

Analyzing the Influences of Puzzle Games on Learners' Learning

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Abstract. Puzzle games has been one of the essential approaches in education. This paper analyzes its positive and negative influence on learners' learning, which aims to explore the possible impacts of puzzle games on learners' learning based on the features of puzzle games. Specifically, the paper focuses on recent studies about puzzle games, learning theories, and any other related topics. Overall, this paper finds that the positive influences of puzzle games include immersive learning, motivational learning, and high-level learning, while negative influences involve low efficiency and declined learning outcomes caused by imbalance. The finding indicates that educational game designers should take these possible influences into consideration, maximizing the positive ones and avoiding the negative ones.

Keywords: Educational game; puzzle game; learning.

1. Introduction

Recent years have witnessed a growing popularity of game-based learning, which is considered as a very effective method for learners, especially for those with less motivation to learn. Puzzle games, one of the common types of educational games, have been analyzed by some researchers, such as Khorammakan et al., who summarize puzzle game learning as an introduction to critical thinking and problem-solving [1]. Also and it can turn passive learners into active ones, improve their interests, satisfaction, and academic performance. However, in domestic and foreign researches, although a lot of them focus on game-based learning or puzzle games, do not pay a lot of attention on the influences of puzzle games as whole. Instead, a lot of them focus on the experiments of puzzle games and analyze the feasibility of puzzle games on a certain field of learning, while others pay attention on the positive influences of games or puzzle games and neglect the underlying negative effect of puzzle games on learners' learning.

Therefore, to fill this gap, this paper focuses on the positive influences as well as the negative ones of puzzle games on learners' learning. This paper reviews a variety of studies about game-based learning, including those which focuses on certain learning theories, influences of game-based learning, the application of puzzle games in a certain field, etc. Then, this paper summarize these researches and forms its own conclusion about the more comprehensive influences of puzzle games.

2. The Influences of Puzzle Games

2.1. Positive Influences

2.1.1. Immersive Learning

The first feature of puzzle game is immersive learning, which is actually an element shared by most games. A very important and famous theory related to immersive learning is Flow Theory, proposed by Csikszentmihalyi. Csikszentmihalyi defines flow as a kind of feeling of devoting one's energy exclusively to an activity [2]. People will be completely engaged into the scene when this kind of psychological state appears, filtering out all irrelevant perceptions. They will only respond to specific goal and feedback, which also accompanies a high degree of excitement and fulfillment. Mahfouz, Joonas and Opara divide flow into three dimensions: control, attention focus, and cognitive enjoyment [3]. According to their interpretation, when learners are in the flow state, they can

manipulate, be absorbed and engaged, and raise their curiosity and intrinsic interest. Although their research focuses on the flow theory in online context, it can also be applied to game context, three dimensions acting as the main ways learners can be benefited from games.

Game as a whole has this kind of feature of “flow,” but how does the puzzle game specifically help learners have immersive learning? Firstly, the feature of challenging-setting of puzzle games make it easy for learners enter into flow state. According to the definition of puzzle game by Dennis Patrick, puzzle game is a kind of game which provides players with certain information or plot, and requires players to find clues and solve puzzles after analyzing and reasoning [4]. From this definition, it can be seen that the characteristics of puzzle game allows it easy to set different challenges for players, and Engester and Rheinberg argues that optimal skill-challenge balance is the main factor which facilitates access to flow state [5]. Therefore, it can be concluded that a well-designed puzzle game facilitates player enter into flow state. The other feature of puzzle game is situational learning, which can also help learners to be immersed in learning. The puzzles are always set in a simulated situation similar to the real scene. Li, Gao and Ling analyze the mode of an escape game from chemistry confined room, which is a game requiring players to solve chemistry-related puzzles to escape the room [6]. They find that a simulated scene is one of the important element in this game. Players will be put into a simulated scene related to chemistry history or social instances, such as a crime scene, where they are required to use their learned chemistry knowledge to solve puzzles. This kind of situational learning can immerse players into the scene, helping them to have a deeper understanding of the development of the history of chemistry and a deeper experience of the hardship of chemists. Another example of situational learning is Huang’s analysis of the educational mode of university English involves a puzzle game called *Who’s the murderer?*, which requires players to act as detectives to find the criminals by analyzing and collaborating with others using English [7]. By participating in this puzzle game, the players can improve their English inadvertently.

2.1.2. Motivational Learning

Puzzle games can also improve the outcome of learners’ learning by motivational learning. Providing players with motivation is also another distinguishing feature of games. Delacruz claims that players’ interactions with an educational game will motivate them and improve their learning, and Plass, Homer and Kinzer summarize the motivational foundation of game-based learning into three elements: triggering learners’ intrinsic motivation, providing learners with more situational interest, and offering learners’ achievement-related goals [8, 9]. Specifically speaking, puzzle games trigger learners’ motivation and interest by two of the basic criteria proposed by Michalewicz: entertainment, which encourages players to solving the puzzle with high interest, and Eureka, which gives players immediate feedback and reward [10]. Khorammakan *et al.* summarizes that these features of game-based education can make passive learners to be active ones, improve their interest, satisfaction and academic performance [1]. Li, Gao and Ling’s analysis of the escape game from chemistry confined room also involves the research of the motivational learning of puzzle games [5]. They find that the chemistry escape room require students to implement interesting experiments to solve puzzles, which can trigger a considerable amount of interest in learners’ heart, spurring their curiosity for unknown matters and learning interest.

Apart from triggering learners’ interest, puzzle games can also provide learner’s with self-efficacy, which is also of great significance for learners to have motivation in their learning. Albert Bandura defines self-efficacy as one’s judgment of personal capabilities [11]. People are assumed to attempt things they believe they can accomplish, and people with high self-efficacy are more willing to accept challenges. Bandura also believes that self-efficacy can directly influence learners’ willingness to take effort and their motivation when meeting difficulties in learning [12]. Therefore, it can be seen that self-efficacy is a very important element of motivational learning. Huang summarizes the resources of self-efficacy: “personal mastery experience”, “vicarious experience”, “verbal persuasion”, and “physical and affective state” [13]. He analyzes the strategies to improve college counselors’ self-efficacy, focusing on these four resources of self-efficacy. Players of puzzles games can also improve their self-efficacy because puzzle games contain all these four resources. Firstly,

players can have quasi-real personal mastery experiences, just like the players in the escape game from chemistry confined room, who are required to do real chemistry experience to escape from a simulated scene. The second feature of puzzle game is collaborative learning. A lot of puzzle games can be designed for group players, and collaborative learning can offer learners vicarious experience learned from others. Liu's research of the influence of virtual environment on learners' self-efficacy and collective efficacy proves the existence of collective efficacy [14]. With controlling other variables, the group who uses virtual environment to study has a better outcome than the other group who does not, which proves that proper collaborative learning can trigger collective efficacy. Players in the puzzle game can similarly improve their collective efficacy by cooperating with others. The third resource is verbal persuasion. Huang proposes that evaluation is one of the strategy to realize verbal persuasion because encourage, positive responses and rewards from the college can increase counselors' self satisfaction and promote their self-improvement [13]. In puzzle games, the situation is very similar. The Eureka moment, one of the criteria of puzzle games proposed by Michalewicz means the immediate feedback and reward given to the player after completion of the tasks [11]. Therefore, the rewards and positive feedback will improve learners' self-efficacy. The last resource of self-efficacy is a good physical and affective state. A well-designed puzzle game can undoubtedly ensure players good physical and affective state if it can have an optimal skill-challenge balance.

2.1.3. High-level Learning

Puzzle games can not only provide learners with a certain environment that can enable them to be immersive and motivational. Also, they can lead to learners' higher levels of learning. The high-level learning provided by puzzle games can be divided into three types: the ability of application and analysis, acquisition of interdisciplinary knowledge, and cultivation of certain thinking modes.

The first type of high-level learning is the ability of application and analysis. Bloom's Taxonomy divides educational objectives into six levels: Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation [15]. Although different educational games target on different learning levels according to their designs, puzzle games can generally reach the level of Application and Analysis. Tuma and Nassar use the example of clinical surgery to explain Bloom's Taxonomy [16]. They list the different levels of learning of the treatment of some specific diseases. For example, in the learning of hernia, level three is "Apply knowledge to diagnose, repair, or prevent complications of hernias" and level four is "Analyze the diagnostic value of imaging, different repair approaches, or recurrence ...". In the learning of shock, level three is "Apply knowledge to diagnose the condition and execute resuscitation measures specific to each type of shock." Level four is "Analyze the evidence concerning best treatment approaches in various settings and differentiate different shock states..." From these two examples, a clear understanding of the Application and Analysis level of Bloom's Taxonomy can be developed, and it is convenient to imagine a common pattern of puzzle games to prove that these two levels can also exist in puzzle games. For instance, there is a math puzzle game, where players act as a knight who aims to escape from a room full of traps, and players need to avoid these traps using their math knowledge. One of the target of this game is to teach players the Pythagorean theorem, so there are some puzzles about the Pythagorean theorem. Instead of just telling learners the meaning of this theorem and give them some abstract assignments, players in this game are required to use their learning of the Pythagorean theorem in practical scenes, such as measuring the sizes of some certain objects to avoid traps. Also, the target of teaching the Pythagorean theorem can also be linked to other targets such as teaching functional equation or circle. Players are required to select the most suitable knowledge to solve difficult puzzles in different scenes, which reaches the level of Analysis. It is a very common pattern of a math puzzle game, and it can prove that the level of Application and Analysis can be easily reached in a puzzle game.

Acquisition of interdisciplinary knowledge is another type of high-level learning in puzzle games. Learners can always gain the knowledge about different fields instead of just being limited to a certain discipline. There are a lot of examples for it. In the escape game from chemistry confined room, Li, Gao and Ling find that one of the element of this game is the combination of the knowledge of chemistry and the knowledge of other fields [6]. Players can get not only get the knowledge of

chemistry, but also obtain the knowledge of behavioristics, psychology, and sociology when acting as a forensic doctor. Another example is a game called *Mortise and tenon joint* developed by Tencent. In this game, players are required to solve some puzzles about traditional Chinese mortise and tenon, during which players can learn both the knowledge of space and Chinese culture. Plass, Homer and Kinzer also concludes that the learning of social knowledge is a very important element in games, which can provide rich contextual information as well as interactions needed for learning in the modern age [9]. Therefore, puzzle games requiring collaborative also have this feature, which is also an aspect of interdisciplinary learning.

The last contribution puzzle games can make to players is the cultivation of certain thinking modes. Sui and Gu analyzes the influence of childish games on kids' thinking mode [17]. Their advise on the design of childish games include the cultivation of kids' spatial thinking, innovative thinking, logic thinking, and imaginative thinking. Kids can cultivate these thinking modes by playing some games including some simple puzzle games such as classifying objects by their different shapes and building a solid toy house using toy bricks.

2.2. Negative Influences

2.2.1. Low Efficiency

The first negative influence puzzle games have on learners is the low efficiency of learning, which is also the negative influences of most types of educational games. Unlike the traditional teaching method, where the learners can just be exposed to the learning materials as soon as they open the textbook, and the knowledge points are just listed on it, game-based learning requires learners to spend a lot of time on the process of the games, such as dealing with the puzzles, which, according to Yucedal, is a very time-consuming activity for learners, and the curriculum will not catch up if it is used too much [18]. Also, it is also very time-consuming for game designers since educational games have only entered the mainstream and there are not much examples and principles to follow, which makes the activity of preparing games with specific objectives which suits students' level very time-consuming [19]. For example, Çelik, Bilgin and Yildiz analyze the disadvantages of a Jigsaw puzzle game, in which the teacher need to first turn the picture into puzzle and then laminate it to make it durable, and it is also very important that the parts do not get lost and mixed with each other [20]. The preparation of the game is quite time consuming for the teacher.

2.2.2. The Imbalance Affecting Learning

Another underlying disadvantage of game-based learning is the imbalance of the game environment, which will lead to unsatisfactory learning outcomes. The imbalance discussed here refer to the imbalance between skill and challenge.

The balance between skill and challenge is of great significance in an educational game, especially in a puzzle game which is full of challenging puzzles. Yu *et al.* claims that it is very important to provide players with the right level of challenge at the right difficulty, which is the method to facilitate them to access to the flow state [21]. Flow state, as mentioned above, can promote learners' learning, but what will happen when the challenge and difficulty is at a wrong level? The first condition is that the level of difficulty is too higher. Nylund and Oskar divide the frustration in game into two kinds: the positive frustration and the negative one [22]. Positive frustration can trigger good game experience, while negative frustration, caused by too much frustration or the wrong part of the gameplay experience, might have a negative impact on the player and then cause anger to arise. Negative frustration therefore affects game experience very quickly, both in enjoyment and immersion. Therefore, a excessive level of difficulty will lead to the imbalance between skill and challenge, causing negative frustration and pose bad influence on learners' learning. The other condition is that the challenge is too easy for learners. In this situation, learners' learning will be also not as good as expected. Plass, Homer and Kinzer explain the meaning of scaffolding in games, which is an assistant in a game for learners to solve problems and tasks [9]. They emphasize the importance of dynamic assessment of learner's learning and the fading of the scaffolding, which indicates that

educational game should have a certain level of challenge, and learners should not always receive assistance at the same level as when they first entered the game. Wibe's research also prove the importance of certain level of difficulty in games [23]. After analyzing the performance of different players under different levels of stress in a certain game, Wibe finds that players in a stressful ambience shows a significant decrease of played time, which means they can finish their tasks more quickly than those who are in a less stressful ambience. Some subjects says that the stressful ambience can motivate them and make the game more fun to play. Therefore, it can be seen that a certain level of difficulty is also necessary, and excessively easy challenge will also lead to declined learning outcomes.

3. Conclusion

Puzzle games have both positive and negative influences on learners' learning. Positive influences include immersive learning, motivational learning, and high-level learning. These positive influences can be attributed to the features of puzzle games or games as a whole, such as easy access to the flow state, providing learners with motivation, and high-level learning underlying in the game mechanics. Apart from these positive influences, puzzle games, however, may also pose some negative influences on learners' learning, such as low efficiency of learning and declined learning outcomes cause by imbalance. Low efficiency is attributed to the feature of games: time-consuming to design and play, and imbalance between skill and challenge can also affect learners' learning performance. To avoid these negative outcomes, puzzle game designers should have a deep analysis of the behaviors and demands of the targeted players, and choose the most suitable style and structure of the game, which can then improve the efficiency of game-based learning. Also, they should use scaffolding properly in games, and set dynamic assessments, which can help them assess the ability of learners timely and have the balance between skill and challenge.

Therefore, puzzle game designers should take these possible influences into account when designing an educational game. Maximizing the influences of the good features of puzzle games, enabling learners to enter into the flow state and offering them opportunities to reach higher level of learning, while also avoiding the negative aspects of games by making tasks less time-consuming and using dynamic scaffolding to ensure the proper level of difficulty.

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