

Knowledge Representation Schema of Educational Gameplay

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Abstract: In educational game design, achieving a balance between engaging gameplay and effective learning objectives is crucial. A well-designed educational game should seamlessly integrate learning content into the game mechanics to ensure players acquire knowledge or skills while enjoying the experience. Various design frameworks have been developed to guide the creation of educational games, helping designers incorporate pedagogical elements into gameplay. However, these frameworks often lack assessment mechanisms that evaluate how well the game facilitates learning. While existing evaluation techniques can assess educational games, they are often extensive and require significant resources. To address this gap, we propose a schema that enables young game designers to analyse their games before committing to a full-scale evaluation. This paper introduces the Ed-WPG schema, designed to analyse educational gameplay as an extension of the WPG schema. WPG schema was developed by us to represent the processes involved in the gameplay and Ed-WPG schema is the extension of the WPG schema to represent what variables need to be analysed at different states of the gameplay.

Keywords: Educational games, Educational gameplay, Knowledge representation, Game-based learning

1. Introduction

Educational games have gained significant attention for their potential to enhance learning through interactive and engaging experiences. The learning objectives should be seamlessly integrated into the game to make educational games effective, thereby enhancing both learning and the overall gaming experience. So, design and evaluation are crucial phases in developing an educational game. Several frameworks in the literature focus on various aspects of game design and pedagogy. The Experiential Gaming Model (Kiili, 2005), Adaptive Digital Game-based Learning Framework (Tan et al., 2007), Three Layered Thinking Model (Fu & Yu, 2008), EFM Model for Educational Game Design (Song & Zhang, 2008), Serious Game Design Assessment (SGDA) Framework (Mitgutsch & Alvarado, 2012) are the frameworks provide valuable perspectives, many lack detailed, practical guidelines for integrating pedagogical goals with game mechanics, and assessment tools for evaluating educational outcomes are often underdeveloped (Sasupilli et al., 2019). So, there is a critical need to focus on evaluation than design because it ensures that intended pedagogical objectives are met and provides insights for refining game mechanics to enhance educational effectiveness.

Existing evaluation techniques include usability testing (Brooke, 1996), pre-test and post-test (Hou & Li, 2014), heuristic evaluation (Fu et al., 2009), stealth assessment (Shute, 2011), and qualitative methods such as interviews. While these methods offer valuable insights, they also present limitations (Sasupilli et al., 2019). Usability testing may focus more on interface issues rather than deeper learning outcomes. Playtesting often requires a significant amount of time and resources for conducting pre-tests and post-tests. Heuristic evaluation, which is developed either for experts or end users, provides a rating of the experience rather than an in-depth analysis. Stealth assessment may struggle to capture nuanced player experiences. These limitations highlight the need for a comprehensive framework specifically designed for analysing educational game gameplay. Few frameworks in the literature claim to be used for evaluating educational games. Learning Mechanics – Game Mechanics (LM-GM) (Lim et al., 2015) is a framework that assesses educational games based on the cognitive skills outlined in Bloom's taxonomy. This framework focuses solely on the structure of the game, without considering its dynamics. Cognitive Game Design Analysis (CGDA) (Ardakan & Zahra Vahed, 2019), aims to structure the analyze but it just provides the list of elements that need to be analysed.

This paper proposes a framework for systematically analysing educational gameplay, bridging the gap between design and evaluation. By focusing on gameplay dynamics, player interactions, and learning impact, the proposed framework provides a structured approach to assessing educational game design by analysing educational gameplay. This approach will enable designers to assess games in the early stages of design and contribute to improving educational game design by gathering insights through the framework.

2. FBS Ontology for Educational Games

To analyze educational games from a design perspective, we used the Function-Behavior-Structure (FBS) ontology (Gero, 1990). FBS ontology is used to analyse or describe a design artifact or process. The FBS ontology

is not a linear model; instead, it emphasizes a loop (see Figure 1). A game is a design artifact designed by game designers and used by the players. So, it is appropriate to use the FBS ontology to describe educational games.

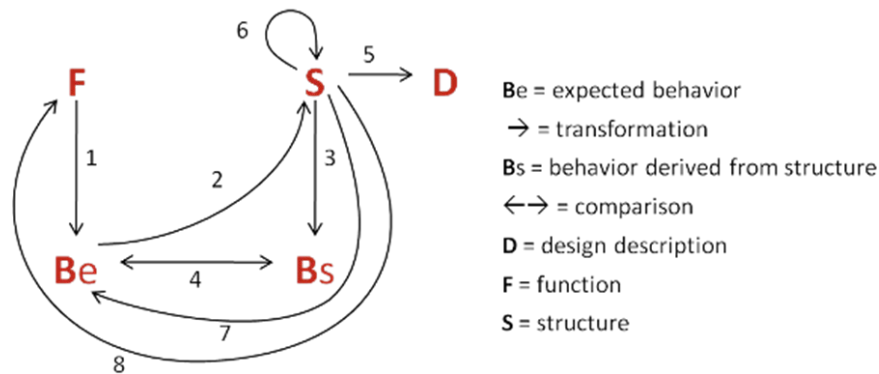


Figure 1: FBS Ontology

However, we applied FBS ontology to describe the game as an artifact (Sasupilli & Bokil, 2023b). We identified challenge and interaction as functional variables, uncertainty and dependency as behavioral variables, and game mechanics and game world as structural variables. Using the FBS framework, we identified functional, behavioral, and structural variables in educational games that also include FBS variables commonly used in games.

<i>Functional Variables:</i>	Interaction and Challenge (Game Variables)
	Acquirement, Assessment (Learning Variables)
<i>Behavioural Variables:</i>	Uncertainty and Dependency (Game Variables)
	Feedback, Progress, Practice (Learning Variables)
<i>Structural Variables:</i>	Game mechanics and Game world (Game and Learning Variables)

These variables define how educational games operate, ensuring learning objectives are embedded in engaging gameplay mechanics. By leveraging the structural components of games such as mechanics, rules, and elements within the game world, educators and designers can create experiences that achieve the functional and behavioural outcomes of educational games. Each variable is described in the following sections using “Scrabble” as example. As Scrabble is a well-known educational board game, it will be easy for readers to understand the concepts.

2.1 Functional Variables

Acquirement: Acquiring knowledge or skills is the primary function of the educational games. Knowledge is one of the game mechanic variables that can be used to build mechanics. Knowledge acquisition can occur by extracting new knowledge or by constructing knowledge based on prior knowledge.

Example: In Scrabble, the players learn new words from the words built by the opponent. The players also apply their factual knowledge to earn points and construct their knowledge if the spelling is wrong.

Assessment: There are two types of assessment when it comes to educational games. One evaluates the player's actions according to the rules, and the other evaluates the player's knowledge. The system or opponent assesses the knowledge applied by the player. In educational games, assessment is a crucial function that must be accomplished. Specifically, when applying their knowledge, players need assessment, and based on the assessment, they can build upon their knowledge.

Example: In Scrabble, the words built by the player are evaluated by the opponent. In the digital version, the system will assess the player. This assessment helps players correct their knowledge.

Interaction: Here, the interaction occurs between the game world and the player, as well as among players. Interaction is a key factor that motivates players to engage with the game. Through interaction, the educational games can provide an engaging learning experience.

Example: In Scrabble, the player draws random letters from the bag and tries to form a meaningful word, placing it on the board. Here, it is observed that the players interact with game elements, such as letter tiles and the words on the board.

Challenge: The primary function of the game is the inclusion of contest, conflict, or competition. A game involves some aspect of competition, even if that competition is with oneself. Conflict is involved in the structure that requires players to struggle toward a goal. Competition and conflict can be involved in achieving the goal in a limited context.

Example: In Scrabble, the player who gains the maximum points by building words out of the limited letter tiles wins the game. The in-game challenge involves building words from the random letters the player receives in each turn. The overall game challenge is to get the maximum points among players.

2.2 Behavioural Variables

Feedback: There are two dimensions to the feedback. One is game perspective feedback, which includes whether the player's action is according to the rules or not. Another one is knowledge-related feedback, which is important in educational games. The knowledge that the player applies can be assessed through providing feedback, or the feedback itself could be new knowledge acquired by the player. Feedback is the behaviour through which function assessment is achieved.

Example: In Scrabble, the words built by the player are checked by the opponent in a board game and by the system in a digital game.

Progress: The player must be aware of how close she is to achieving the winning condition. The progress can also be analysed in two dimensions. One is progress toward winning conditions, and the other is progress in learning outcomes.

Example: In Scrabble, the points indicate the player's progress. In the long term, the player may observe progress in their knowledge of English word spelling and vocabulary.

Practice: The educational games should have the behaviour of practice or repeatability. The game should generate different situations or possibilities to acquire or apply knowledge. Challenge is an important functional variable in a game, and if the experience of challenge is no longer present once the knowledge is acquired, then the game is of no use.

Example: In Scrabble, the new random letter tiles are added to the tray after every turn to produce different possibilities and maintain challenge.

Uncertainty: Games have an uncertain outcome related to achieving a goal. Uncertainty is one of the dynamics created by game mechanics. The function of game design is to create a system with challenges, which can be achieved by incorporating uncertainty as a behavioural aspect in the gameplay. So, uncertainty is considered a behaviour of the game.

Example: In Scrabble, there is uncertainty in obtaining the letter tiles, creating opportunities to build different words with the available letters.

Dependency: The actions of the player depend on the actions of the opponent player, a team, or a system. In the case of a single-player game, the actions of the player depend on the system. This dependency on the opponent's actions creates conflict, and the dependency on the system presents a challenge.

Example: In Scrabble, the player builds the word, including at least one letter from the board.

2.3 Structural Variables

Game Mechanics: Rules vary for each game, but all games have established rules, making the gameplay structured. The combination of rules and tokens/game elements is game mechanics. The game mechanics are created by the following variables: physical skills, intellectual skills, chance, and knowledge. The game mechanics create conflict that leads to dependency as the behaviour that creates functions such as interaction, acquirement and challenge.

Example: In Scrabble, players receive letter tiles randomly from the bag. After every turn, the player should have seven letter tiles on the tray. This mechanic creates a challenge through uncertainty.

Game World: The game world plays an important role in educational games. The elements or tokens in the game world can carry educational properties.

Example: In Scrabble, the letter tiles have letters, and the board is filled with words during gameplay.

3. Schema for Educational Gameplay

In educational games, learning occurs while the player engages with the game. The gameplay needs to be analysed to determine the level of knowledge the game demands and the level of knowledge the player can gain from it. The FBS variables of educational games provide a lens on every event of the gameplay. These variables provide a specific direction to analyse educational gameplay. The formal analysis of educational gameplay involves a systematic examination of the game's elements and mechanics, considering its alignment with learning objectives and its potential to facilitate meaningful learning experiences. By conducting this analysis, educators and game designers can identify strengths, weaknesses, and opportunities for improvement, creating more effective and impactful educational games.

The proposed Ed-WPG (Educational-Winning state, Planning state, and Game state) schema (see Figure 3) is developed based on the WPG (Winning state, Planning state, and Game state) schema (see Figure 2) of gameplay (Sasupilli & Bokil, 2023a) and FBS variables of educational games. WPG is a knowledge representation schema for a gameplay, which describes the process of gameplay and the transition from one state to another within the gameplay. We incorporated FBS variables of educational games into the WPG schema to propose an Ed-WPG schema for educational gameplay.

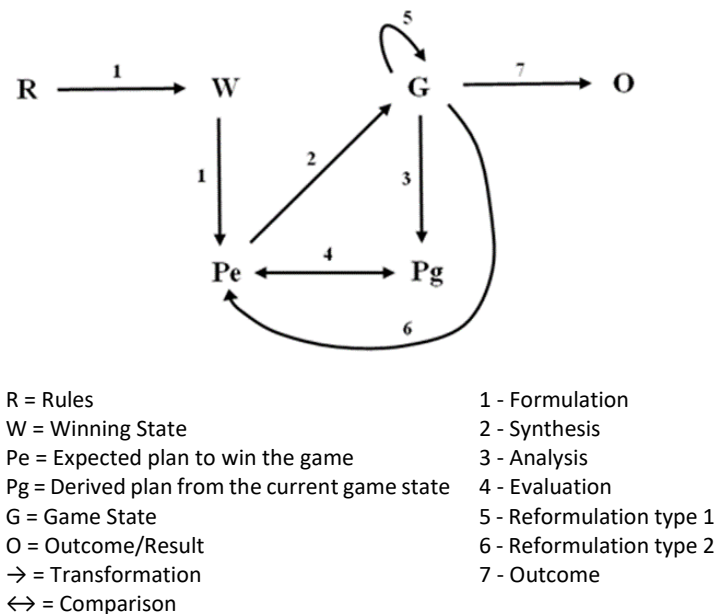


Figure 2: Basic WPG Schema

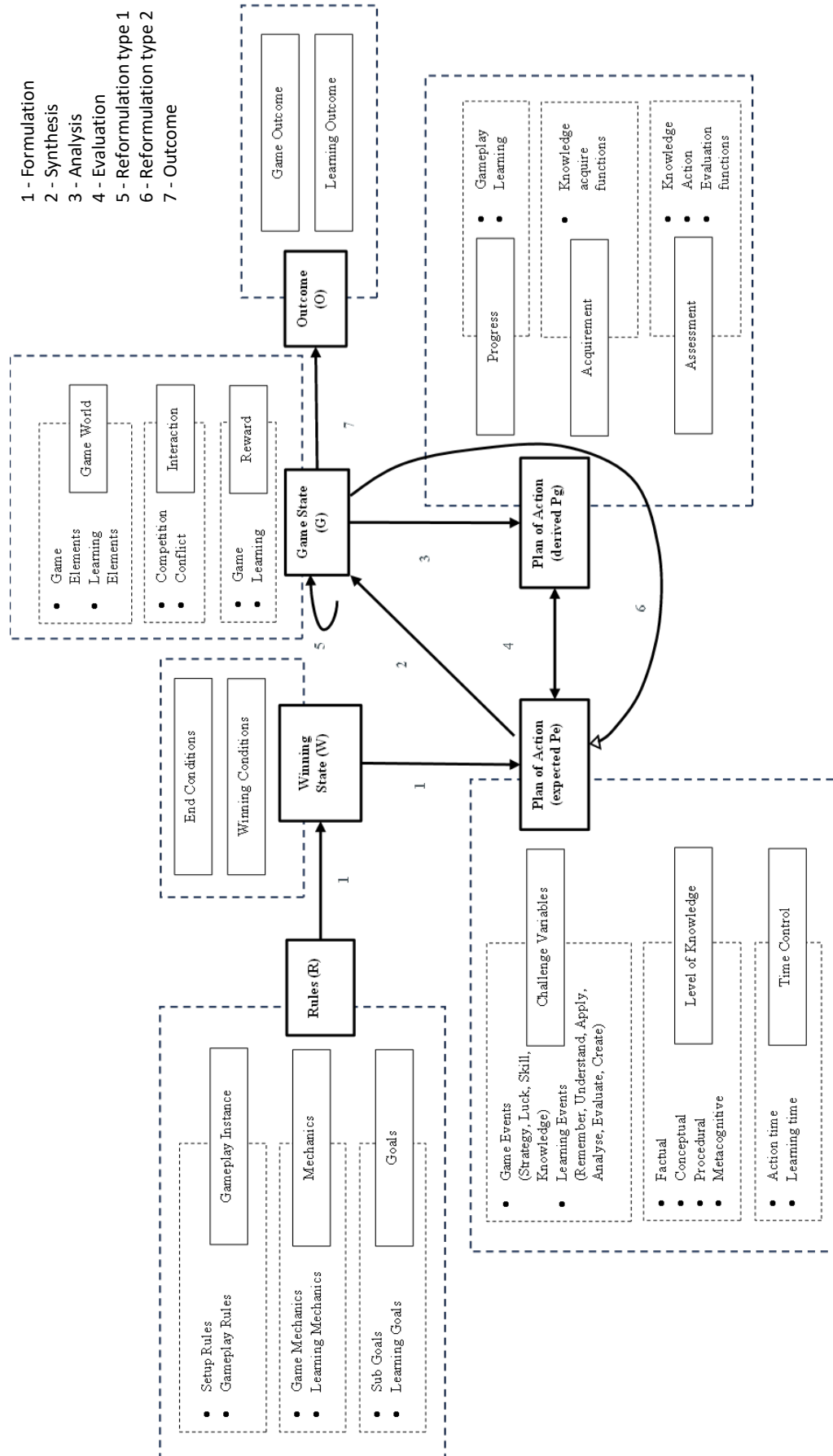


Figure 3: Basic Ed-WPG Schema

3.1 States in Ed-WPG Schema

The following are the states in the Ed-WPG schema and their role in educational gameplay.

3.1.1 Rules (R)

Here, the setup required before starting the game, the distribution of resources if necessary, the game mechanics, and the goal are interpreted by the player. In some educational games, the rules are built around learning content. In such cases, learning begins with interpreting the rules.

Components of Rules

Gameplay Instance: The gameplay instance involves setup and game rules. Before starting the gameplay, the game requires a setup, which is the initial or 0th game state, to start the gameplay. The rules outline what is and is not allowed in the gameplay. The transition loop between the planning and game states occurs when understanding and applying the rules is achieved. So, knowing the rules is the initial requirement to play the game.

Mechanics: The rules include everything that can happen in the gameplay, like the token's properties, what is allowed, when the player gets a reward, and how, etc. But among these rules, there are mechanics that are part of the rules. Mechanics are possible actions players need to change the game state or interact with the game world. These mechanics can be game mechanics, learning mechanics, or sometimes both. The type of mechanic can be analysed later, but in this state, the player understands the mechanics.

Goal: All these setups, rules, and mechanics are used to achieve the goal. The goal and rules define the game and set its boundaries. Understanding what needs to be achieved sets the goal for the player.

The gameplay instance, mechanics, and goal describe the game. Based on the understanding of the game rules, the players interpret the winning state of the gameplay.

3.1.2 Winning state (W)

A goal of the player is to win the game. The winning state is derived from the rules. All players in the game strive to achieve the winning state by following the rules. The goal may or may not be related to the learning objective, but the path to reach the winning state should be related to the learning content.

Components of Winning State

Winning Condition: The conditions that must be achieved to become a winner of the gameplay are interpreted by the player to start the gameplay. Here, the designer or the expert can analyze the winning conditions. The winning condition can be to achieve a specific game state before other players or before the time limit, gain the maximum score or points than other players, etc.

End Condition: The condition that ends the game is just as important as the winning condition. In some games, the winning condition must be achieved before the end condition, while in others, achieving the winning condition is equivalent to meeting the end condition. The relationship between the winning condition and the end condition has no significant influence on the learning content. However, it is interesting to analyse the relationship between the end and winning conditions.

3.1.3 Plan of action (expected) (Pe)

The expected game plan includes the intermediate goals and plan of action derived from the winning state. The players formulate a plan to change the game state, leading to the desired winning state.

Components of the Expected Plan of Action

Challenge Variables: In educational games, a challenge is defined by the game mechanics, which serve as constraints in the gameplay. These game mechanics are based on the abilities required to apply them. So, Strategy, Luck/Chance, Skill, and Knowledge are the game mechanic variables based on which the mechanics are created, and these mechanics define the challenge in the gameplay. Mechanics created based on knowledge are the learning mechanics that lead to a learning experience and the application of knowledge.

According to Bloom's Taxonomy, learning requires cognitive skills such as remembering, understanding, applying, analysing, evaluating, and creating. Games have the potential to achieve lower-order to higher-order skills. Therefore, in educational games, the level of cognitive skill required to apply the learning mechanics in gameplay is also a challenge variable that needs to be analysed.

Level of Knowledge: When knowledge is involved in the mechanics, analysing the level of knowledge required to use them provides insight into the content that the gameplay is dealing with. Factual, Conceptual, Procedural, and Meta-cognitive are the levels of knowledge considered in this framework based on two-dimensional bloom's taxonomy.

Time Control: Having time to plan is a crucial factor to focus on when analysing educational gameplay. Having some time to plan allows the player to focus on what the game intends for them to understand or learn during gameplay. If the player gets time to plan the act, then how this time is utilized needs to be analysed.

3.1.4 Game state (G)

Describes the game components and their relationship. It captures the play at every specific moment. The knowledge can be applied and acquired at this state.

Components of Game State

Game World: In this process, the player interacts with elements in the game world to generate a game state. Therefore, the elements in the game world need to be analysed to determine the balance of game elements and learning elements within the game world. In educational games, the elements within the game world serve as representations of educational content, thereby enhancing the learning experience.

Interaction: The interaction level is higher in games than in other alternative educational aids. Interaction is the functional variable of the game, and it can be observed in the game state. If the actions of the player are influenced by the actions of the opponent or by elements in the game world, then conflict arises in the gameplay. If there is a conflict, the players change to the same game state, and if there is only competition, then the players have separate game states. Conflict creates better interaction than competition in the gameplay. Sometimes, games involve both competition and conflict to create interaction.

Reward: Rewards help maintain motivation throughout the gameplay, complementing the challenge. Rewards include elements that enhance gameplay, such as power cards, and those that are collected to determine the winner, like points or coins. Analysing the rewards in terms of frequency, how they are gained, and how they are used in the gameplay will help us understand the motivation and relation between the rewards and learning in educational gameplay.

3.1.5 Plan of action (derived) (Pg)

The derived plan is the plan that is derived from its Game State (G) to lead to the winning criteria. The derived plan from the game state helps to understand the game state and come up with a plan to change the game world.

Components of the Derived Plan of Action

Progress: As soon as the player changes the game state, the game world responds. The player can observe the progress in the gameplay. The player may move closer to or away from the winning state. Analysing the progress of the player in the gameplay concerning learning content is important for educational games. In some games, learning progresses as the gameplay progresses, and in others, learning progress can be observed after multiple gameplay sessions. Sometimes, learning the game itself is learning the content. So, the relationship between gameplay progress and learning progress needs to be analysed to understand the learning outcome of the educational game.

Assessment: In educational gameplay, feedback should be provided for applied knowledge and action. In the case of board games, the player provides feedback, while in digital games, the system offers feedback. In board games, a player's actions can be observed by their opponent, but this knowledge is often neglected as they are busy with their own gameplay. Therefore, the functions that evaluate the knowledge applied by the players need to be analysed to understand how the gameplay ensures that the content knowledge applied by the player to progress is correct.

Acquirement: The assessment provided by the system or the opponents about the applied content knowledge by the player helps acquire knowledge. The opponent's actions as part of their gameplay also help the player acquire content knowledge. In digital games, providing hints can help the player acquire knowledge. Analysing the knowledge acquisition functions of the gameplay provides an understanding of the scope of derived content knowledge in the gameplay.

3.1.6 Outcome (O)

The outcome of the gameplay or game is derived once the game state reaches the winning condition. According to the gameplay, the outcome is the score, winner, etc., but in educational gameplay, the outcome also includes the learning that the player achieves.

At each state in the gameplay, the player interacts with gameplay components, which facilitates the learning experience.

3.2 Processes in Ed-WPG Schema

The seven processes connect three states (Winning State, Planning State, and Game State) in the Ed-WPG Schema: formulation (1), synthesis (2), analysis (3), evaluation (4), two reformulation processes (5, 6), and outcome (7). These processes transform one state into another.

3.2.1 Formulation

This process occurs at two levels. First, rules are transformed into a winning state space ($R \rightarrow W$), where players interpret rules to understand winning conditions and mechanics.

In Scrabble, players must pick seven letter tiles from the pouch and place them on their tray before starting the game. There is a common board to put the word. The setup of the game is both separated and common. Because of the common space, there is interaction, and separate spaces create uncertainty. Players must build meaningful words using available letter tiles, including one letter from the board, to place them on the board. The game elements are separated and common due to the board. The player who gains the most points is the winner, and this is the winning condition of the game. The game ends when one of the players finishes all the tiles in the tray and the pouch. The end condition and the winning condition are not related, but they do not influence the objective of the educational content. The points are gained by building words that carry the maximum points. So, the winning condition is indirectly related to the learning objective.

Second, formulation transforms the winning state into an expected plan ($W \rightarrow Pe$). Players plan actions to achieve the winning condition, often applying knowledge.

In Scrabble, based on the letter tiles and available positions, the player visualizes the possible words and chooses the best word that provides maximum points. In this process, the mechanics are analysed. Picking up seven random letter tiles is based on chance, visualizing possible letters is based on knowledge, and choosing the best words to play is a combination of knowledge and strategy. So, the mechanics are built based on three game mechanic variables: chance, knowledge, and strategy. As the game mechanic variables exceed two, it produces an effective gameplay experience. Chance creates the uncertainty. The level of knowledge involved in applying the mechanic is factual knowledge. The first mechanic is a game mechanic, the second is a learning mechanic, and the third is a combination of both learning and game mechanics. Games that have both learning and game mechanics are effective in educational games. The gameplay allows for time to think and act, which is beneficial for educational games that focus on knowledge.

3.2.2 Synthesis

The player generates a game state from the expected plan ($Pe \rightarrow G$).

In Scrabble, the player decides the word to play and makes the first change in the game state. Here we analyse the elements in the game world. The elements in Scrabble are board and letter tiles. The pouch and tray used to place letter tiles are game components that have no impact on gameplay. This game board serves as both a learning and a game element, as there are places on the board that give more points, and once the words are placed on the board, it provides knowledge of unknown words to other players. The letter tiles also serve as both learning and game elements, as the letters on the tiles act as a constraint to apply knowledge, and the points on the letter tiles help them to strategize to gain points. The action of one player does not directly affect the actions of the other player. However, in the end, the scores are compared, so there is no conflict, but rather competition. The points are the rewards in this game, and they are gained through knowledge, so the rewards are related to learning.

3.2.3 Analysis

The player derives a plan from the game state ($G \rightarrow Pg$), analysing it to construct or acquire knowledge.

This state is analysed after the opponent players change the game state in their turns. In Scrabble, unknown words are new knowledge to the player. If a player plays a word that is spelled wrong, then it gets corrected by opponents, which constructs knowledge based on prior knowledge. In this game, gameplay progress is related to learning progress, i.e., better knowledge helps in better performance in the gameplay.

3.2.4 Evaluation

The player compares expected and derived plans ($Pe \leftrightarrow Pg$), refining both gameplay and knowledge.

In Scrabble, the player applies knowledge to add letter tiles to the board to make a word with at least one letter on the board. At every turn, the knowledge and game plan derived from the game state are compared to move further in the gameplay. Along with the knowledge, the game state is also compared to determine whether it has reached either a winning condition or an end condition.

3.2.5 Reformulation type 1

The player modifies the game state ($G \rightarrow G'$).

In Scrabble, the player interacts with the same elements in every turn, so further analysis may not be necessary.

3.2.6 Reformulation type 2

The player modifies the expected winning plan state ($G \rightarrow Pe'$).

In Scrabble, the player repeats the same mechanics in every turn, and there are no other mechanics left to analyse. Further analysis at this state may not be necessary.

3.2.7 Outcome

After reaching a winning or end condition ($G \rightarrow O$), the outcome is produced.

In Scrabble, the winner is determined by points. Learning outcomes include exposure to new words and correction of mistakes.

Based on the analysis, Scrabble is an effective educational game that serves the learning objective without neglecting the gameplay experience. In Scrabble, learning occurs in all three states: the Planning state, the Game state, and the Derived plan state.

4. Conclusion

The focus of the Ed-WPG schema is to analyse gameplay through three states: the expected plan state derived from the winning state, the game state, and the derived plan state from the game state, as shown in Figure 4. The games analysed in this paper involve sequential gameplay. For continuous gameplay, analysis can be conducted after gameplay, as it consists of a single continuous event, where any change in the game state is treated as an event. By structuring analysis around the planning state, game state, and derived plan state, the schema helps identify where and how learning occurs, ensuring that educational games are assessed for both design and effectiveness. Learning across all three states enhances the effectiveness of the educational game.

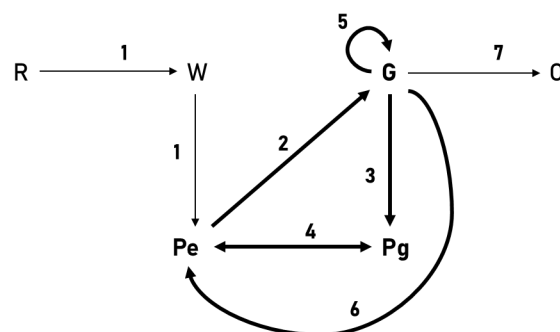


Figure 4: Learning Loop in Educational Games

This paper presents a gameplay analysis conducted by the author. To make this approach structured and usable by others, we are developing a query-based tool based on the Ed-WPG schema. The tool consists of a set of questions with response options for each state, guiding users through gameplay analysis. It will be evaluated in the future in terms of usability and consistency.

Ethics and AI Declaration: Ethical clearance was not required for the research. AI tool is used just for grammar correction.

References

- Ardakan, M. A., & Zahra Vahed. (2019). A conceptual framework for cognitive game design analysis (CGDA). *International Serious Games Symposium (ISGS)*, 81–88
- Brooke, J. (1996). SUS: A “Quick and Dirty” Usability Scale. In *Usability Evaluation In Industry* (Vol. 189, Number 194). London, England.
- Fu, F. L., Su, R. C., & Yu, S. C. (2009). EGameFlow: A scale to measure learners’ enjoyment of e-learning games. *Computers and Education*, 52(1), 101–112.
- Fu, F. L., & Yu, S. C. (2008). Three layered thinking model for designing web-based educational games. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, 5145 LNCS, 265–274
- Gero, J. (1990). Design Prototypes: A Knowledge Representation Schema for Design. *AI Magazine*, 11(4), 26.
- Hou, H. T., & Li, M. C. (2014). Evaluating multiple aspects of a digital educational problem-solving-based adventure game. *Computers in Human Behavior*, 30, 29–38.
- Kiili, K. (2005). Digital game-based learning: Towards an experiential gaming model. *Internet and Higher Education*, 8(1), 13–24.
- Lim, T., Carvalho, M. B., Bellotti, F., de Freitas, S., Louchart, S., Suttie, N., Berta, R., & De Gloria, A. (2015). The LM-GM framework for Serious Games Analysis. *British Journal of Educational Technology*, 46(2), 391–411.
- Mitgutsch, K., & Alvarado, N. (2012). Purposeful by Design: A Serious Game Design Assessment Framework. *Proceedings of the International Conference on the Foundations of Digital Games, FDG 2012*, 121–128.
- Sasupilli, M., & Bokil, P. (2023a). Knowledge Representation Schema of the Gameplay.
- Sasupilli, M., & Bokil, P. (2023b). Understanding the Games Using Function Behaviour Structure Ontology. *Smart Innovation, Systems and Technologies*, 346, 319–328.
- Sasupilli, M., Bokil, P., & Puneekar, R. M. (2019). Game Design Frameworks and Evaluating Techniques for Educational Games: A Review. *Research into Design for a Connected World*, 1, 277–286.
- Shute, V. J. (2011). Stealth assessment in computer-based games to support learning. *Computer Games and Instruction*, 55(2), 503–524.
- Song, M., & Zhang, S. (2008). EFM: A model for educational game design. *Technologies for E-Learning and Digital Entertainment*, 509–517.
- Tan, P.-H., Ling, S., & Ting, C. (2007). Adaptive digital game-based learning framework. *DIMEA '07: Proceedings of the 2nd International Conference on Digital Interactive Media in Entertainment and Arts*, (1), 142–146.