Video games as tools for education

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Abstract

Video games are a unique form of media that combine a high level of engagement with a large amount of content. Whereas traditional forms of media are either one or the other, video games are unlike any other media before it by combining both aspects. This paper examines utilizing the advantages of video games as a tool for education. Applying video games to education allows the massive media penetration already created by video games to further education. The scale of the video game industry is unlike any other form of media, for example the industry has exceeded over 43.4 billion dollars in sales in 2018 Entertainment Software Association (ESA) (2019). Retrieved from 2019-Essential-Facts-About-the-Computer-and-Video-Game-Industry.

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Introduction

Although video games are typically considered unrelated to education, there are interesting qualities that would be ideal if they could be applied to education. Video games are extremely engaging, often times, difficult to put down, even after many hours of playtime. Whereas reading or watching educational material is tiresome and difficult to complete. Passive media, such as television captures interest but does not require engagement. As a result it can easily be blocked out or the person watching can easily get distracted. Textbooks are on the opposite side of the spectrum, they demand engagement in order to actually be read and understood. However, textbooks and similar educational materials do not capture interest, in fact they typically repel it. Video games are in an ideal middle spot, they capture interest but still require the player to interact with them.

From this, video games could be used to more effectively teach students on specific topics. This concept is not unheard of, the idea of 'gamification' has long been a tool to increase human engagement. For example, the surge in productivity applications that reward users for spending time focusing for a set amount of time, such as the mobile application, 'Forest: Stay focused'. Gamification has also been used extensively in marketing in the form of loyalty programs that give rewards for a set amount of purchases. For example, the 'My Starbucks reward' program has users accumulate stars and upgrades by purchasing at Starbucks. The common idea between these methods is to tap into the social and motivational drivers to dramatically change behavior.

The surprising effectiveness of gamification has primarily been from an economic perspective as a tactic to sell more products or to develop more addicting content. However, in recent years, gamification has been receiving increased interest from an educational perspective. A great success in the area comes from the mobile application Duolingo. Duolingo is a free application that teaches users foreign languages. The application motivates users to continue learning by using features typically associated with video games such as streaks (a counter to measure consecutive days the application

is used), digital currency, a set number of lives, and many more. These features increase the addictiveness of the application thereby increasing the amount of time users spend learning new languages. This is further evidence to the power of gamification on tasks typically not associated with video games. Whereas learning a language could be considered tedious and uninteresting in a typical classroom environment, over 1.2 billion users voluntarily use Duolingo to effectively learn languages on their own time (Vesselinov & Grego, 2012). This is further proof that the features in video games that are motivating and enjoyable can be transferred to non game tasks.

These techniques are consistent with recent papers on the topic of gamification. The literature review 'Gamification of education and learning: A review of empirical literature' (Majuri, Koivisto & Hamari, 2018) reports signaling achievement and progression are strong motivators in educational gamification. This could imply a disconnect in traditional education where students do not receive immediate feedback on their level of mastery of what they are studying. The paper also notes that many forms of gamification depend on quantifying performance in a visually pleasant way, typically done by positive images accompanied by positive verbal cues. This sense of signaling accomplishment could be a major driver of motivation, especially in groups who feel unrecognized in their talents.

The act of playing has a major role in child development (Bjorklund & Pellegrini, 2003). It contributes to both cognitive and social development. Like video games, it also offers an opportunity to engage with others. A potential point of interest is looking at the effect of play at a later stage of development or even at adulthood. A large portion of research is targeted at children when in play could still have a noticeable effect at a later age.

At this point, the wide variety of video games should be mentioned. A different level of complexity combined with various different genres of games can have vastly different effects on the player. Some video games are purely for entertainment while others tell a story. Some are designed for the purpose of education and others for emotional comfort. 'The Benefits of Playing Video Games' (Isabela Granic & Engels,

n.d.) discusses the different types of video games and their benefit. The paper presents a conceptual model measuring video games by their degree of complexity and the level of social interaction. A strategy game like Starcraft would rate high on both complexity and social interaction whereas a puzzle game like Bejeweled would be more non-social and simpler. Being simpler does not necessarily mean the game is worse or easier, but instead measures the complexity of tasks required to complete the game. Isabela Granic and Engels (n.d.) note that one of the top reasons for playing video games is emotion and mood management. They report that the "high level of control and loss of self-consciousness" is a highly immersive and rewarding quality of video games that are emotionally engaging. This could indicate that video games can be aimed to build social skills and treat anxiety.This study also draws attention to the concerning areas of video games also, namely addition, depression, and abusive interactions through socially connected systems. It has already been brought up that gamifying marketing is an effective way to change a person's behavior in a way that is not in their favor. Just as misinformation can be spread through other media, video games may expedite this process by their highly engaging nature and their ability to immerse the player in the situations they present. With new advances in VR and graphics technology, I predict this will become a serious issue in which there are malicious systems designed to harm a person's emotional state.

Strategic and complex video games on the other hand are interesting due to the cognitive load associated with them. These types of games reward players who are skilled at the game. This is the topic of interest in Gray (2017)'s paper overviewing the use of video games in cognitive science. Here video games are not the topic of interest but the cognitive skills that go into playing them such as spatial awareness in games like Tetris and reaction time in games like League of Legends. The paper explores different topics in cognitive science related to video games. The idea of studying skill acquisition through video games is deeply connected with the idea that they can be used to improve performance in other areas unrelated to the game itself.

From this overview of gamification I think there is a strong connection between

learning and video games. Applications like Duolingo show how a broad concept such as language acquisition can be gamified. Many other educational applications target similar areas and are typically interested in learning as a process of memorizing and understanding new information. This type of application lends itself well to games which can highlight progress and give rewards based on completion. I am interested in the area of logic and reasoning. This specific topic is essentially important in STEM fields like computer science which heavily rely and borrow on formal logic. However, these topics typically do not receive as much attention as other areas even though they give a strong foundation. I believe that puzzle games can specifically target this area of computer science, since much of the core concept of many computer science topics boils down to problem solving through logic. Logical reasoning and solving puzzles share an intimate connection that I believe support one another. By creating a game in which a user solve puzzles related to a topic in computer science I theorize they can learn more effectively than traditional methods in education. The null hypothesis H_0 is that playing a gamified version of a computer science topic will have no difference in the material learned than compared to traditional methods. My alternative hypothesis, $H_1 : \mu_1 > \mu_2$, is that gamifying a specific topic in computer science will result in higher levels of understanding in a quicker time frame.

Methods

This section will explore potential experimental setups that can be used to test the described alternative hypothesis. Any experiment will first need the actual video game or at least an interactive prototype of the topic being tested. I have been using Unity3D, a game engine that allows for the quick development of interactive systems. I am interested in the use of finite state machines which are models of computation. As a result a possible gamified version of this topic is the open ended puzzle solving of writing 'programs' with finite state machines (FSMs). Typically this is tedious but with an interactive system, students can have a visual representation of the states and the connections between them. The entire FSM can then be simulated and the student will

have immediate feedback on what the results of the selected inputs and transitions were. By playing with a FSM students will most likely learn its behavior faster than with a description of one.

A between groups setup can divide a group of students into two three groups. The first two should have no experience in the computer science topic chosen, in this case FSMs. Once the first two groups complete their tasks they are then tested in a standardized way, most likely a college level exam. The third group can be used in a post-hoc analysis to ensure we are correctly measuring proficiency in the selected topic. This approach allows us to better see the effect of the game itself compared against traditional methods. However, since the groups are independent it will be difficult to measure acquisition since we will be indirectly measuring performance through the standardized test.

An alternative approach is a between groups study. This will only require two groups, the control group from before and the experimental groups which have been combined into one. Every subject will be exposed to every level of the variable. Here, students would first get a short introduction to the computer science topic which would model traditional methods of teaching and then take an assessment. They would then play the topic video game and take another assessment and the experiment would then measure the change in accuracy and time taken. This setup is more targeted to research acquiring skill through video games but is also more difficult to determine the degree to which video games specifically has effected the outcome of the second assessment. Having each subject take both assessments may simply increase the second assessment's score by virtue of the students being more familiar, a common issue in testing.

This experimental setup is largely dependent on the game itself. To be a video game, it must be interactive at a minimum and in order to effectively perform this experiment, it must be engaging enough to capture the students' attention. The barrier to learn should be low as too complex of task will most likely discourage students from putting in the effort to fully utilize the system.

See the appendix for a visual of the system designed for the topic of FSMs. In the

interest of time the experiment was not performed to the methods described above. Instead students were asked to play a prototype and feedback was recorded from a survey given to them afterwards.

Results

The following questions were asked on the survey: 1. Do you typically play video games as a form of entertainment? 2. Was the FSM game easy to learn? 3. Do you feel you either learned something new or reinforced your knowledge ? 4. Would you use this as a tool to study voluntarily? 5. Did any of the questions feel boring? All five questions were asked as yes/no questions.

A total of four students played the prototype and responded to the survey. All four said they do play video games casually for entertainment regularly. Half the students said the game was easy to learn. Three of the students said the controls were easy to use. All four said they would use this as a tool to study and none said any of the questions were boring.

The survey results gives me confidence that video games are a valuable tool in learning. An interesting note was that all four students responded that none of the questions in the game were boring. All of the questions preprogrammed in the FSM game were taken or modeled from a foundations of computer science textbook, this supports our earlier claim that positive aspects of video games can mask the less desirable aspects of other tasks. All four students had experience with a models of computability class which most likely affected the results in some way. Naturally, a sample size of four student with whom I knew all four personally is not an ideal sample group and a far larger group is required for truly meaningful results.

I believe since the questions were presented as a puzzle students were engaged by the proposition of an interesting challenge but actively took part in solving the problem by having an environment that allows them to defer part of the cognitive load to the game application.

Discussion

The results from the survey are promising especially in students response to voluntarily using video games as tools to study. I am particularly interested in a field experiment were the video games used is deployed online for users to freely access. From there, we can collect data on amount of playtime, times attempted per problem, and accuracy. A field experiment is exciting because of the prospect of testing an extremely diverse range of users. Although we sacrifice some control over the experiment setup, I believe the increase in diverse subjects makes up for this. Topics on education should not be restricted to sample populations consisting only of college undergraduate students. Testing this experiment in the context of standardized tests may be difficult. Creating a test to match the same content taught between a traditional model and the video game topic would be difficult.Using existing grades may be difficult due to many universities strict FERPA policies.

A unique opportunity in using games as tools for education is the ability to collect more data than is typically collected from a traditional assessment. Along with standard measure like time, accuracy, game statistics (e.g. number of nodes used) we can also reconstruct every action the student took by keeping a log of all actions taken by the student. This could lead to interesting experiments that explore the thought processes taken by the student. If we can reconstruct a logical sequence of steps to get from a problem to a solution, we could infer if the student has truly mastered the content, a task not possible in traditional exams.

Another area of interest is the level of trust students put in the information presented. Although not explicitly asked no student questioned the content of the game in terms of accuracy. A potential side effect of a highly engaging and immersive environments is that students may be more willing to accept the information without critical doubting it first. This could lead to adverse effects where information on topics could be gamified to sway public opinion.

References

Bjorklund, D. F. & Pellegrini, A. D. (2003). Child development and evolutionary psychology. *71*.

Gray, W. D. (2017). Game-xp: Action games as experimental paradigms for cognitive science. *Topics in Cognitive Science*, (9), 289–307.

Isabela Granic, A. L. & Engels, R. C. M. E. (n.d.). The benefits of playing video games.

Majuri, J., Koivisto, J. & Hamari, J. (2018). Gamification of education and learning: A review of empirical literature.

Vesselinov, R. & Grego, J. (2012). Duolingo effectiveness study.

Appendix

FSM simulator Interface

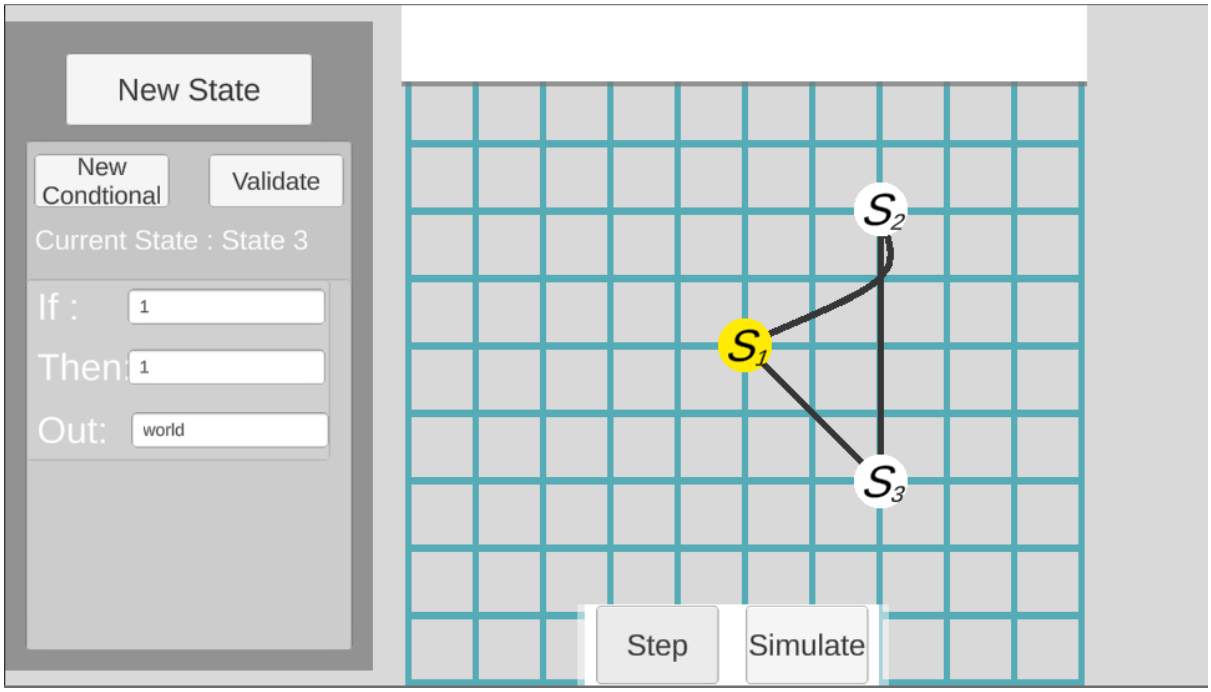

Figure A1. The above is the prototype for a FSM game. Users can place nodes on the grid on the right. The left panel controls the inputs and outputs of each state along with what other states that node is connected to. The highlighted node is the current state, i.e. what step of the simulation we're on. The top bar represents an object like a "console" and output from the FSM appears here. Students are given preprogrammed tasks to solve. An example of these are build a FSM that outputs the string 'ARCH BAD' exactly twelve times with a max number of five nodes.
Like a FSM nodes can have multiple connections, in order to maintain simplicity all the FSM were set to be deterministic.

The surveys were performed by giving students a link to a Google form with the five questions.

Survery results, 0 = no, 1 = yes

	A	B	C	D
1	1	1	1	1
2	1	1	0	0
3	1	1	0	1
4	1	1	1	1
5	0	0	0	0