Serious Games for the therapeutic and cognitive intervention of children with ADHD

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RESEARCH PROTOCOL

1 Introduction

Attention Deficit Hyperactivity Disorder (ADHD) is widely regarded as one of the highest communal neurodevelopmental disorders in infantile, affecting between 4% and 8% of individuals worldwide (Sújar, 2022). This complex disorder is characterized by symptoms such as impulsivity, hyperactivity, chronic social anxiety, and learning disabilities. Currently, existing treatments for ADHD focus on alleviating symptoms and enhancing overall performance (Rijo et al., 2015), including prescriptions, psychiatric and behavioral therapies, and cognitive training. As a novel intervention, Serious Video Games (SVGs) have been suggested as an adjunctive treatment option for children with ADHD (Rijo et al., 2015).

Against this backdrop, the present research project seeks to explore the effectiveness of developing SVGs for assessing, therapeutic treating, and cognitive training of children between the ages of 5 and 11 who have been diagnosed with and are living with ADHD. This will be done by incorporating a qualitative and theoretical objective. This project chapter will encompass a comprehensive methodology paradigmatic perspective of the research, delineation of different research assumptions with a detailed outline of the methodology and research methods and design outlined.

This research methodology chapter discusses the overall emphasis on the different philosophical and paradigmatic perspectives with a subsection focusing on the meta-theoretic assumptions, and theoretic assumptions. It will then cover the nature of the research methodology, research design, and research method, and conclusively coupled with a conclusion.

2 Paradigmatic perspective

There are four paradigms relevant to computing studies:

- The Positivism Paradigm:

  The Positivism Paradigm is concerned with objective and empirical data, seeking to identify and explain causal relationships (Oates, 2006:313). In the context of Serious Video Games for children with ADHD, this paradigm would focus on collecting quantifiable data on the effectiveness of the games in managing ADHD symptoms. In other words, the Positivism paradigm emphasizes the use of quantitative methods to study phenomena and is often associated with the natural sciences (Oates 2006:313). While it may be

applicable in some aspects of serious games for children with ADHD, it may not capture the subjective experiences of the children, which are important in understanding the effectiveness of the games. The reason is that Positivism assumes that objective reality can be only observed and measured through scientific methods and that knowledge is discovered through empirical observation and testing.

- The Interpretivism Paradigm:

The Interpretivism paradigm focuses on the subjective and contextual nature of human experience, seeking to understand the meaning behind people's actions and experiences (Oates 2006:314). In the context of serious games for children with ADHD, this paradigm would seek to understand the experiences of the children and how they perceive the games, rather than just focusing on quantifiable data. In other words, the Interpretivism paradigm emphasizes the use of qualitative methods to understand the meaning and context of human experiences (Oates 2006:314).

- The Critical Paradigm:

The Critical paradigm is concerned with understanding power relations and social structures that contribute to societal problems (Oates 2006:316). Furthermore, Oates (2006:316) also explicates Critical research in IS and computing as being concerned with identifying power relations, conflicts, and contradictions, and empowering people to eliminate them as sources of alienation and domination. In the context of Serious Games for children with ADHD, this paradigm would focus on the broader societal and cultural factors that contribute to the prevalence of ADHD and the need for alternative treatments like Serious Video Games. In other words, the Critical paradigm emphasizes the role of power and politics in shaping social phenomena and is often used to critique dominant ideologies and power structures (Oates 2006: 316). While it may be useful in examining the power dynamics involved in the development and distribution of serious games for children with ADHD, it may not be directly applicable to understanding the effectiveness of the games themselves. The reason is that Critical theory assumes that society is structured around power and oppression and that research should aim to challenge and change social structures. While this paradigm may be relevant to the broader social implications of serious games for children with ADHD, it may not be as applicable to the specific research questions related to the effectiveness of serious games in managing ADHD symptoms.

All three paradigms have some applicability in the context of Serious Games for children with ADHD, as each offers a unique perspective and approach to understanding the issue. However, the most appropriate paradigm would depend on the research problem, objectives, and methodology of this project. In conclusion, while all paradigms may have some applicability in the context of Serious Games for children with ADHD, the Positivism paradigm may be more directly applicable in understanding the effectiveness of the games and the objective experiences or observations of the children. The positivism paradigm can be applied in the following ways:

1. Quantitative measurement of outcomes: The positivism paradigm emphasizes the importance of measuring outcomes using objective, quantitative methods (Park *et al.,* 2020). In the context of ADHD therapy using serious games, means using standardized assessments to measure the child's cognitive and behavioral progress over time. In other words, assessments can be used to measure changes in a child's attention and hyperactivity levels before and after using serious games (Park *et al.,* 2020).

2. Objective observation: The positivism paradigm emphasizes the importance of objective observation of phenomena (Park *et al.,* 2020). In the context of ADHD therapy using serious games, means using video recordings or other forms of observation to objectively measure the child's behavior during gameplay. This can provide valuable data on the child's attention, impulse control, and other relevant behaviors (Park *et al.,* 2020).

Overall, the positivism paradigm can be applied in the context of using serious games for the therapeutic and cognitive intervention of children with ADHD to provide rigorous, empirical evidence of the effectiveness of these interventions (Park *et al.,* 2020). By using objective measurement, experimental design, objective observation, and hypothesis testing, serious games can be evaluated scientifically and systematically to support their use as valuable tool in ADHD therapy (Park *et al.,* 2020).

2.1 Theoretic assumptions

Theoretical assumptions in computing studies that are relevant to the context of Serious Video Games for children with ADHD:

- Cognitive Load Theory

  This theory suggests that the brain has a limited capacity for processing information and overloading it can lead to cognitive overload and decreased performance (Krath *et al*., 2021). In the context of serious games for children with ADHD, it is important to consider the cognitive load of the game and ensure that it does not overwhelm the player.

- Social Learning Theory

This theory posits that people learn through observation and imitation of others' behavior (Krath *et al*., 2021). In the context of serious games for children with ADHD, it may be useful to include social elements in the game, such as multiplayer modes or virtual coaches, to facilitate social learning.

- Flow Theory

This theory suggests that people are most engaged and motivated when they are in a state of "flow," which occurs when they are fully immersed in an activity that is challenging but not too difficult (Krath *et al*., 2021). In the context of serious games for children with ADHD, it is important to design games that are challenging but not frustrating, and that provide a sense of progression to keep the player engaged.

- Self-Determination Theory

This theory posits that people are most motivated when they feel autonomous, competent, and connected to others (Krath *et al*., 2021). In the context of serious games for children with ADHD, it may be useful to design games that allow for player choice and autonomy, and that provide opportunities for social connection and feedback.

Overall, these theoretical assumptions can apply to the context of serious games for children with ADHD, as they provide useful frameworks for understanding how people learn and engage with technology. However, the fact and truth of individual differences and preferences when designing serious games for this population it is important to keep in mind that every child with ADHD is unique, and what works for one may not work for another.

3 Research methodology

3.1 Methodological assumptions

The main objective of this project is to evaluate the cognitive and therapeutic intervention of children living with ADHD using Serious Games. Adding on the aforementioned, this research project will adhere to a Mixed Methods research methodology, which prioritizes the combination of both quantitative and qualitative research methods to provide a more comprehensive understanding of a research question.

In the context of serious games for the therapeutic and cognitive intervention of children with ADHD, mixed methods research could involve gathering both quantitative data on cognitive and

behavioral outcomes, as well as qualitative data on children's experiences and perceptions related to the serious game intervention. Gathering and evaluating data through the analysis of written/spoken words and documented data (Baptista & Oliveira, 2019). This mixed-methods approach was chosen due to its relevancy for this type of research because it can provide a more comprehensive and measurable understanding of the experiences and outcomes of children with ADHD who use serious games as a therapeutic and cognitive intervention (Baptista & Oliveira, 2019).

The quantitative aspect of the mixed-methods approach can involve using standardized measures and surveys to measure cognitive and behavioral outcomes of children with ADHD, such as improvements in attention, executive function, and behavior (Basias & Pollalis, 2018). For example, standardized assessments will be used to measure changes in attention, executive function, and behavior before and after the intervention (Basias & Pollalis, 2018). Furthermore, the quantitative methodology can also be used to measure the frequency and duration of use of the serious games, as well as any adverse (Basias & Pollalis, 2018).

On the other hand, the qualitative methodology aspect of the mixed-methods approach involves the use of non-numerical data to gather insights and understanding of the experiences and perspectives of the children and their caregivers (Basias & Pollalis, 2018). In other words, the qualitative methodology can be used to gather information about how the children engage with the serious games, their experiences of the intervention, and any perceived benefits or drawbacks. Moreover, qualitative methods such as interviews, expert reviewer focus groups, and participant observation can be used to gather information about the experiences of the children and their caregivers regarding the use of serious games as a therapeutic intervention (Basias & Pollalis, 2018). Finally, this methodology may be more applicable in the context of serious games for children with ADHD, as it allows for a deeper understanding of the subjective experiences of the children. This is justifiable because qualitative assumes that reality is subjective, and that people construct their meanings and interpretations of events (Basias & Pollalis, 2018).

<u>This mixed-methods approach can help to explore the following questions</u>:

1. How do children with ADHD perceive and respond to the use of serious games as a therapeutic intervention?

2. What are the potential benefits and drawbacks of using serious games as a therapeutic intervention?

3. What factors contribute to the effectiveness of serious games as a therapeutic intervention?

4. What are the challenges and barriers to implementing serious games as a therapeutic intervention?

4 Research Methods

4.1 Software Development Method

The Agile methodology and SDLC can be relevant in the use of serious games for the therapeutic and cognitive intervention of children with ADHD in several ways (Rijo *et al*., 2015).

Overall, the Agile methodology can be relevant in the development of serious games for the therapeutic and cognitive intervention of children with ADHD by enabling iterative development, continuous improvement, collaborative development, and flexibility. This can be seen in Figure1 and Table 1, below:

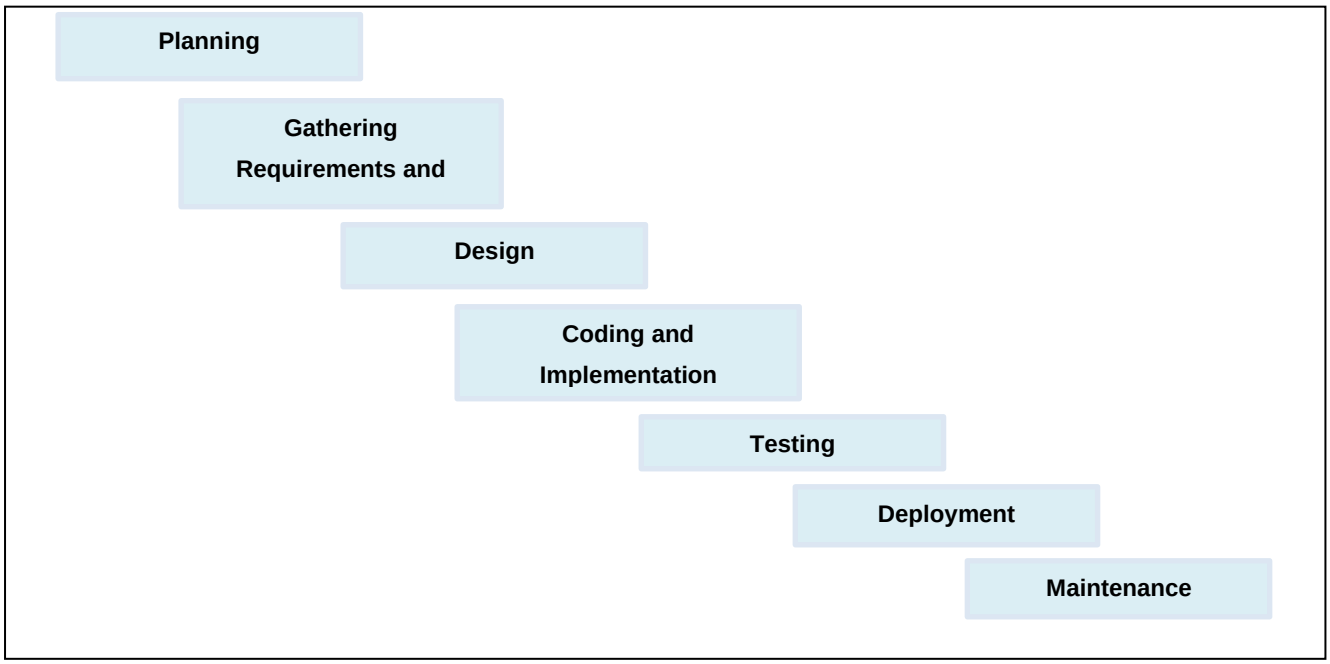

Figure 1. *The SDLC Diagram*

Source: (Mahalakshmi & Sundararajan, 2013:192)

Stage	Description
Stage 1: Planning	This stage involves the initial formation of the Serious Game

Stage 2: Gathering Requirements and Analysis	This stage involves the gathering or collecting of various credible research articles and many other available research tools, to analyze, understand and define the requirements of this research project.
Stage 3: Design	This stage involves gathering all the software and hardware tools needed for the design and construction of this game, furthermore, this also includes learning all the required programming languages. Moreover, the draft design of the game is also formulated in this stage.
Stage 4: Coding and Implementation	This stage involves the development of the Serious Game using the Godot 4.0 Software Application.
Stage 5: Testing	This stage involves the gathering or collecting of various credible research articles and many other available research tools, to analyse, understand and define the requirements of this research project.
Stage 6: Deployment	This stage involves testing the game on myself. The reason for the game not being tested on its intended audience is due to the rules and regulations of the North-West University which requires that one obtains an Ethical Clearance Permit first.
Stage 7: Maintenance	This stage will not only keep track of the software and hardware maintenance but also continually search for upgraded and innovative design and analysis conducts to improve the serious game and its impact in managing ADHD.

Table 1 . *The SDLC Stage Descriptions*

Source: (Mahalakshmi & Sundararajan, 2013:192)

Finally, the steps in agile software development will include Project planning, Requirement analysis, Design, Implementation, Testing, Deployment and Maintenance (Tam *et al.*, 2020).

4.2 Research Method

The introduction of Design Science theory will help the research project in developing an effective and working artifact, this can be done by trailing after the seven rules of Design Science Study Methodology as shown in Table 2, below:

Design Science Rules	**Descriptions in context**

Design by way of an artifact (Hevner *et al*., 2010)	Design Science research must yield a practical artifact in the form of a method, model, installation, and even a construct (Hevner *et al*., 2010). In the context of serious games for ADHD, the design of the game will be informed by existing research on ADHD interventions, as well as input from expert reviewers.
Relevance of the problem (Hevner *et al*., 2010)	Design Science study wishes to construct technology-oriented resolutions for or to imperative and applicable corporation or business issues (Hevner *et al*., 2010). In the context of serious games for ADHD, the problem is to develop effective game-based interventions that can improve cognitive and behavioral outcomes in children with ADHD.
Evaluation of the design (Hevner *et al*., 2010)	The value, excellence, and efficiency of a developed or designed artifact should be thoroughly displayed through finely implemented assessment processes (Hevner *et al*., 2010). In the context of serious games for ADHD, the game will be evaluated by measuring changes in cognitive and behavioral outcomes in children with ADHD after playing the game.
Contributions of the research (Hevner *et al*., 2010)	Operative Design Science study should offer transparent and provable inputs on the subjects of designing artifacts and designing foundations, including designing methodologies (Hevner *et al*., 2010).
Research rigor (Hevner *et al*., 2010)	Design Science study depends upon employing approaches that are rigorous in equally building and assessing the constructed artifact (Hevner *et al*., 2010).
Search process through design (Hevner *et al*., 2010)	The pursuit of effectual and successful artifacts demands using and applying existing and accessible means to attain anticipated results while satisfying principles in the problematic surroundings (Hevner *et al*., 2010). In the context of serious games for ADHD, this involves implementing the artifact, such as by testing the game with a small group of children with ADHD to gather feedback on its effectiveness and usability.
Research communication (Hevner *et al*., 2010)	Design Science study should be communicated efficiently and successfully similarly and equally in cooperation with technology-oriented and management-oriented meetings (Hevner *et al*., 2010).

***Table 2**. Design Science Research Rules*

Source: Hevner et al. (2010).

Design Science Methodology (DSM) is an iterative process that involves creating and testing artifacts, such as systems or tools, to solve real-world problems When applied to the use of serious games for the therapeutic and cognitive intervention of children with ADHD, DSM can provide a structured and systematic approach for developing effective game-based interventions (Peffers et al., 2020).

Overall, DSM can provide a structured approach to designing and developing serious games for ADHD interventions that are tailored to the specific needs and challenges of children with ADHD. In other words, by involving users in the design process and evaluating the effectiveness of the games, DSM can help to ensure that the games are effective in improving cognitive and behavioral outcomes in this population (Peffers et al., 2020). Moreover, by following a structured and iterative approach, designers can create games that are tailored to the needs and preferences of children with ADHD, and that are effective in improving cognitive and behavioral outcomes (Peffers et al., 2020). Finally, DSM allows for ongoing evaluation and refinement, ensuring that the game remains relevant and effective over time (Peffers et al., 2020). The visual paradigm is seen in Figure 1, below:

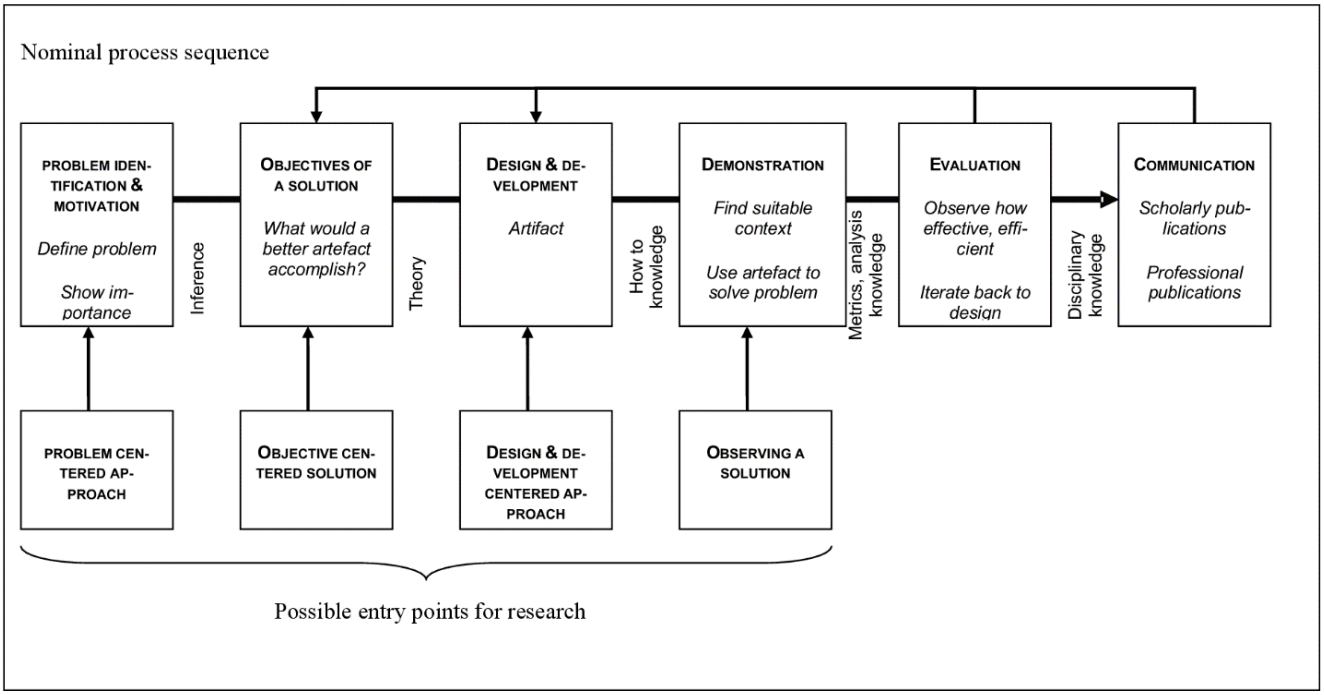

***Figure 2**. Design Science Research Process Model*

Source: (Peffers et al., 2020)

5 Research Design

In choosing this study design, it is based on the following:

Research Problem Statement:

- The research problem is the need to establish the efficacy and effectiveness of serious games as a viable intervention option for addressing the cognitive and behavioral symptoms associated with ADHD. While serious games have shown promise as a potential intervention tool, particularly in engaging and motivating children, there is still a lack of empirical evidence regarding their effectiveness in improving cognitive and behavioral outcomes. Additionally, questions remain regarding the optimal design features and content of serious games for ADHD therapy, as well as how to personalize interventions to meet individual children's needs. Therefore, the research problem is how to effectively evaluate the use of serious games as an intervention option for children with ADHD and determine the most effective design features and personalized approaches.

Research Aims:

- Develop well-designed and well-conducted research that can provide valuable insights into the potential benefits of serious games as a complementary intervention for children with ADHD. Moreover, the research aim is to investigate the efficacy and effectiveness of serious games as an intervention option for improving cognitive and behavioral outcomes in children with ADHD. This includes examining the potential benefits of serious games in addressing specific symptoms of ADHD, such as attention and impulse control, as well as evaluating the impact of serious games on broader cognitive and behavioral outcomes, such as academic performance and social skills. Additionally, the research aim may involve identifying optimal design features and content for serious games in the context of ADHD therapy, as well as exploring ways to personalize interventions to meet the unique needs of individual children with ADHD.

Research Objectives:

- Determine the effectiveness of serious games as an intervention option for improving cognitive and behavioral outcomes in children with ADHD, compared to traditional behavioral therapies or medication.

The research design that can be relevant in the context of the use of serious games for the therapeutic and cognitive intervention of children with ADHD, includes:

- Single-case experimental design: Single-case experimental designs involve measuring the outcomes of a single participant over time, with repeated measures during different phases of intervention (Rahman, 2020). In the context of serious games for ADHD therapy, a single-case design will be used to measure changes in the cognitive and behavioral skills of an individual expert reviewer before, during, and after the use of a serious game intervention. This will allow for the in-depth analysis of expert reviewers and a child with ADHD who uses will use serious games as an intervention, while examining the child's experiences, outcomes, and the specific features of the intervention that were most effective (Rahman, 2020).

- Mixed-methods design: As already stated under section 4.1. Methodological Assumptions, Mixed methods designs involve using both qualitative and quantitative research methods to gather and analyze data (Rahman, 2020). In the context of serious games for ADHD therapy, a mixed-methods design will be used to gather quantitative data on cognitive and behavioral outcomes, while also gathering qualitative data such as participant feedback on the usability and acceptability of the serious game intervention (Rahman, 2020).

- Surveys and questionnaires: These methods involve collecting self-reported data from participants about their experiences, attitudes, or behaviors (Rahman, 2020). Surveys and questionnaires can be useful for gathering information about a large number of participants and for exploring relationships between variables. In the context of this project, expert reviewers who have used a serious games intervention will be surveyed, asking about their perceptions of the intervention's effectiveness, their individual experiences with the intervention, and the specific features of the intervention that were most helpful (Rahman, 2020).

- Observational research: This method involves observing and recording behavior or events as they occur in a natural setting (Rahman, 2020). In the context of this project, observations will be conducted to observe the expert reviewers as they use a serious game intervention, recording their behaviors, reactions, and interactions with the game (Rahman, 2020).

The participants in this project who serve as observers consist of expert reviewers and children between the ages of 5 and 11 who are diagnosed with ADHD. However, due to ethical clearance concerns, no testing, observation, or assessment will be conducted on the children. It should be noted that each observer's experience and reality of living with ADHD are unique, and their management of symptoms varies accordingly. Consequently, their response to the Serious Game developed in this context is likely to be highly contingent upon their individual preferences for entertainment and cognitive capabilities.

Overall, in the pursuit of assessing the efficacy of serious games for therapeutic and cognitive intervention in children with ADHD, it is crucial to adopt a stringent methodology regardless of the selected research designs. Finally, this project will adhere to all but excluding the last phases namely “Long-term Follow-Up”, “Clinical Trials” and “Long-term Trials”, with the other methodologies, to the IDEAL – Game framework research design developed by (Sújar, 2022), as shown in Figure 3:

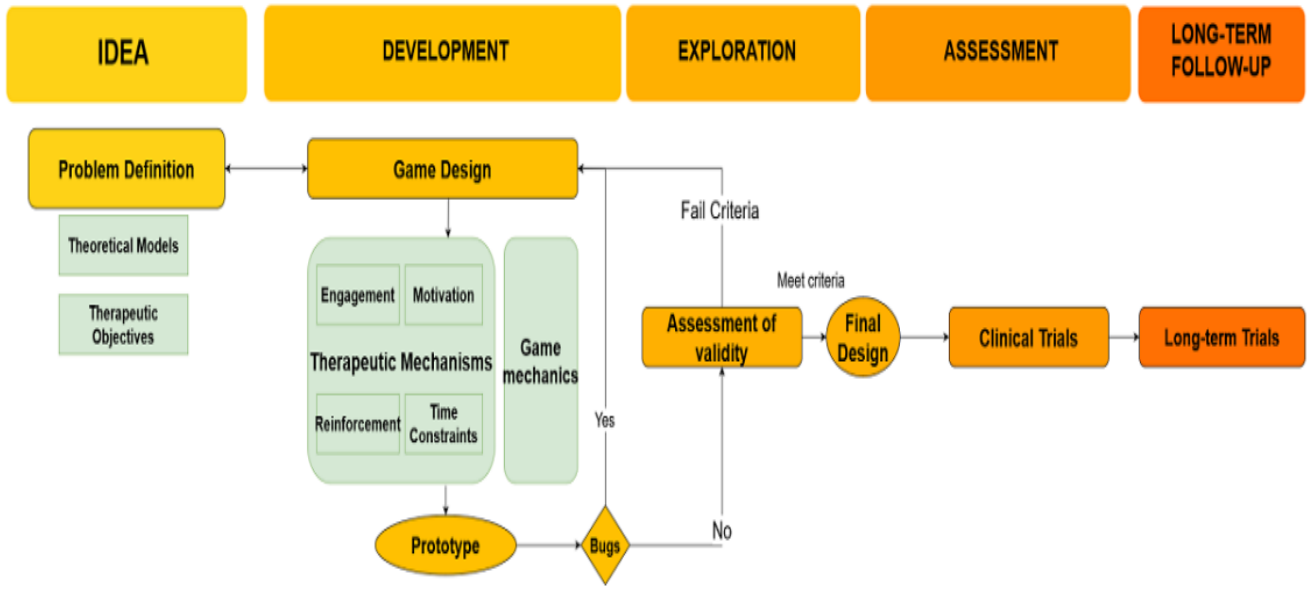

***Figure 3**. IDEAL-Games framework designed to develop an overall conductor for Serious Game-grounded ADHD intervention.*

Source: (Sújar, 2022)

6 Conclusion

In conclusion, the present research project aims to explore the effectiveness of developing Serious Video Games (SVGs) for assessing, therapeutic treating, and cognitive training of

children with ADHD. To achieve this objective, the research methodology chapter discussed different philosophical and paradigmatic perspectives that are relevant to computing studies. The Positivism, Interpretivism, and Critical paradigms were discussed in terms of their potential applicability to this project, with the Positivism paradigm appearing to being the most directly applicable in understanding the effectiveness of the games and the objective experiences of the children. Furthermore, by incorporating a qualitative and theoretical objective, the research methodology chapter outlined a comprehensive approach that considered different philosophical and paradigmatic perspectives to achieve the research objectives. Additionally, the Agile methodology and SDLC were found to be relevant in developing serious games for ADHD interventions due to their iterative development, continuous improvement, collaborative development, and flexibility. With that said, Design Science Methodology (DSM) was found to provide a structured and systematic approach for developing effective game-based interventions that are tailored to the specific needs and challenges of children with ADHD. The research design chosen for this study was based on the need to establish the efficacy and effectiveness of serious games as a viable intervention option for addressing the cognitive and behavioral symptoms associated with ADHD. To achieve these goals, a variety of research designs were identified, including single-case experimental design, mixed-methods design, surveys and questionnaires, and observational research. Finally, by using a comprehensive and rigorous approach, this chapter aimed to provide valuable insights into the potential benefits of serious games as a complementary intervention for children with ADHD, ultimately contributing to the improvement of their cognitive and behavioral outcomes.

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