Maximizing Effectiveness of Educational Games through Gaming Experience

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ABSTRACT
Educational games face a dual challenge in both trying to meaningfully educate players while holding their attention long and well enough for the lessons to be engrained. This paper surveys research pertaining to the effectiveness of educational games and how to provide the best Gaming Experience to engage students while providing challenge and opportunities for "flow".

Author Keywords
learning; education; gaming experience; flow; motivation; player experience; challenge

INTRODUCTION
Video games are a quickly growing part of modern life. The games industry already outstrips films in sales, and is continuing its upwards trend (Cox et. al)[5]. As gaming grows more ubiquitous, education, along with other fields, has started incorporating video games into products and services to entice and motivate students. This begs the question: how effective are these gamified school lessons? How can we design them so that they achieve their learning objectives and also provide enough fun for students to be intrinsically motivated to play? If they are providing worthwhile learning experiences, how do we make sure students get the most out of these games? Research has been done as to how best to maintain a good Gaming Experience (GX) to keep students playing and reaching higher learning goals. To improve the GX, designers must maximize engagement, flow, immersion, presence, enjoyment, and challenge. We discuss a subset of this research, focusing on flow, motivation, and challenge's roles in enhancing GX.

GAMIFICATION
Gamification is used to engage users by using game-like techniques, such as scoreboards and personalized fast feedback, to encourage users in tasks. Deterding et. al.[8] define gamification as the use of game design elements in non-game contexts. Using gamification can lead to a higher level of engagement in students; however, an inappropriate use of gamification may overemphasize the in-game reward aspect, which can give users a false sense of achievement.

One successful instance of gamification is used for computer courses at a particular university in the Netherlands. There they identified each student as one of four player-motivations: Explorer, Achiever, Socializer, and Winner. The school, appropriately named GamificationU, used 7 tools for gamification. These included tools like point systems allowing the students to add extra points to their final scores in classes. Other tools allowed students at a certain level to unblock content that may not be accessible to students at lower levels. However one of the major drawbacks from this use of gamification is the amount of time that is required of the teachers to implement a system at the university level. Not only is more time invested in catering to different students habits, computer-assisted management tools have yet to be built to assist in the analytics and to gather student feedback.

EDUCATIONAL VIDEO GAME EFFECTIVENESS
Video games with the intent of educating the player in a particular field have become prevalent, but there does not seem to be much evidence of games fulfilling this primary role, as presented by Linehan[9]. Instead, educational games tend to fall into either a category of obviously educational video games, which players avoid, or fall short of teaching the lessons meant for the player. Because of this, educational games have been considered to be chocolate-covered broccoli Bruckman [4]. In order to push games outside of the stigma of chocolate-covered broccoli, it is necessary to do two things: design games so that they sufficiently teach the material desired while not focusing too heavily on the educational aspect, and enhancing the education of these games by giving them the same feel as a commercial video game.

The goals of educational and traditional games are slightly divergent, with the goals of educational games being solely to teach a subject and ensure the player has learned it, and the goals of traditional games lean more towards the idea of providing longer term challenges and rewarding players for learning the skills required to complete the challenges. Combining these two sets of goals may be the avenue of making educational video games more successful, according to Linehan[9]. The proposed way of doing this is to use Applied Behavioral Analysis (ABA) as a framework. What this means is that educational video games must assign different goals according to the behavior observed by the player. This leads to a system of constantly analyzing performance to cater to the desires of a player, ultimately enhancing their gameplay by presenting positive and negative feedback and new goals depending on different behaviors. By breaking up the single goal of an educational game the player has a higher chance of continuing play and learning more aspects of the subject.

Making the goals of the game intrinsic is a major property of making educational games seamless in their attempt to teach a lesson while keeping the player engaged. Intrinsic learning requires the embedding of learning outcomes of a teaching program within the mechanics of a game Linehan[9]. In essence, this would cause a player to learn as a secondary outcome of completing a task set as part of the game. This opposes the traditional layout of educational video games by making gameplay a blanket over the educational portion of a game. It may be possible to use this method for the more basic subjects such as reading and arithmetic, but it is more feasible for abstract subjects or those where the player can grasp a broader subject.

However, to keep player fixed on a game not only the monotony of the goals needs to be broken up, but also the layout of the game itself. Players can often discern an educational game from a traditional or commercial game through the visuals alone. Bellotti[2] suggests that using visuals that are more like the traditional games players enjoy may enhance the player's interaction and in turn their education received from playing the game by encouraging them to play longer and explore more of the environment. In creating a game that is more aesthetically pleasing to the user, the educational aspects become more intrinsic while bringing the gameplay to the forefront. Making this jump from education as a focus of a game to a mechanic would push educational games into a realm where enjoyment of the game and educational effectiveness are present in equal measure.

GAMING EXPERIENCE

A key requirement when trying to make educational games achieve their goal of learning is to give the player a good Gaming Experience (GX). A good Gaming Experience is characterized by player engagement, occurrences of flow, immersion, presence, enjoyment, and challenge. Specifically, these terms are defined as:

- Engagement - how involved a player is
- Flow - the experience of being "in the zone"
- Immersion - cognitive involvement of the player
- Presence - the feeling of being in the game world
- Enjoyment – the player's perception of fun
- Challenge - the perception of difficulty, as reflected by the gamer

Many of these factors interact with each other. For instance, challenge affects engagement, motivation, and immersion, can break flow, interrupt presence and make or break the enjoyment of a game.

Flow

Research on the effects of flow-state and video game self-efficacy on motivation is fairly limited. However, there has been insight into these constructs through the use of serious games, or games meant to provide learning, meaning, or similar outcomes rather than pure leisure experience. Pavlas et. Al.[11] found that flow is not only useful from a game-based learning standpoint but also that videogame self-efficacy plays an important role in this relationship. Their study looks at the strategy-based game InnerCell, where players must defend the body from infection at the cellular level.

To understand how different attributes affect gameplay, multiple versions of the InnerCell game were used. These versions include a fantasy version, realistic version, human interaction version, and a proactive conflict version. Because the fantasy version reflects current gameplay the best, it was used as the baseline for the results. The study was conducted over a semester with 120 undergraduate students enrolled in psychology and measured videogame self-efficacy, flow state, declarative knowledge, motivation, knowledge organization, and application. In this list of attributes, two were of particular interest: flow and self-efficacy. Here, flow is identified as an optimal experience that is characterized by clear goals, concentration, the merging of action and awareness, a distorted sense of time, the presence of feedback, balance between skill and challenge, a sense of control, and intrinsic motivation. Self-efficacy is an individual's personal belief in their ability to perform tasks and behaviors.

The procedure Pavlas employed consisted of randomly assigning a version of the game to each of the 120 students. After receiving training, being presented with the game story, and completing pre-measures, participants played the three levels of InnerCell. After all students had played all three levels, analyses of covariance (ANCOVA) were conducted comparing each of the other three versions to the fantasy condition. Out of the attributes, only the flow state and self-efficacy covariates were of significance, which resulted in large F-values and large overall model effect sizes. This indicates that flow-state is positively related to motivation and quantifiable learnable outcomes. Finally, the results from Pavlas' experiment show that flow is not only useful from a game-based learning standpoint but also that video game self-efficacy plays an important role in this relationship. Taking what has been learned from this study we can assume that flow-state and self-efficacy may transfer over to other processes of learning.

Motivation

Players are drawn into good games that can keep them engaged during play (Birk, Mandryk)[3]. The more engaged a player becomes in the game, the more motivated the player will be to return to play game more. Research has been done to learn which ingredients make a successfully engaging game and the results have shown that the controller, the interface between the player and the game, plays a large role in the player's motivation towards the game. Depending on the game the player is playing, the controller can either enhance the player's experience and motivate the player or cause the player to lose interest in the game they are playing. Birk and his colleagues performed an experiment with the use of three game controllers to test the player's experience with games. In this experiment, a custom game which could be played with all three controllers was created to make the experiment more credible. Of the three controllers used in the experiment, the Kinect showed to enhance the agreeableness within the context of the game being played which suggests that games designed to either promote social connections or serve as "social icebreakers" would benefit the Kinect the most.

Player's Experience

To fully understand the player's experience (PX), research has been done to understand how a player feels about the game, how the player feels about their self during gameplay, and how the game actually makes the player feel. The player's experience with the game was also affected by the type of controller they used. If the controller made sense with the game, the player's experience would be enhanced. This results in a positive boost to the player's motivation towards the game.

Personality in Game

Players exhibited a significant change in their game-self per controller type. This change also varied between game and type of game.

Challenge

Contrary to software design principles, where ease-of-use is a prime goal, video games attempt to give the players a challenge in order to motivate them to continue playing. Successfully completing challenging tasks is always a satisfying experience. As a designer, you must balance the challenge of a game to positively influence the other factors of the Gaming Experience.

Inverted-U

The Inverted-U hypothesis states that a moderate level of challenge provides the highest engagement. Bearing this in mind, with regards to educational games, this can be extrapolated into the idea that not providing a high enough challenge will result in less learning. However this does not always prove to be the case. Lomas et. al.[10] found that easier challenges can provide higher engagement, especially with inexperienced players. The Effectance Motivation Hypothesis suggests that success rate increases motivation. This can lead to other problems, however. Lomas et. al. theorized that success had to be attributed to the player's competence or learning. The ideal would be an increase in success due to player learning, which is the goal for educational games.

Optimal Challenge

The optimal challenge is highly dependent on the expertise of the player. For example, expert chess players have the best Gaming Experience when the probability of success is only a meager 20%. This contrasts greatly with the Lomas [10]'s experiment where engagement seemed to solely follow the Effectance Motivation Hypothesis. This can be explained by hypothesizing that players with more expertise seek a greater challenge. It is also entirely possible that the participants in Lomas's experiment were not intrinsically motivated enough while playing the game to seek greater challenges. In addition to providing the right level of challenge, it is important to provide the right type of challenge. Simply increasing the physical demand of the game does not increase engagement. Cognitive challenge contributes most to a positive gaming experience. When designing educational games, this is even more important. Cox et. al.[5] illustrated this in their experiment comparing engagement in tower defense games. Placing more towers without having to strategize as to the best method of spending resources was less engaging than managing a more limited resource pool. But why does challenge provide heightened engagement, more instances of flow, increased immersion, and greater enjoyment? Abuhamdeh and Csikszentmihalyi[1] suggest that for goal-directed activities, more challenge results in more intrinsic rewards. Their study produced the aforementioned chess player figure. Their results also strongly correlated performance with enjoyment. These figures seem to be at ends. Succeeding in the face of a high perceived challenge must be very rewarding for players to enjoy only winning 20% of matches. A key to these studies is that challenge is only effective when the challenging activity is intrinsically motivated, that is, the actor is not forced to engage in the activity, but rather is doing it for enjoyment, personal gain, or entertainment. Thus games must be entertaining enough for the challenge of a game to enhance Gaming Experience and keep players playing and learning.

Difficulty Dynamics

Games often incorporate different difficulty levels in their gameplay, allowing users to select a level of challenge that best suits their preferences. However, these systems are not perfect, as the users still can only choose between a limited number of predefined levels of challenge. In addition, the method of switching between these modes usually involves having to interrupt the game to enter a menu, or in many cases can only be set when the game begins. While there are games that try to address this by dynamically altering difficulty during gameplay through the steady introduction of harder or more demanding mechanics and adversaries, the introduction of these systems actually brings in its own set of problems. Most of these automatic progression systems have no opt in or out, they simply look at the player's progression, and if the player is steadily overcoming obstacles, the difficulty is raised. Modifying the game's difficulty in this way disregards the player's emotional state, as it fails to take into account the player's satisfaction with their current difficulty level. This can actually be detrimental for the game, as a player who is currently content, and perhaps even prefers playing the game at an easier, more leisurely difficulty level may be forced by such an automatic system to play at a more difficult mode outside their comfort zone. Potentially this could lead to a decreased satisfaction with the game for that user, along with whatever losses in sales/reputation that could consequentially bring to the game.

Dynamic alterations of difficulty based on the player's emotional state in addition to his/her previous accomplishments offer a less stressful solution to difficulty progression. Deng et. al.[6] suggest the use of biometrics to dynamically alter a game's difficulty based on the player's current stress levels. Specifically, they developed a thermal imaging camera, StressCam, that can be calibrated to watch for changes in heat in specific target regions. Data from this is then measured against predetermined threshold values to determine elevated or lowered stress. Their initial experiment had several participants of varied gaming experience levels play a game set up to automatically adjust its difficulty level based on data taken in from the camera. Users were asked every minute via on-screen popup to rate their current level of stress and enjoyment, which was used to determine the aforementioned stress change thresholds. What Deng's group found was that by the end of play, every participant's game had adjusted itself to a level that roughly matched their reported level of gaming expertise. While these findings do appear promising, Deng et. al. note that the current system is limited in that it does nothing to separate the level of engagement the player is currently experiencing from their stress level, likewise no distinction is made between a state of relaxation and one of boredom. They propose that in addition to further study in regard to gaming application, StressCam can potentially be used in other entertainment fields. One such example that they suggested was automatically adjusting music to match a user's preferences.

DISCUSSION

Educational games tend to fall into two categories: chocolate-covered broccoli and pure chocolate. That is either they fail to truly entertain or fail to effectively educate. To satisfy this pair of goals, utilizing a framework such as Applied Behavioral Analysis (ABA) could lead to games that can provide the best of both worlds. By integrating learning into the game intrinsically, educational games become more effective at both tasks. Research by Linehan[9] and Abuhamdeh[1] both emphasize the importance of intrinsic motivation. In order to facilitate intrinsic motivation, games must provide a good Gaming Experience. Many factors go into a Gaming Experience capable of enhancing learning. Most important among these are facilitating flow, motivating the player, and providing the player with the right challenge. To facilitate flow, a player must be presented with clear goals, given sufficient feedback, and empowered so that they may enter a state wherein their sense of awareness is merged with their actions, concentration is at its peak, and their sense of time distorts as they are completely immersed within the game's challenges. Pavlas et. al.[11] achieved this in their InnerCell experiment while also introducing the importance of self-efficacy. Many factors affect the motivation of a player, even things as seemingly trivial as the controller being utilized at the time (Birk & Mandryk[3]). Key to both motivation and flow is providing the right challenge. This is a particularly difficult challenge in itself. Optimal challenge is subjective, depending both on the player's expertise as well as his/her intrinsic motivation to achieve within the game's context. The Inverse-U Hypothesis discussed in Lomas et. al.[10]'s paper applies at times, while at others motivation seems to only correlate with success as described by the Effectance Motivation Hypothesis. Difficulty needs to scale and adapt dynamically to best guide a learning experience. Deng et. al.[6] attempted to achieve this by reading biometric data, but we are still a long ways off of offering a perfectly customized challenge to players.

CLOSING REMARKS

Educational video games have great potential to enhance learning in a fun way. Much research has been done trying to advance them to a more effective state. In the past, such titles have often had a disconnect in design between their intended purpose of education, and their function as games. Researchers and developers alike are realizing that simply taking rote exercises and draping them in the trappings of a game isn't enough on its own to produce a compelling experience that players will actually want to play and participate in.

REFERENCES

1. Abuhamdeh, S. and Csikszentmihalyi, M. The Importance of Challenge for the Enjoyment of Intrinsically Motivated, Goal-Directed Activities. Personality and Social Psychology Bulletin 38, 3 (2012), 317–330. http://psp.sagepub.com/content/38/3/317.abstract
2. Belloti, F., Berta, R., De Gloria, A. and Primavera, L. Enhancing the Educational Value of Video Games (2009)
3. Birk, M. and Mandryk, R. L. Control your Game-Self: Effects of Controller Type on Enjoyment, Motivation, and Personality in Game. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI' 13). ACM, New York, NY, USA, 685 - 694. DOI=10.1145/2470654.2470752 http://dl.acm.org/citation.cfm?id=2470752
4. Bruckman, A. Can Educational Be Fun? *Game Developer's Conference*, (1999).
5. Cox A., Cairns P., Shah P., and Carroll M., 2012. Not doing but thinking: the role of challenge in the gaming experience. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '12). ACM, New York, NY, USA, 79-88. DOI=10.1145/2207676.2207689 http://doi.acm.org/10.1145/2207676.2207689
6. Deng, Z., Pavlidis, I., Shastri, D., and Yun, C. O' Game, Can You Feel My Frustration?: Improving User's Gaming Experience via StressCam. In *Proc. CHI 2009,* ACM Press (2009), 2195-2204.
7. Deterding S., 2012. Gamification: designing for motivation. interactions 19, 4 (July 2012), 14-17. DOI=10.1145/2212877.2212883 http://doi.acm.org/10.1145/2212877.2212883
8. Deterding S., Dixon D., Khaled R., and Nacke L.. 2011. From game design elements to gamefulness: defining "gamification". In Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments (MindTrek '11). ACM, New York, NY, USA, 9-15. DOI=10.1145/2181037.2181040 http://doi.acm.org/10.1145/2181037.2181040
9. Linehan C., Kirman B., Lawson S., and Chan G., Practical, Appropriate, Empirically-Validated Guidelines for Designing Educational Games (2011)
10. Lomas D., Patel K., J. Forlizzi L., and K. R. Koedinger. 2013. Optimizing challenge in an educational game using large-scale design experiments. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '13). ACM, New York, NY, USA, 89-98. DOI=10.1145/2470654.2470668 http://doi.acm.org/10.1145/2470654.2470668
11. Pavlas, D., Heyne, K., Bedwell, W., Lazzara, E., & Salas, E. (2010). Game-Based Learning: The Impact of Flow State and Videogame Self-Efficacy. Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 54(28), 2398–2402 http://pro.sagepub.com/content/54/28/2398.abstract