Understanding the Elements of Challenge and Skills in Educational Games

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Abstract: Although researchers suggest that games have a positive experience in a learning outcome, there is still a lack of investigation on the potential of game mechanics for better flow experience and learning outcome. According to the literature, the flow state in the game creates player engagement which leads to a positive learning outcome. Based on flow theory, challenge and abilities are two crucial game elements to achieve a flow state. This paper discusses the importance of conflict and competition in generating challenges. In gameplay, the players use their abilities demanded by the game to complete the challenge. This paper discusses the role of different skills required to play the game, and through these abilities, the players learn. This paper explains the correlation between challenge and various skills needed to play games. Conflict can be the better approach to generate the challenge because it is endogenous. Knowledge is a crucial ability to incorporate into educational games. This paper also explains the role of prior knowledge, and it is observed that the player achieves a better learning outcome if the game demands some level of prior knowledge to play the game.

Keywords: Challenge, Conflict, Competition, Abilities, Knowledge

1. Introduction

Games designed for a primary objective other than pure entertainment are called serious games. As the nature of the games has changed dramatically, the researchers are focusing on the potential of games. The main objective of educational games is to help the player to construct knowledge about academic concepts and to train certain skills. Games-based Learning (GBL) has developed a reputation among educationalists; it is perceived as a potentially engaging form of supplementary learning that could enhance the educational process and has been used at all levels of education (Hou and Li, 2014) (Mahmoudi *et al.*, 2015). Despite this recognition, there is still a lack of empirical evidence supporting the relationship between attributes of games with learning attributes.

Opening up the 'black box' of games would enable us to focus on specific principles or mechanisms. This finer-grained approach could unlock the relationship between game elements and learning. Most of the papers discussed motivation, engagement, and flow (Hamari *et al.*, 2016) of the game. Still, these papers did not mention what kind of variables of game mechanics like motor skills, strategy, knowledge, memory, and chance were involved in the game and its correlation with learning achievement. It is required to establish the relationship between academic achievement and game-based learning (Sepehr and Head, 2018). Efforts are needed to articulate clear relations between variables of game mechanics and a range of outcomes, from a broad level and gradually narrowing down to specific gameplay mechanics.

The main functionality of the game is the challenge. Games must be challenging to engage and immerse the players in the gameplay. Based on the game definitions, a game is built as an activity. While designing the games for education, the designers develop the activity first based on the educational topic. Later, the game elements are incorporated to generate interaction between players, randomness, uncertainty, etc., to make an activity challenging. This activity in educational games will be related to academic topics and other abilities. The appropriate challenge in the activity is important in games. Some papers state that educational game with appropriate challenge retrieves learning outcome. The balance of challenge and skill is very important to achieve the flow state. On the broader level, competition and conflict can be used to generate challenges. This paper explains the role of competition and conflict in gameplay in educational games. It also explains the different types of abilities the game demands and the prior knowledge in educational games.

2. Flow Experience

There are theories in the literature that discuss the importance of flow experience in educational games. Malone and Lepper introduced a taxonomy with two parts that work together for intrinsic motivation in educational environments: individual motivation and interpersonal motivation (Malone and Lepper, 2021). Individual motivations include challenge, curiosity, control, and fantasy. Interpersonal motivations focus on the

relationship between the players, which have cooperation, competition, and recognition. As per Malone and Lepper taxonomy, combining individual and interpersonal factors leads to the player experience. This Self-determination theory is fundamentally concerned with well-being, but later it was extended to player experience (Ryan, Rigby and Przybylski, 2006). According to self-determination theory, enjoyment is derived from playing games that rely on three basic psychological needs: 'Autonomy' describes the need to feel that one is in control over their own life and that one's actions are self-endorsed. 'Competence' is the need to act effectively and feel capable in one's activities. 'Relatedness' is the sense that one is within the game world. Flow state is regarded as the ideal condition of mind and body, accompanied by immersion and enjoyment. The flow channel, with its optimal balance between challenge and skill, is the actual definition of competence in Self-determination theory. Self-determination theory seems to be an approach for making predictions about the quality of motivation, whereas flow is the autotelic experience, a concept related to intrinsic motivation and engagement.

Mihaly Csikszentmihalyi explains happiness and engagement as a state of "flow". According to Csikszentmihalyi, flow is a state of complete absorption or engagement in an activity and refers to the optimal experience (Csikszentmihalyi, 1990). Later on, researchers devised a set of theories to assist people in entering the flow state (Kiili and T Lainema, 2008) (Jennett *et al.*, 2008). Since then, these theories have been applied to various domains, including game design, to create better human interactive experiences. The flow can be considered an important factor of player engagement in game design. Researchers developed different game design frameworks based on flow theory (Kiili, 2005). According to Csikszentmihalyi's research and observations, the flow has eight major components: 1. a challenging activity requiring skill, 2. a task with clear goals, 3. a task that provides direct and immediate feedback, 4. a sense of control, 5. merging of action and awareness, 6. concentration on the task at hand, 7. the loss of self-consciousness, and 8. an altered sense of time. The designer must fulfill the first five components in the game to make players achieve a flow experience because they are the objectives. If the game satisfies the first five components, then the player experiences the other three components, showing that the player is in the flow state. The first component of the concept of flow is 'challenging activity requiring skill'. As mentioned above, the balance between the challenge involved in the game and the abilities of the player is most important to experience a flow state. So, identifying the mechanisms to create challenge is important to understand its effect on learning outcome of educational games.

As all the theories mentioned the importance of challenge, this paper focuses on understanding the challenge. According to the above theories, the challenge is an important concept involving the game system and players. Due to the involvement of the player, the skills required to win the challenge also have to be considered to understand the elements of challenge in games (Vahlo and Karhulahti, 2020). Flow theory is incorporated into game design to address the various skill levels players possess when performing a task or activity. So, Flow theory is used to understand the mechanisms to create a challenge because it focuses entirely on the challenge and its correlation with skills.

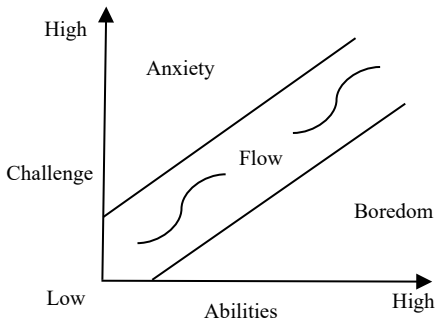

Figure 1: Flow in single-player games

Although challenges and difficulty are related, the two terms should not be used synonymously. As an analytical concept, the challenge can be thought of as a task or a problem, the difficulty is determined by the performer's abilities, knowledge, and skills (Iversen, 2012). The activity in the game is itself a challenge for the player. In the case of single-player games like Bubble Shoot, the challenge is to shoot the bubble with the same color. Shooting the bubble requires a certain angle and strategy to get more bubbles in one shot. In some games like Candy Crush, completing the game within the time limit or number of moves is the challenge. But perspective towards the challenge is different when other players are involved in the gameplay, i.e., multi-player games. Another

way to generate challenge that is through uncertainty. The uncertainty can be caused by including chance through dice or randomness.

3. Challenge

Many researchers tried to explain challenges and the role of challenges in educational games. According to the literature, the challenge in games positively affects learning directly and via increased engagement (Hamari *et al.*, 2016). The challenge in the game is a strong predictor of learning outcomes. For the designers of educational games, the results suggest that the challenge in the game should be able to keep up with the learner's growing abilities to endorse continued learning in game-based learning environments.

There are different types of challenges specific to that particular game. In the case of multi-player games, beating the skills of the opponent is a bigger challenge than the in-game task difficulty. In Chess, the player tries to win over the opponent player's strategy. In Scrabble, it is the player's knowledge versus opponent's knowledge.

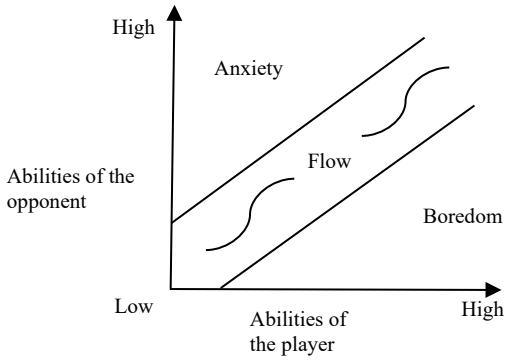

Figure 2: Flow in multi-player games

Based on the above figures, on a broader level, the challenge consists of two elements: competition and conflict. One common feature of game definitions is the inclusion of conflict or competition. There are numerous ways to formulate this and emphasize subtle differences, from underlining the agony between players to emphasizing the struggle participants must engage. Dempsey side-step the competition definition by deciding that it is possible to compete with oneself (Dempsey, 2002). Abt's definition specifies achieving objectives in a limiting context is called conflict with the game world (Dempsey *et al.*, 2002). Salen and Zimmerman's conflict is any problem artificially created by the game designer for the player to solve (Salen and Zimmerman, 2004). These definitions show that competition and conflict are essential elements in defining games. Even Malone and Lepper's taxonomy discusses competition as interpersonal motivation. They discussed three types of interaction between the players: Cooperation, Exogenous and Endogenous competition, and Recognition (Malone and Lepper, 2021). A combination of individual motivating factors and interpersonal factors work together for motivation in educational games.

3.1 Competition

Competition is an extrinsic element of the challenge in the game. In single-player games, competition is generated with external limitations such as timer, points, number of moves, and resources. As all the validations concerning external constraints are done at the end of the gameplay. So, competition is the end game element of challenge. In competition, the opponent's actions do not have any effect on the player's gameplay, but it has an impact on the winning outcome of the game. For example, in snake and ladder, players do not affect each other's gameplay, but in the end, the player who reaches first is the winner.

Competition with self. The players compete with their scores. This type of competition can be observed in single-player digital games but not in board games because board games need at least two players to play. For example, in Tetris (a digital game), the player tries to overcome the previous score. In this case, the player competes with the timer. For example, in brain-training mini-games like Peak, the player always tries to gain maximum points in the time limit. It also overlaps with the competition with self because the player always tries to better their performance in the time limit.

Competition with an opponent. The player competes with another player. For example, snake and ladders, guess the fence, etc., in which each player plays their independent game without involving in the gameplay of the opposite team. But there will be a winning team who gains the maximum points in 'guess the fence' and the player completes the goal first in snakes and ladder. The competition is extrinsic outside the gameplay.

Competition in Educational games. Ideally, when competing with others, learners must work harder; as a result, all students improve their knowledge, allowing them to progress. Without competition, only the best of the class would improve their knowledge. Many studies have found positive effects of competition in GBL, such as enhanced motivation, a higher tendency to make risky plays, and decreased cognitive load (Admiraal, Huizenga and Akkerman, 2011) (Ercil, Ozcelik and Sahin, 2015). These positive effects may indirectly lead to the learning outcome and motivate players extrinsically to put forth more effort on gameplay but not through the game mechanics. One of the papers also mentioned that a game with no competition enhances knowledge better than the competition (Chen, Liu and Shou, 2018). It is so because players may emerge into competition and not concentrate on the content. The challenge based on competition always refers to time, i.e., who finishes first, external timer and playing for long without losing a life. Because competition refers to time, it is always an external element called exogenous mechanic.

3.2 Conflict

Conflict is any problem artificially created by the game designer between the players (Salen and Zimmerman, 2004). In single-player games, conflict is generated with non-player characters, and these conflicts are solved in the gameplay. So, it can be called an in-game element of challenge. In multi-player games, the conflict between the players is generated by common resources, having control over the opponent's game elements, etc. In conflict, the opponent's actions affect the player's gameplay and vice versa. As all these actions occur in gameplay, conflict is an intrinsic element and endogenous mechanism to generate challenge.

Conflict with self. The dilemma of making decisions in the gameplay is clearly observed in single-player games. For example, in Cross Words, the challenge is to form maximum words with the available alphabets. In Scrabble, also players try to form a word with the alphabets they get randomly.

Conflict with opponents. Here the opponent's skills will create the challenge. In this type of game, the opponent's actions will affect the gameplay. In the educational game 'Three Sticks', the player's knowledge regarding geometrical shapes will affect other opponent's gameplay.

Conflict with the game world. This type of conflict is mainly seen in role-playing games or single-player games. For example, Pac man, escaping from the enemies coming randomly from different directions is a challenge.

All the above conflicts are observed in the gameplay. So, conflict is an intrinsic challenge of the game.

Conflict in Educational Games. In the literature, no paper mentioned directly that conflict in the game enhances the learning but instead mentioned that challenging activity in the game enhances the learning outcome (Hamari et al., 2016). As conflict is an intrinsic element, it is an endogenous mechanic to generate the challenge, and it may positively affect learning outcomes (Malone and Lepper, 2021). The conflict in the game can be a special predictor of learning outcomes. Gameplay is nothing but solving the problem, and the player creates a problem for the opponent in a game based on conflict. Creating a problem requires more knowledge, which may positively affect learning outcome. More empirical studies are required in this area to understand the role of conflict in interaction, flow experience, and learning outcome.

Conflict is endogenous, and competition is the exogenous mechanic to generate the challenge (Malone and Lepper, 2021). Competition and conflict may both motivate the player to play the game. It can also be that one encourages the player more than the other. So, knowing which element of challenge enhances the learning outcome is essential. Competition and conflict are generally considered a mode of interaction with the game world or other players. But these modes of interaction are part of the challenge and can help to increase or decrease the difficulty of the challenge. According to the literature, there is one more interaction mechanic called cooperation. This kind of interaction is observed between the players in the games where they play together to achieve the goal. In cooperation-based games also, either conflict or competition or both is observed. In any team-based game, the challenge generates because of the team's abilities versus the opposite team's abilities. There is cooperation within the team and conflict between the teams.

4. Abilities

Abilities are required to achieve the winning condition or to face the challenge. Players need various abilities to play games like Physical abilities, Intellectual abilities. The player requires knowledge and other skills when it comes to educational games. The game designers create challenges based on at least one of these abilities. Challenges based on more than one ability will be more effective.

4.1 Physical abilities

Field games are the best examples to explain physical skills. The field game requires physical skills specific to the game, so the skills of the opponent team decide the level of challenge in the game. The board game carrom is a good example of a mix of physical skill and thinking, but physical skills dominate the game. It depends heavily on the control over force executed by the finger. However, these physical actions in the game are from the player's taught process, but it has to be accomplished through the player's physical skills. Any digital racing games or other games that require speed or shooting require motor skills. The player should be able to move from one key to another quickly.

In the case of educational games, these motor and physical skills can be used to train the players. Simulation games like landing flights or driving use motor skills to train players. In the case of learning academic content or acquiring knowledge, the game mechanics dominated by motor skills will train the player in a particular skill but not in acquiring knowledge. It is not endogenous if the player is running for some correct answer and the competition or rewards are based on who runs first, nothing to do with learning. Here the competition might externally motivate the player to play but does not contribute to the learning outcome. The player emerges more into running than acquiring knowledge.

4.2 Intellectual abilities

Some of the games involve the ability that is thinking or strategizing. A simple example that is based on strategizing is knots and crosses. It focuses mainly on problem-solving abilities, and the opponent creates the conflict. The opponent's skill of visualisation and strategy is a challenge to the player. The game mechanics based on strategy generates conflict between the players rather than competition. Competition can be generated externally by including a timer or by competing to finish first. So, in strategy-based games, competition is the external element of challenge. The games based on thinking and strategizing can be used to train problem-solving skills. In learning academic content, this skill can help to gain learning outcome if strategizing is based on knowledge of the content.

Memory: In the game 'Match the pair' all the cards are laid face down. Players have to make a pair of similar cards by flipping the cards. It forces the player to recall where the required pair card is located. Because the playing cards are laid down face down randomly, there is an element of chance that all players experience. But the dominant ability in the game is memory. In educational games, if the conflict is based on memory, it will help to acquire knowledge. This ability can be used in games based on academic content like factual knowledge, for example, vocabulary.

4.3 Knowledge

Knowledge is an important ability in educational games. Using knowledge as a requirement to complete a challenge helps to enhance the learning outcome. For example, Scrabble primarily relies on knowledge and memory of words and spellings. The challenge is to build words from the set of alphabets. Because the alphabets are selected blindly from the pouch, there is also a small component of chance. Clearly, the three variables, knowledge, thinking, and chance, are playing a role in that order with no contradiction with each other. But it gives an advantage to players with 'knowledge' of words. So, the dominant variable is knowledge.

4.3.1 Prior Knowledge

In terms of gameplay, it is known that how the in-game performance of learners varies with different levels of prior knowledge. Few studies also tested with simulation games that players having prior knowledge perform well in educational games than players with less prior knowledge (Yeonjoo *et al.*, 2019) (Dong, Jong and King, 2020). The players with prior knowledge follow a systematic approach towards the gameplay with better speed, accuracy, and a less cognitive load than players with less prior knowledge or no prior knowledge.

But here the question comes, is it important to have prior knowledge to play educational games? This can be answered using flow theory for games. The prior knowledge and challenge are dependent on each other. If there is no prior knowledge and the challenge requires knowledge to play, it leads to anxiety. The player does not feel challenged if the prior knowledge is high. But the other necessary abilities in the game can engage the player to practice because the gameplay is different every time you play a game.

In terms of learning, it is largely unknown how the learning outcome of the players varies with different levels of prior knowledge. It will be interesting to see the learning outcome of players with prior knowledge and no prior knowledge. The ideal learning curve can explain this concept.

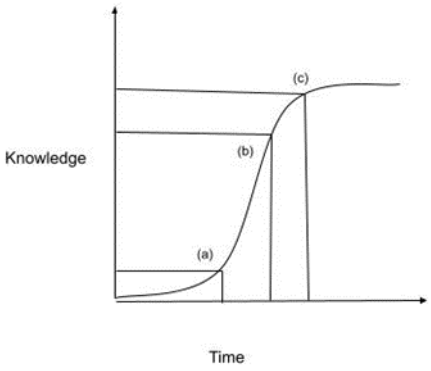

Figure 3: Learning curve in educational games

If the player has no prior knowledge about the concept that the game is trying to make the players learn, then reaching a point (a) in the above figure takes a lot of time (multiple plays). The knowledge acquisition is very slow if the player has no prior knowledge. If the player already has the knowledge till point (a) before, the player takes significantly less time or number of plays to reach point (b) because the game helps to build their knowledge based on prior knowledge. If the player has prior knowledge, we observe the significant difference in knowledge gained with one or two plays. If the player has complete knowledge till point (c) on the topic based on which the educational game was made, then there might not be knowledge gained from the game, but it can be used for practice. Other game elements can engage the player and motivate the player to play the game.

Other abilities and chance in the game can engage the players and motivate them to play the game, but knowledge enhances learning. Games that include conflict with knowledge make the game endogenous. If the player is improving his gameplay, and this improvement can be referred to as learning the content, then it is called an endogenous game. If the game involves other abilities without knowledge and asks questions between the gameplay like a quiz, then it is an exogenous game. Exogenous games can create a game environment and fun but will not enhance learning. Combining knowledge with other skills can make games both endogenous and engaging.

5. Chance

In games like Snakes and Ladders and Tambola, all the actions taken place in the game are governed by a random number. In Snakes and Ladders, all the actions are governed by the number that is generated by the dice. In the game Tambola, a person is assigned to take one number at a time from the bowl, and the player who makes the first row or column will gain points, and the full house will be the winners. So, all the actions are governed by a person who picks a number randomly. Chane has nothing to do with the player's skill. The player cannot manipulate their gameplay through their abilities. Instead, the external element of the gameplay will manipulate the player’s gameplay.

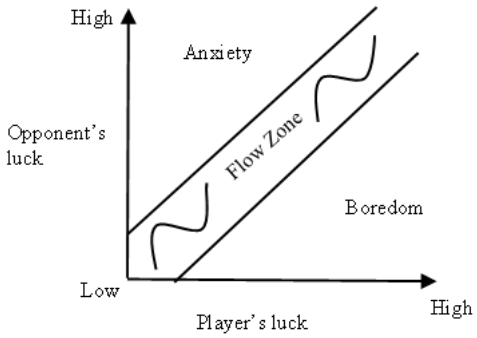

Figure 4: Flow in chance-based games

According to flow theory, in chance-based games, it is player's luck versus opponent's luck. The opponent's luck is the challenge for the player. If the opponent's luck is greater than the player's luck, it leads to anxiety and if the player's luck is greater than the opponent's luck, it may lead to boredom. The uncertainty is high in the games based on chance because no skill is involved. In complete chance-based games, there is no conflict between the players. It has only competition between the players. To experience the flow state, the major component of the flow "sense of control" is important. This can be achieved by adding one of the abilities to the chance. For example, Ludo has both luck and strategy/thinking skills. Even though luck dominates the game, the player will feel a sense of control over his actions. In the case of educational games, if the competition is based on luck and knowledge, then there will be uncertainty in the game, and it also leads to learning outcome if the dominant skill is knowledge. Knowledge will create a sense of control to experience a flow state.

6. Conclusion

According to flow theory, challenge and abilities are the important variables in experiencing a flow state during the gameplay. Completing the activity in the game with some limitations is a challenge in the case of single-player games. In the case of multi-player games, the abilities of the opponent players are the challenge. Based on flow theory, competition and conflict are two mechanisms to generate challenge. Most of the games have both competition and conflict to build challenges. Competition can motivate the player to play games, but conflict helps in enhancing learning through games because it is an endogenous mechanic. The challenges in the game require different abilities like physical, intellectual, and knowledge to play. Chance is another necessary element in games based on chance, but it is not an ability. These three abilities and chance can achieve all the challenges in the games. Chance with the combination of any of the abilities will create the feeling of ease of control which is important for the flow experience.

In the case of educational games, knowledge as an ability plays an essential role in enhancing learning. Other skills can make the game engaging and interesting, but knowledge helps the player to build understanding based on prior knowledge. If the game has a conflict as a challenge and knowledge as the ability to complete the challenge, it makes the game endogenous and enhances the learning outcome. More empirical studies are required in this area to build a correlation between the conflict and learning outcome.

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