# Towards a Cross-Domain Ontology for Serious Games

Kalthoum Rezgui[1,*], Besma Ben Amara[2,*] and Hédia Mhiri Sellami[3,*]

***Abstract*— As digital technologies continue to evolve rapidly, Serious games (SG) have emerged as powerful tools for education, training, decision-making, and other diverse domains that leverage game-based mechanics to enhance engagement and learning outcomes. However, their effectiveness is often limited by the lack of structured knowledge representation and adaptability to various learning contexts. Ontologies offer a solution by providing a formalized, machine-readable structure that enhances content organization, reasoning, and personalization within SGs. This paper presents a cross-domain ontology for SGs that aims to provide a unified framework for representing the key concepts, relationships, and dynamics within SGs across various domains. It also aims to bridge gaps between different fields by formalizing the diverse aspects of SGs, such as learning outcomes, player engagement, interactivity, and feedback mechanisms. By integrating concepts from multiple domains, the proposed ontology enables better understanding, analysis, and development of SGs, facilitating their application in diverse contexts. Furthermore, the ontology serves as a foundation for semantic interoperability between SGs and related systems, promoting the creation of more adaptive and personalized gaming experiences tailored to specific learning or developmental objectives.**

**Keywords: Serious Games, Ontologies, Cross-domain, Knowledge Representation, Interoperability.**

## I. INTRODUCTION

During recent years, Serious Games (SGs) have gained widespread recognition as effective tools not only for education, professional training, and healthcare, but also across a wide range of domains such as engineering, military, environmental science, marketing, and scientific research.

Unlike traditional entertainment games, these serious SGs are designed with explicit learning objectives, aiming to improve knowledge acquisition, problem-solving skills, and behavioral change in diverse domains such as healthcare, education, business, and engineering [1]. Moreover, their interactive and immersive nature, enhanced by personalization and adaptation enabled by artificial intelligence (AI), fosters engagement, making them valuable for experiential learning [2]. However, despite their potential, SGs often lack structured knowledge representation, which limits their ability to provide adaptive and personalized learning experiences.

Ontologies, as formal knowledge representation models, offer a promising solution to these challenges. They provide a structured, machine-readable framework that enables intelligent reasoning, content organization, and interoperability between different information systems. By integrating ontologies into SGs, it becomes possible to create adaptive learning and training environments where game content dynamically adjusts to users' needs, prior knowledge, and personal goals. Additionally, ontologies facilitate interoperability between SGs and other educational technologies, supporting the seamless exchange of knowledge between systems. In fact, recent researches ([3]; [4]) have explored the role of ontologies in SGs, demonstrating their ability to enhance knowledge structure, content adaptation, and decision making support. Nevertheless, existing implementations often remain domain-specific, lacking a generalized approach that can be applied across various disciplines. This paper addresses this gap by proposing a cross-domain ontology for SGs to enhance their knowledge structuring, interoperability, and AI-driven adaptation, thus making SGs more flexible and effective across diverse fields. The proposed ontology will, also, enable reusability of game mechanics, improves personalization, and fosters cross-disciplinary collaboration. Morevover, by applying a shared ontology, developers and researchers can create more intelligent and scalable SGs for education, healthcare, cybersecurity, and beyond.

### *A. Advantages of a cross-domain ontology for SGs*

As stated earlier, a major advantage of a cross-domain ontology is interoperability, which allows SGs from different disciplines to share a common knowledge structure. This makes it possible to integrate learning resources and training modules from various fields, enriching the learning experience. For instance, a serious game designed for medical training could incorporate business simulation elements to teach healthcare management principles, creating a more holistic educational tool. Another key benefit is adaptive and personalized learning [5]. Ontologies provide a structured representation of domain knowledge, allowing SGs to dynamically adjust learning paths based on player performance, prior knowledge, and goals. In addition, enhanced knowledge

[1]Kalthoum Rezgui is with the University of Manouba, ISAMM, Manouba, Tunisia. kalthoum.rezgui@isamm.uma.tn

[2] Besma Ben Amara is with the University of Tunis El Manar, FSEGT, Tunis, Tunisia. besma.benamara@fsegt.utm.tn

[3] Hédia Mhiri Sellami is with the University of Tunis, ISG of Tunis, Tunis, Tunisia. hedia.mhiri@isg.rnu.tn

[*] SMART Lab, University of Tunis, ISG of Tunis, Tunis, Tunisia.

structuring and intelligent reasoning contribute to making SGs more dynamic. By embedding formal ontologies, games can facilitate intelligent decision-making, where the system suggests new learning paths based on the player's actions. For example, a cybersecurity training game could infer a player's understanding of network vulnerabilities and recommend customized remediation strategies. A cross-domain ontology, also, improves the reusability of game components, which reduces development costs and accelerates content creation. For example, a leadership training game designed for corporate environments could reuse decision-making mechanics from a military strategy game, allowing for broader applicability of game elements. Moreover, AI-driven adaptation and content generation become more efficient with ontologies. AI techniques can use ontological structures to generate game content dynamically, making games more scalable and cost-effective. Finally, a cross-domain ontology facilitates interdisciplinary research and development, allowing experts from different fields to collaborate more effectively. By using a unified knowledge representation framework, SGs designers can integrate concepts from multiple disciplines, leading to richer, more comprehensive learning experiences.

### *B. Applications of a cross-domain ontology in SGs*

The benefits of a cross-domain ontology can be observed in various real-world applications.
In healthcare training and simulation, SGs are used to train medical professionals in virtual patient diagnosis and surgical procedures. Ontologies play a crucial role in structuring medical knowledge and integrating it with psychological and ethical considerations.For example, Touch Surgery [6], a simulation-based SG, exemplifies how structured knowledge representation can improve medical training by providing real-time feedback on surgical techniques.
In cybersecurity and risk management, SGs are used to train professionals in detecting and mitigating cyber threats. A cross-domain ontology enhances these games by linking cybersecurity concepts with legal frameworks and business risk assessment strategies, helping players understand security issues from multiple perspectives. An example of this is CyberCIEGE [7], a cybersecurity training game developed by the Naval Postgraduate School, which teaches players about network security through interactive scenarios.

SGs are also widely used in STEM education, helping students grasp complex scientific, engineering, and historical concepts through interactive learning.

Beyond education, SGs have significant applications in corporate training and leadership development. Business simulation games help professionals develop decision-making, negotiation, and management skills. By integrating a cross-domain ontology, these games can model psychological theories and strategic frameworks, providing players with a deeper understanding of leadership dynamics. The military and defense sector has also benefited from ontology-driven serious games. Training simulations for soldiers often involve battlefield strategy, logistics, and emergency response scenarios. A cross-domain ontology enhances these games by integrating knowledge from crisis management, tactical operations, and diplomatic conflict resolution.

The rest of this paper is structured as follows: Section 2 provides an overview of related work in SGs and ontologies. Section 3 describes in detail the process of the SG ontology construction. Finally, Section 4 concludes with insights on the potential impact of ontology-driven SGs in various domains.

## II. RELATED WORK

The past few years have witnessed a growing adoption of gaming, which has been increasingly utilized for entertainment and learning [8], skill development [9], therapy [10], and training [11]. Among these applications, SGs have emerged as a distinct category, designed with explicit educational or training objectives beyond mere entertainment. These purpose-driven games leverage video game and simulation technologies to engage players in meaningful tasks, incorporating innovations like extended reality [12], and AI to create immersive experiences.

A comprehensive review by Gazis and Katsiri (2023) [13] categorizes digital games and delves into serious games' applications, game engines, and advancements, underscoring their growing significance in diverse fields. Additionally, a systematic literature review by Ud Din et al. (2023) [14] identifies evolving trends in serious games, highlighting their applications, methodologies, and the increasing interest in leveraging serious games for educational and training purposes.

The reminder of this section reviews relevant literature on SGs design, ontologies, and their convergence.

### *A. Serious Game Design*

Several approaches have been proposed to design and develop serious games, ranging from domain-specific methods to more general frameworks. Examples include the GREM model [15], which is based on game rules and scenarios; the Serious Game Development Process, inspired by traditional software engineering paradigms [16]; and Informant Design, a participatory methodology for mini-game development [17]. Another notable approach is the DPE (Design, Play, Experience) framework, an extension of the MDA (Mechanics, Dynamics, Aesthetics) framework, which emphasizes iterative development but lacks participatory design and a clear balance between fun and educational goals [18]. More recently, the SGDA-IE approach (SG Design Approach based on Iterative Evaluation), which uses a taxonomy model of game characteristics through three abstraction levels, has been introduced [19]. This method provides a structured, step-by-step process for educators, students, researchers, and designers to develop SGs in various contexts. It promotes participatory design and enhances the understanding of key game elements to create engaging and motivating serious games. However, it lacks a unified knowledge representation to help designers seamlessly integrate concepts across multiple disciplines.

It is worth mentioning that a major challenge in SG design is requirements specification, which involves defining key characteristics and mapping them to game components, including instructional elements [20]. While some models offer guidance, they have limitations. For example, the LM-GM model [21] links learning mechanics to game mechanics but lacks clarity in connecting game elements to educational objectives and distinguishing component relationships, limiting creative design.

### B. Integrating Ontologies into Serious Games

Ontologies serve as structured frameworks to represent knowledge within a domain, facilitating shared understanding and interoperability. In the context of SGs, ontologies can enhance the representation of complex information, enabling more effective learning experiences. The convergence of SGs and ontologies offers opportunities for creating intelligent and adaptive learning environments. Pérez et al. (2023) [4] examined the potential of combining AI with serious games to create more adaptive learning environments. Their work highlights how data collected through games can inform AI algorithms, leading to more personalized and effective learning experiences.

Said et al. (2019) [22] proposed a domain-specific ontology aimed at enhancing personalization in SGs used for stealth assessment of learner competencies. Their ontology models player experience by incorporating user profiles, learning styles, and gameplay preferences. The authors introduce a player segmentation approach to guide in-game modifications and establish links between game scenarios and specific academic program objectives. Furthermore, they define reasoning rules that recommend games tailored to each learner's assessment trajectory.

Stavrakis et al. (2021) [23] introduced an application-level ontology integrated into a SG designed to foster Nutrition Literacy (NL) and Food Literacy (FL) among adolescents and young adults. The game leverages a recipe ontology to support personalized gameplay and simulate realistic dietary decision-making. Built upon a theory-driven design framework, the game combines elements from cooking, roguelike, and puzzle genres to maximize engagement and promote sustainable behavioral change.

In [3], the authors introduced a prototype digital game called *Onto-Ling*, which aims to teach linguistic ontologies through an interactive game-based environment. The game uses ontologies to structure and present complex linguistic knowledge, making it easier for learners to understand and apply.

## III. Methodology

To construct a cross-domain ontology for serious games, we adopt *Methontology* [24], a structured and mature methodology for ontology development. This approach provides a systematic framework for defining, conceptualizing, formalizing, implementing, and evaluating ontologies.

The development of the cross-domain SGs ontology follows the main phases of Methontology:

### A. Specification Phase

The first step is defining the purpose, scope, and intended application of the ontology.

**Domain**: The ontology addresses the domain of SGs applied across multiple fields, including but not limited to healthcare, cybersecurity, business, and education.

**Purpose**: The primary purpose of the ontology is to provide a shared conceptualization and a semantic foundation for the design, development, adaptation, and evaluation of SGs across diverse domains. Specifically, the ontology serves to:

- Facilitate interoperability between SGs platforms, learning management systems (LMSs), health information systems, corporate training systems, multi-agent systems and AI-driven tutoring systems, etc.
- Enable cross-domain game analytics, allowing researchers and developers to assess the effectiveness of SGs across different disciplines using consistent semantics.
- Enhance reusability, allowing game designers to incorporate pre-defined domain concepts, learning objectives, and game mechanics into new SGs.

**Intended Users**: The ontology is designed to support a variety of stakeholders involved in the design, development, deployment, and evaluation of SGs across domains:

- Game designers and developers: To design games that integrate pedagogical objectives, domain-specific knowledge, and adaptive mechanics.
- Educators and Instructional Designers: To specify learning objectives, assessments, and player profiles in line with curriculum requirements.

- Domain experts: To contribute validated domain knowledge that games will embed, such as concepts, processes, threats, diseases, etc.

**Information Sources**: The ontology is constructed by consolidating knowledge from a wide variety of information sources, including:

- Existing ontologies and standards in various domains, including Learning (e.g., SCORM (Sharable Content Object Reference Model), xAPI, IMS Learning Design (IMS-LD), Competency Ontologies (LOM, InLOC)), Gamification (e.g., Gamification Ontology (2017), OntoGamif [25], Game mechanics (e.g., Game Ontology Project (GOP) [26], Mechanics-Dynamics-Aesthetics (MDA) Framework), Domain knowledge (e.g., Medical Subject Headings (MeSH), Cybersecurity Knowledge Framework (NIST NICE), Business Process Modeling Notation (BPMN)), and AI Planning (e.g., Planning Domain Definition Language (PDDL) [27].
- Educational frameworks and pedagogical models, such as Bloom's Taxonomy, Competency-based Learning (CBL) [28], Constructivist learning environments, etc.

**Competency Questions (CQs)**: To establish clear requirements of our cross-domain SG ontology, the following competency questions are formulated:

- What are the core components of a SG across different domains?
- How can cross-domain knowledge be reused when creating new SGs?
- How do gamification elements contribute to player engagement across domains?
- What learning outcomes are targeted in a serious game for a specific domain (e.g., cybersecurity skills or medical decision-making)?
- What types of game mechanics are used in SGs to engage learners?

*1) Conceptualization phase:* In this phase, domain knowledge is structured into a conceptual model using taxonomies, hierarchies, and relationships. Key concepts include:

- Game Elements: player, environment, game mechanics, feedback, reward, assessment, etc.
- Domain-Specific concepts: medical diagnosis, network security, business strategy, environmental policies, etc.
- Pedagogical Strategies: learning objectives, difficulty progression, assessment criteria, etc.

The list of concepts of the proposed SG ontology is presented in Table I. Besides, Figure 1 below presents a graphical representation of the concepts of the proposed SG cross-domain ontology and the relationships between them.

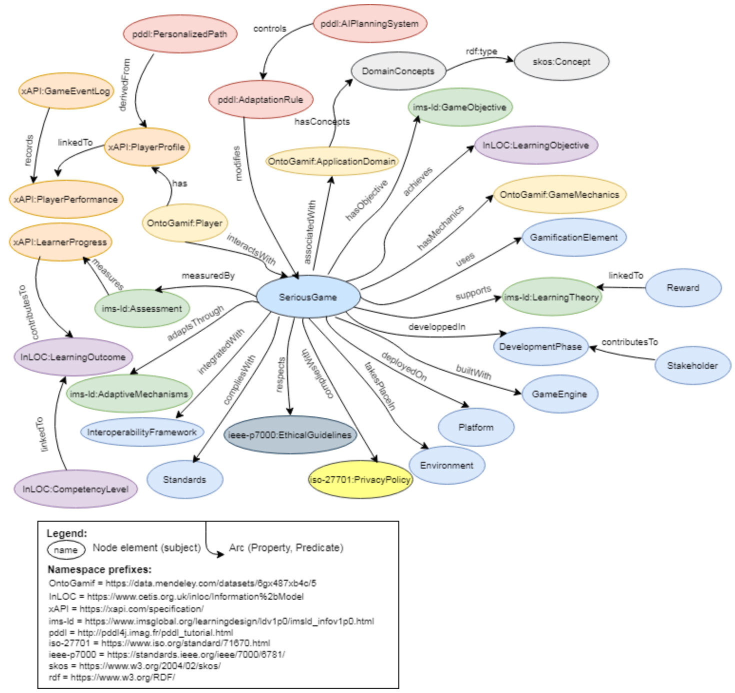


Fig. 1. Graphical representation of the Serious Game Ontology.

*2) Formalization Phase:* In the formalization phase, we employ the Description Logics (DL) formalism to formalize the conceptual model obtained in the conceptualization phase. These definitions are illustrated in Table II with the subsumption relations that exist between concepts.

*3) Implementation Phase:* The formalized ontology is implemented in the Web Ontology Language (OWL) using the Protégé ontology development tool. Classes, properties, and instances are defined based on the structured knowledge from the conceptualization phase. Figure 2 depicts the hierarchy of the SG ontology's concepts in the Protégé editor.

*4) Evaluation Phase:* In this phase, we employed the Pellet reasoner to validate both the consistency and classification of the developed SG ontology. Consistency checking ensures that classes can be instantiated without contradiction, confirming the logical soundness of the ontology. Classification checking involves analyzing the relationships between classes to infer an updated class hierarchy based on their definitions.

## IV. CONCLUSION

In this paper, we proposed a cross-domain ontology for SGs as a crucial step toward improving the design, interoperability, and intelligence of game-based learning systems. By establishing a shared semantic framework, our ontology enables more consistent structuring of knowledge, game mechanics, and adaptive strategies

TABLE I

CONCEPTUALIZATION OF CROSS-DOMAIN ONTOLOGY FOR SGS.

| **Concept** | **Definition** | **Hierarchies / Subclasses** | **Relationships** |
|---|---|---|---|
| SeriousGame | Digital interactive game designed for training, education, simulation, or other non-entertainment purposes across domains | - | hasMechanics, hasObjective, achieves, associatedWith, uses, compliesWith, builtWith, supports, deployedOn, integratedWith, takesPlaceIn, adaptsThrough, measuredBy. |
| GameMechanic | The rules and interaction methods that govern gameplay | Points, Levels, Quests, Turn-taking, Randomness | partOf SeriousGame |
| GameObjective | Purpose or goal of the game | CognitiveObjective, BehavioralObjective, SkillDevelopmentObjective | linkedTo GameChallenge |
| LearningObjective | Intended learning outcome | KnowledgeAcquisition, SkillPractice, AttitudeChange | achievedBy SeriousGame |
| LearningTheory | A formalized framework or model which explains how people acquire knowledge, develop skills, and change behaviors | Constructivism, Behaviorism, ExperientialLearning | supportedBy SeriousGame |
| GamificationElement | Engagement enhancement feature | Badges, Leaderboards, Rewards, Avatars, Challenges | usedBy SeriousGame |
| PlayerProfile | Characterization of the player | NovicePlayer, IntermediatePlayer, ExpertPlayer | linkedTo PlayerPerformance |
| ApplicationDomain | Thematic field covered by the game | HealthDomain, CybersecurityDomain, BusinessDomain, EngineeringDomain | associatedWith SeriousGame |
| DomainConcept | Core knowledge items per domain | Disease (Health), Threat (Cybersecurity), Process (Business), SystemComponent (Engineering) | reusedBy SeriousGame |
| Standard | Existing educational/game standards | SCORM, xAPI, IMS-LD | compliedWith by SeriousGame |
| Competency | Specific skill or knowledge area | - | measuredBy Assessment |
| DevelopmentPhase | Lifecycle stage of a SG | ConceptualDesign, Prototyping, Testing, Deployment, Evaluation | partOf SeriousGame |
| Stakeholder | SG creation participants | GameDesigner, GameDeveloper, Educator, DomainExpert | contributesTo DevelopmentPhase |
| GameEngine | A software development environment designed for the creation and deployment of SGs. | Unity, UnrealEngine, Godot | builtWith by SeriousGame |
| PrivacyPolicy | A formal set of rules and practices that govern how personal data collected during the use of a SG is collected, stored, processed, shared, and protected. | - | compliedWith by SeriousGame |
| EthicalGuideline | A formal or informal set of principles and norms that guide the ethical design, development, and deployment of SGs | - | respectedBy SeriousGame |
| (...) | (...) | (...) | (...) |

TABLE II

DEFINITION OF THE SG ONTOLOGY'S CONCEPTS (IN TBOX).

| **Concept** | **Definition** | **Subsumption Relation** |
|---|---|---|
| SeriousGame | SeriousGame $\sqsubseteq$ ($\geq$ 1 hasObjective.GameObjective) $\sqcap$ ($\geq$ 1 hasMechanics.GameMechanics) $\sqcap$ ($\geq$ 1 interactsWith.Player) $\sqcap$ ($\geq$ 1 measuredBy.Assessment) $\sqcap$ ($\geq$ 1 developedIn.DevelopmentPhase) $\sqcap$ ($\geq$ 1 usesPlatform.Platform) $\sqcap$ ($\geq$ 1 supports.LearningTheory) $\sqcap$ ($\geq$ 1 compliesWith.Standards) | SeriousGame $\sqsubseteq$ Thing |
| Player | Player $\sqsubseteq$ ($\geq$ 1 hasProfile.PlayerProfile) $\sqcap$ ($\geq$ 1 hasPerformance.PlayerPerformance) $\sqcap$ ($\geq$ 1 hasProgress.LearnerProgress) | Player $\sqsubseteq$ Thing |
| PlayerProfile | PlayerProfile $\sqsubseteq$ ($\geq$ 1 linkedTo.GameEventLog) | PlayerProfile $\sqsubseteq$ Thing |
| GameObjective | GameObjective $\sqsubseteq$ ($\geq$ 1 achieves.LearningObjective) | GameObjective $\sqsubseteq$ Thing |
| Assessment | Assessment $\sqsubseteq$ ($\geq$ 1 measuredBy.SeriousGame) | Assessment $\sqsubseteq$ Thing |
| AdaptiveMechanisms | AdaptiveMechanisms $\sqsubseteq$ ($\geq$ 1 adaptsThrough.Assessment) | AdaptiveMechanisms $\sqsubseteq$ Thing |
| GameMechanics | GameMechanics $\sqsubseteq$ ($\geq$ 1 uses.GamificationElement) | GameMechanics $\sqsubseteq$ Thing |
| GamificationElement | GamificationElement $\sqsubseteq$ ($\geq$ 1 linkedTo.Reward) | GamificationElement $\sqsubseteq$ Thing |
| DevelopmentPhase | DevelopmentPhase $\sqsubseteq$ ($\geq$ 1 develops.SeriousGame) | DevelopmentPhase $\sqsubseteq$ Thing |
| GameEngine | GameEngine $\sqsubseteq$ ($\geq$ 1 builds.SeriousGame) | GameEngine $\sqsubseteq$ Thing |
| ApplicationDomain | ApplicationDomain $\sqsubseteq$ ($\geq$ 1 hasConcept.DomainConcept) | ApplicationDomain $\sqsubseteq$ Thing |
| EthicalGuidelines | EthicalGuidelines $\sqsubseteq$ ($\geq$ 1 respectedBy.SeriousGame) | EthicalGuidelines $\sqsubseteq$ Thing |
| Stakeholder | Stakeholder $\sqsubseteq$ ($\geq$ 1 contributesTo.DevelopmentPhase) | Stakeholder $\sqsubseteq$ Thing |
| (...) | (...) | (...) |

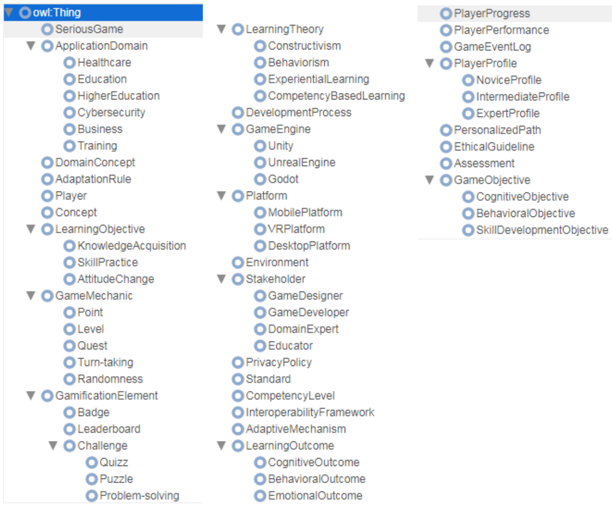


Fig. 2. Class hierarchy of the SG Ontology.

across multiple domains. This cross-domain approach enhances interoperability, allowing for the reuse of game components across diverse applications. It, also, supports semantic interoperability with existing standards and ontologies. By enabling a unified and intelligent approach to SGs, a cross-domain ontology unlocks new possibilities for developing scalable, reusable, and adaptable SGs for a wide range of fields. Ultimately, it lays the groundwork for the next generation of context-aware, intelligent, and learner-centered serious games.

## References


[1] Gee, J. What video games have to teach us about learning and literacy. *Computers In Entertainment (CIE)*. **1**, 20-20 (2003)

[2] Westera, W., Prada, R., Mascarenhas, S., Santos, P., Dias, J., Guimarães, M., Georgiadis, K., Nyamsuren, E., Bahreini, K., Yumak, Z. & Others Artificial intelligence moving serious gaming: Presenting reusable game AI components. *Education And Information Technologies*. **25** pp. 351-380 (2020)

[3] Medina, D., Maturana, G., Villa, F. & Zapata, C. A prototype for a serious digital game to teach linguistic ontologies. *ArXiv Preprint ArXiv:1909.07371*. (2019)

[4] Pérez, J., Castro, M. & López, G. Serious games and ai: Challenges and opportunities for computational social science. *IEEE Access*. **11** pp. 62051-62061 (2023)

[5] Rezgui, K., Mhiri, H. & Ghédira, K. An ontology-based approach to competency modeling and management in learning networks. *Agent And Multi-Agent Systems: Technologies And Applications: Proceedings Of The 8th International Conference KES-AMSTA 2014 Chania, Greece, June 2014*. pp. 257-266 (2014)

[6] Lang, F., Willuth, E., Haney, C., Felinska, E., Wennberg, E., Kowalewski, K., Schmidt, M., Wagner, M., Müller-Stich, B. & Nickel, F. Serious gaming and virtual reality in the multimodal training of laparoscopic inguinal hernia repair: a randomized crossover study. *Surgical Endoscopy*. **37**, 2050-2061 (2023)

[7] Irvine, C., Thompson, M. & Allen, K. CyberCIEGE: gaming for information assurance. *IEEE Security & Privacy*. **3**, 61-64 (2005)

[8] Martinez, L., Gimenes, M. & Lambert, E. Entertainment video games for academic learning: A systematic review. *Journal Of Educational Computing Research*. **60**, 1083-1109 (2022)

[9] Barr, M. Student attitudes to games-based skills development: Learning from video games in higher education. *Computers In Human Behavior*. **80** pp. 283-294 (2018)

[10] Fleming, T., De Beurs, D., Khazaal, Y., Gaggioli, A., Riva, G., Botella, C., Baños, R., Aschieri, F., Bavin, L., Kleiboer, A. & Others Maximizing the impact of e-therapy and serious gaming: time for a paradigm shift. *Frontiers In Psychiatry*. **7** pp. 65 (2016)

[11] Green, C. & Bavelier, D. Action video game training for cognitive enhancement. *Current Opinion In Behavioral Sciences*. **4** pp. 103-108 (2015)

[12] Checa, D. & Bustillo, A. A review of immersive virtual reality serious games to enhance learning and training. *Multimedia Tools And Applications*. **79**, 5501-5527 (2020)

[13] Gazis, A. & Katsiri, E. Serious games in digital gaming: A comprehensive review of applications, game engines and advancements. *ArXiv Preprint ArXiv:2311.03384*. (2023)

[14] Din, S., Baig, M. & Khan, M. Serious Games: An Updated Systematic Literature Review. *ArXiv Preprint ArXiv:2306.03098*. (2023)

[15] Zarraonandia, T., Diaz, P., Aedo, I. & Ruiz, M. Designing educational games through a conceptual model based on rules and scenarios. *Multimedia Tools And Applications*. **74** pp. 4535-4559 (2015)

[16] Saavedra, A., Rodrıguez, F., Arteaga, J., Salgado, R. & Ordonez, C. A serious game development process using competency approach: Case Study: Elementary School Math. *Proceedings Of The XV International Conference On Human Computer Interaction*. pp. 1-9 (2014)

[17] De Jans, S., Van Geit, K., Cauberghe, V., Hudders, L. & De Veirman, M. Using games to raise awareness: How to co-design serious mini-games?. *Computers & Education*. **110** pp. 77-87 (2017)

[18] Winn, B. The design, play, and experience framework. *Handbook Of Research On Effective Electronic Gaming In Education*. pp. 1010-1024 (2009)

[19] Ben Amara, B., Mhiri Sellami, H. & Ben Said, L. An approach for serious game design and development based on iterative evaluation. *Journal Of Software: Evolution And Process*. **36**, e2680 (2024)

[20] Amara, B., Sallami, H. & Said, L. The Principal Characteristics of a Serious Game to Ensure Its Effective Design. *Proceedings Of DiGRA 2022 Conference: Bringing Worlds Together*. (2022)

[21] Arnab, S., Lim, T., Carvalho, M., Bellotti, F., De Freitas, S., Louchart, S., Suttie, N., Berta, R. & De Gloria, A. Mapping learning and game mechanics for serious games analysis. *British Journal Of Educational Technology*. **46**, 391-411 (2015)

[22] Said, B., Cheniti-Belcadhi, L. & El Khayat, G. An ontology for personalization in serious games for assessment. *2019 IEEE Second International Conference On Artificial Intelligence And Knowledge Engineering (AIKE)*. pp. 148-154 (2019)

[23] Mitsis, K., Zarkogianni, K., Bountouni, N., Athanasiou, M. & Nikita, K. An ontology-based serious game design for the development of nutrition and food literacy skills. *2019 41st Annual International Conference Of The IEEE Engineering In Medicine And Biology Society (EMBC)*. pp. 1405-1408 (2019)

[24] Fernández-López, M., Gómez-Pérez, A. & Juristo, N. Methontology: from ontological art towards ontological engineering. (American Association for Artificial Intelligence,1997)

[25] Bouzidi, R., De Nicola, A., Nader, F. & Chalal, R. OntoGamif: A modular ontology for integrated gamification. *Applied Ontology*. **14**, 215-249 (2019)

[26] Zagal, J. & Bruckman, A. The game ontology project: Supporting learning while contributing authentically to game studies. (International Society of the Learning Sciences, Inc.,2008)

[27] Muppasani, B., Pallagani, V., Srivastava, B. & Mutharaju, R. Building and Using a Planning Ontology from Past Data for Performance Efficiency.. *PLATO@ ICAPS*. (2023)

[28] Rezgui, K., Mhiri, H. & Ghédira, K. Ontology-based e-Portfolio modeling for supporting lifelong competency assessment and development. *Procedia Computer Science*. **112** pp. 397-406 (2017)