The importance of design for educational games

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Educational games are considered interactive activities that should be just as motivating and engaging as regular digital games, but players will learn rather than just be entertained. Despite some limited success over the past few decades, educational games have failed to reach mainstream adoption or success. This chapter claims that such a failure is the result of poor design. Designers can create better educational games once they have a better understanding of how to design games. To this end, three aspects of game design are investigated to see how they relate to the design of successful games.

Firstly, how players learn or come to understand something while playing a game. Secondly, how designers can ensure players remain motivated to play the game. Lastly, how both education and motivation should be considered from the perspective of gameplay.

Keywords educational games; serious games; game design; flow theory

1. Introduction

Some researchers have suggested that students lack motivation to engage in learning [1, 2]. Some students are not interested in learning facts or mathematical concepts. As well, many are uninterested in learning in a traditional classroom environment [3]. Therefore, an educational experience that is more motivating would benefit students. Digital games are regarded as a motivating form of activity [4, 5]. The following general observations suggest digital games are motivating: one, there are groups of people who play games for extended periods of time; two, there are groups of people who are unwilling to stop playing once they have begun; and three, large numbers of digital games are sold each year [6]. Researchers value digital games for their motivational capacity. Thus, educational digital games could provide the motivating educational experiences that such researchers desire.

Despite their potential, educational digital games have not become a great success. Educators do not have a wide variety of relevant games available to supplement their courses. Playing these games is not a common activity inside or outside the school environment. Although games are popular, more non-educational games are being developed, sold, and played than educational ones [6, 7]. Only a small number of educational games were noticeably popular, such as the Math Blaster series, the Carmen Sandiego series, and the Oregon Trail [8]. Experimentation of digital games in a classroom environment has occurred [9, 10], but there has been no adoption of games into the curriculum after such experiments. Overall, the potential of educational digital games has not been realized.

Educational games have not been successful due to their design [5, 11-13]. Some game designers have created educational games that are not motivating or enjoyable [12]. Even outside of education, many game designers make these same mistakes [13, 14]. Other designers create a game and then add educational content to it, assuming this creates an educational game. This results in creating games from an instructionist perspective, one that gives facts to players and then tests their knowledge [4, 8, 15]. However, perspectives other than instructionist can be applied to games. Games can be designed from a constructivist perspective [5, 8]. These games involve exploration or “free play”, and creating objects or worlds. Multiplayer games have also been considered educational because they encourage social interaction and cooperation [11]. Even games without educational content have been regarded as educational [2, 3]. Therefore, designing games to be educational involves more than just adding some educational content.

Educational digital games will become more successful and more mainstream as their design improves. In other words, designers need to improve their understanding of how to design educational games. First, designers need to understand how games can provide an experience that is conducive to learning [16]. Such an experience is one which provides opportunities for learning and support for deeper understanding. Second, designers need to understand how a game is motivating or enjoyable. Games are not inherently motivating [13, 14]. Many people have started playing certain games only to lose interest after a brief period of time. Designers of those games were unable to create a motivating experience for players.

In this chapter we will discuss topics most relevant for improving the design of educational digital games. These topics include how to design: an educational experience, a motivational experience, and an enjoyable experience. First, we will examine how people learn from playing a game. This will clarify how to design an educational experience. Next, we will examine how players become bored or frustrated while playing a game. This is important for understanding how to design a motivational experience. Lastly, we will examine the concept of gameplay and how it can combine the topics of education and motivation to result in an enjoyable experience. As designers understand gameplay they will come to understand how to design better educational games.
2. Education

Educational digital games should provide an environment for learning. Learning results from engaging with information and the learner trying to understand or make sense of it. In a very general sense, learning can be considered as the formation and revision of mental models [17]. Mental models are knowledge structures that explain, describe, or model phenomena that someone has experienced [3, 17]. This experience determines the correctness and completeness of the resulting models. For example, someone who goes fishing for the first time could consider: what fishing involves, how to use a fishing rod, and where one goes to fish. Throughout her fishing experience, she develops and refines a model of fishing. If she does not catch a fish though, her model will be incomplete. Similarly, if no one shows her how to use a fishing rod, her model may be incorrect.

Therefore, people form and revise mental models as they perceive and interact with phenomena in some environment. In the case of digital games, the environment is composed of information representations. Such representations are collections of symbols that encode information including causal, functional, semantic or structural properties or relationships [18, 19]. The blocks in the game Tetris are examples of information representations, encoding the following: one, the size of the block; two, the spatial position of the block inside the game grid; and three, the spatial orientation of the block. In some versions of Tetris, the blocks are also colored differently. However, this color is merely for aesthetics: the color does not encode any information about the block. Color is thus a presentational aspect of the block, not a representational one. In other games, color could encode some meaningful information. For example, the subject area for questions in Trivial Pursuit are color coded. The subject areas could have been encoded differently such as by using symbols. Thus, the designer chooses what information is represented to players and how that information is encoded.

Players perceive information representations as they engage with a game. Then they must interpret the meaning of these representations. If interpreted correctly, players will know or understand what information was encoded within the representation. If not correctly interpreted, players will not know what the representation means. This results in players being confused, such as: not knowing what purpose some object or message in the game serves, not understanding how they are supposed to use some object, and not knowing what goal they are trying to accomplish in the game. These players will end up with incomplete or incorrect mental models. Therefore, representations that are not understood by players will impede their learning.

The designer's choices regarding representation is important for creating an optimal learning environment. Designers should represent information that is relevant or necessary to play the game. Information should also be given as players need it, rather than all at once [14]. In the context of educational games, this information is what will be learned. Yet, the information should not seem irrelevant to the progress of the game. The purpose of the game Carmen Sandiego is for players to learn certain geographical facts. However, players are not told that the country of Greece has a certain flag. Players are instead told they need to go to a country with a certain flag. Then players need to make the connection between listed countries and the described flag. The geographical facts that designers wanted players to learn are integrated into the game itself: knowing and learning those facts are necessary in order to play the game.

However, designers should also consider the effect representation has on understanding information. Different forms of representations are more effective for different ways of thinking about information [18]. How some information is represented to players will influence the way they perceive, understand, and reason with that information. As an example, consider a game about building a city. Players may want to know about the distribution of wealthy citizens in their city. The designer could represent this information by numbering sections of the city and provide a chart of citizen income vs section number. Such a chart could help players understand change of income in those sections over time, but it would be difficult to know what is special about certain sections that lend themselves to certain incomes. The designer could also change the height of houses in the city so that they are proportional to the income of the houses' owner. Changing the height of houses allows an easy comparison between nearby and adjacent homes, but distant places may be difficult to compare. Similarly, small differences in income would not be represented well as small variation in height would be difficult to detect. The designer could instead provide a map of the city that is color-coded by income. This will show the distribution of wealth in the city in a much better manner than the other methods, but will not help with visualizing changes of wealth over time. The designer could also choose to represent information regarding income in a variety of ways, rather than only one. Therefore, the designer should choose to represent information players need in whatever manner is most appropriate. Otherwise, players may have difficulty understanding or obtaining the information they want.

Games do not only provide information though. Games are also interactive. Players interact with representations in a game to overcome obstacles and achieve goals. Players can also interact with representations to better understand them [20, 21]. As an example, consider a game about a Rubik's cube. The main representation in this game would be the cube. One way of interacting with the game would be to rotate sections of the cube. This interaction is part of playing the game: players have to rotate sections of the cube to match tiles of the same color. Players could also rotate the cube to view its various faces. This interaction is not part of playing the game: it is not required to solve the cube. It is included to help players find the position of various colored tiles. Without it, players would have to remember the position and color of tiles on the cube's hidden faces. As such, designers also need to consider how players will interact...
with the representations of the game. Representations could be made interactive to make the game easier to play or to aid players in their attempts to understand the game.

3. Motivation

We shall now turn to how designers can make a game motivating to play. Game designers often use Csikszentmihalyi's flow theory when they need a theory of motivation [14, 22]. Flow is a state of optimal experience and intrinsic motivation, available to any person regardless of age, gender, or cultural background [23]. Flow can also be experienced while playing educational digital games [22]. The main criterion for creating the flow experience in a game is to have a balance between the difficulty of tasks for players to accomplish, and the level of their ability or skill to accomplish those tasks [14, 22]. Tasks that are too difficult for players to perform will result in frustration. Tasks that are too easy will require little effort, and thus result in boredom. In both cases, players lose their motivation to play the game.

Designers can consider a game as a series of tasks. Some tasks can also be viewed as problems players must solve. The difficulty of a task can be broken down into actual difficulty and perceived difficulty [14]. Perceived difficulty refers to how difficult players perceive the task to be. Actual difficulty refers to how difficult the task actually is for players to complete. The task of pushing a ball to some goal is one example. Having the goal at the top of a hill is a more difficult task than if the goal was at the bottom. Similarly, the task could be more difficult if someone else keeps trying to take the ball away. These are examples of actual difficulty. A higher perceived difficulty could result from the hill looking steeper than it is. Perceived difficulty can be higher or lower than actual difficulty, as players incorrectly or incompletely understand the task to perform. This fictional task will have a different level of actual difficulty than the real task. How similar a fictional task is to the original real task determines the closeness of the original task's perceived difficulty to its actual difficulty.

Designers can think about difficulty in terms of representation: what information about a task designers choose to represent, and how well that information be represented. Such information could include: the objective or purpose of the task, what players must do to accomplish it, or how players will go about accomplishing the task. This information could be represented in an obscure manner or not represented at all. The less information players have about a task, the more difficult it is to conceptualize. For example, suppose that a character is placed in a room with a door. If nothing else is provided, players may not know what to do. Players could be given a message that says the character needs to escape through the door. Instead, players could be given the hint that the character must leave by having water slowly fill the room. How well players interpret these representations also affects how correctly or completely they understand the game.

Difficulty can also be considered in terms of interaction. Typically, this refers to the accuracy or precision of performing some action [24]. Consider jumping over a hole. The jump is more difficult if players must press the jump button at a very precise time. It would also be more difficult if players must land their jump on a small or moving platform. However, other aspects of interaction can be considered. A task can be more difficult if players have to accomplish it by using inappropriate, awkward, or complex interaction techniques [20]. For example, in the game Super Monkey Ball players must maneuver a ball across some landscape. However, players do not control the ball. Instead, they rotate and tilt the landscape to direct the ball and change its speed. This makes the ball difficult to stop or position accurately, leading to a more difficult game.

Determining whether the difficulty of any task is appropriate depends on the skill of the player. The ability or skill level of players could include a number of factors, such as: how familiar they are with the controls of the game, how well they can use those controls, how clearly they understand the representations in the game, how accurate their mental models of the game are, and so on. A player's skill may increase as he or she progresses through the game. Thus to maintain flow, designers need to ensure two things: one, that the difficulty of tasks increases as players progress through the game; and two, that the players' skill remains balanced with the difficulty of tasks.

4. Gameplay

Designing gameplay well is considered by researchers to be crucial for effective game design [13]. Gameplay consists of: one, goals for players to achieve; two, non-trivial challenges that players overcome in order to accomplish those goals; three, actions that players perform to overcome those challenges; and four, choices that players make about what action to perform and when to perform it [25, 26]. These aspects of gameplay are all interconnected. Designers first consider what the game will be about. Then, they break the game down into various sections and decide on each section's content [14, 24].

However, designers should not consider content in ignorance of the topics previously discussed. Designers should choose goals and challenges that lead to a proper progression of difficulty. Otherwise, players may not experience flow. The actions available to players depend on the challenges and goals. However, the actions should also depend on what
information players wish to manipulate. The choices available for players depend on how all of this content is represented. Players interpret the representations to determine what goal they should be pursuing and how to accomplish it. The content that designers choose is largely a creative process. Yet it should be done to ensure proper consistency and connectivity with the rest of the game.

As an example, consider a game about building a city. The overarching goal could be to build a booming metropolis. That goal is broken down into various sub-goals of population growth: needing 1000 people, next 20,000, then 300,000 and so on. The challenges would be balancing the needs of the population with their growth. Needs could include jobs, fresh water, education, security, entertainment, and so on. The actions players could perform would be constructing buildings or roads. While they could just have a button to build, players may want more information. Thus, designers need to include some interaction to provide information about water supply, population density, the effects of buildings on surrounding areas, and so forth.

For educational games, designers should also consider the connection between gameplay and learning. Players can learn the content of the game. In the city example above, they could learn that residential means an area for people to live. Players also learn through playing the game: interpreting represented information, interacting with these representations, and using both to build mental models. These models could be applicable to the real world or be limited to the game environment. For example, players could learn that for every 25 tiles of residential area there should be 1 police station. This could be crucial for playing the game but is not helpful for the real world. However, players could also learn the connections between population growth, economic development, and crime. Players could learn how to click buttons for placing buildings. Yet, they could also learn how to optimize land usage for economic growth and environmental sustainability. What designers choose to make the game about and what aspects of that are emphasized ultimately determines what players could learn [10].

5. Conclusion

In the past, designers have focused too much on adding factual content to a game and calling it educational. Despite some limited success, these games did not achieve the mainstream success of current popular games. Success in the entertainment aspect of games depends on how well they are designed. The same holds true for educational games [11].

In this chapter we broadly discussed the design of learning experiences in a game. Learning can be seen as the formation and revision of mental models. This can result from instruction. For example, a game could describe or explain the water cycle. Players would thus learn the water cycle from absorbing that explanation. Learning can also result from engagement with the game. Players develop models of the information that is embedded in the game itself [10]. For example, the water cycle is implemented into a puzzle in some game. To solve the puzzle, players must understand how the water cycle functions.

Players that engage with various processes come to better understand those processes. Designers should take advantage of this in their design. For example, many games require players to use problem solving skills. However, players may not realize they are performing problem solving. They may also not realize how applicable such skills can be outside the environment of the game. This is a result of the game's design: the designer included problems for players to solve, but did not clarify how those problems apply to the contexts outside the game. Players should discover how to improve their problem solving skills while playing the game. More successful educational games can be created, designers just need to realize how their choices affect the educational value of games.

References