used to represent more than one mechanic or dynamic within the game. For example, points can be used as a representation of feedback and progression, as well as relationships and competition, when combined with a leaderboard.

Design matters: the successful game is not the one that utilizes the most elements, but the one that utilizes them effectively. Digital games offer the perfect venue for creating elaborate extrinsic reward structures. Points, levels, badges, leaderboards, reputation scores, etc. can all be

implemented with a few lines of code and a simple graphic design. But sometimes, simplicity is the answer. For instance, on *LinkedIn.com*, a social network for professionals, users fill out their profile with their education, previous experiences, skills, recommendations, and other information relevant to employment and business. In order to provide a better service and target users more effectively, *LinkedIn* needs them to provide as much detail as possible about their professional selves. As such, encouraging users to fill out their profiles was very important, and the website introduced a feature to that effect. It consisted of a simple progress bar that showed the user how much of their profile was completed (on a scale from 0 to 100%) and suggested steps that could be taken in order to increase completeness (such as adding a photo, a reference, and so on). This feature was simple, yet very effective: overall profile completeness increased by 20%. (Gossen, 2013). By no means did a simple progress bar turn filling out a profile into a game or even a fun activity. However, it gave users real-time feedback, a sense of progression (a *process* of moving from one point to another, as opposed to starting out with nothing and ending up with a full profile), and a sense of completion (seeing how close one is to the end of the bar), which was enough to motivate them.

Educational games should focus on awakening learners' internal motivation and enthusiasm by allowing space for imagination, role-playing, gifting, and so on. For example, one can intrinsically motivate learners by giving them a chance to explore the content at their own pace, finding "hidden" information on their way (such as mathematical problems that are a little more tricky, or interesting trivia to accompany a history lesson).

Competition can be a powerful motivator. Software companies usually employ specific language vendors in order to test localization (translation from English to the local language of a country) quality and usability of their products for non-English speakers. In the case of *Windows 7*, which

was released in 36 languages, this approach would have been challenging and very costly for Microsoft, given the size of the task (hundreds of thousands of dialog boxes and interface elements to be reviewed). The company found another way: the test group led by Ross Smith developed a Language Quality Game that was destined for internal use by Microsoft employees (Smith R. , 2009). In the game, native language speakers in Microsoft offices around the world voluntarily reviewed dialog boxes. If they found no mistakes, they submitted a positive review; otherwise, the review was negative, and the text would be sent on to professional translators for further analysis. For each submitted review, employees were awarded one point; no other rewards were offered, but the game displayed each employee's score on a leaderboard. The result was that individual employees and entire offices started to compete in order to have the highest number of points. The game lasted for one month, during which over 4,600 employees reviewed more than 530,000 screens, sparing Microsoft a lot of expenses in the process. However, competition also has its drawbacks. While it is highly motivating for successful players, those who don't make it to the top of the leaderboard can feel demotivated. Putting too much emphasis on competition can also change the outlook of players in a way that is not desirable in educational games (the end goal becomes being the best as opposed to learning).

Students can also be motivated by allowing them learn from each-other. This can be done by letting a student who has already assimilated a part of the lesson to assist another in understanding it. Such a system fosters interaction between students and encourages those who do well to help those that need it, which can be stimulating for both parties.

A good educational game uses extrinsic motivators to draw the students in, but focuses on stimulating their intrinsic motivation with other elements and themes. Motivation that comes

from within is more powerful and persistent, which makes it more likely to positively affect performance in the long run.

5. Existing initiatives in gamified education

One of the earliest investigations into the potential of gaming as an educational tool was a report by Malone (1980), *What Makes Things Fun to Learn? A Study of Intrinsically Motivating Computer Games*. The research conducted with elementary school students found that the presence of a clear objective and feedback were the most important drivers of intrinsic motivation in educational games. The paper also lays down basic guidelines for educational game design, supported by a theory that identified three categories of motivational factors: *challenge*, *fantasy*, and *curiosity*. *Challenge* pertains to uncertain outcomes and can be implemented through the use of randomness, variable difficulty levels, and multiple goals. *Fantasy* relates to the immersive quality of the game and is recognized as an important attribute for generating motivation on an emotional, as well as a cognitive level. *Curiosity* can be sparked by pointing out to the player that they can achieve a more complete or consistent level of knowledge within the game.

Educational games have come a long way since 1980 and many initiatives have emerged, spurred by technological advances and the ease of access brought on by the Internet. For example, *Memrise.com* is a website launched in 2010 that is designed as a tool to help users learn foreign languages (Bjoran, 2011). The system is based on cognitive research and utilizes mnemonic devices (referred to as *mems*) to help users learn new words. Each new word is represented by a seed planted in a virtual garden which requires watering (practice) in order to

grow into a full plant, and which will wilt if the user does not water it regularly. Such a design fosters repetition and habit formation, since learners are encouraged to practice each word in their collection on a regular basis. Users practice by taking regular tests and are awarded points for each correct answer; these points are displayed on a leaderboard, which allows users to compete with their friends and contacts. In addition, users can create their own *mems* for words they already know, for example in their native language. The result is a complex gamified environment: users are initially introduced to playful elements that relate to *easy fun*, as mentioned in 4.2 (the idea of the garden, collecting the plants), after which a routine is established (regular watering of the plants). After this, the pace picks up as players discover the larger scope of the game, with elements that relate to *people fun*, as well as *serious* and *hard fun*: competition and collaboration through helping others learn.

Duolingo.com, another language-learning website launched in 2011 uses quite a different approach (Mims, 2011). The website doubles up as a translation platform for webpages and documents on the internet. Users choose the language they wish to learn, and monitor their progress along a *skill tree*. Skills range from basic vocabulary groups (such as animals or food) to more advanced linguistic concepts (possessive forms, conjugation, syntax, etc.). Users complete skills by successfully passing tests (trials against the clock in which they have a limited number of "lives"), which in turn unlocks new skills to be learned. The website offers lessons for each language, and learners also have the option to create their own lessons for others to use. The most interesting part is the way users put their new knowledge into practice. Indeed, users are prompted to translate sentences taken from documents and pages on the Internet and matched with their skill level (so that beginners are given short and simple sentences, while more difficult ones are given to more advanced users). Furthermore, users earn additional points for assessing

each-other's work: they rate each translation on quality, so that the best one is chosen for each sentence in a document. This allows the website to offer a crowd-sourced translation service to people and organizations with special uploader accounts. As a result, not only do users enjoy a free and fun language-learning platform, but they are also driven by the feeling that they are providing a valuable service. Indeed, translating documents and making information accessible to more people gives them a sense of greater purpose and reinforces their bond with the community the online community (*people fun, serious fun)*.

While the first two examples are intended to be used separately from the school environment, other projects also exist that aim to bring gamification into the classroom. One such initiative is *ClassDojo*, described by its creators as *"behavior management software"* (Colao, 2012). The concept is based on the conclusions of the Stanford marshmallow experiment, a series of studies on delayed gratification in children. These studies found that, rather than intelligence, certain personality traits such as self-discipline and persistence are more important in determining a child's future academic performance (Shoda, Mischel, & Peake, 1990) and other life outcomes, such as body-mass index (Schlam, Wilson, Shoda, Mischel, & Ayduk, 2013). *ClassDojo* puts these insights into practice by providing teachers with a way to reinforce good behavior in students through gamification. Using a computer or smartphone, teachers can give real time feedback and rewards for good behavior. Students receive positive or negative points in different categories such as class participation, completing homework, teamwork, creativity, curiosity, and so on. These are displayed on their profile, along with an avatar that can be customized using some of the rewards. The software also makes it easy for teachers to gather behavior data and analytics on individual students as well as groups, which can be shared with school administrators and parents.

Some initiatives take it even further by adopting gamification as an inherent component of school life. For instance, Quest to Learn is a school opened in New York City in 2009 in which the entire curriculum is gamified (Salen, Torres, Wolozin, Rufo-Tepper, & Shapiro, 2011). The school initially opened with one sixth grade class, and plans to add a new grade each year until 2015 in order to offer a full middle- and high-school education. The school's curriculum is co-designed by educators, curriculum specialists, and game designers. Every part of the curriculum is framed as a quest or mission that requires the students to apply game thinking and strategy in addition to the concepts they are learning. Students also learn to design games themselves, which teaches them valuable 21st century skills such as digital literacy and systems thinking.

The projects listed above, and many others, are all good examples of practical applications of gamification. However, they cannot be regarded as experiments in the scientific sense of the word. Rather, these initiatives are examples of learning by doing. Even though they may yield useful data in the future, advancing the theory is not their explicit objective. In order to achieve the latter, an experiment needs to test specific hypotheses in a controlled environment. It remains unclear which aspects of gamification are the most effective in producing motivation and improving student performance in an educational setting. This is why the main objective of this thesis is to propose an experiment that can be used in order to investigate and quantify the effects of gamification on academic performance. A better understanding of this relationship can be used to establish specific design guidelines for standardized gamified solutions in schools.

6. Experiment design

This section describes an experiment that can be carried out in order to measure the effect of different game elements that trigger motivation on academic performance.

6.1.Method

Participants are selected among primary school students in the same grade aged 7 to 8 years. To ensure that the samples are representative, subjects are selected from different schools within the city. Subjects are randomly assigned to treatments to reduce variance. Furthermore, gender and social background (parents' income and education, etc.) are used as blocking factors in order to achieve a closer match between the different treatment groups. The design of the experiment is between-subject, which means each subject only undergoes one treatment in order to avoid learning effects.

In order to minimize the impact of prior knowledge and provide an equal footing for the participants, the experimenter selects a topic that is part of the subjects' normal curriculum (i.e. age-appropriate) but has not yet been covered in class. The experiment is carried out in a classroom, i.e. in a natural environment.

Subjects are divided into five treatment groups. The first group establishes a base case corresponding to a contemporary classroom, while each consequent treatment becomes progressively more gamified.

- The first treatment group attends a regular instructor-led lesson: students are given printed booklets with relevant texts and pictures which are perused in accordance with a lesson plan designed by the instructor. For a given text or image, the teacher may choose

a student who will read or describe it out loud, or he may instruct the students to study it by themselves. After reading, the teacher asks a few questions about each element. Students may respond if they raise their hand, but they receive no reward for a correct answer.

- The second group undergoes a similar treatment, the major difference being that they are given computers and the content of the lesson is digitalized. Computers also allow for video and audio clips to be played. The objective of this treatment is to check whether the simple fact of studying on computers can produce a significant increase in motivation (as suggested in 3.2.3.). Questions and discussion are handled in the same way as in the first treatment.
- The third group goes through a more interactive version of the lesson. The content progression remains linear, but students are prompted to answer questions about the content in real time. If a student answers wrong, the program displays the correct answer and points to where the information can be found in the text (or graphic or clip). The program also allows the teacher to track each student's performance more closely and assist those who have difficulties with the lesson.
- In the fourth treatment, students receive points for correct answers and badges for achievements (such as being the first to answer a question, getting all answers right, completing the lesson, etc.). However, these are only visible to each students and the teacher. This isolates the effect of the extrinsic rewards from other phenomena such as competition.

- The fifth and final group goes through a fully gamified lesson described in the following subsection. Students have more freedom in perusing the content of the lesson; in addition, more complex dynamics such as competition and collaboration are introduced.

After undergoing the corresponding treatments, all groups take an identical multiple choice test about the material covered in the lesson. A multiple choice test is used in order to reduce the subjective aspect of the assessment (answers can be either true or false; there are no partially correct answers). In order to discourage random guessing, giving no answer is made more beneficial than giving a wrong one (negative points for random answers). In addition, the experimenter can determine whether students are guessing at random by performing a Chi-squared test on the answers. For example, if the questions in the test have four possible answers, a subject who is guessing can be expected to give each answer with a probability of 0.25. However, the data points created by guessing subjects should not be excluded from the analysis.

6.2.Design of the gamified lesson

The gamified lesson incorporates several game-elements discussed in this paper and intended to enhance student motivation and engagement. This subsection elaborates on the design of the lesson. A history lesson on the Roman Empire intended for students aged 7 to 8 years is used as an example.

Upon starting the program, students are shown a short introductory video presenting the rules and objectives of the game, as well as explaining the interface. The contents of the lesson are arranged in sections, each pertaining to a specific topic. For example, the lesson about the Roman Empire can be divided into four sections about the empire’s foundation and expansion, social and political life, the military and technology, and culture and religion.

Students progress within the game by earning points for completing tasks; the basic task is to peruse the information within a section (reading texts and charts, watching video clips, etc.). Each piece of information is immediately followed by two questions about its contents; players are given three attempts to answer each question and earn points for each correct answer. For example, after viewing a video about the early years of Rome, students are asked questions about the year of foundation and the names of the legendary founders of the city.

In order to move on to the next part of the lesson, a player must acquire a minimum number of points within the current section. For example, the section about political and social life in the Roman Empire comprises five content elements (two texts, two videos, and one chart), each associated with two questions. Students receive 20 points for perusing each element, and 10 points per correct answer. In order to move on, a student must score 150 points out of a possible 200.

At all times, the game's interface shows how many points a student has earned within a given section, as well as the number of points required to unlock the next one (visualized as a progress bar). In addition, the interface suggests the next step (e.g. which text or video to study next), but students are ultimately free to peruse the content within a given section in any order they choose. Those that outperform the threshold can help those whose performance is lacking. If a student fails to answer a question after the three allotted attempts, he or she chooses one of the players who have already found the answer and asks for help. The program connects the two, and the successful student helps his counterpart by highlighting the passage of a text or a part of a video containing the answer to the question. The teacher monitors each player's activity at all times and is responsible for directly assisting any student who fails to score the required number of points for a given section (even after using every available attempt).

Players also receive badges that represent specific achievements. Some examples of achievements are: answering all questions within a section correctly, being the first to complete a section, successfully assisting another student, answering “bonus” questions at the end of the lesson, etc.

The scores of the ten leading students are displayed on a leaderboard, along with the badges they have earned. The scores of those who do not make it into the top ten are not displayed in order to reduce the negative aspects of competition such as pressure.

6.3.Analysis

The results of the multiple choice test are analyzed by performing a Kruskal-Wallis test on the average scores of the five groups. If the results of the test are positive, i.e. at least one sample is found to be significantly different from the others, specific sample pairs should be compared using the Mann-Whitney U test. The expected outcome is that each consequent treatment will produce a higher average than the base case.

Since the point of the experiment is to analyze the inherent motivational power of each teaching method, task-contingent rewards should not be used, in order to minimize confounding effects. The experimenter can offer a small reward (such as candy or crayons) to the participants. However, monetary rewards should be avoided when dealing with children because of ethical considerations and the fact that children’s relationship with money can be different from that of adults. Therefore, budget considerations only play a limited role in determining the number of subjects and the power of the test. This enables the experimenter to increase the number of subjects at little cost in order to reduce variance and increase statistical power. Furthermore, in

order to obtain a more representative picture of the population, the experimenter can choose to run several sessions of the experiment (e.g. in different towns).

6.4.Discussion

In order to have external validity, economic experiments should meet certain precepts, as first established by Smith (1982).

The *non-satiation* precept states that, given a costless choice between two alternatives that are identical except that the first yields a greater reward than the second, subjects will always choose the first alternative because they are utility maximizers. Subjects derive utility from rewards even if they are not monetary, so this precept is met. The *saliency* precept requires that subjects must be "*guaranteed the right to claim a reward which is increasing (decreasing) in the goods (bads) outcome, of an experiment*". In essence, this means that good decisions result in increasing rewards, and vice-versa. In addition, the rules of the experiment must be strictly enforced and subjects cannot be deceived. The proposed experiment meets non-satiation and saliency, which are required to qualify as an *economic experiment* i.e. distinct from psychological experiments.

In order to qualify as a *controlled economic experiment*, two more precepts must be met. *Privacy* requires that subjects' outcomes and payoff alternatives be known only to themselves. The goal is to mitigate social pressure and make sure that each individual cares only about their own outcome. In the proposed experiment, privacy can be met by implementing a *single-blind* procedure, whereby subjects are assigned random numbers or aliases at the start of the experiment in order to remain anonymous to the experimenter. Finally, *dominance* states that in order to motivate subjects to think about their choices, the reward structure must dominate any subjective costs (i.e. mental effort) associated with the tasks. However, the purpose of this

experiment is precisely to measure the effect of motivation derived from non-monetary rewards. Therefore, this precept cannot be met.

Nevertheless, the proposal qualifies as an *economic experiment*. Furthermore, the nature of the subject pool, the task, and the environment in which the task is carried out label it as a field experiment. Indeed, attending a lesson and taking a test in a classroom is as close to natural as it gets for elementary school students. Therefore, the results of the experiment should have strong external validity, as they accurately describe what would happen in the real world.

7. Conclusion

Gamification provides opportunities to tap the motivational power of games in many fields, including education, by adding game elements to non-game settings. One of the major issues of this approach, however, is the lack of a systematic method for creating gamified experiences. Indeed, design is a subjective notion; there is no perfect formula for creating educational games, and effective designs involve innovation, uniqueness, and a creative spark.

Nevertheless, this paper presents an overview of some game elements and techniques that can be used to elicit motivation, supported by an analysis of the underlying psychological and behavioral mechanisms involved in the process.

The paper's foremost contribution is the description of an experiment that can be used in order to examine the relationship between motivation and actual academic performance, which had not been thoroughly investigated in the existing literature. The results of this experiment can be used to develop guidelines for developing gamified educational environments.

References

Ash, K. (2011, March 14). Digital gaming goes academic. *Education Week*, pp. 24-28.

Bjoran, K. (2011, June 23). Plant a New Language in Your Mind. *MIT Technology Review*. Retrieved from http://www.technologyreview.com/news/424453/plant-a-new-language-in-your-mind/

Colao, J. J. (2012, August 15). Can Software Build Character? Applying The 'Marshmallow Test' To The Classroom. *Forbes Magazine*. Retrieved from http://www.forbes.com/sites/jjcolao/2012/08/15/can-software-turn-kids-into-better-people/

Dickey, M. D. (2005). Engaging By Design: How Engagement Strategies in Popular Computer and Video Games Can Inform Instructional Design. *Educational Technology Research and Development*, 67-83.

Entertainment Software Association. (2011). *Essential Facts About The Computer And Video Game Industry.*

Gee, J. P. (2003). What Video Games Have to Teach Us About Learning and Literacy. *Computers in Entertainment*.

Gee, J. P. (2008). Learning and Games. In K. Salen, *The Ecology of Games: Connecting Youth, Games, and Learning* (pp. 21-40). Cambridge, MA: The MIT Press.

Gneezy, U., & Rustichini, A. (2000). Pay Enough or Don't Pay at All. *Quarterly Journal of Economics*, 791-810.

Gordon, B. (2013). (K. Werbach, Interviewer) Retrieved from https://class.coursera.org/gamification-002/lecture/67

Gossen, R. (2013, January 17). *The Gamification of Clinical Trials: What's Next?* Retrieved from RebarInteracive: http://rebarinteractive.com/gamification-clinical-trials/

Hunicke, R., LeBlanc, M., & Zubek, R. (2004). *MDA: A Formal Approach to Game Design and Game Research.* Retrieved from http://www.cs.northwestern.edu/~hunicke/pubs/MDA.pdf

Interactive Software Federation of Europe. (2012). *Video Games in Europe: Consumer Study.* Retrieved from http://www.isfe.eu/sites/isfe.eu/files/attachments/euro_summary_-_isfe_consumer_study.pdf

Ke, F. (2009). A qualitative meta-analysis of computer games as learning tools. In R. E. Ferdig, *Handbook of Research on Effective Electronic Gaming in Education* (pp. 1-32). New York, NY: IGI Global.

Klopfer, E., Osterweil, S., & Salen, K. (2009). *Moving Learning Games Forward.* Cambridge, MA: The Education Arcade.

Lenhart, A., Kahne, J., Middaugh, E., Macgill, A., Evans, C., & Vitak, J. (2008). *Teens, Video Games and Civics.* Retrieved from http://www.pewinternet.org/Reports/2008/Teens-Video-Games-and-Civics.aspx

Lepper, M. R., Greene, D., & Nisbett, R. E. (1973). Undermining children's intrinsic interest with extrinsic reward: A test of the "overjustification" hypothesis. *Journal of Personality and Social Psychology,* 129-173.

Malone, T. W. (1980). *What Makes Things Fun to Learn? A Study of Intrinsically Motivating Computer Games.* Retrieved from http://cci.mit.edu/malone/tm%20study%20144.pdf

McGonigal, J. (2011). *Reality is Broken: Why Games Make Us Better and How They Can Change the World.* New York, NY: Penguin Press.

Mims, C. (2011, May 2). Translating the Web While You Learn. *MIT Technology Review*. Retrieved from http://www.technologyreview.com/news/423894/translating-the-web-while-you-learn/

Olson, C. K. (2010). Children's Motivations for Video Game Play in the Context of Normal Development. *Review of General Psychology*, 180-187.

Pope, D. (2003). *Doing school: How we are creating a generation of stressed-out, materialistic, and miseducated students.* Yale University Press.

Prensky, M. (2001). *Digital Game-Based Learning.* McGraw-Hill.

Ryan, R. M., & Deci, E. L. (2000). Intrinsic and Extrinsic Motivations: Classic Definitions and New Directions. *Contemporary Educational Psychology*, 54-67.

Salen, K., Torres, R., Wolozin, L., Rufo-Tepper, R., & Shapiro, A. (2011). *Quest to Learn: Developing the School for Digital Kids.* Cambridge, MA: The MIT Press.

Schlam, T. R., Wilson, N. L., Shoda, Y., Mischel, W., & Ayduk, O. (2013). Preschoolers' Delay of Gratification Predicts their Body Mass 30 Years Later . *The Journal of Pediatrics*, 90-93.

Schwartz, D. L., & Arena, D. (2013). *Measuring What Matters Most: Choice-Based Assessments for the Digital Age.* Cambridge, MA: MIT Press.

Shoda, Y., Mischel, W., & Peake, P. K. (1990). Predicting Adolescent Cognitive and Self-Regulatory Competencies from Preschool Delay of Gratification: Identifying Diagnostic Conditions. *Developmental Psychology*, 978-986.

Shute, V., & Ventura, M. (2013). *Stealth Assessment: Measuring and Supporting Learning in Video Games.* Cambridge, MA: MIT Press.

Smith, R. (2009, July 31). *Ross Smith: Portfolio selection and game theory in defect prevention*. Retrieved from Microsoft Press Blog: http://blogs.msdn.com/b/microsoft_press/archive/2009/07/31/portfolio-selection-and-game-theory-in-defect-prevention.aspx

Smith, V. L. (1982). Microeconomic Systems as an Experimental Science. *The American Economic Review*, 923-955.

Thaler, R. (1981). Some Empirical Evidence on Dynamic Inconsistency. *Economics Letters*, 201-207.

Trope, Y., & Liberman, N. (2010). Construal-level theory of psychological distance. *Psychological Review*, 440-463.

Werbach, K. (2012). *For the Win: How Game Thinking Can Revolutionize Your Business.* Wharton Digital Press.

Wigfield, A., Guthrie, J. T., Tonks, S., & Perencevich, K. C. (2004). Children's Motivation for Reading: Domain Specificity and Instructional Influences. *The Journal of Educational Research*, 299-310.

Wittgenstein, L. (1958). *Philosophical Investigations.* (G. E. Anscombe, Trans.) Oxford: Basil Blackwell.

XEODesign. (2004). *XEODesign: Research.* Retrieved from XEODesign website: http://nicolelazzaro.com/wp-content/uploads/2012/03/4_keys_poster3.jpg

Zichermann, G., & Linder, J. (2010). *Game-Based Marketing: Inspire Customer Loyalty Through Rewards, Challenges, and Contests.* John Wiley & Sons.