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VIDEO GAMES AS LEARNING TOOLS

Dissertation within the scope of the Master Degree in Design and Multimedia, with guidance provided by professor Rui Alexandre Neves Craveirinha and Nuno Miguel Cabral Carreira Coelho and presented to the Faculty of Science and Technology of the University of Coimbra.

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Video games as learning tools (Part I)

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Index

Abstract

This dissertation aims to target some of the issues that the modern education systems in most of the world have when catering to a technologically advanced and ever-evolving generation of students.

To accomplish this, I will look to analyze the current state of the educational system and how it can be improved using video games, while the second part will be dedicated to the development of a video game designed to be utilized in classrooms as a tool to teach plant biology to students enrolled in the eighth grade under the Portuguese educational system.

Keywords

Video games, Society, Learning, Training

1| Introduction

Games have power. Games have the power to teach, train and educate. Games have the power to bring people together. Games have the power to reveal and build character. They have the power to heal and promote health. On the other hand, they also have the power to deceive, bankrupt and seduce. (D. MICHEL AND S. CHEN, 2008)

Most people have played games since childhood. In preschool and kindergarten, children are taught games as a socializing activity and to prepare them for organized learning. Some of these games are taught by peers, at camps, and birthday parties, and others are taught by teachers inside the classroom.

Games like *Poker*, *Canastra* and even the *Broken Telephone* bring people of all ages together not only increasing socialization skills but even teaching about the complexities of communication and human psychology. (D. MICHEL AND S. CHEN, 2008)

Video games, even if not as old, have been around for decades. In 1962, MIT student Steve Russell creates *Spacewar!*, the first computer-based video game and over the following decade, the game spreads to computers across the country, soon followed by the 70's and the start of a whole new culture. With the popularization of arcades and personal video game consoles, we have witnessed this medium grow through the years and are starting to realize the potential it has.

In the United States, a person that plays video games regularly from the point they start attending school up until graduating high school will, on average, spend around 10,000 hours playing video games. During this time, with perfect school attendance, this same person would have spent roughly 10,080 hours inside a classroom. There is an education system at work in parallel to school that is making people who play regularly good at something. Directing this motivation towards real world problems would provide us with an unprecedented human resource. (JANE MCGONIGAL. *TED TALK: VIDEO GAMES FOR A BETTER FUTURE*, 2010)

Somewhere along the video game life timeline, academics like Ian Bogost, Paul Gee and many others saw value in video games that was beyond simply entertaining an audience which lead to the expansion of the industry, creating things like teaching tools for children, simulations for professional training and even games with the purpose of persuading or sending a message about something.

Polemic Games aims to demystify the popular idea that games can be used exclusively as an entertainment medium by exploring a particular type of video games that can easily pass unnoticed. This dissertation will also focus on aspects such as the current state of modern education and its advantages and disadvantages, the benefits that video games provide and how these can be utilized to improve the traditional methods of teaching in the sense of making them more suited for an ever-evolving, technology proficient generation of students.

Throughout this dissertation, the main focus will be to explore the lesser known side of the video game industry in an attempt to highlight the potential contribution it could offer society with focus on education through the analysis of a collection of research and data on the subject, the current role of video games as teaching tools and subsequent use of said analysis as a foundation to develop a prototype that could be effectively utilized for such ends.

2| Objectives

The main goal of this dissertation will be to analyze the side of the video game industry that focuses less on the entertainment component and more on transmitting some sort of tangible message or knowledge to the players, utilizing the results to create a video game that can ultimately be used to teach basic concepts about a topic to a specific target audience.

The game will be designed with the intent of being used as a tool to aid traditional education in the subject of plant biology through a core experience that can be defined as a resource management game. It will be aimed primarily, but not exclusively at Portuguese eighth grade students.

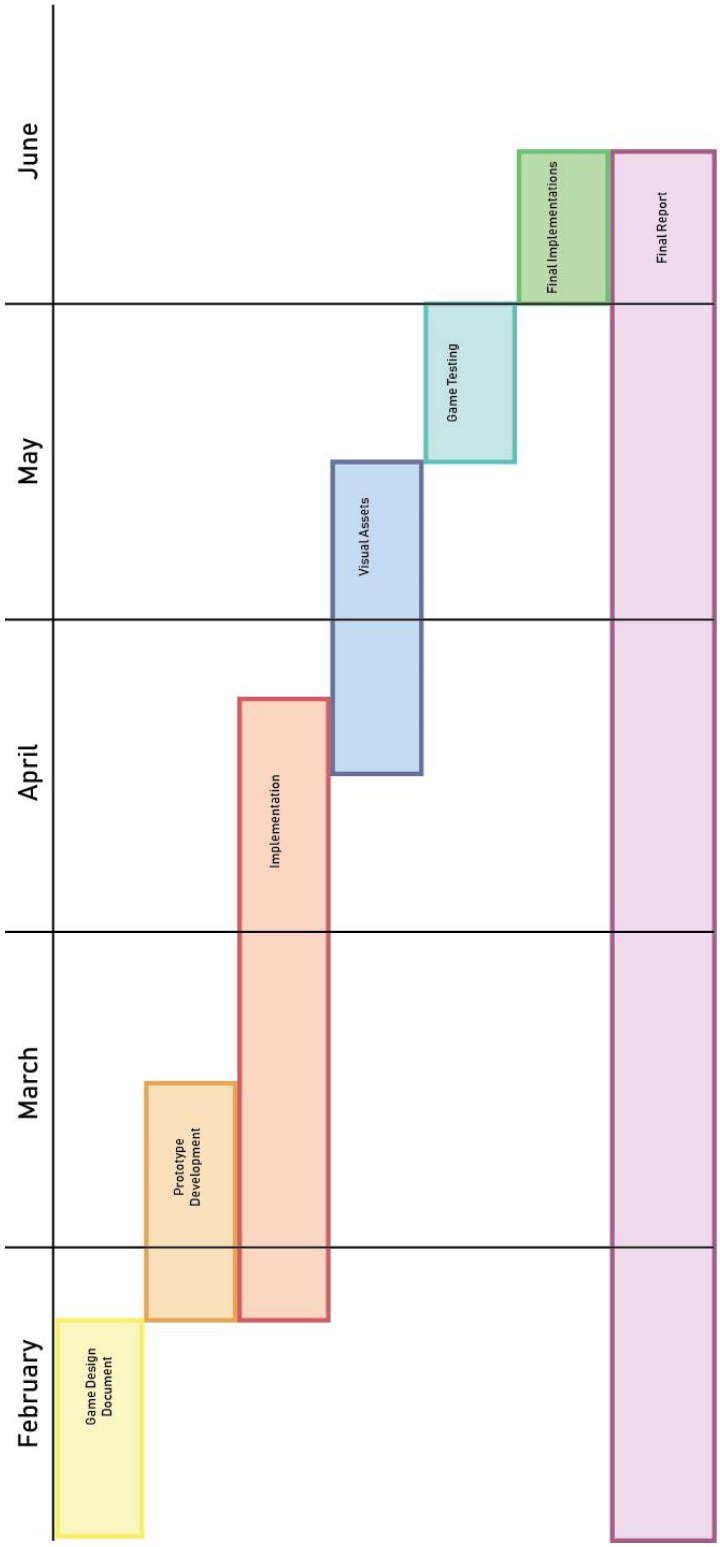
3 | Methodology

Throughout the development time of this dissertation, the aim is to reach certain objectives:

- Investigate how the modern education system works for most students through research about education and learning theory.
    - How does the current educational system work;
    - How can it be improved with regards to the current generation of students;
    - How can video games be used to achieve this;
- Analyze the current state of the industry regarding video game production for education and training. (Educational games and serious games)
    - How do educational games work;
    - How they can be better utilized for teaching in schools;
- Design and develop an entertaining video game prototype that can teach plant biology.
    - Achieving a balance between learning and having fun;
- Test the prototype with subjects belonging to the target audience.
- Iterate the design based on player feedback.

3.1 | Project Planning

Table 1 - Schedule



4 | Motivation

As someone that very recently experienced how the modern education system works from a student's perspective, I found myself having a hard time motivating myself to learn specific subjects under the provided curriculum. Everything that a student is required to learn in school nowadays, albeit mathematics, chemistry or history, is important in some way or another for the growing process of a future member of society, but different personalities, home educations and interests have put not only myself but many other students in a position where we were "forced" to learn something that did not resonate with us.

After many years of playing games and a few making them, I started thinking if there was an effective way to connect something I loved to education, a very important part or my process of self-growth.

When presented with "educational games" as a child and young teenager, I regarded most of them as interactive lessons when they were unable to keep me motivated like other "traditional" games did. I started thinking about how everything I know about renaissance Italy (which is not a lot, but it is something) was from playing some of the first *Assassin's Creed* games, and about world history came from playing *Civilization* games when I was younger. These games taught me something without even trying because they were fun and engaging.

With this in mind, imagine how powerful a game could be if it was actually trying to teach the player something while remaining engaging at the same time? Video games can be a vessel for transmitting knowledge alongside traditional methods by being more appealing and accessible to students that find it hard to learn in the current education system. Having more methods of teaching means that teachers are able to more efficiently educate a broader group of students.

This is the challenge I have set for myself with this dissertation, in an attempt to make the process of learning from school a little more enjoyable for the digital native generation that I am a part of.

5 | State of the Art

5.1 | Education

Children are taught from a young age all sorts of games to enable socialization and further organized learning. Thanks to their simple rules and requirements, games like *Musical Chairs* or *Hide and Seek* are played everywhere by people of all ages. (D. MICHEL AND S. CHEN, 2008)

Plato drew the connection between *play* and *education*, recommending the use of games for the education of children. For young adult students he saw philosophical discourse as a form of educational game. This leads to the developed notion of hypothetical questions, thought experiments and philosophical games as a way to examine opposing viewpoints, leading Plato's students to be able to see both sides of an issue so that they could work on it well and fairly. (PLATO. *THE REPUBLIC*, 2000)

Military officers have used games like Chaturanga, Chess, Go and Chinese Chess to teach strategy and combat tactics for over a thousand years.

Behaviorism and Constructivism

When it comes to learning as a whole, many have attempted to theorize how it works on a biological and psychological level. For the purposes of this work, the focus will turn to the ones more relevant to both video games as learning tools and the traditional classroom philosophy: *Behavioristic* and *Constructivist* theories. (I. BOGOST, 2007)

In a short and over-simplified way, Behaviorism focuses on observable behavior while disregarding any activities of the mind, learning through understanding an already defined set of rules that are set as absolute and ultimately true. Following this train of thought, knowledge is acquired through reinforcement of positive and negative feedback. Something is either right or wrong, producing different responses which are followed by different feedback. (J. B. WATSON, 1913) A massive portion of modern education systems fall under this category through the classic classroom method of teaching: a student is expected to demonstrate he has understood whatever knowledge he has acquired, with the source of direct feedback being the teacher who is going to either reward (positive feedback) "good behavior" or punish "bad behavior" (negative feedback).

On the other hand, Constructionism supports the idea of learning through doing, that there is no concrete knowledge in the world and the mind subjectively creates it through experiencing things and reflecting on them. To do this, the learner must reconcile something new with previously acquired knowledge by asking questions, exploring and assessing what they know. Constructivist teachers tend to encourage students to constantly question how the activity is helping them gain understanding on a matter, leading to, ideally, creating "expert learners". (J. D. RASKIN, 2002)

Regarding the behaviorist approach to video games:

> *If behaviorism relies on an empirical, scientific worldview - that of a singular, knowable universe of concepts – then a behaviorist model of educational video games transfers that universe onto the game world. (…) In doing so, video games simulate the actual dynamics of the material world, and playing such games has the same effect as would real learning in the material world. (I. Bogost, 2007)*

This leads to video games being categorized into positive and negative feedback. Since most video games reinforce their content through gameplay, the player is going to respond with different behaviors. If the behavior encouraged by a game is regarded as correspondent to what a normal educator would positively reinforce in the material world, then the game has practical value. However, if that is not the case and the behavior corresponds with something that would normally be negatively reinforced, then the game is perceived as dangerous and undesirable. (I. BOGOST, 2007)

The biggest example of a video game that suffered massive behaviorist media backlash is the *Grand Theft Auto* series. The similarities between the environment presented in-game and the material world are very obvious and "realistic", which makes just as easy to pair them together psychologically. If the player is rewarded for behavior that he would be punished for in real life should they try to mimic it, then this positive feedback might translate into real world behavior.

The behaviorist view is problematic for numerous reasons. Through it, we could view video games that positively encourage negative incentives can only be damaging, never beneficial. But playing a role in a video game does not automatically imply validation for the behavior the game models. It ascribes a singular, rationalist approach upon the content of video games. (I. BOGOST, 2007)

> *Even though the player of a game might carry out the actions of the criminal, or the ninja, or the humanitarian, he does not necessarily endorse, reject, or adopt them outside of the game. (I. Bogost, 2007)*

However, as behaviorists have documented, the kinds of intermittent reinforcement schedules that are doled out to video game players are the most effective for training new behaviors. Being immersed in these gaming environments teaches players an essential basic lesson: persistence in the face of failure reaps valued rewards. (I. GRANIC, A. LOBEL AND R. C. M. E. ENGELS, 2014) (S. B. KENDALL, 1974)

The other side of this issue rests on the constructivist-influenced approach to video games. Video games teach abstract principles that service general problem-solving skills and learning values. *Microsoft Flight Simulator* is an excellent example of learning through experimentation. By placing the player in an environment extremely similar to what a real plane cockpit might be like, they might be encouraged to try different approaches to the problem while at the same time learn the ins and outs of flying a plane within the risk-free environment that is a simulator without fear of incompetence or incomplete mastery. (I. BOGOST, 2007)

In 2005, James Paul Gee argued that a game like *Ninja Gaiden* that uses a system where a player is faced with increasingly more difficult challenges allows the player to come up with solutions later. By slowly demonstrating to the player which tools he has available to him, they are later incentivized to turn skills into strategies. Gee also argues that the RTS game *Rise of Nations* encourages players to think in terms of relationships instead of isolated events or facts, allowing the player to abstractly look at a problem and, subsequently, creatively come up with a solution for each problem without the restrictions of a behaviorist classroom. Players start viewing the game as a system and not a set of discrete skills. However, a constructivist view on video games risks total divestiture of the specificity of a particular video game in favor of the general, abstract principles it embodies. (I. BOGOST, 2007)

What a constructivist approach can easily fail to provide is a sort of specialization. By providing problems in such a way that they must be solved by malleably adapting to them can produce less optimal and more "generic" solutions, resulting in a learner that is good at solving lots of different problems, but not great at solving anything.

Rhetoric in video games

Rhetoric is defined by "the art of effective or persuasive communication". (Oxford Dictionary)

However badly connotated the word might be nowadays, often associated with the expression "empty rhetoric" as a way to describe an elaborate and well-crafted speech that is devoid of any actual meaning, rhetorical practice is an effective way to transmit a message or idea to a specific audience. Kenneth Burke argues that rhetoric is the predecessor of the need to identify with others. He extends rhetoric beyond persuasion, instead suggesting "identification" as a key term for the practice. He also argues that people use symbolic systems to reach this identity. Burke expands the meaning of rhetoric beyond the traditional speech and writing by including nonverbal domains when realizing humans are creators and consumers of symbolic systems. This expansion of the concept allows video games to be viewed as vessels for rhetoric. (K. BURKE, 1950)

Regarding a broader view of rhetoric as a concept, Bogost suggests the name *procedural rhetoric* for the practice of using processes persuasively, just as verbal rhetoric is the practice of using oratory persuasively and visual rhetoric is the practice of using images persuasively. Procedural rhetoric is a general name for the practice of authoring arguments through processes. Its arguments are made not through the construction of words or images, but through the authorship of rules of behavior, the construction of dynamic models. (I. BOGOST, 2008)

(…) video games do not simply distract or entertain with empty, meaningless content. Rather, video games can make claims about the world. But when they do so, they do it not with oral speech, nor in writing, nor even with images. (…) video games make argument with processes. (I. Bogost, 2008)

Through processes, games can make arguments about how things do or do not work. Any game that tries to emulate a realistic scenario as closely as possible can be argued to possess the power to make these arguments.

An example of rhetoric through process exists in the form of *The McDonald's Video game* by Italian art collective *Molleindustria*. This artifact puts the player in charge of several different branches that together form the fast-food titan that is McDonald's, from tending to livestock to arranging business meetings and even management of an actual restaurant. Through playing the game, the player is forced to make difficult, morally ambiguous choices for the good of the company. With this experience, the player learns about the necessary evils that are part of running a business in the fast-food industry. This particular title was made with the intention of clarifying some of the more questionable business practices not only McDonald's but other large corporations have. Players learn to "read" this argument in the system of play and can interpret the relevance of the argument in the context of their own lives. (I. BOGOST, 2008)

Another example is *America's Army: Operations*, a U.S. Army released, government funded first-person shooter game that was conceived and openly publicized as an Army recruiting and communications tool, designed to recreate the life of a member of the U.S. Army for the benefit of young American citizens. While this game shares a lot of similarities with others within the genre, the desire to offer a realistic look at the life of a soldier meant eliminating many of the conventions of movement in both conventional and tactical first-person shooter games: by enforcing the strict Rules of Engagement directly from the army's books onto the player, it created a whole different experience and message. If the player decides to play this game like any other shooter, they will quickly find themselves in a prison for lack of discipline, which can even lead to the player being eliminated from the game and required to create a new ID. The direct mapping of in-game behavior to the very ability to continue playing serves as a convincing procedural rhetoric for the chain of command, the most important portion of structure a new recruit should understand immediately. (I. BOGOST, 2008)

> *(…) make arguments about how social or cultural systems work in the world—or how they could work, or don't work. (I. Bogost, 2008)*

According to Bogost, video games are models of real and imagined systems and, when we play them, we can interpret the arguments they make and consider their place in our lives. In this way, playing video games is a kind of literacy, but instead of helping us read books or write articles it helps us critique the systems we live in. Like previously mentioned, the procedural rhetoric provided by this video game literacy can be a powerful ally to the more traditional methods of teaching.

> *(…) once we understand video games as procedural representations that make arguments about systems in the world, they resemble creative artifacts as much as—and perhaps more so—than they do pedagogical tools. Educators should consider adopting video games as artifacts to be discussed alongside traditional media in subjects like literature, language arts, history, and art, teaching game playing as an argumentative and expressive practice alongside reading, writing, and debating. (I. Bogost, 2008)*

5.2 | Video games beyond entertainment

Video games as a complement to education

> *School teaches basic skills. (…) School teaches test-taking behavior. And school teaches about authority: teachers know more and have more power; students have no power. Students' ability to express agency is limited to "petty transgressions" or "achievements of excellence" within the structure provided by the school. (B. Laurel, 2004)*

The education system for most of the world has been unchanged for decades: groups of students are supposed to learn from a teacher, someone who has superior knowledge on the matter, by either listening or mimicking what they say or do.

Traditionally, this method has been supported by syllabuses constructed by professionals on the matter.

Books are a fantastic tool to preserve and transmit knowledge, but throughout the last few years we started teaching a young generation that is very attached to the digital world, making them less and less effective at transmitting knowledge.

In 1997 Don Tapscott, a specialist on the application of technology in society, published *Growing up Digital: The Rise of the Net Generation*, commenting on the impact of the new digital generation that was, at the time, on the rise. He argued that:

> *The New Generation is exceptionally curious, self-reliant, contrarian, smart, focused, able to adapt, high in self-esteem, and has a global orientation...there has been a change in the way children gather, accept and retain information. (D. Tapscott, 2000)*

With this, Tapscott concludes that this new generation of technologically advanced students would soon transform traditional forms of teaching and learning. With society overtaken by new technologies, traditional teaching methods should start adapting to a new generation not by getting replaced, but by working alongside these new technologies by using them to complement themselves. (D. TAPSCOTT, 2000)

This is where the implementation of video games into the education system comes in. They offer a different approach to learning that better panders to the needs of the current, technology driven youth.

Digital Natives are used to receiving information really fast. They like to parallel process and multi-task. (…) They thrive on instant gratification and frequent rewards. They prefer games to "serious" work. (M. Prensky, 2001)

These are characteristics prominent in what is considered "good" game design nowadays, making them the perfect solution for the issue at hand. Video games are also naturally built around several learning principles we have been guiding ourselves by for years. According to Gee, video games can improve on education in the following axes: Identity, Interaction, Production, Risk Taking, Customization, Challenge and Consolidation and Agency. (J. P. GEE, 2008)

Any learning experience requires commitment from the student. They must learn to embrace a new **identity** by valuing the world regarding the new knowledge they are acquiring. Video games capture players through just that, either by allowing them to embody an appealing character (like Kratos from *God of War*) or giving them the tools to create their own (like the *Elder Scrolls* series). The identity of doing science or building something follows the same rules, so why should it be less appealing?

Video games are, quite literally, **interaction**. Without it, it's not really a game, since it doesn't do anything until the player does something with or to it. This covers the biggest weakness the book has, like mentioned before, since the lack of response tends to make it less appealing for the current, technology driven generation. By constantly providing the player with feedback and new problems to solve, a video game keeps the user engaged. In any teaching environment, books need to be complemented with something that will interact with the student.

In many games, players are also responsible for a portion of its building process, **producing** part of the game. The player is not just a "reader", but also a "writer", in a way. Open-ended games like *World of Warcraft*, where millions of players create their own separate stories or games with stage-building tools like *Track Mania Nations* are great examples of this. Allowing players to contribute to the experience can greatly enhance its effectiveness in ways a strict, pre-defined course cannot.

Being a virtual world, good video games lower the consequences of failure. If you do fail, the game just sends you to the nearest checkpoint, leading the player to try new things, explore and **take risks**. In most education systems nowadays, students are given very little room for taking risks, with failure bearing such harsh consequences.

Players can always, in one way or another, **customize** their experience by tweaking the game to their liking. Games often have different settings and difficulty levels in order to pander to a wider range of people. Since curricula are made the same for everyone, it doesn't cater for specific needs or nuances of students. In the words of Albert Einstein, *"If you judge a fish by its ability to climb a tree, it will live its whole life believing it is stupid."*

Games often offer players a set of **challenging** problems for them to solve over and over again until the solution is routinized and automated through repetition (with variance). Every once in a while, the game will throw the player a new, more complex challenge to force them to think of a new strategy and **consolidate** this new knowledge with the one that they previously acquired, only to be challenged again later. Bereiter and Scardamalia call this the *"Cycle of Expertise"*: the way anyone becomes an expert at anything. Good games are meant to be "pleasantly frustrating" by staying within the range of competence and skill of the player, albeit at the outer edge. That is, the player is always able to progress while being constantly challenged, offering a highly motivating state for learners. A worrisome number of students nowadays are faced with challenges that are out of their level of "expertise" on a matter. School is often too easy for some students and too hard for others, even in the same classroom.

Thanks to all the referred principles, players are given a real sense of **agency** and **control**, they sense ownership over what they are doing through interacting, customizing, creating and being challenged and stimulated. Such a feeling is very rare in schools.

Looking back at all this, we realize that people actually pay money to solve long, difficult and complex virtual problems through playing good video games, while this is not the case with the long, difficult and complex problem of studying in school. (J. P. GEE, 2011)

In summary, game designers convince the player to learn how to play the game by making it fun.

Games are effective at teaching and training students of all ages and in many situations because they are highly motivating, and because they communicate very efficiently the concepts and facts of many subjects. Games allow the player to assume realistic roles, face problems, formulate strategies, make decisions and get fast feedback on the consequences of their actions, all without the cost of real world consequences or errors. (CLARK C. ABT, 1987)

5.3 | Benefits of playing video games

Cognitive Benefits

Playing video games promotes a wide range of cognitive skills. This is particularly true for action video games, many of which are violent in nature. A meta-analysis by researchers from Northwestern University and Temple University, on training studies with subjects possessing very little familiarity with action games, concluded that the spatial skills improvements derived from playing commercially available shooter video games are comparable to the effects of a formal course aimed at enhancing these same skills. Furthermore, this meta-analysis showed that spatial skills can be trained with video games in a relatively brief period, that these training benefits last over an extended period of time and that these skills transfer to other spatial tasks outside the video game context. (I. GRANIC, A. LOBEL AND R. C. M. E. ENGELS, 2014) (D. H. UTTAL, N. G. MEADOW, E. TIPTON, LINDA L. HAND, ALISON R. ALDEN AND C. WARREN, 2012) These training studies have critical implications for education and career development. (I. GRANIC, A. LOBEL AND R. C. M. E. ENGELS, 2014)

Preliminary research has also demonstrated that these cognitive advantages manifest in measurable changes in neural processing and efficiency. A study on magnetic resonance imaging by neuroscientists found that the mechanisms that control attention allocation were less active during a challenging pattern-detection task in subjects that regularly played video games than in those that didn't, leading the researchers to suggest that action game players allocate their attentional resources more efficiently and filter out irrelevant information more effectively. (I. GRANIC, A. LOBEL AND R. C. M. E. ENGELS, 2014) (D. BAVELIER, R.L. ACHTMAN, M. MANI AND J. FÖCKER, 2012)

Video games are controlled training regimens delivered in highly motivating behavioral contexts (…) because behavioral changes arise from brain changes, it is also no surprise that performance improvements are paralleled by enduring physical and functional neurological remodeling. (D. Bavelier, 2011)

These changes in neural functioning may be one means by which the cognitive skills gained through video games generalize to contexts outside of games.

However, not all video game genres have documented cognitive performance benefits. The most robust effects on cognitive performance come from playing action video games and not from, for example, puzzle or role-playing games. (C. S. GREEN, D. BAVELIER, 2012). These cognitive enhancements are likely a product of the visually rich three-dimensional navigational spaces and fast-paced demands that require split-second decision making and acute attention to unpredictable changes in context. (I. GRANIC, A. LOBEL AND R. C. M. E. ENGELS, 2014)

In addition to spatial skills, scholars have also speculated that video games are an excellent means for developing problem-solving skills. (M. PRENSKY, 2012) Problem solving is central to all video game genres. In-game puzzles range in complexity from finding the quickest route to discovering complex action sequences based on memorization and analytical skills. (I. GRANIC, A. LOBEL AND R. C. M. E. ENGELS, 2014)

Exposure to these sorts of games with open-ended problems has influenced a generation of children and adolescents growing up as “digital natives”. Instead of learning through explicit linear instruction, many children and youth problem-solve through trial and error, recursively collecting evidence which they test through experimentation. (M. Prensky, 2001) (I. Granic, A. Lobel and R. C. M. E. Engels, 2014)

Finally, video games are associated with an additional cognitive benefit through enhanced creativity. Playing any kind of video games regardless of genre enhances children’s creative capacities, like shown by a study conducted in 2012 that tested almost 500 12-year-old students. This study found that the more kids played video games, the more creative they were in tasks such as drawing pictures and writing stories. (L. Jackson, 2011) (I. Granic, A. Lobel and R. C. M. E. Engels, 2014)

Motivational Benefits

Video games can promote an effective motivational style both in and outside gaming contexts. Children develop beliefs about their intelligence and abilities, beliefs that underlie specific motivational styles and directly affect achievement. Children who are praised for their traits rather than their efforts develop an entity theory of intelligence, which maintains that intelligence is an innate trait, something that is fixed and cannot be improved. In contrast, children who are praised for their effort develop an incremental theory of intelligence, believing that it is malleable, something that can be cultivated through effort and time. (C. DWECK AND D. MOLDEN, 2005) Video games are an ideal training ground for acquiring an incremental theory of intelligence through providing players concrete and immediate feedback regarding specific efforts players have made. (I. GRANIC, A. LOBEL AND R. C. M. E. ENGELS, 2014)

Immediate and concrete feedback in video games serves to reward continual effort and keep players within a zone that balances optimal levels of challenge and frustration within sufficient experiences of success and accomplishment. (TOPIC EXPANDED ON VIDEO GAMES AS A COMPLEMENT TO EDUCATION, *CHALLENGE*)

These implicit theories of intelligence have implications for how failure is processed and dealt with: If one believes that intelligence or ability is fixed, failure induces feelings of worthlessness, while if intelligence or ability is presumed to be a mark of effortful engagement, failure signals the need to remain engaged and bolster one's efforts. In turn, this positive attitude toward failure predicts better academic performance. (L. BLACKWELL, K. TRZESNIEWSKI, 2007) Notably, video games use failure as motivational tools and provide only intermittent chances for large-scale success.

Although playing games is often perceived as frivolous pastime, gaming environments cultivate a persistent, optimistic motivational style which in turn may generalize to school and work contexts. (I. GRANIC, A. LOBEL AND R. C. M. E. ENGELS, 2014)

5.4 | Serious games

A serious game is a game in which education (in its various forms) is the primary goal, rather than entertainment. (D. Michael and S. Chen, 2006)

To the general population, the term *Serious Game* seems like an oxymoron, combining an adjective one would use to describe something of great importance with entertainment. However, the main goal of a serious game, refuting this oxymoron, is to overlap entertainment and education in a way that each side can use tools from each other to achieve their goals. (D. MICHEL AND S. CHEN, 2008)

Clark C. Abt described serious games as having an "explicit and carefully thought-out educational purpose":

Games may be played seriously or casually. We are concerned with serious games in the sense that these games have an explicit and carefully thought-out educational purpose and are not intended to be played primarily for amusement. This does not mean that serious games are not, or should not be, entertaining. (Clark C. Abt, 1987)

Considering this, a *Serious Game* is, by definition, a game whose primary focus is not to amuse or entertain, but to teach a lesson, deliver a message or provide an experience.

In *America's Army: Operations* (MENTIONED IN RHETORIC IN VIDEO GAMES) developed by the U.S. Army as a recruiting tool, when played by a civilian the game can still be an entertaining experience, even if that is not its main focus and, at the same time, to an enlisted squad leader preparing for a mission, this game may be an important part of his training. Whether or not they find it entertaining, isn't of paramount importance to their superiors as long as it fulfils its purpose: to provide basic insight on rules of engagement and the chain of command.

Image 1 - America's Army: Operations, In-game

Why use serious Games?

Play is the basis for all culture. Law, philosophy, art and other aspect of human culture arise "in the form of play", and even such serious human activities as war bear the formal characteristics of play. (J. HUIZINGA, 1949) Playing can mean to escape from reality and look at it from a different angle. Play can be formal or organized, competitive or cooperative. Play can take us out of our everyday lives and immerse us into an alternate reality which provides a new perspective on otherwise familiar situations, stressing innovation and creativity.

This also applies to education, where the classroom presents the universe in small pieces (Pretend), its success in teaching required the attention of the students (Immersion), it's based on rules, and it's social, grouping students by age and learning ability. As children we learn to play and as we grow up, we play to learn even if the "play" doesn't feel like "play".

In the same manner, all games, video games or otherwise, require enough commitment from the player to learn something, even if only the basic rules of the game. After the basics are solidified, then comes refinement through trying different strategies and ways of increasing the chances to reach the main goal of the game. This is the main point of a serious game: to teach something to its players and, if possible, let them have fun while doing it. Like mentioned in chapter in *Video games as a complement to education*, the new generation of students and trainees has grown up with video games, making them a comfortable and familiar medium.

Since games are a form of expression, be it ideas, information or beliefs, they have potential to be used in any environment where there is someone who has something to teach, a skill to pass on, or a message to preach. (D. MICHEL AND S. CHEN, 2008)

When considering the educational value of other media such as books or movies, it can be observed that those that attempt to teach something to the reader or viewer have a lesser effect. The intended moral or meaning of a story is often ignored when blatantly stated, this effect being much greater when the message is instead woven into the characters, setting and plot-line in an almost incidental and subliminal way. (D. MICHEL AND S. CHEN, 2008)

Serious games have the potential to extend the value of training films and books by allowing the player to not only learn, but also to apply and demonstrate what they have learned through interaction (D. MICHEL AND S. CHEN, 2008) (TOPIC EXPANDED ON VIDEO GAMES AS A COMPLEMENT TO EDUCATION)

> *(…) game designers are not educators and educators are not game designers. The results of one group attempting to operate on their own within the domain of the other are seldom exemplary. However, by combining the skills of game designers with those of educators, serious games can be a force in teaching students of all ages. (D. Michael and S. Chen, 2006)*

5.5 | Importance of fun to serious games

Why do people frenzy over a football match? Why does a gambler lose himself in his passion? This intensity and immersion finds no explanation in biological analysis. However, this very intensity and absorption lies the foundational and essential qualities of play. (J. HUIZINGA, 1949)

If this aspect of play is allied to teaching and learning, it could make for a very powerful tool. If someone is a football fan, they will eventually find themselves knowing player names, numbers and statistics by heart just from casually enjoying the game. They acquire this knowledge naturally, without pursuing it. Making learning in schools exciting and engaging enough that students learn this way can drastically improve their effectiveness. Knowing this, we attempt to combine education with something inherently entertaining.

> *Edutainment is defined by video games, television programs, or other material, intended to be both educational and enjoyable. (Oxford Dictionary)*

The whole point of *edutainment* was to make education entertaining, thereby motivating students to learn on their own. However, the uneven track record of *edutainment*, especially in classroom settings, has made some educators wary and unsure if they trust anything that smacks of fun.

Should a serious game be fun, though? The main argument in favor of instilling fun into serious games is that is helps motivate the players to play and learn on their own. (D. MICHEL AND S. CHEN, 2008)

> *This idea of people motivated to learn on their own explains why simulations aren't just another activity to embed into a workshop. They can literally change the way people learn. If a simulation is fun, the simulation takes on a life of its own. (Michael Bean, 2012)*

A survey of serious game developers, educators and researchers done by David Michael and Sande Chen in 2005 shows that over 80 percent of respondents said that the "element of fun" was either Important or Very Important.

Question: How do you rate the importance of the "element of fun" in serious games?	
Very Important	**33.33%** (21)
Important	**47.62%** (30)
Useful, but not a primary goal	**15.87%** (10)
Less Important	**3.17%** (2)
Not Important	**0.00%** (0)
Survey note: 63 Participants	

Table 2 - Survey Results

From the results, seeing that not a single participant found the element of fun to be completely irrelevant to the development of a serious game, even if the goal of the game is not *entertainment*, fun cannot be totally discounted.

When games are in the day's lesson plan, getting students to play them is as simple as assigning them as work, having them pass or fail according to how they did or didn't do the assignment. This runs into the same problem of the traditional teaching method, where there is no source of motivation for the student. The ideal situation would be to have the students wanting to play the serious game, even on their free time. (D. MICHEL AND S. CHEN, 2008)

Like mentioned earlier in this chapter, it's possible for entertainment to also be educational. The reverse is also true, and "fun" isn't the only form of entertainment, nor the only way to incentivize player interest in a game.

5.6 | Getting players to play

People become motivated to learn on their own when they can relate to what's being taught and see how it affects their lives. Combined with easily customized content, serious games could be created to reflect the specific region, city, school, or place of business where the player resides. People like to see themselves and hear about themselves. When shown their world in the game, a person will want to play. (D. MICHEL AND S. CHEN, 2008)

Picking up on the last sub-chapters topic (Importance of fun to Serious games), making games that are not fun to play does not solve the issue at hand. If a game is simply a traditional class in digital form, most of the time, that will not be enough to really catch a student's full attention. However, if the game presents itself as something "fun" or, at the very least, something that will make students want to play it rather than being assigned to do it, it is much more likely to grab their attention and interest because they made the decision to engage with it. This way, if the player is fully committed to an experience by their own interest in it, they enter a state where acquiring knowledge becomes second nature. They don't even know they are learning, but they are.

6 | Case studies

A selection of serious and educational games was analyzed to achieve a basic understanding of what makes them effective or ineffective. Some were selected for this study because they were specifically made to teach the player about a certain topic, while others seemed relevant for tackling subjects not often portrayed in video games, but doing it in great detail, leading to a learning experience about something that the player might not have known about.

It is also important to point out that due to the limited resources provided for this dissertation, this was a selection made to be as thematically and mechanically varied as possible given the titles that seemed relevant for this particular study.

Democracy 3

Democracy 3 is a game that attempts to emulate the complexity of running a country through a prime-minister role, simplifying it through a system of interconnected icons. The player is expected to manage a country to the best of their ability while facing challenges commonly encountered by people in such roles.

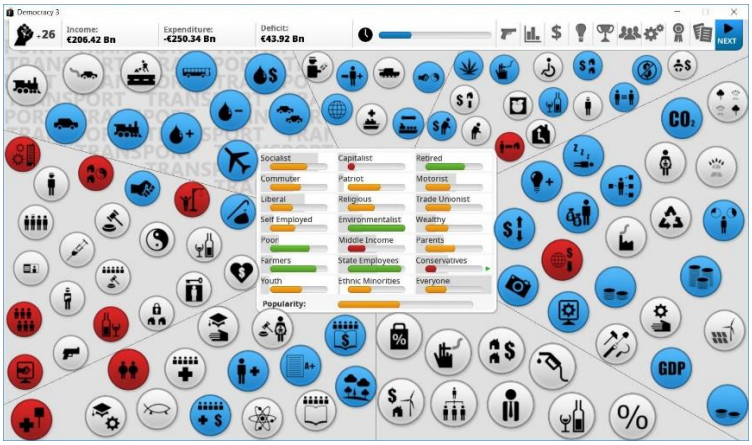


Image 2 - Democracy 3, Overview

This is where the icon system comes into place. The player is presented with a rather large amount of icons that represent different statistics like the GDP, Tourism or Pollution (Blue icons), policies like Tobacco Tax, Armed Police Forces and Road Maintenance (White icons), as well as prejudicial and beneficial situations like a Doctor's Strike, Internet Violence or Technological Advantages (Red and Green icons). These are all organized into different categories like Transport, Economy and Public Services for better navigation. Every icon, being beneficial or prejudicial, is affected by other icons that make it increase or decrease. For example, while Street Gangs and Alcohol Abuse make the Crime rate increase, Community Policing and Education make it decrease.

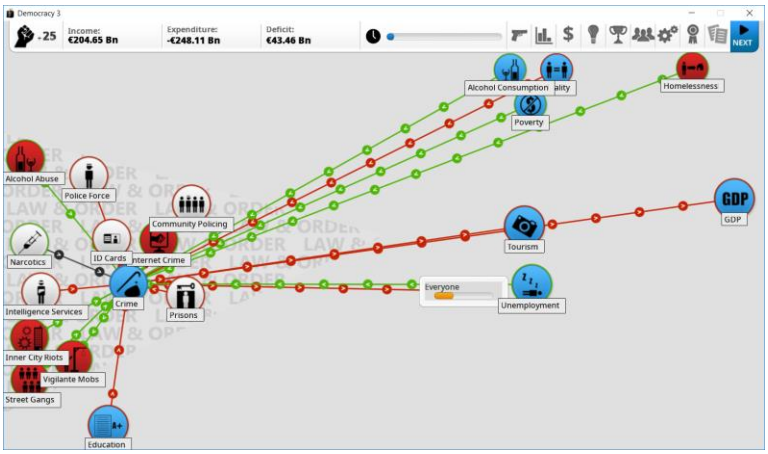


Image 3 - Democracy 3, Links

In the center of the dashboard, the player is presented with an overview of how popular his political party is amongst different voter groups. Every voter fits into one or multiple groups where the player's popularity is positively or negatively affected by statistics and policies.

The player is also given control of a group of ministers, one for each icon group, which grants the player points that can be used to implement, remove, or chance policies. Each turn represents a quarter of a year, and at the end of each one the situation in the country is updated and the player gets more influence points to spend.

Image 4 - Democracy 3, Policies

Although at first glance the game can be overwhelming just by the sheer amount of information, the icon and link system if easy to understand after a few minutes. *Democracy 3* was designed more with teenagers and young adults in mind. It makes an excellent job at representing how being in a position of power demands sacrifice and making difficult decisions. In the tutorial, the first thing the player is told is that it is impossible to make everyone happy, and sometimes things that are often vilified in real life, like income taxes, are necessary to maintain a healthy income to invest in public necessities.

This game aims to clear the mystery behind the questionable decisions that politicians sometimes make in real life, by putting the player in a situation where they have no choice but to implement measures that make people unhappy for the sake of the nation in the long run, while at the same time teaching how two different aspects of society might seem like they are not related at all, only to be indirectly connected through others.

Wolf Quest

Wolf Quest was created to provide insight into the life of gray wolves and the ecology of Yellowstone National Park. The player is asked to customize their own wolf to control and is immediately thrown into the park with a small tutorial to follow.

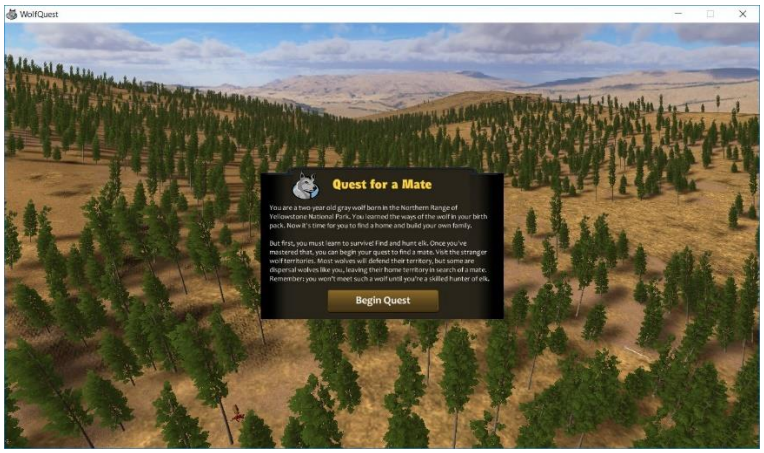


Image 5 - Wolf Quest, Start

The main goal of the game is to find a mate, establish a den and territory and procreate. While aiming for this, the player is able to hunt elk, communicate with other wolves (players or not) and explore the region. Most of the activities available to the player are connected by a mode that is always ready for use that allows the player to see scent. This mode grants the player to understand the importance of scent in the way a wolf perceives the environment.

The player is also presented with a health and stamina bar. Health is lost when injured by other animals or environmental hazards and can be replenished by feeding on prey, while stamina depletes when moving, requiring the player to sit or lay down for rest.

Image 6 - Wolf Quest, In-game

After learning how to properly hunt and finding a suitable mate, the player must tend not only for themselves but also for their pack, with special importance given to infants that cannot hunt on their own.

Although *Wolf Quest* can be very repetitive by forcing the player to hunt the same prey numerous times using the same tactics, as well as long stretches of following scent, making it less engaging as the time goes on, it accurately depicts the cycle of life of a gray wolf in a simulated wild environment, making the player search for food, fight for territory and raise wolf pups.

Lure of the Labyrinth

Lure of the Labyrinth is a free browser game aimed at young math students that puts the player in the role of someone searching for their lost pet. After following it into a sewer system, they learn of a pet food company run by monsters operates there. The player goes undercover doing different jobs for these monsters in order to find their missing friend.

A point-and-click style of gameplay makes the player go from room to room using a map, each with a different math challenge to be complete.

Image 7 - Lure of the Labyrinth, Start

These challenges can range from simple multiplication and division to geometry, all put into a specific context of a job. These instances are all tied together by story development through comic strips.

Image 8 - Lure of the Labyrinth, Narrative

Image 9 - Lure of the Labyrinth, Mini-game

When the player resorts to the map to reach the next challenge, it will always be in the form of a challenge as well, like instead of telling the player to go to room 10, it tells them to move past 3 corridors and then choose the seventh door on that corridor which, when combined with a comic strips, attempts to keep the game from feeling like a collection of math mini-games connected by pointless walking, giving *Lure of the Labyrinth* moments between tasks where the player is reminded that they are playing a game and not taking an interactive class.

Despite this, *Lure of the Labyrinth* seems to still fall into the same category as more traditional digital math games, except it has a narrative attached to it. When looking at math in particular, the key to absorbing knowledge is repetition which, because it has its pace split into pieces by the various walking segments and transitions, falls short of what it was designed to do.

ElectroCity

ElectroCity places the player into the role of mayor of a small town in New Zealand, with management focused on environmental impact. A very simple interface provides the player with all the information they need: Population, happiness, budget, tax rates, resources and environmental impact. The simple mechanics and colorful artwork make this game perfect for teaching young children about the impact that many human activities have on the environment.

The map is represented through a grid, where every cell is filled with a different type of terrain. Depending on said terrain, the player is able to perform different actions. For example, the player can build windfarms on hills, farmland on plains or even cut down forests. Every action costs money and impacts the environment in different ways.

Image 10 - ElectroCity, Overview

The main goal of the game is to expand the city as much as possible by generating wealth and making the population grow. The player's actions will also have an impact on how the population feels about living in their town. One of the keys for success in *ElectroCity* is being able to balance the tax rates. If they are too low, there is not enough money to efficiently expand, but if they are too high, population happiness will plummet, making people leave the town.

Image 11 - ElectroCity, Improvements

Overall, this game plays like a simpler, more accessible version of *Democracy 3*, focusing on running only a small town instead of a whole country, which allows the player to focus on only a few variables at a time. It sends a clear message about basic tax economy and environmental management to the player in short play-sessions, which makes it ideal for classroom use. It was built specifically for students between grades 7 and 9 and teachers, with an easily accessible and manageable premise.

By combining simples but engaging mechanics with vibrant and clean art, *ElectroCity* succeeds in drawing attention to itself and then keeping it. After playing it, the player can easily realize that they learned something new about the environmental impact of a specific structure, how it worked or how taxes work within a very simplified scope. It succeeds in teaching something, without the player realizing it.

Parable of the Polygons

Parable of the Polygons is a simple browser game designed with the intent to represent how actions that might seem harmless can make a harmful world.

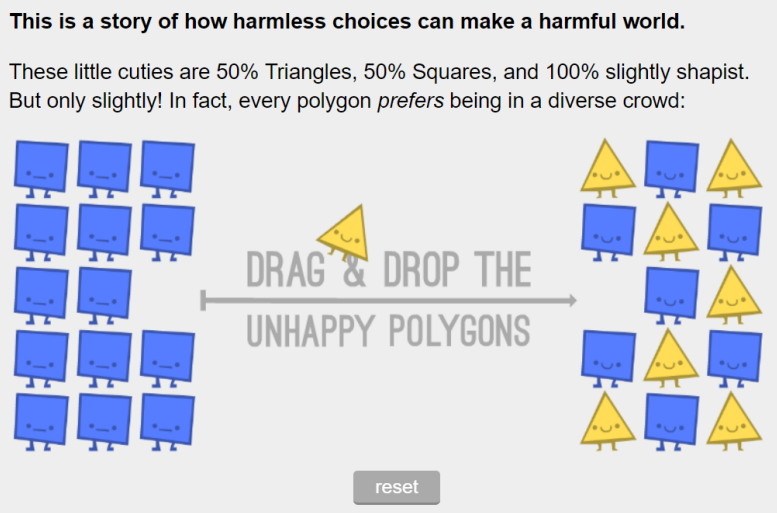


Image 12 - Parable of the Polygons, Premise

Laid down on a grid are yellow triangles and blue squares. They are unhappy when completely surrounded by members of the opposite shape, indifferent when surrounded by the same individuals as them, and happy when in the middle of a diverse crowd. The goal of the game is to move unhappy individuals around the grid until no one is unhappy.

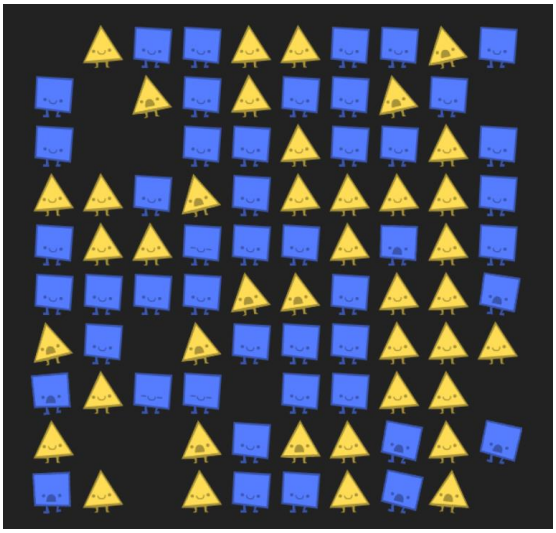


Image 13 - Parable of the Polygons, Segregation

After successfully rearranging the board and making every individual satisfied, it is very obvious that the population becomes segregated. This point is enhanced further by a simulation included in the games website that makes unhappy individuals move in the board until everyone is satisfied, producing a segregation value.

The shapes are intended to act as a metaphor for humanity's discrimination issues that lead to the separation of whole communities through mass segregation. It is also highlighted that because there was a bias at

one point, people are currently born into segregation, so even if there is no bias, cultures still do not get mixed up.

Having no bias is not enough to end segregation nowadays. If people look for just a little diversity in their communities, the amount of repetition decreases dramatically. All it takes is a change in the perception of what an acceptable environment looks like.

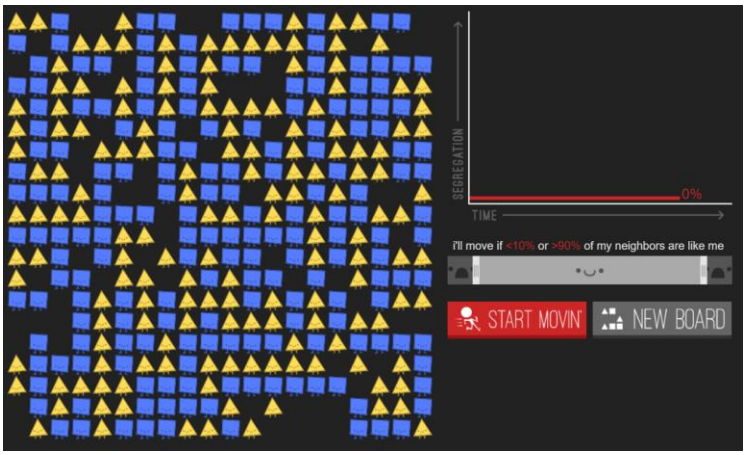


Image 14 - Parable of the Polygons, Overview

In conclusion, *Parable of the Polygons* was designed not necessarily to teach something, but to send a message. Through making the player experience the problems of discrimination through direct interaction, the game manages to much more clearly and effectively make its point across. When experiencing something directly and taking time with it, it is easier to come to an understanding of it than simply reading or hearing about it once.

Overall Analysis

Looking back at these five case studies, we can conclude they are all educational in one way or another:

- ***Democracy 3*** was not designed with the immediate purpose of teaching about the inner-workings of managing a country through politics, but the simplification of otherwise complex systems paired with a good level of attention to detail provides a wholesome, fun and educational experience that offers most players something new, even if it is just a small detail about how a certain component works.

- ***Wolf Quest*** was designed to show how a wolf lives inside a natural reserve and puts the player in direct control of a specimen, presenting them with the same choices and obstacles this particular species lives with. By doing this, the designers manage to more effectively explain how wolves live not by directly telling them what happens, but by presenting the necessary tools to the player and allowing them to discover and solve different situations on their own, much like a real-life wolf would.

- ***Lure of the Labyrinth*** is a more traditional educational game with a few twists. It takes a similar approach to more traditional math games with simple number games for children. However, I don't believe it is enough to simply combine regular mathematics with a narrative and colorful artwork in order to make it more interesting. Mathematics is best learned through practice and repetition but the addition of mini-games and a narrative to a regular math class only splits the repetition, not adding anything that makes the repetitiveness itself more enjoyable.

- ***ElectroCity*** was designed to reinforce very basic concepts for a younger audience and achieved it by expertly utilizing simple mechanics and an appealing visual style to spread awareness about more complex issues in the hope of making the player interested in them. By designing the game towards children, the designers aimed to shed some light on issues such as tax management and the environmental struggles of resource extraction in a simple and understandable way and, because the game was designed to be played in classrooms along with a teacher, making the player ask questions.

- ***Parable of the Polygons*** aims not to necessarily teach about a certain topic, but rather to send a message. It tackles the issue of discrimination in a way that, instead of just telling the player about the problem, it creates a situation where the player is able to see it unfold as a result of their own actions. This way, the message has a much more powerful impact because the player feels directly involved with it.

Taking this into consideration, when considering the design for a game to be used in schools, the level of complexity and presentation is key. The game, even if it is built with the purpose of teaching, should not do so forcefully, but rather by weaving its fundamental message into the game mechanics seamlessly in such a way that the player is learning while still having fun. It does not matter how important the message or teachings of the game are if the player takes no interest in learning it.

7 | Initial Game Concept

Overview

The goal of this game is to teach basic concepts about plant biology to students enrolled in the eighth grade in Portugal. This particular demographic was chosen due to its integrands being old enough to understand and work with semi-complex game mechanics and not old enough to the point where they might find the topic disinteresting. The game will also approach multiple topics that are currently part of the eighth grade's biology curriculum in Portugal. Other arguments are weaved indirectly into the game through secondary mechanics and premise:

- Humanity's global impact on the environment;
- Different crops, trees and hops have different biological needs;
- Resource and space management;
- Basic microeconomics: Supply and Demand.

Development will focus on personal computers with minimal hardware requirements.

Story

Earth's natural resources are compromised due to decades of environmental negligence by humanity. This leads to a space station being launched with the purpose of recreating conditions previously present on Earth in order to regrow and repopulate ecosystems.

The player takes on the role of an astronaut working at this station, receiving intel from Earth on what needs to be more urgently produced. Different crops or trees require different conditions and structures to grow, and as time passes the player must adapt the space station to cater to Earth's different needs. By producing and sending products back to Earth, it will impact its economy by influencing offer and demand.

Goal

The goal of the game is to rebuild Earth's natural ecosystems in the shortest time possible.

Mechanics

At its core, this is a resource management game. The player is presented with an isometric grid where different plants can be grown. The player has access to unlimited materials to plant and build structures with, so the only focus should be on completing the assignments from Earth as efficiently as possible. By planting different things and sending them back to Earth, the player gains progress towards rebuilding Earth's natural ecosystems. There is no losing condition, meaning the player's performance will be solely based on how fast they can achieve a full rebuild.

Planting

Different plants and crops have different needs in order to grow healthily: While a cactus can be grown in low humidity, a cabbage will thrive on moist and fertile soil. The player will be able to change a tile's composition in order to cater to what he pretends to grow there.

Products will take time to grow, varying depending on their type and if they are planted under the right conditions.

Building

Particular structures might be required to grow something. For example, to grow vines the player might be required to build a wooden support structure, a greenhouse to grow strawberries or irrigation systems for vegetables. These buildings will take space in the grid, so optimizing it will a priority for the player.

Buildings take a certain amount of time to build, but the player is allowed to create and destroy them at will in order to cater to different needs.

Economy

As the player sends products back to Earth, humanity's needs are going to change. If Earth tells the player that it needs tomatoes (meaning the value of a tomato is high), the player is meant to plant more tomatoes. As he sends these to Earth, their value will progressively drop until there is more offer than demand and the most sought-after product is something else, encouraging the player to adapt and change his plantation.

When a product reaches the Earth, it has a certain commercial value. This value will directly impact how much progress towards rebuilding the ecosystems that particular product got. The higher the value of the cargo sent, the faster the rebuild.

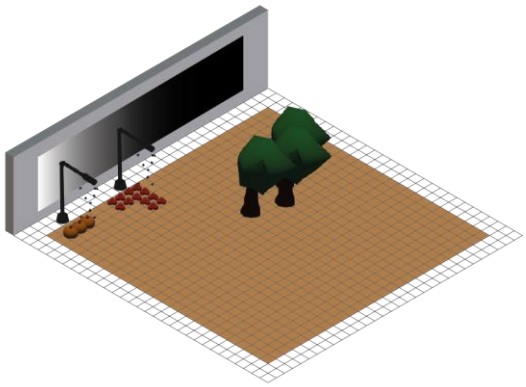


Image 15 - Game Concept, First Sketch

Projeto Fénix:
Game Design Document
(Part II)

September, 2018

9 | Overview

9.1 | Theme, Setting and Genre

The goal of this game is to teach basic concepts about plant biology to students enrolled in the eighth grade in Portugal. This is achieved through placing the player in the role of a crew sent to space on a station tasked with reproducing Earth's conditions in order to rebuild its various ecosystems.

Although the main focus of the project is to teach about plant biology, other arguments are weaved indirectly into the game through secondary mechanics and premise:

1. Humanity's global impact on the environment;
2. Different crops, trees and hops have different biological needs;
3. Resource and space management;
4. Basic microeconomics: Supply and Demand;
5. Basic mathematics: water and hormone placement.

9.2 | Core Gameplay Mechanics

- Planting
- Building
- Economy

9.3 | Target Platforms

- PC

9.4 | Project Scope

Game Time Scale

From the 8th of February to late-August (7 months)

Costs

This project aims to be cost-free.

- Unity (Game Engine)
- Blender (3D Modelling)
- Adobe Illustrator (UI)

9.5 | Core Gameplay Mechanics (Detailed)

At its core, this is a resource management game. The player is presented with an isometric grid where different plants can be grown. The player has access to unlimited materials to plant and build structures with, so the only focus should be on completing the assignments from Earth as Efficiently as possible. By planting different things and sending them back home, the player gains progress towards rebuilding Earth's natural ecosystems. There is no losing condition, meaning the player's performance will be solely based on how fast they can achieve a full rebuild.

Planting

Different plants and crops have different needs in order to grow healthily: While a cactus can be grown in low humidity, a strawberry will thrive on moist and fertile soil. The player will be able to change the composition of the grid's tiles in order to cater to what he pretends to grow there.

Products will take time to grow, varying depending on their type and living conditions.

Building

Particular structures might be required to grow something. For example, a greenhouse to grow strawberries or irrigation systems for vegetables. These buildings will take up space on the grid, so optimizing them should be one of the player's main focuses.

Buildings take a cycle to build, but the player is allowed to create and destroy them at will in order to cater to different needs.

Economy

As the player sends products back to Earth, humanity's needs are going to change. If Earth tells the player that apples are needed (meaning the value of a apples is high), the player is meant to plant more apples. As these are sent to Earth, their value will progressively decrease until there is more offer than demand and the most sought-after product is something else, encouraging the player to adapt and change his plantation.

When a product reaches the Earth, it has a certain commercial value attached to it. This value will directly impact how much progress towards rebuilding the ecosystems that particular shipment had. The higher the value of the cargo sent, the faster the rebuild.

9.6 | In-game controls

Key	Function
TAB (hold)	Options
Space Bar	Advance Cycle
Left Mosue Button	Select/Place
W,A,S,D	Move Camera
P	Plants
B	Structures
I	Hormones
H	Harvest Mode
Numbers 1 to 8	Select Item
R	Rotate Plant/Structure

Table 3 - Controls

10 | Story and Gameplay

9.1 | Story (Brief)

Earth's natural conditions have changed drastically as a result of various human activities. In order to reconstruct these ecosystems and maintain a healthy supply of food and oxygen for humanity, the player is sent to space in order to recreate the conditions once common on the Earth's surface.

9.2 | Story (Detailed)

During the 24th century, mankind started suffering severe consequences from actions that were carried out during centuries. General environmental negligence led to the destruction of most natural ecosystems, making it almost impossible to grow food naturally. In response to this, the UN create project *Phoenix*, with the goal of returning Earth to a healthier state. This program launches a number of space stations with the purpose of recreating the conditions previously found on Earth and slowly rebuild what was lost during the last few centuries. The player assumes the role of a worker on one of these space stations, receiving directives from the UN with instructions on what to prioritize, and is given full control of the station's operations.

9.3 | Gameplay (Brief)

Resource management game. The player has free reign over a plantation presented in the form of an isometric grid. Different things can be planted and they take time to grow. Structures to aid the plantations can also be built and destroyed over time. From time to time, a shipment will be sent back to Earth containing everything that was harvested since the last sent shipment.

9.4 | Gameplay (Detailed)

Plants

Every plant has certain properties that are common between all types:

- **Dependency** on **water** (Levels 1-4, 1 being something that required little water to grow and 4 something that thrives on humidity) and **sunlight** exposure (Levels 1-4, similarly to water);
- **Hormone**, which defines any extra bonuses a plant might benefit from;
- **Size**, which defines how much space a plant takes up on the grid while it is growing;
- **Growth time**, which is defined by the number of cycles (see **Time** section on this chapter) the plant requires in order to become fully grown and ready for harvest.

When fully grown, a plant can be harvested and added to a deposit to be shipped back to Earth (see **Shipments** section on this chapter). This state is indicated by a shovel icon on the plant's tooltip When harvested, the plant will have a certain commercial **value** attached to it, which is influenced by how favorable were the conditions where it grew (How well the dependencies and special conditions were met while growing) and the current demand for that plant in particular.

Plant Value (Bonuses and Penalties)

Every plant starts off with 100% value, meaning that it is worth exactly as much as the player paid for it on the cycle that it is placed on the field. As cycles pass, this value will be updated depending on how well the plant requirements were met. These bonuses and penalties are applied to every plant on each cycle advancement.

Bonuses

- **Growing:** +(5 x number of occupied grid slots) %
- **Perfect sun and water levels:** +25%
- **Active Gibberellin Hormone:** +35%
- **Special requirement was met (if there was any):** +35%

Penalties

- **Failing sun and water level requirements:** -(25 x number of levels over or under the requirement) %
- **Failing to meet special requirement (if there was any):** -30%
- **The plant is diseased:** -30%
- **Coronal Mass Ejection:** -(10 x number of unprotected grid slots occupied) %
- **Plant is already harvest-ready:** -25%

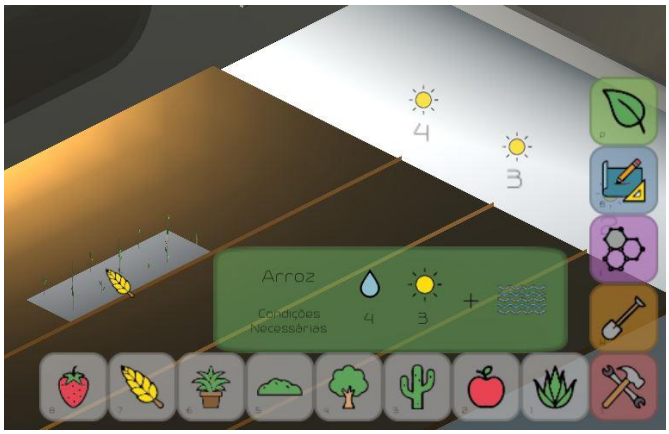


Image 17 - Plant requirements

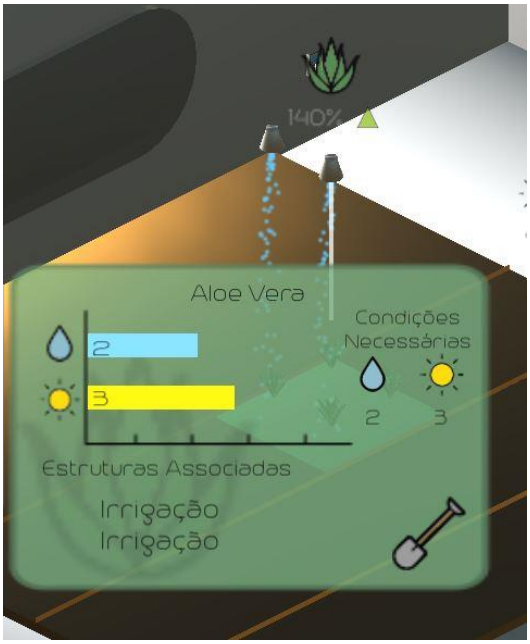


Image 16 - Plant information

Image 18 - Plant Tooltip

	Water	Sunlight	Special Need	Growth Time	Size	Initial Cost
Rice	4	3	Water pit	3	1x3	50-120
Aloe Vera	2	3	-	2	2x2	30-120
Cactus	1	4	-	3	1x1	30-80
Moss	4	1	Sunblock	5	2x2	70-150
Strawberry	3	3	Greenhouse	4	1x2	50-120
Apple	2	3	-	5	3x3	90-170
Ornamental Plant	2	2	-	4	2x3	60-130
Eucalyptus	3	3	-	6	3x3	80-150

Table 4 - Types of Plants

Water

Every plant requires a certain amount of water. This can be provided by building irrigation systems on slots occupied by the plants. Each irrigation unit can be adjusted to different supply levels of water. The mean of the water supply affecting all the slots of a plant is the level of water the plant is currently getting access to.

At any given time, the player has enough water to supply a certain number of slots on the grid. If a slot on the grid is receiving water, that water unit is not available to be used on other slots until the source is moved or removed. A total of 25 water units are available.

Sunlight

Sunlight is always available through a window on the space station. Plants closer to the window receive more sunlight, while the opposite is true for the ones that are planted further away. Each section of the terrain is marked with a certain sunlight exposure level. If a plant is planted on a single level, it gets that much sunlight. If not, a mean is calculated between all of the grid slots the plant occupies. The plant gets that much sunlight, rounded up or down.

Structures

Structures can be built to aid in the growth of plants. They can be constructed and removed at will, with an associated cost (see **Economy and Ecosystem Rebuild** section on this chapter).

	Effect	Building Time	Size	Cost
Sunblock	Partially blocks sunlight that reaches the affected slot (-1 sun on affected slots)	1	1x1	50
Greenhouse	Aids in the growth of **Strawberries** (+ value)	1	1x2	75
Water pit	Aids in the growth of **Rice** (+ value)	1	1x3	75
Irrigation System	Provides water to the affected slot	1	1x1	20

Table 5 - Types of Structures

Hormones

Certain hormones can be injected into the soil on specific grid slots. These provide benefits to plants that are occupying that slot. They have a high purchase cost and must be used efficiently for the investment to be worthwhile. If a third of a plant's occupied slots are affected by a certain hormone, the plant benefits from its effect.

	Effect	Cost
Auxin	Skip the second-to-last stage of growth.	25
Gibberellin	Boosts the final value.	25
Cytokine	Eliminates and grants immunity to **Disease**	25

Table 6 - Types of Hormones

Time

Time advances in **cycles**. A plant can take from 2 to 6 cycles to grow, depending on the type. Structures will require a cycle to be built, meaning they will only start taking effect on the cycle following the one that the player was on when it was placed.

Hazards

When a cycle passes, there is a chance of a random event (a **Hazard**) occurring.

	Effect	Solution
Disease	Infected plant does not grow and value decreases rapidly. Adjacent plants have a chance to become diseased if the original source is not terminated (.	**Cytokine** hormone
Coronal Mass Ejection	Ejection of plasma and magnetic fields from Solar Flares. Decreases the quality of all active plants not under the effects of a **Sunblock**.	**Sunblock** structures

Table 7 - Types of Hazards

Disease has a 3% chance of affecting any plant on the field each cycle. After infecting a plant, it has a 5% chance to spread for each grid slot occupied by the infected plant that is adjacent to another plant. **Disease** is immediately cured by applying **Cytokine** to the infected plant's soil. A diseased plant can be identified by an icon accompanied by a blue tint on the plant model.

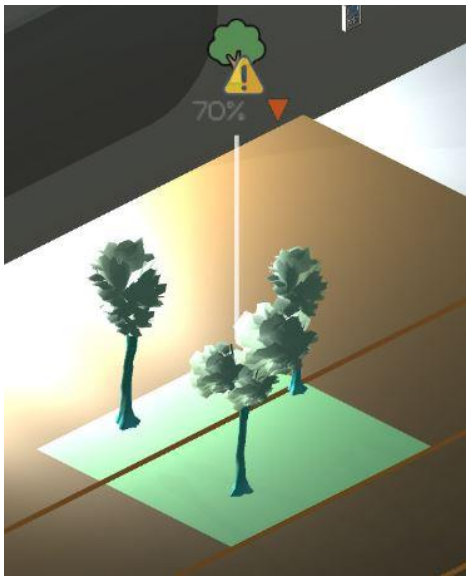


Image 19 - Disease

Coronal Mass Ejections have a 5% chance of happening every cycle. When triggered, the player is given a notice and 5 cycles to prepare. When the **Coronal Mass Ejection** cycle comes, every plant loses 10% value for each occupied slot not protected by a **Sunblock**. This event does not trigger during the first 5 cycles of a new game.

Image 20 - CME warning

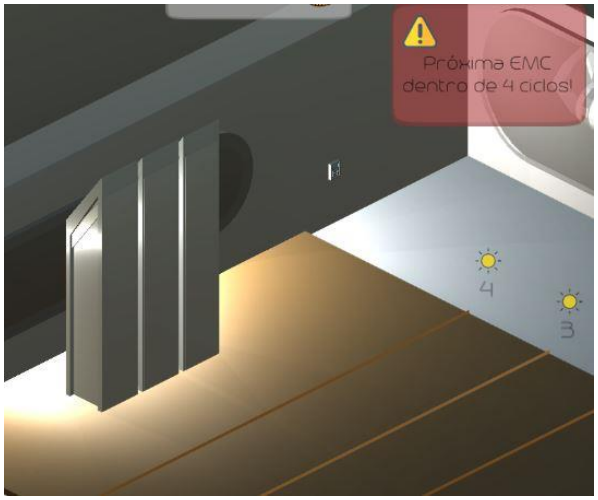


Image 21 - Sunblocks

Grid

The play area consists of a 10x10 grid where the player is free to build and plant, as well as change the soil properties on independent grid slots. Grid slots can be either free or occupied by a plant or structure.

Shipment

Every 8 cycles, the harvested plants are shipped to Earth and converted into money, according to their value. When a shipment is sent, it affects all of the plant's economic value. Prices of plants that were included in the shipment will decrease by 10% for each instance of that plant on the shipment (if 4 rice plants were shipped, their price drops 40%, and if a single apple tree was shipped its price drops 10%) and prices of plants not included in the shipment rise by a flat 25%. This change happens as soon as the shipment button is pressed.

Image 22 - Inventory and plant prices

Economy and Ecosystem Rebuild

Progress is tracked by accumulating money towards an Ecosystem Rebuild. The value of each shipment will dictate how much progress is earned. The more valuable a shipment is, the more money the player gets towards the Rebuild. When reached, the player's performance is graded based on many cycles they needed to achieve the main goal. Less cycles mean a faster rebuild and better grade. These points are represented through money, which can be used to buy seeds, structures and hormones. The player is required to get the best value possible from each shipment, making enough profit to buy more materials and still keep some money to be counted towards the rebuild. The player is provided with 1000 coins to begin with and the main goal is to reach 3000.

Image 23 - End screen

Assets

2D Assets

UI

- Game banner
- Menu buttons
- Interface icons
- Plant icons
- Structure icons
- Plant Status cards
- Structure Status cards

3D Assets

Environmental

- Shuttle
- Plantation
- Fire Extinguisher
- Box
- Control Panel
- Door
- Walls
- Suits
- Water Tank

Objects (Plants)

- Rice (All stages of growth)
- Aloe Vera (All stages of growth)
- Cactus (All stages of growth)
- Moss (All stages of growth)
- Strawberries (All stages of growth)
- Eucalyptus (All stages of growth)
- Apples (All stages of growth)
- Ornamental (All stages of growth)

Objects (Structures)

- Sunblock
- Greenhouse
- Water Pit
- Irrigation System

Code

Menus

- Main Menu
- Pause Menu

UI

- Interface

Systems

- Plants
- Structures
- Hormones
- Hazards
- Grid Interactions (Planting, Harvesting, Building, Hormones)
- Game loop
- Shipments
- Economic System
- End condition

8 | Conclusion

The main purpose of this dissertation was to explore new ways of teaching the future generations through alternative, less traditional methods. Allying this idea with the practice of bringing people joy through video games seemed like a natural fit, as well as a considerable challenge.

Throughout the months I worked on this project, I realized that the educational system and the overall methods we use to teach might, arguably, need some improvement, but that making those improvements is no easy task. The human mind is a very complex thing and the process of transmitting knowledge to one another might be simple in nature, but it is just as complex at heart.

Although I do believe that changing something as intricate as the modern school system by myself with only a few months-worth of work would be close to impossible, I still get a sense of fulfillment by telling myself that I was on the right path and that hopefully, one day, something close to what I accomplished here is done on a larger, more impactful way.

The final prototype shies a bit from what was initially planned, which is not a surprise. I am still proud of the final product which allowed me to explore new and interesting game design techniques and patterns that I had never used before, as well as shy away from the comfort of the code compiler and broaden my skills. Being the first time that I took on a project of this dimension by myself, it really made me realize that making games is a long and hard process, filled with backsteps and unexpected occurrences that no amount of planning can prepare a designer for. It was, at the end of the day, a growing experience, not only as a professional, but also as a person.

The prototype could certainly have benefited from a longer testing period, as well as a more fleshed-out tutorial experience that simply was not possible due to time constraints. Ideally, the game components not directly related with code would also have been done by someone with more understanding, in order to deliver a better overall experience. I do believe, however, that what I am presenting here represents a solid prototype for an idea that with the right team and budget could be molded into something that could really impact the way we teach.

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Image References

Annex

Post-Test changes

- v1.1 - Added cost to hormone and structure tooltip
- v1.2 - More visible irrigation locations
- v1.3 - Added icon to show when a plant is at the last stage
- v1.4 - Updated price table to be clearer
- v1.5 - Changed sun level indicator positions on the terrain
- v1.6 - Hormones now take effect on 1/3 of occupied slots, instead of half
- v1.7 - Gibberellin's bonus is now proportional to occupied slots

Iconography, third-party assets

	**Freepick, FLATICON**		**Freepick, FLATICON**
	**Good Ware, FLATICON**		**Freepick, FLATICON**
	**Freepick, FLATICON**		**Iconnice, FLATICON**
	**Freepick, FLATICON**		**Creaticca Creative Agency, FLATICON**
	**Freepick, FLATICON**		**Smashicons, FLATICON**
	**Freepick, FLATICON**		**Freepick, FLATICON**
	**Freepick, FLATICON**		**Freepick, FLATICON**
	**Freepick, FLATICON**		**Smashicons, FLATICON**
	**Freepick, FLATICON**		**Good Ware, FLATICON**
	**Freepick, FLATICON**		**Freepick, FLATICON**

Fonts

- Trench thin

Pre-Deadline Extension Plan