Purchase College
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Senior Project in Economics, School of Natural and Social Sciences

Gamifying the Classroom: Using Game Theory to Analyze Motivation in the U.S. School System

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Abstract:

In 2013 6.8% of people between the ages of sixteen and twenty-four did not have high school diploma (NCES, 2014). This is a symptom of a larger issue of dropout rates across the United States. As a result, dozens of programs have been put forth as a means to remodel the U.S. school system which has not fundamentally evolved since the industrial revolution. However, none of these programs addressed the issue of student engagement in the U.S. school system (Paige, 2011). Instead they focused on teacher accountability, and the centralization of education. In response to the lack of literature surrounding the subject, this paper examines the role of intrinsic and extrinsic motivators in schools and its impact on students. Specifically, it examines video games and gamification and their effect on students and schools. As a result of the analysis, it was discovered while video games could be effective for some students, schools would receive a better payoff if they also implemented gamification tactics.

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1 Introduction

In 2006 approximately 73.06 million students were enrolled in public and private schools across America (NCES, 2019). Within ten years that number rose by 4.35% to 76.238 million students, with 6.8% of people under the age of twenty-four not receiving a diploma in 2013 (NCES, 2019, 2014). Between 2006 and 2016, dozens of programs have been put forth as a means to remodel the U.S. school system, which has not fundamentally evolved since the industrial revolution. The most notable examples include the "No Child Left Behind Act[1]", now known as the ESSA or the "Every Student Succeeds Act[2]", and most recently common core[3] ("Every Student Succeeds Act…"). However, neither program addressed the issue of student engagement in the U.S. school system (Paige, 2011). Instead they focused on teacher accountability, and the centralization of education.

Further, literature such as (Christle, Jolivette, & Nelson, 2007), which analyzed the characteristics related to dropout rates such as enrollment per institution, attendance rate, retention rate and more, as means to identify positive relationships with dropout rates. While (Yuane, Konold, & Cornell, 2016) strived more to discover inverse relationships with dropout rates, such as student support, and high academic goals. As result both papers inadvertently discussed both

[1] **No Child Left Behind Act**- Signed into effect in 2001, the NCLB reaffirmed past laws to provide funding for programs in primary and secondary schools.
[2] **Every Student Succeeds Act**- December 10, 2015 President Obama sign the ESSA into effect. Much like NCLB, the ESSA provided for programs, however, with the distinction to help students in low income and high-risk neighborhoods.
[3] **Common Core**- A program designed for U.S. school systems, instituted during the Obama administration in 2013. The program was intended to provide a minimum requirement for every school district across the U.S. In 2015 its limitations were expanded upon by the ESSA.

extrinsic[4], and intrinsic[5] variables, respectively, and their relationships with dropout rates. However, neither paper forwardly analyzed their variables in this way.

In response, this paper will examine intrinsic and extrinsic motivators as they their effects on students and schools. Specifically, how does the incorporation of videogames in the academic setting compare to gamification as a motivator and a learning tool? When video games are applied to an academic setting they become extrinsic motivators. However, gamification is inherently intrinsic in its goal. That said both devices do incorporate internal and external incentives in practice.

2 Literature Review

2.1 Video Games

Motivation among K-12 students continues to be an issue on a global scale. Combined with ineffective policy and the continual increase in students annually, many researchers have turned to alternative educational means in order to analyze their effectiveness. Additionally, the accessibility of the internet has brought the ingenuity of educational video games into many classrooms. As an educational tool, this genre of game has proven continuous reliability as a means of motivation amongst K-12 students. However, emerging research in the effectiveness of non-educational video game play has indicated the reliability of other game genres as well.

For example, Adachi (2013), a study conducted in Canada over a five-year time span, focused on the advantages of strategy games in the development of strategical thinking in high

[4] **Extrinsic Motivators**- incentives that guide individuals in completing tasks in order to receive an external reward separate from the desired task.
[5] **Intrinsic Motivators**- factors that provide incentives for people to find internal satisfaction in completing certain tasks.

school students. The games in this study have been equated to *Splinter Cell* and *World of Warcraft*, both of which incorporate heavy problem-solving skills into game-play. Some of the variables the study explored included academic grades, self-reported problem-solving skills, and variables surrounding strategic and fast paced video game play. The study showed a positive relationship between strategic video gameplay and self-reported problem-solving skills, and self-reported problem-solving skills and academic grades. As a result, the authors also concluded that there was a positive indirect relationship between strategic video gameplay and academic grades. The paper also suggests that while video games are valuable to high schoolers, due to their impulsive nature, adults are more likely to implement strategies into gameplay.

Similarly, Krcmar et al. (2018) studied the relationship between stress relief and video game play. It consisted of 117 college students that were split into experienced and inexperienced gamers. The study then had their participants complete the “No Russian” level of Call of Duty: Modern Warfare 2. This particular level was chosen due to its controversial morality. In this particular level, the player is to act as an American undercover agent looking to execute an attack on a Russian airport. In order to keep their cover, the player has to decide whether or not to kill airport civilians. The experiment sought out to answer several questions. First, what effects does gameplay have on perceived anthropomorphism (believing to have human characteristics and emotions) of game characters, stress, and guilt? Secondly, how do experienced and inexperienced players differ in regards to these same three characteristics?

They were able to accomplish this by exploring the differences in system processing, one and two, as well as their relationship to stress and experienced and inexperienced players. In their literature review they found that system one processing, which occurs when the player is overly immersed in the graphics and mechanics of the game, is prevalent in inexperienced gamers. In contrast, system two processing, the result of players looking beyond these game particulars to focus on the strategic components, is found among experienced participants.

Further, the paper examined the connection between the number of bullets used and the self-reported guilt and stress levels experienced by the player. The results found a negative relationship between gameplay and perceived anthropomorphism of characters, as well as a negative relationship between gameplay and stress from shooting. There were positive relationships found between perceived anthropomorphism and stress, and perceived anthropomorphism and guilt. Finally, those who felt stress from shooting fired fewer bullets.

Overall the results of this study imply that those who have more experience with video are able to separate in-game characters from real people. Because of this separation, more experienced players are also able to focus more on gameplay and strategy rather than guilt and stress.

Krcmar et al. (2018) and Adachi et al. (2013) both analyze the inherent advantages of non-educational video game activity through the lens of MMORPGs[6]. These include the development of strategic thinking over time, and an indirect negative relationship between game play and stress. However, there is some literature that argues that this type of videogame play has some inherent issues. Swing et al. (2010) is one of these journals. The article attempted to establish whether there is a connection between attention issues in children and teenagers, and television and video game use. The study looked at data accumulated by the SWITCH obesity prevention project, consisting of 1323 students with an average age of 9.6, and 210 teenagers. Further, they analyzed "parent- and child-reported television and video game exposure as well as teacher-reported attention

[6] **MMORPG**- Massively Multiplayer Online Role Play Game. An immersive game played across multiple severs across the world by millions of people

problems" for the younger group, and self-reported use and attention problems for teenagers. The data was collected over a 13 month period.

The findings indicated that both video games and television had a small to moderate, but statistically significant, positive correlation to attention problems. This correlation was found more so with video game exposure. Furthermore, adjusting for age and gender did not change the outcome. However, issue with this argument is even if there was a statistically significant positive correlation between video games and attention issues is the magnitude of their relationship large enough to cause concern

The results of this study also outlined the fact that attention issues at the first time interval were weakly and negatively associated with changes in attention problems by the fourth time interval with younger subjects rather than older. This is relevant because the negative association was weak as well, which indicates that long-term video game and television exposure from a young age does not cause a large increase or decrease in attention issues.

2.2 Gamification

What is Gamification? How does gamification work? How do you "gamify" a situation? How can gamification be used to change behavior, develop certain skills, and drive innovation? Burke (2014) answered these questions using qualitative data extracted from interviews with various firms and organizations. In this book gamification is defined not simply by the badges and leader boards often associated with video games, but by several key principles. These include aligning the goals of the host, company or group, with that of the audience as opposed to trying to get the audience to do what the host wants. Further, the importance of building a strong audience community, the separating of larger goals into smaller sections, and finally knowing your audience so that you can provide better intrinsic motivators rather than only extrinsic. Stimulating intrinsic motivation is especially important in that it will keep the audience returning and engaged, even more so than extrinsic motivators would.

Several of the misconceptions surrounding gamification include notions that gamification is just adding video game qualities to a business model, by adding these game qualities that alone will increase consumer involvement in their product, and that gamification will increase worker output for the company. However, given the definition of the properties of a successfully gamified scenario, gamification should not be seen as a means to solve all of the host's engagement issues and especially not overnight.

Ultimately, this author defined gamification as a means to motivate a target audience into achieving a certain goal. This audience can consist of consumers, workers, or even students. Regardless of the target audience, however, the author warns against conflicting goals. Specifically, Burke warns against the use of company goals as an incentive to a gamified system as opposed to target audience motivated goals. Another defining motivator of a gamified solution was the role of social media as a means of building a sense of community. Burke highlights the role of community as crucial to the success of the solution because the accomplishment of certain goals isn't is only given meaning in the context of the community. A final key to stimulate motivation for the target audience is the separation of goal into sub-goals or the accomplishment of smaller activities to show progress rather than the daunting task of the overall goal.

Aside from defining gamification, the book acts as a guide to build potential gamified solutions. It also provides defining criteria for future analysis of programs in order to determine if they have been gamified and how they might be able to incorporate a more efficient solution to the gamification of the system. This will be useful in the creation of a gamified implementation of education.

Burguillo (2010) purposes several important questions throughout his paper. How does competition-based learning affect the classroom environment? Does competition-based learning provide an effective means of motivation for students? How does the implementation of video game-based learning, and game theory, coincide with competition-based learning as a means to build upon engagement in students?

He does this over the span of ten years by collecting the basic syllabi and responses for the course's final project. The syllabi always included a mixture of three other teaching styles alongside competitive-based learning. These included collaborative-based, problem-based, and project-based learning. Specifically, the collaborative aspect allowed the inclusion of game theory. The paper incorporates the use of AI as well as player versus player "games". The paper found that students over the years reported mostly positive feedback regarding their desire to learn. Further, students reported motivation triggered by the competitive aspect the course presents as well as enjoyment despite failure in competitions. Overall, the paper outlines a syllabus for practical use in tech-based classrooms.

The syllabus provided in the paper is what is of most interest. As previously mentioned, it provides an outline for future use. However, many of the points implemented in the syllabus followed gamified practices found in Burke(2014). For example, the syllabus has aligned the goals of the course with that of the student which includes a competitive atmosphere and a desire to learn the course material. There is also an emphasis on community collaboration through the use of group assignments and exercises. Finally, the assignments are given in smaller increments before a larger increment such as problem-based assignments compared to project-based ones.

The incorporation of gamification into education is even more so explored in Dicheva (2015) in which the authors conducted a systematic mapping study in order to analyze the specific characteristics involved in the success of gamification in practice. Specifically, the paper conducted an exploration of game elements as opposed to specific intrinsic motivators. They did this through the search of seven scientific databases which resulted in the analyzation of 1647 papers. Of these papers, 34 presented empirical studies that were used in the course of this study. The paper outlined six dimensions for which the research would be examined. These include game elements, type of application, education level, academic subject, implementation, and results of the evaluation. The concluding goal of this paper centers around the following question: What does the analyzation of gamification in education expose about the characteristics of extrinsic motivators?

Ultimately, the authors classified the papers into a two-level framework “game mechanics” and “gamification design principles”. On the second level of the framework, “design principles”, visible status and social engagements were the most prevalent in an educational setting. Visible status operating similarly to a leader board and social engagement refers to social media. In contrast, studies that examine personalization were rarer. Similarly, badges, points, and a leader board were all high ranking qualities of game mechanics alongside levels.

As the paper progressed they explored the types of application methods and found that blended learning courses were most common and found in 18 of the 34 papers. It should be noted that only 2 papers were actually conducted in the K-12 setting while the others were centered around continuing education and training. Additionally, a majority of gamified courses were computer science and information technology-oriented, and implementation could be seen through the use of technology. Finally, the reported results of the examined studies were positive.

The majority of what is expressed in this study can also be found in Burke (2014), however Dicheva (2015) is mostly reliant on empirical data rather than qualitative. Also, they base their definition of gamification around extrinsic motivators as opposed to both extrinsic and intrinsic. Further, while these two papers are successful in defining gamification as well as its characteristics, it still lacks an in depth exploration of the application process in K-12 classrooms.

The case study Shute et al. (2012) examines such as application in the U.S. school system. The study used both qualitative and quantitative data collected at two timestamps 6 months apart. They used schools with similar demographics as control groups. Specifically the study measured the following two components in the study as it pertains to student growth throughout the program of Quest to Learn "(1) the need to recognize and support new competencies, and (2) student (dis)engagement relative to current, outdated educational systems" (Shute 2012). To assess these components the paper looked at system thinking, teamwork and time management.

The study found that students showed greater system thinking skills from the first time interval to the second, no overall difference in teamwork skills, and improvement in time management. The authors also indicated their model to be a reliable measure of the Quest to Learn's program.

Not only did the paper discover a reliable method to decide the effectiveness of Quest to Learn programs, but it affirmed Q2L's reliability for certain programs while highlighting some of the areas that require further attention. For example, while students showed an increase in system thinking skills, the growth was not as significant as in time management. Further the school noted that there was no overall difference in teamwork skills for students over the course of the study. What this result suggests is that the school should develop their programs further such that there is a greater focus on teamwork skills. The study's affirmation of the reliability of Q2L programs also affirms how gamification can function as a tool for learning.

However, even with this case study the surrounding literature on the topic of motivation in K-12 classrooms has not increased the number of gamified educational programs. Thus this paper strives to examine both the costs and benefits of the implementation of non-traditional educational programs such as video games and gamification through the lens of game theory.

3 Application

With the provided scope of the surrounding literature the goal of this paper relies on the lay out as a foundation in the process of examining the payoffs of these programs as a thought experiment. This paper, through the use of game theory, will implement both simultaneous and sequential move games as a means to mathematically express the maximization of both the student and the school system.

3.1 Video Games in Sequential and Simultaneous Move Games

As previously established the U.S. school system is flawed. With the dropout rates among high school students hitting 6.8% in 2013, and the failure of past programs to increase participation rates, many have shifted their sights to other means to motivate students.

Videogames and gamification have been previously studied, however, there has not yet been an analysis using rational thought. The use of game theory allows for this specific type of analyzation and is supported by visual representation. However, to begin game theory analysis, otherwise known as game analysis, there first needs to be a strategic game. Dixit (2009) lays the ground work for defining game theory, and basic game creation and analysis. One of the first steps it attributes to creating a game is clarifying the scenario.

Examining in school video game use first, more specifically strategic video game software, there would be two scenario types. The first includes two possible games, one where a school has the opportunity to offer the software to students who only benefit from its use, and another where a school has the opportunity to offer the software to students who would never benefit from its use. The second scenario a game where school has both types of students attending.

In all cases the list of player will be include the School, the student that benefits from the game use, labelled Child Type One, and/or the student that is harmed by video game use, Child Type Two. Here School's moves will always include to either Offer or Not Offer the software, and both Child Types can either Play or Not Play it. Next, in order to rationally choose the most likely outcome each player must have their own set of payoffs assigned and ranked based on their values. This is enacted in Table 1. below.

Video Game Ranking:

School	**Child Type One**	**Child Type Two**
Cost of Software-> -2	*Good Grades*-> 2	*Good Grades*-> 2
No Software-> 0	*Bad Grades*-> -2	*Bad Grades*-> -2
Game Use-> 2	*Games*-> 1	*Games*-> 1
No Game Use-> -1	*No Games*-> 0	*No Games*-> 2
Good Grades-> 3	*Exposure*-> 1	*Exposure*-> -1
Bad Grades-> -3	*No Exposure*-> -1	*No Exposure*-> 1

Table 1. *The ranking from this table can be added together to get the payoffs of each situation.*

More than a list of each player's preferences, Table 1 can also be analyzed for each player's nature. For example, both Child Type One and Child Type two have a desire to receive good grades which can only happen if the child types move toward what is most useful for them. Again in the case of Child Type one the most useful would be to play, and in contrast Child Type Two would find it more useful to not play and instead to learn by other available means. Because of the difference in nature, while both players due have a desire to play games and therefore have a one point base line for playing it Child Type One's move to not play has a rank of 0.

In comparison, although Child Type Two enjoys games, Not Play still results in a better outcome and therefore Not Play has a rank of 2 as opposed to 1. The last difference in the two child types is the 1 payoff Type One receives from being exposed to the software, while the lack of exposure for Type Two would be beneficial.

Alternatively, School's variables Good Grades and Bad Grades are determined by each student type's moves. For example, if both child types move for their preference and therefore receive good grades then good grades would be added to School's payoff for that specific path of play. Further, although offering the software incurs a cost of -2 to School as long as one student Plays then the cost can be made up for by +2.

This is best represented in the split school scenario shown in figures one through four.

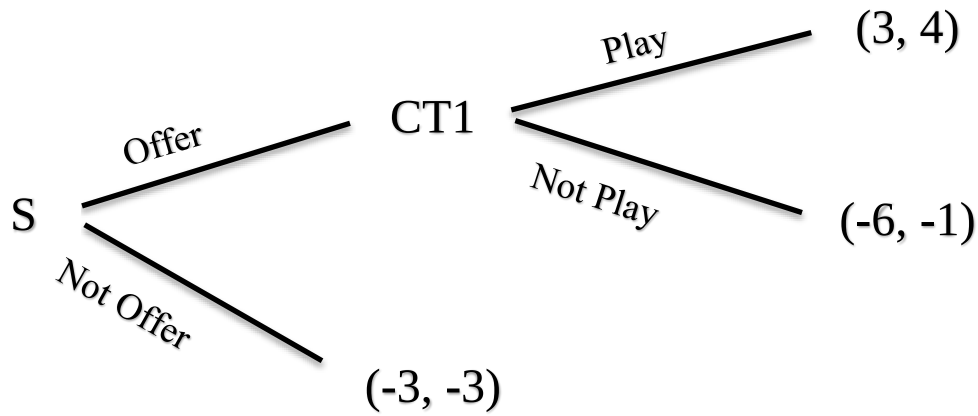


Figure 1. *Here CT1 is representative of Child Type One while School is represented by S. The payoffs are ordered in the following way S, CT1. Please find the mathematics behind each payoff at the end of the paper.*

Figure 1. is the first result of the split of the two Child Types. Here School plays first and Child Type One plays second in a purely sequential game. As a result, the payoffs are listed (School, Child Type One). As previously stated, the calculations for each payoff are a combination of the rankings from table one. For example, given the path of play, sequential order of moves, (Offer, Play) School receives a payoff 3. This payoff is a direct result of the cost of the software because it was offered (-2), plus the software use from Child Type One's move Play (+2) and whether or not the Child received good grades (+3). Once all of these rankings are combined, the payoff is 3 as portrayed in Figure 1.

These results can be repeated for School's other payoffs by using the equation

$$\boldsymbol{S_1 = ostat + gstat_s + cti_1}$$

Where $\boldsymbol{S_1}$ is the school with Child Type One students, $\boldsymbol{ostat}$ represents Offer status or whether or not School moves Offer or Not Offer, $\boldsymbol{gstat_s}$ is the status of game use using School's rankings, and $\boldsymbol{cti_1}$ stands for child type influence for when there is a Child Type One School.

Although Child Type One has similar factors contributing to their payoffs, a different equation can be used to consistently calculate them.

$$CT_1 = ggstat + gstat_1 + exp_1$$

Here CT_1 indicates that this equation is to calculate the payoff for Child Type One, while $ggstat$ represents the status of their grades more specifically their good grade status. This should not be confused with $gstat_1$ which is reserved for the status of the students choice to play the game. Finally, exp_1 is meant to represent whether the student is exposed to the game.

For an example of this equation in practice the path of play (Offer, Play) will be examined. For the first variable,$ggstat$, Child Type One receives a payoff for good grades, because of their benefit from playing the software. Next $gstat_1$ receives the ranking (1) from actually playing the game. Similarly, because of Child Type One's exposure to the game exp_1 is also (1). Therefore the equation will be $CT_1 = 2 + 1 + 1$ or 4 as portrayed in Figure 1.

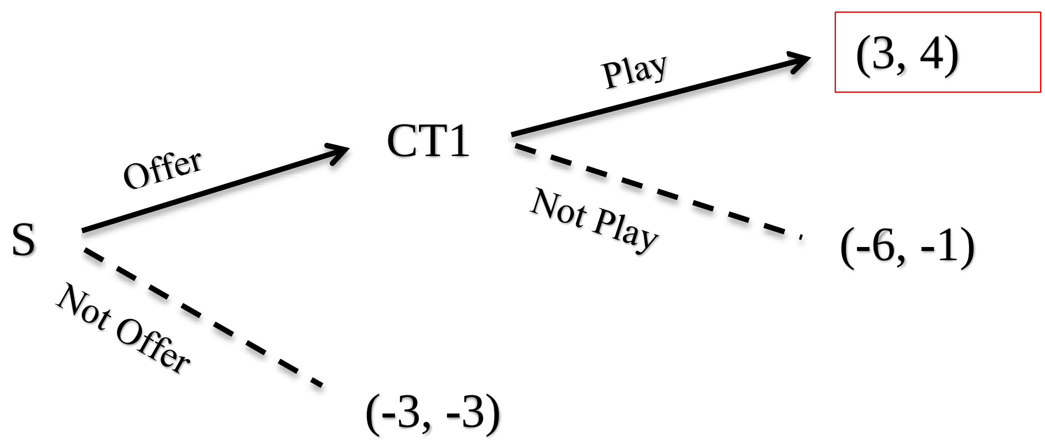


Figure 2. *This Figure represents the analysis of the rollback equilibrium of this game. Here the order of arrows depict the path of play which lead to the equilibrium which is surrounded by a box. Conversely the moves with strikes through them are the option that were not chosen The underlined numbers are meant to represent which payoffs are being compared to one another.*

Earlier, when defining the nature of each of the players Child Type One it was stated that that they would benefit the most from the software use. Upon further analysis, the rollback equilibrium, best possible move combination both players could come to, of this game supports what was initially stated. As portrayed in Figure 2. the equilibrium of the game follows the path of play (Offer, Play) with an equilibrium payoff of (3, 4).

The rollback is determined by examining the terminal, last possible, node. In this case there are three, each which have payoffs listed following them. However, because Child Type One is the last player to move, their choices must be examined first. Here the player must decide between the payoffs 4 and -1. As 4 is a higher number Child Type One would choose to Play, for a payoff of 4, as opposed to Not Play.

As a result there is an assumption that School knows that Child Type One will never move Not Play their decision is instead between 3, if they Offer, and -3, if they don't offer. Because 3 is a better payoff than -3, School will choose to offer which results in the rollback equilibrium of (Offer, Play).

From the first stage of finding the equilibrium its Child's choices that impact School's final decision to Offer. As previously stated, by the second stage of the rollback process School is already aware that Child Type One would make the decision to Play over Not Play, because of the payoffs Child Type One would receive as a result. If Child Type One's payoffs were ranked differently, such that the move Not Play would reward the student with a higher payoff than Play, School would instead decide to Not Offer for a payoff of -3 as opposed to -6. This is an important distinction to make as the reason the rollback equilibrium of this game is (Offer, Play), as opposed to (Not Offer), is because the payoffs and desires of both players are aligned with one another through the variable good grades.

This 'alignment' is similar to practices found in gamification, where the 'host', or entity with viewers, aligns their goals with their audience. However, there are several flaws with how this process is adopted into the U.S. school system.

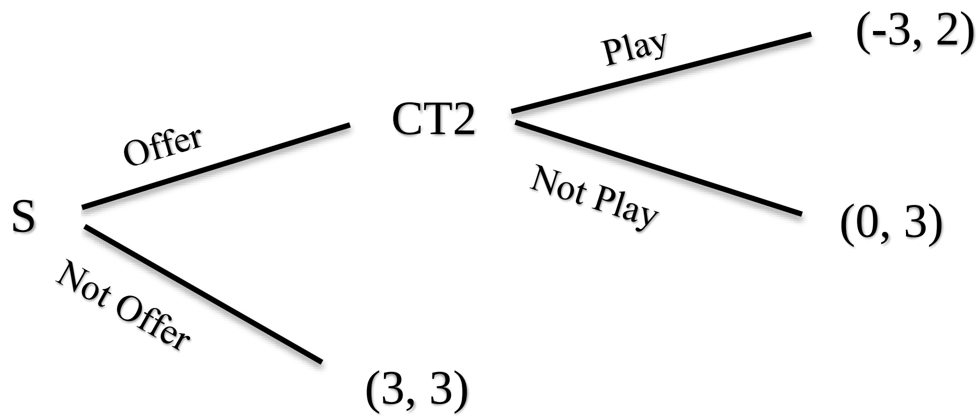


Figure 3. *Similar to Figure 1. this game represents its payoffs in the order S, CT2, where S represents School and CT2 represents Child Type Two.*

In a School with only Child Type Two students, represented in Figure 3., you will see a very similar set up to a School with Child Type One students. Once again School will move first to either Offer or Not Offer the software. Should School Offer Child Type Two will be allowed to either Play or Not Play.

The payoffs from this game tree can be calculated similarly to the way the previous game's payoffs were calculated. In fact, the even the equations can be written the same way. However, there are still a few key differences. For example, the payoff equation for School in the Child Type One example was $\boldsymbol{S_1 = ostat + gstat_s + cti_1}$ where each variable represented a different ranking listed in Table 1. The main difference between the equation for the first school and the new school is the variable $\boldsymbol{cti_1}$**.** Because the game represented in Figure 3. includes a student of a different Child Type, the how the path of play impacts grades is heavily dependent on the Child Type. Instead of a student who is positively impacted by the software, this game includes a student who is negatively impacted. As a result the new variable is $\boldsymbol{cti_2}$ and the equation is displayed

$$S_2 = ostat + gstat_s + cti_2$$

Where S_2 represents the payoff for School two, $ostat$ and $gstat_s$ remain the same, and cti_2 represents Child Type influence from the second student type.

Similarly the new Child Type equation, $CT_2 = ggstat + gstat_2 + exp_2$, takes after the first one. Here, instead of using the Child Type One rankings, Child Type two rankings would be inputted to the equation.

In contrast to the Child Type One school, this game indicates that Child Type Two has a preference towards Not Play. This is due to the harm they would receive from playing the game as they would have an opportunity cost of time they could have spent studying. Further, School has a higher payoff overall compared to the first game.

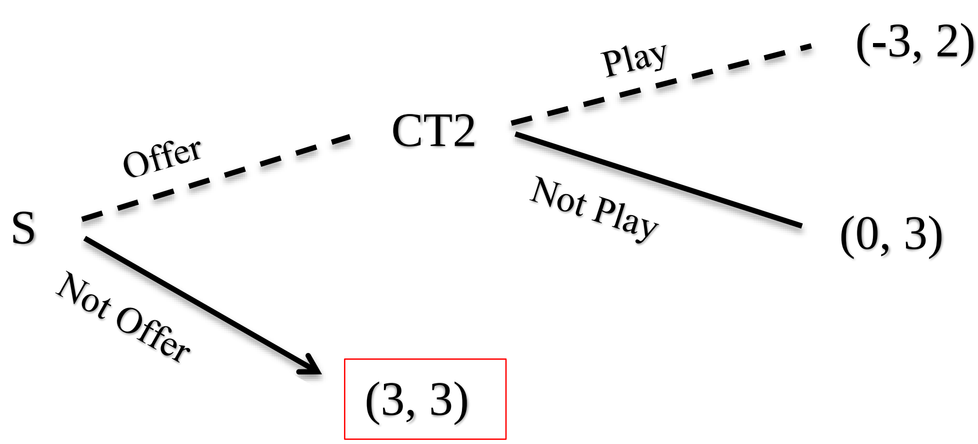


Figure 4.

This Figure displays a rollback equilibrium of (3, 3) with a path of play of (Not Offer). It was established beginning in the terminal node where Child Type Two had to decide between the moves Play which has a (-2) payoff and Not Play (3) payoff if School moves Offer. As a result the student would decide to Not Play for the (3) payoff. Knowing the students decision School would then have to decide between Offer which would result in a (0) payoff for them and Not Offer for (3). Since (3) is a better payoff than (0) School would move Not Offer.

The result from this game is vastly different from that of the first game. Again this due to the fact that Child Type Two gains more from not playing the software, and School wanting Child Type Two to get good grades.

However, despite the insight provided by these games a school where every student learns the same way is impossible. Therefore a more accurate account of a situation where school makes the decision to either implement or not implement a specific software for student benefit is a dual student type model. Figures 5 and 6. are just these models. Here the game includes both sequential and simultaneous aspects, and students of both Child Types can be found.

Because of the simultaneous additional rankings must be included to accurately represent the result of the interactions. This is portrayed in Table 2.

Simultaneous Game Additions:

	CT2 Play	**CT2 Not Play**
CT1 Play	1 , 1	-1 , 0
CT1 Not Play	0 , -1	0 , 0

Table 2. *In this table CT1 stands for Child Type One, and CT2 stand for Child Type Two. In the sub-game of Figure 1 these ranks should be added to the rankings in Table 1, where the first number in this Table is for Child Type One and the second one is for Child Type Two. This table is supposed to represent what happens when the two child types interact as a result of the software.*

Above, Table 2. depicts interaction between the two player types. When both students Play both receive an additional (1) to their payoff as it would be mutually beneficial to both players. However, if only one person Plays then that student receives a (-1) added to their payoff, while the other student receives a (0). If neither student plays they neither receive a benefit nor incur a cost. The reason both students incur the same cost or benefit to their rankings is because this table solely ranks the values of the interaction.

The new table along with having two both student types attend the same school, result in new payoff equations for each player.

$$\boldsymbol{S_{1+2} = ostat + gstat_{s_1} + gstat_{s_2} + cti_1 + cti_2}$$

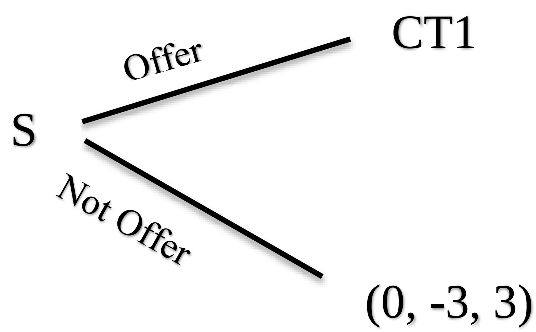
There are no new variables implemented in Schools new payoff equation, instead School's payoff can now be calculated by combining both of its previous equations with the exception of one $\boldsymbol{ostat}$. This is because, if the School does Offer the software would be available to all students much like in previous games, therefore they would only incur the cost once.

Similar to School's new payoff equation, both Child Types keep most of the same variables from their previous equations as illustrated bellow.

$$\boldsymbol{CT_1 = ggstat + gstat_1 + exp_1 + int}$$

$$\boldsymbol{CT_2 = ggstat + gsta_2 + exp_2 + int}$$

However, instead of combining both of their equilibriums for one payoff, each student receives their own as they are still two separate players. The new variable $\boldsymbol{int}$ was also added to both payoffs to represent the interaction variable portrayed in Table 2.



CT2

	Play	Not Play
Play	**(2, 5, -1)**	**(5, 3, 3)**
Not Pay	**(-7, -1, -3)**	**(-4, -1, 3)**

Figure 5. *Similar to Table2. CT1 and CT2 are representative of Child Type One and Child Type Two respectively. Further, School is represented by S. The payoffs are ordered in the following way S, CT1, CT2. Please find the mathematics behind each payoff at the end of the paper.*

In Figure 5. School begins as a sequential game. This is because for the game to arise School has to make the first move. This is best exemplified by comparing the after effects of each of School's moves. For example, after School's move of Offer a simultaneous move game between the two student types are invoked. In contrast, when School moves Not Offer neither child type can react because there is nothing to react to. In other words, School moves first because Child can't Play if the software is not available to them.

The simultaneous inclusion in Figures 5 and 6. is representative of the interaction between two player types. As a result there is some positive effect when both Child Type One and Two. For Child Type Two this effect is ultimately mitigated by the negative effects of Playing. However, Child Type One's effects are only amplified by the interaction of (Play, Play).

Because of the contrasting effects of the interaction of Play, Play this strategy combination can never be the equilibrium strategy, the result, of a situation where the positive effect caused by the dual Play is negated by Child Type One's preferences. This is further supported in Figure 6. where the rollback equilibrium is portrayed.

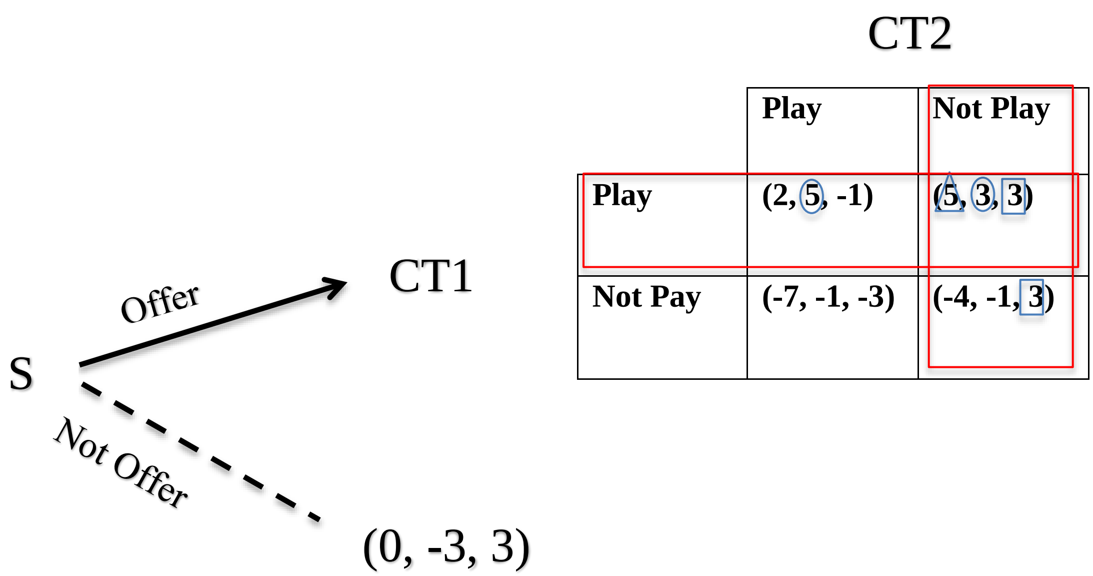


Figure 6. *Triangle indicates the result of a comparison of School's move. Circle is to indicate the result in comparing Child Type One's moves, and square for Child Type Two.*

In order to find the resulting pattern of moves for this game, path of play, an analysis of the rollback is necessary. Much like the name implies, to analyze the rollback would be to start from the end and move backwards through the game. Because there are no moves after School were to move to Not Offer the software the payoffs in that scenario are definitely (0, -3, 3).

However, the result when School Offers is not as straightforward because of the simultaneous sub-game. Therefore in order to find the rollback equilibrium the simultaneous move game must first be solved. There are many analytic strategies capable of doing so, however, checking for dominant strategies within the game table will be the first approach. If a Child Type does have a dominant strategy it would mean that, for that player, one of their moves has a clearly better payoff than their other strategy.

Examining Child Type Two's moves first, when Child Type One moves Play, Child Type Two will move to Not Play because they would a receive a payoff of (3) as opposed a payoff of (-1) if they moved to Play. Similarly, when Child Type One moves to Not Play, Child Type Two would choose Not Play again for a payoff of (3) rather than a payoff of (-3) if they moved Play. Because in both scenarios Child Type Two receives a better payoff if they move Not Play, Not Play is their dominant strategy.

In contrast, when Child Type Two moves Play, Child Type One receives a higher payoff of (5) if they move Play as well. When Child Type Two moves Not Play, Child Type One would prefer a payoff of (3) opposed to (-1), therefore they will move Play again. This makes Play Child Type One's dominant strategy. Since both Child Types have dominant strategies this would make the sub-game equilibrium (5, 3, 3). However, the sub-game equilibrium is not always the rollback equilibrium.

The final decider of the rollback equilibrium is School. With their knowledge that their move Offer the will result in (5, 3, 3) and Not Offer resulting in (0, -3, 3) they will move Offer so they receive a payoff of (5) instead of a payoff of 0. This is despite Child Type Two receiving a higher payoff if School were to Not Offer. In other words, because School receives a higher payoff when they Offer they have an incentive to Offer despite one Child Type being slightly worse off in comparison.

3.2 Gamification in a Purely Sequential Move Game

Although the videogame example does incorporate some aspects of gamification, such as interaction between players, and aligning their goals with that of the students, there is still some inefficiency portrayed in the model. For example, although the rollbacks from the split school game were able to theoretically benefit all students in the schools, as previously mentioned it's not realistic. Further, when there was a model implemented for both Child Types, School still had an incentive to move in favor of one student at the expense of another.

What this portrays that currently the U.S. school system is managed under three key assumptions. The first that every student operates the same way, the second that it's every student should want good grades, and the third that the Child Types operate on a binary instead of a spectrum. The second assumption is what hinders the model the most, because instead of aligning their goal with that of the students, School wants to align the students goals with their own. This logic is faulty as depicted by drop-out rates, grades may not always be the priority of the student, and pushing that goal onto them might instead agitate the situation.

Instead what can be done is to first understand what the student wants. So what do all students want? Well one way to figure it out could be to survey student interest, it would probably be more helpful to understand that on a school by school level. Alternatively, what is known is that students have a wide variety of interests that can't be solely encompassed by good or bad grades. As a result it would be simplest to have one player represent students. This would in turn allow all child types to be combined as one and portray it in a separate ranking table. This is done in Table 3.

SCHOOL	CHILD TYPE 1	CHILD TYPE 2	CHILD TYPE 3
Cost of Software-> -2	Pursue-> 2	Pursue-> 2	Pursue-> 2
No Software-> 0	Not Pursue-> -2	Not Pursue-> -2	Not Pursue-> -2
Pursue-> 3	Opportunity->1	Opportunity-> 1	Opportunity-> 1
Not Pursue->-3	No Opportunity-> -1		Partial Opportunity->.5

Table 3.

There are of course some key differences between this table and the earlier examples. For instance, while school will retain their same moves Offer and Not Offer the software if they instead incentivize students to do what's best for them, the students moves can instead be changed to either Pursue, or Not Pursue what percentage of game play would be best for them. Further, because schools align their wants with their audience, the students, they now receive (3) per student that Pursues and (-3) for every student that doesn't.

Subsequently, most Child Types will also receive a ranking if they are the given the opportunity to pursue their path and a negative ranking if they aren't. In the cases of Child Type Two and Three, Child Type Two is always given the opportunity to Pursue what's best because they benefit from no game play, while Child Type Three is always at least given a Partial Opportunity because they benefit from some balance of complete software use and no software use. Unlike in other games there is no variable for game or no game use because it is already considered in Pursue and Not Pursue. The same can be said for the good grade, bad grade variables.

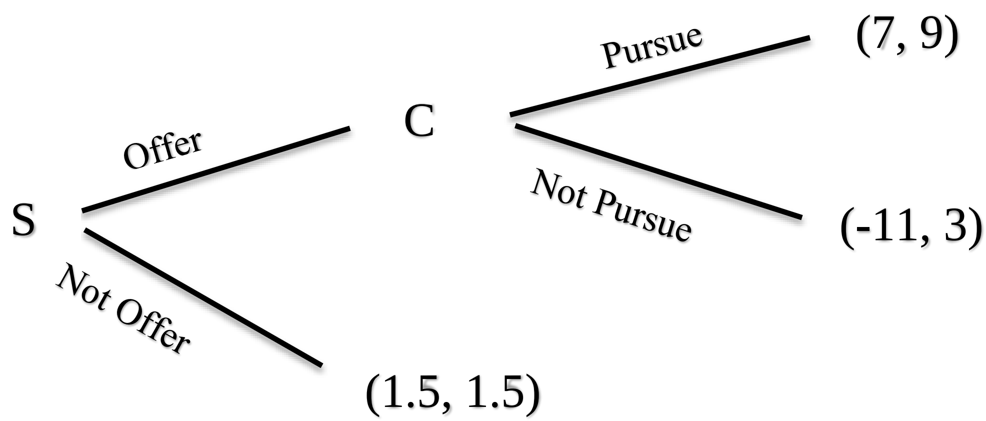


Figure 7. *This table operates under the assumption that each Child Type is aware of their type.*

Much like in previous examples the new game will be a completely sequential move game where School moves first and Child moves second. Here the first payoff is assigned to the School while the second is assigned to Child.

To find the payoffs for this tree a similar approach to how School's payoffs were calculated will be administered. For example, in School's payoff equation

$$\boldsymbol{S_{1+2+3} = ostat + pstat_{s_1} + pstat_{s_2} + pstat_{s_3}}$$

Although most of the variables differ from past equations, with the exception of $\boldsymbol{ostat}$, School's equation is still the result of the accumulation of each child types defining movements. It should also be noted that each $\boldsymbol{pstat}$ is representative of a different players' ability to pursue what is preferable to them with the sub-scripts indicating which $\boldsymbol{pstat}$ belongs to which player using School's rankings.

Payoff for this tree operates in a similar manner with the cumulative rankings of each player type being combined for each path.

$$\boldsymbol{CT_{1+2+3} = pstat_1 + pstat_2 + pstat_3 + opp_1 + opp_2 + opp_3}$$

Here the various $pstat$ variables still represent the pursue status of each Child Type, however they are acquired using each of the Child Types rankings as opposed to School's. Further the different opp variables are meant to represent whether or not each player has the opportunity to pursue what's best for them.

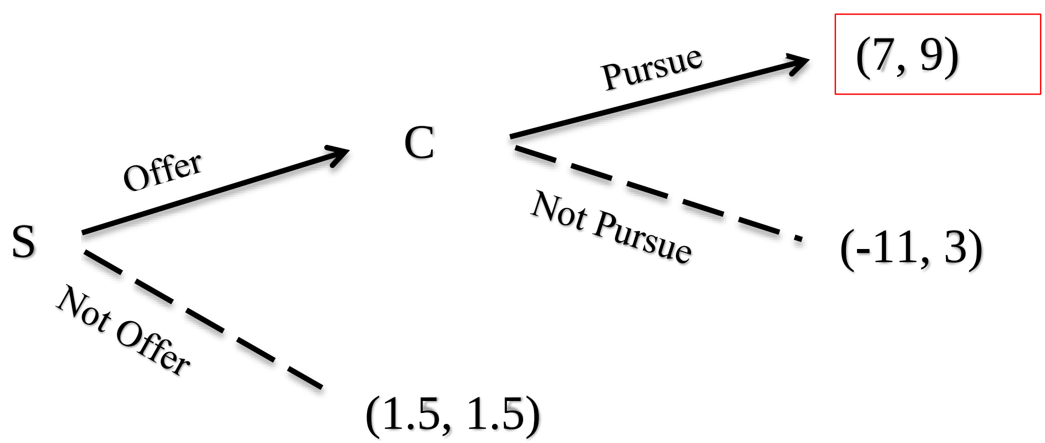


Figure 8.

The rollback equilibrium here is ultimately (Offer, Pursue) with an equilibrium payoff of (7, 9). This was established by Child deciding between their payoffs of (3) for Not Pursue, and (9) for Pursue. Because 9 is the better payoff Child would pick to Pursue. Because School knows Child will Pursue what's best for them if they do Offer they can compare the payoff they would receive if they did Offer (7) to if they play Not Offer (1.5). Therefore School would prefer to Offer, resulting in the payoff (7, 9) as previously stated.

What this game reinforces is that once Schools aligns their goal with students they can receive an overall better payoff. Even with the third student missing School would still receive a payoff of (4) which is still a higher equilibrium payoff than most other games, even lacking the variable for game use.

4 Conclusion

As time passes drop-out rates continue to increase. A main source of drop-out rates is lack of student motivation. Although the U.S. school system has tried alternative programs, most have revolved around teacher accountability and therefore not tackled the main issue of motivation. A few methods that have proven to tackle this issue are video games and the implementation of gamification into schools. This was discovered through analysis of literature and game analysis using Game Theory.

Using game analysis several scenarios were implemented. The first two showed split child schools where students either benefit or don’t benefit from the software, and a third showed a combination. The first three schools also depicted a scenario were a program to be implemented into the current school system. These games supported the influence of each player type onto Schools decision, while the third game portrayed how School’s decision to Offer or Not Offer would ultimately depend on the percentage of each type at the school, in which case one student would always be worse off. Conversely, the fourth game depicted a school with gamification implemented with Schools once more having to decide between offering and not offering a software. What this showed was that once schools aligned their goal with the students, as opposed to the alternative, they receive a better payoff overall and students now all receive a better payoff.

5 Calculations

****N/A: That variable is applicable in that scenario (Typically occurs in Not Offer scenarios because there are no game to be played and/ or an interaction doesn't exist)****

Figure 1.

$\underline{S_1 = ostat + gstat_s + cti_1}$

- **(Offer, Play)**
  - $S_1 = -2 + 2 + 3 = 3$
- **(Offer, Not Play)**
  - $S_1 = -2 - 1 - 3 = -6$
- **(Not Offer)**
  - $S_1 = 0 + N/A - 3 = -3$

$\underline{CT_1 = ggstat + gstat_1 + exp_1}$

- **(Offer, Play)**
  - $CT_1 = 2 + 1 + 1 = 4$
- **(Offer, Not Play)**
  - $CT_1 = -2 + 0 + 1 = -1$
- **(Not Offer)**
  - $CT_1 = -2 + N/A - 1 = -3$

Figure 3.

$\underline{S_2 = ostat + gstat_s + cti_2}$

- **(Offer, Play)**
  - $S_2 = -2 + 2 - 3 = -3$
- **(Offer, Not Play)**
  - $S_2 = -2 - 1 + 3 = 0$
- **(Not Offer)**
  - $S_2 = 0 + N/A + 3 = 3$

$\underline{CT_2 = ggstat + gstat_2 + exp_2}$

- **(Offer, Play)**
  - $CT_2 = -2 + 1 - 1 = -2$
- **(Offer, Not Play)**
  - $CT_2 = 2 + 2 - 1 = 3$
- **(Not Offer)**
  - $CT_2 = 2 + N/A + 1 = 3$

Figure 5.

$\underline{S_{1+2} = ostat + gstat_{s_1} + gstat_{s_2} + cti_1 + cti_2}$

- **(Offer, Play, Play)**
  - $S_{1+2} = -2 + 2 + 2 + 3 - 3 = 2$
- **(Offer, Play, Not Play)**
  - $S_{1+2} = -2 + 2 - 1 + 3 + 3 = 5$
- **(Offer, Not Play, Not Play)**
  - $S_{1+2} = -2 - 1 - 1 - 3 + 3 = -4$
- **(Offer, Not Play, Play)**
  - $S_{1+2} = -2 - 1 + 2 - 3 - 3 = -7$
- **(Not Offer)**
  - $S_{1+2} = 0 + N/A + N/A - 3 + 3 = 0$

$\underline{CT_1 = ggstat + gstat_1 + exp_1 + int}$

- **(Offer, Play, Play)**
  - $CT_1 = 2 + 1 + 1 + 1 = 5$
- **(Offer, Play, Not Play)**
  - $CT_1 = 2 + 1 + 1 - 1 = 3$
- **(Offer, Not Play, Not Play)**
  - $CT_1 = -2 + 0 + 1 + 0 = -1$
- **(Offer, Not Play, Play)**
  - $CT_1 = -2 + 0 + 1 + 0 = 5$
- **(Not Offer)**
  - $CT_1 = -2 + N/A - 1 + N/A = -3$

$\underline{CT_2 = ggstat + gstat_2 + exp_2 + int}$

- **(Offer, Play, Play)**
  - $CT_2 = -2 + 1 - 1 + 1 = -1$
- **(Offer, Play, Not Play)**
  - $CT_2 = 2 + 2 - 1 + 0 = 3$
- **(Offer, Not Play, Not Play)**
  - $CT_2 = 2 + 2 - 1 + 0 = 3$
- **(Offer, Not Play, Play)**
  - $CT_2 = -2 + 1 - 1 - 1 = -3$
- **(Not Offer)**
  - $CT_2 = 2 + N/A + 1 + N/A = 3$

Figure 7.

$\underline{S_{1+2+3} = ostat + pstat_{s_1} + pstat_{s_2} + pstat_{s_3}}$

- **(Offer, Play)**
  - $S_{1+2+3} = -2 + 3 + 3 + 3 = 7$

- **<u>(Offer, Not Play)</u>**
  - $\boldsymbol{S_{1+2+3} = -2 - 3 - 3 - 3 = -11}$
- **<u>(Not Offer)</u>**
  - $\boldsymbol{S_{1+2+3} = 0 - 3 + 3 + 1.5 = 1.5}$

$\underline{\boldsymbol{CT_{1+2+3} = pstat_1 + pstat_2 + pstat_3 + opp_1 + opp_2 + opp_3}}$

- **<u>(Offer, Play)</u>**
  - $\boldsymbol{CT_{1+2+3} = 2 + 2 + 2 + 1 + 1 + 1 = 9}$
- **<u>(Offer, Not Play)</u>**
  - $\boldsymbol{CT_{1+2+3} = -2 - 2 - 2 + 1 + 1 + 1 = -3}$
- **<u>(Not Offer)</u>**
  - $\boldsymbol{CT_{1+2+3} = -2 + 2 + 1 - 1 + 1 + .5 = 1.5}$

Works Cited

Adachi, Paul J. C., and Teena Willoughby. “More Than Just Fun and Games: The Longitudinal Relationships Between Strategic Video Games, Self-Reported Problem Solving Skills, and Academic Grades.” *Journal of Youth and Adolescence* 42, no. 7 (July 2013): 1041–52. https://doi.org/10.1007/s10964-013-9913-9.

Burguillo, Juan. (2010). Using game theory and Competition-based Learning to stimulate student motivation and performance. Computers & Education. 55. 566-575. 10.1016/j.compedu.2010.02.018.

Burke, Brian. *Gamify : How Gamification Motivates People to Do Extraordinary Things*. Brookline, MA: Bibliomotion, Books + media, 2014. Print.

Christle, Christine A., Kristine Jolivette, and C. M. Nelson. "School Characteristics Related to High School Dropout Rates: RASE RASE TL & LD." *Remedial and Special Education* 28.6 (2007): 325-39. *ProQuest.* Web. 12 May 2020.

Dicheva, Darina, Christo Dichev, Gennady Agre, and Galia Angelova. “Gamification in Education: A Systematic Mapping Study,” n.d., 14.

Dixit, Avinash K., et al. Games of Strategy (Third Edition). W. W. Norton & Company., 2009.

“Every Student Succeeds Act (ESSA) | U.S. Department of Education.” Accessed October 16, 2019. https://www.ed.gov/essa.

Jia, Yuane, Timothy R. Konold, and Dewey Cornell. "Authoritative School Climate and High School Dropout Rates." *School Psychology Quarterly* 31.2 (2016): 289-303. *ProQuest.* Web. 12 May 2020.

Krcmar, Marina, Rory McGloin, Kirstie M. Farrar, and Shu Scott Li. "'What Is My Call of Duty?': Exploring the Importance of Player Experience in a First-Person Shooter Video Game." *Journal of Gaming & Virtual Worlds* 10, no. 2 (June 1, 2018): 167–87. https://doi.org/10.1386/jgvw.10.2.167_1.

National Center for Education Statistics. (2014). Digest of education statistics. Retrieved from https:// nces.ed.gov/programs/digest/d14/tables/dt14_ 219.70.asp

NCES. "School Enrollment in The United States from 1965 to 2016 for All Levels of Public and Private Schools, with Projections up to 2028 (in 1,000s)." *Statista*, Statista Inc., 31 Mar 2019, https://www.statista.com/statistics/183826/us-school-enrollment-for-all-levels-of-public-and-private-schools/

Paige, David D. "Engaging Struggling Adolescent Readers Through Situational Interest: A Model Proposing the Relationships Among Extrinsic Motivation, Oral Reading Proficiency, Comprehension, and Academic Achievement." *Reading Psychology* 32, no. 5 (September 2011): 395–425. https://doi.org/10.1080/02702711.2010.495633.

Shute, Valerie J., and Robert Torres. "Where streams converge: Using evidence-centered design to assess Quest to Learn." *Technology-based assessments for 21st century skills: Theoretical and practical implications from modern research* 91124 (2012).

Swing, E. L., D. A. Gentile, C. A. Anderson, and D. A. Walsh. "Television and Video Game Exposure and the Development of Attention Problems." *PEDIATRICS* 126, no. 2 (August 1, 2010): 214–21. https://doi.org/10.1542/peds.2009-1508.