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THE NEW FRONTIERS OF DIGITAL LEARNING. INNOVATIVE ONLINE LEARNING TOOLS FROM THE UNIVERSITY TO THE WORKPLACE

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Table of contents

Introduction

The present doctoral project has been selected and co-funded by Regione Lazio under the "Industrial Doctorates Program" (Regional Law 13/2008): *"Initiative to strengthen research and innovation in Lazio – incentives for innovation-oriented doctoral studies for enterprises and public administration.*" The program aims to foster constructive collaborations among research institutions, businesses, and public bodies. The primary objective of the program is to provide support for doctoral research projects that show a high degree of innovation, with specific attention to digital innovation and technology transfer. The research proposal aligns with Regione Lazio's "Digital Agenda 4.0", which acknowledges "Information and Communication Technologies" (ICT) as a key driver for innovation in both economic and social domains, warranting strategic investment in research and development.

In recent years, significant methodological and technological transformations have been observed in the field of education and training, particularly in the domain of developing soft skills (Prensky, 2001). The advent of the *Digital Learning* paradigm (Wilson, 2004), which utilizes devices to promote learning and introspection, is the driving force behind these changes, that promote learning process and stimulate personal reflection. This interactive and adaptive teaching approach facilitates learning and motivates participants in the learning process.

In contemporary training contexts, Serious Games (SGs) have emerged as a versatile pedagogical tool, demonstrating strong adaptability across diverse educational settings. These games have been shown to promote active involvement and engagement among participants, thereby facilitating reflection and the internalization of the changes brought about by experiential learning process. Their effectiveness lies in their ability to activate metacognitive and reflective processes, thus fostering the internalization of content and awareness of one's learning journey (Anolli & Mantovani, 2011). By combining playful elements—such as challenge, scoring, feedback, and immersion—derived from the gamification approach, with clear educational objectives, SGs emerge as potentially effective tools for the development of soft skills.

This project has been developed in collaboration with *Studio Saperessere Srl,* the co-founding partner of the PhD project, launched in June 2022. The company designed

“ZooTeams,” a SG intended to support online training programs and foster active learner engagement. However, the game required scientific validation to assess its effectiveness and methodological reliability. The current doctoral research was therefore initiated with the aim of exploring the conditions, approaches, and methodologies most suitable for the effective implementation of Game-Based Learning (GBL) in educational and training contexts (Kapp, 2012), and in digital learning environment, with the goal of enhancing its replicability and pedagogical impact. Furthermore, the thesis seeks to investigate the potential of SGs as effective tools for learning and developing the key competencies of the 21st century, with a particular emphasis on soft skills (OECD, 2019).

The trajectory of this research is designed to systematically guide the reader from a comprehensive theoretical foundation (Chapters 1, 2, and 3) to the depth insight of empirical studies (Chapters 4, 5, and 6). **Chapter 1** provides a theoretical foundation for the study of SGs within the broader framework of “gamification”, defined as the integration of game elements and mechanics in non-game contexts to enhance motivation, engagement, and learning (Deterding & Walz, 2014). The theoretical analysis reviews international literature on educational game design processes, highlighting how these approaches can promote active, reflective, and experiential learning.

Chapter 2 explores the concept of Serious Games (SGs) as defined by Bergeron (2006), who describes them as digital applications that combine entertainment with educational objectives, promoting skills and attitudes transferable to real-life contexts. To shed light on the digital aspect of SG's meaning, this thesis will use also the term "Digital Serious Games" (DSG). A considerable emphasis is placed on insights from educational psychology and cognitive neuroscience, which demonstrate that the human mind processes and organizes information in a simulated, situated, and multisensory manner. The employment of Serious Games (SGs) in simulated, realistic scenarios guarantees secure environments, enabling participants to experience behaviors, make decisions, and reflect on the consequences of their actions. Consequently, SGs play a substantial role in the cultivation of psychosocial skills.

Chapter 3 explores the concept of soft skills, emphasizing those defined as 21st-century key competences. These competencies are deemed essential for effective engagement in both professional and social contexts within a technologically advanced environment. The chapter employs a range of theoretical frameworks to identify the cognitive, communicative,

and interpersonal skills that are conducive to enhancement through the utilization of DSGs. Such frameworks encompass the PIAAC surveys (OECD, 2009) and the Collaborative Problem-Solving framework (OECD, 2017), which elucidate the potential of DSGs to foster collaboration, effective communication, problem-solving, and teamwork skills in digital and collaborative environments. The literature review presented here also provides observable indicators and assessment tools to measure the competencies acquired through these learning experiences.

The subsequent chapters report empirical contributions. The first empirical study (**Chapter 4**) presents a systematic literature review intended to serve as a preliminary validation of the assumptions made in previous chapters. Following an examination of the conceptual underpinnings of "gamification" (chapter 1), of DSG (chapter 2), and the cultivation of soft skills (with particular emphasis for the aspects of collaboration) (chapter 3), chapter 4 offers a response to the following questions: *what theoretical frameworks underpin the use of Digital Serious Games to foster collaboration, in which learning contexts and target groups are they applied, what domain-specific learning outcomes are reported, and which cognitive, affective, social skills, and group processes do they promote?*. Using rigorous and replicable methodology for the analysis and selection of studies (Moher et al. 2009), 29 relevant international articles were identified.

The second empirical study (**Chapter 5**) presents the applicative part of the research. It reports the results of an educational intervention using the DSG "ZooTeams", developed by the partner company, which was implemented in the experimentation to enhance learning outcomes among university students, especially in pre-service teacher target. A quasi-experimental study was employed within a Design-Based Research (DBR) methodology (Collins, et al., 2004; DBR Collective, 2003), which guided the iterative development, implementation, and refinement of the intervention over two academic years. The primary aim of this study was to ascertain the extent to which the implementation of DSG has produced tangible outcomes. Furthermore, the aim was also to establish a standardized and replicable intervention methodology for its utilization within the education and training sectors.

The third empirical study (**Chapter 6**) explores a specific aspect of the efficacy of the DSG "ZooTeams," by examining students' perceptions of soft skills development. This

approach provides a subjective perspective on the gaming experience, focused specifically on the use of DSG “ZooTeams.” The examination of students' perceptions, in regard to the relationship between the EGameFlow scale (Chen et al., 2018) and assessments scales on problem-solving self-efficacy and teamwork, provides a more nuanced understanding of the impact of the game on the development of specific skills, that have been categorized as follows: problem-solving self-efficacy, interpersonal skills, and collaborative work orientation. This adds depth and validation to the broader findings on the effectiveness of the DSG. This chapter brings the discussion full circle, linking the practical application of the DSG (chapter 5) to its implications for soft skills development (chapter 3) and the underlying psychological mechanisms (chapter 2).

This doctoral thesis contributes to the scientific debate on the use of DSGs as learning tools by validating their impact on development of learning and soft skills in educational settings. It also offers methodological insights into the design of innovative educational and training interventions, while stimulating reflection on their practical implications for businesses, training providers, and educational institutions.

The overarching objective of this doctoral research is to facilitate the preparation of students in educational and training disciplines to facilitate the transition more effectively and consciously from university to the workplace. The development of soft skills such as collaboration, effective communication, and teamwork is promoted, as these skills are indispensable for both individual and professional advancement within complex and rapidly evolving organizational environments. The integration of “gamification” and DSGs into training pathways is a promising strategy for the practical implementation of innovative psycho-educational models that enhance 21st-century key competences.

FIRST PART: THEORETICAL CONTRIBUTIONS

Chapter 1
Gamification in educational and training contexts

"A game is a system in which players in an abstract challenge, defined by rules, interactivity and feedback, that results in a quantifiable outcomes often eliciting an emotional reaction."

(Koster, 2005)

The concepts of "gamification" and Serious Games are easy to explain to children. The luckiest ones are accustomed to seeing the world as a place where play and simulation surpass the quality of time and experience of reality. They are able to learn, know and reproduce phenomena at the neurophysiological, mental and social levels. This allows them to understand, trace and anticipate the course of complex phenomena in reality and to create new scenarios (Anolli & Mantovani, 2011, p. 9).

Games involving adults present a more complex scenario. The most significant obstacle is the adult-centric perspective that views play as a waste of time and an activity confined to the realm of children (Colli et al., 2021). Nonetheless, there has been an escalating perception in recent years that games can function as an incentive for motivation and facilitate learning in adult settings. The rethinking of the relationship between play and work is developing thanks to new learning models.

To define "gamification," it is useful to analyze the constituent elements of Raph Koster's definition of a game, as presented in his seminal work *A Theory of Fun* (2005). The first element is the concept of the *system*, which posits that the environment within which a game unfolds comprises interconnected components that facilitate player actions and behaviors. This suggests that *players*—defined as individuals who interact with the game and engage in various activities or behaviors—occupy the game environment, whether it be virtual or real. The third distinguishing feature is the concept of *abstract*, which implies that a game mimics the behavior of real-world occurrences and serves as a simulation of reality. Such simulations serve as enhanced models to describe, understand, and explain real-world processes and phenomena (Anolli & Mantovani, 2011, p. 30). The concept of *challenge* refers to the game's capacity to engage players by presenting them with goals to achieve. *Rules* are also fundamental, as they delineate the modalities of play, establishing both constraints and

possibilities (e.g., time limits, permissible actions). *Interactivity* is another essential element, allowing players to recognize the range of choices available to them and to act accordingly, while understanding that outcomes are not entirely predictable. This presumes that individuals engage in self-comparison either with the game itself or with other players (Smuts, 2009, p. 65), and that they anticipate receiving *feedback*. Feedback consists of responses to player actions, delivered either instantaneously or at the conclusion of gameplay. The idea of *quantifiable outcomes* ensures that results are clearly defined and measurable—an aspect that is particularly relevant in educational contexts. Finally, the *emotional reaction* produced by a game plays a fundamental role, fostering player engagement and enhancing both performance and motivation.

Within gameplay, individuals exercise autonomy by making decisions and employing strategies. This process often leads to a state of deep immersion, during which players become disengaged from their external environment. In 1990, Mihaly Csikszentmihalyi, a co-founder of positive psychology, introduced the concept of *flow* to describe this phenomenon. Temporary detachment from reality and intense goal-pursuit focus are characteristics of *flow*., which produces a sensation of fulfillment even in the absence of achievement of goals (Csikszentmihalyi, 1990). According to the flow theory, intrinsic motivation is crucial to the enjoyment of gameplay because it enables happiness to arise from the activity itself, irrespective of outside rewards.

Games have been shown to facilitate the fulfillment of fundamental human needs, thus positioning them within the upper echelons of Maslow's (1943) hierarchy of needs from an evolutionary psychological perspective.

Gamers have the ability to develop a sense of competence by mastering problems, to boost their self-esteem by achieving goals, to create a sense of community by collaborating with others, and to feel satisfied when their contributions are acknowledged.

Therefore, it can be posited that games have the capacity to engage the social, emotional, cognitive, and motivational aspects of human needs. The integration of "gamification", particularly Serious Games (SGs), within training and educational contexts offers a novel, engaging pedagogical approach aimed at enhancing student performance across a range of settings, including academic institutions and professional environments.

1.1. Definitions of "gamification"

The term "gamification" was coined in 2008 by Brett Terrill, within the digital media industry (Terrill, 2008). However, it was not until 2010 that the concept began to gain broader traction. Initially, gamification was primarily implemented for marketing purposes. However, as its potential became more widely recognized, an increasing number of companies began to adopt gamification strategies to enhance both customer experience and individual and organizational performance.

Despite growing academic and practical interest in the topic, a universally accepted definition of gamification has yet to be established in the literature. Broadly speaking, gamification—characterized by the use of rewards, points, levels, and other game elements—has emerged as an innovative pedagogical approach with the potential to enrich the teaching and learning process and increase learner motivation (Barragán-Pulido et al., 2023). One of the earliest and most frequently cited definitions was proposed by Deterding et al., who defined gamification as "the use of game design elements in non-game contexts" (Deterding et al., 2011, p. 10). This definition highlights the inherently multidimensionality of gamification, underscoring its relevance across a wide array of fields.

A review of 208 publications on gamification published between 2008 and 2016, conducted by Bozkurt and Durak (2018), found that 45.19% of the studies focused on education. Theoretical discussions of gamification and its core concepts constituted 14.42% of the literature. Other domains represented in the dataset included health (11.06%), marketing (8.17%), design (7.21%), business (6.73%), engineering (1.92%), libraries (1.92%), tourism (1.44%), management (1.44%), and communication (0.48%). In a complementary perspective, Huotari and Hamari (2012) defined gamification as: "a process of enhancing a service with affordances for gameful experiences in order to support user's overall value creation." Following this line of thinking, gamification may be considered a marketing tool, aimed at improving service quality and product usability.

Another perspective highlights gamification's potential for addressing complex problems and fostering user engagement. In this vein, Zichermann and Cunningham (2011) defined the concept as "the process of game-thinking and game mechanics to engage users and solve problems" (Zichermann & Cunningham, 2011, p.14). Research has shown that games aimed at engaging and motivating individuals have been applied across diverse contexts, yielding a range of outcomes—from enhanced engagement to increased motivation

and participation. In 2012, Karl Kapp offered a more expansive definition of gamification, integrating it within the broader context of learning processes. This definition serves to anchor the central theme of this thesis: “gamification is using game-based mechanics, esthetics and game thinking to engage people, motivate action, promote learning and solve problems” (Kapp, 2012, p. 10). This process involves the integration of game-like elements into real-world environments, with the primary objective of leveraging positive experiences to achieve serious and tangible goals (e.g., fostering educational or behavioral change) and developing skills and competencies applicable to everyday life.

1.1.1. Elements of educational game design

Game player engagement is contingent on the appropriate integration of elements fostering immersive and challenging environments. At this stage of the analysis, a comprehensive investigation is necessary to identify the most commonly employed game elements in the design of educational and learning-focused games, and to assess their contribution to the teaching-learning process. Kapp (2012, pp. 26-49) outlined several game elements that are essential for effective learning:

- **Abstraction of concepts and reality:** Abstraction supports players’ understanding of complex, real-world concepts by rendering them dynamic and intelligible through hypothetical, imaginary, or fictitious representations (i.e., operating models). The benefits of abstraction in games are numerous: it helps players navigate the game’s conceptual framework, clarifies cause-and-effect relationships, removes extraneous environmental distractions, and facilitates focused engagement. Ultimately, abstraction enables players to grasp complex ideas more efficiently and within a shorter time span.
- **Goals:** Goals equate to quantifiable objectives. Their inclusion in a game encourages players to explore various strategies and methods to achieve them. From an educational standpoint, it is essential to define a series of sub-goals that will collectively support the attainment of a broader, overarching objective.
- **Rules:** There are four primary categories of game rules. *Operational rules* define how the game is to be played. *Foundational rules* serve as formal structures governing the game’s internal logic. *Implicit rules* (or *behavior rules*) regulate the social contract between players, shaping acceptable conduct. Lastly, *instructional*

rules guide the learning process within the game, helping players internalize instructional objectives (Salen & Zimmerman, 2004, p. 80).

- **Conflict, competition, and cooperation:** A game may involve one or more of these elements. In *conflict*, players strive to defeat an opponent—either another player or the game system, itself—to achieve victory. *Competition* entails players vying for the highest score or optimal performance, without directly interfering with one another. Finally, *cooperation* involves players working together toward a shared goal, emphasizing the social dimension of gameplay.
- **Time:** Time is a crucial motivating factor in gameplay, often reflecting real-life applications. In game design, *temporal compression* is a key strategy used to accelerate the consequences of player actions, promoting a more immediate and efficient understanding of time-based progression within the game.
- **Reward structures:** Reward structures make a game more engaging and serve primarily to facilitate learning, rather than representing ends in themselves. They may take various forms (e.g., badges, points, leaderboards) and aim to sustain engagement while supporting the development of relevant skills, abilities, or knowledge within the learning process.
- **Feedback:** In educational games, the continuous provision of feedback is essential. Feedback typically falls into one of two categories: *informational feedback*, which indicates whether a response or action is correct or incorrect; or *directive feedback*, which provides guidance to help the player progress toward the intended outcome.
- **Levels:** Game levels can be classified into three distinct types. The *structural level* refers to the organization of the game into stages or missions that players must complete. The *playing level* indicates the degree of difficulty associated with gameplay. Finally, the *player level* represents the knowledge, experience, and skills acquired through gameplay.
- **Storytelling:** Storytelling is a fundamental component of gamified learning and instruction, as it enhances relevance and meaning within the game experience. In educational contexts, the integration of a compelling narrative can promote the development of key competencies, behaviors, and knowledge, all of which support the achievement of specific instructional goals.

- **Curve of interest:** The curve of interest refers to the flow and sequencing of events over time that sustain player engagement. In the context of learning design, the curve of interest is a valuable tool for identifying fewer engaging components within a game and enhancing the overall learning experience.
- **Aesthetics:** Aesthetic components are central to game design, contributing to player engagement and immersion. The deliberate use of visual design, auditory elements, and color schemes captures and sustains attention, thereby deepening players' involvement in the game environment.
- **Replay or "do over":** Replay refers to the opportunity to experience failure within a low-stakes environment, allowing players to explore, make decisions, and revise those decisions without real-world consequences. The ability to retry fosters reflective learning, supports experimentation, and reinforces the pedagogical value of learning through error and iterative practice.

A growing body of research is demonstrating the efficacy of gamification elements in supporting learning and instructional processes. However, the categorization of game design elements remains fragmented within the academic community. A systematic review conducted by Thiebes and colleagues (2014) analyzed 29 studies published between 2010 and 2013 investigating the mechanics of gamification. Using a structured approach, the authors classified gamification mechanics into five categories: system design, challenges, rewards, social influences, and user-specific factors.

Similarly, a systematic mapping study by Dicheva and colleagues (2015) examined 34 papers published between 2011 and 2014 focused on game elements in educational contexts (Table 1). The authors identified key design principles commonly used in educational gamification, including visual status indicators, social engagement, freedom of choice, freedom to fail, and rapid feedback. Among the most frequently implemented game mechanisms were points, badges, and leaderboards. Most of the research that was analyzed documented significant increases in student engagement across forums, projects, and other learning activities. Moreover, the findings indicated that student contributions exhibited an upward trend in terms of both quantity and quality. Concurrently, the proportion of students who successfully completed voluntary or challenging assignments and passed their courses exhibited an appreciable increase. A notable observation was the diminution in the performance disparity between the high-performing and low-performing children. Furthermore, students generally

perceived gamified learning environments as more motivating, engaging, and accessible compared to traditional classroom environments.

Table 1. Educational gamification design principles in Dicheva et al.'s (2015) review

Design principles	Game mechanics used
Goals: specific, clear, moderately difficult, immediate goals	
Challenges and quests: clear, concrete, actionable learning tasks with increased complexity	
Customization: personalized experiences, adaptive difficulty; challenges that are perfectly tailored to player skill, increasing in difficulty as player skill expands	
Progress: visible progression to mastery	Points, progress bars, levels, virtual goods/currency
Feedback: immediate feedback or shorter feedback cycles; immediate reward instead of vague long-term benefits	
Competition and cooperation / social engagement loops	Badges, leaderboards, levels, avatars
Accrual grading	Points
Visible status: reputation, social credibility, and recognition	Points, badges, leaderboards, avatars
Access/unlocking content	
Freedom of choice: multiple routes to success, allowing players to choose their own sub-goals within the larger task	
Freedom to fail: low risk from submission, multiple attempts	
Storytelling	Avatars
New identities and/or roles	Avatars
Onboarding	
Time restriction	Countdown clock

Another systematic review of empirical research on gamification applied in teaching and learning settings was conducted by Zainuddin and colleagues (Zainuddin et al., 2020), who analyzed 46 papers. The majority of participants, founded in the select studies, expressed a preference for leaderboards, which significantly enhanced their motivation to engage in flipped, mixed, and gamified learning environments, according to the review. In a related study, Ortiz and colleagues (2016) discovered that the adoption of gamification components, particularly leaderboards, resulted in significant improvements in learning outcomes, motivation, and engagement. Chang and Wei's (2016) research indicated that, subsequent to virtual gifts and points, team leaderboards constituted the third most engaging gamification

method. This feature promoted a strong sense of social connection among students, driven by competition and point-based comparisons displayed on the leaderboards.

These findings underscore the importance of integrating core gameplay mechanisms during the design of learning experiences. A wide range of interrelated components must be carefully considered to ensure educational effectiveness. The following section will examine the existing literature on gamification in learning, highlighting both the fragmented nature of current research and the considerable potential for gamification to improve learning outcomes across educational domains.

1.2. State of the art of gamification in learning context

As demonstrated by Kapp (2012, p. 77), the effectiveness of gamification and game-based learning in facilitating student engagement and improving learning outcomes is well-supported. Kapp referenced numerous systematic reviews and meta-analyses underscoring the potential for these methodologies to inform the design of meaningful educational and instructional games.

Vogel and colleagues (2006) conducted a meta-analysis to evaluate the hypothesis that cognitive and attitudinal outcomes differ between traditional classroom instruction and approaches involving computer gaming or interactive simulations. Their findings revealed a positive effect size for interactive simulations and games compared to conventional teaching methods. Similarly, Ke (2009) performed a qualitative meta-analysis synthesizing data from 65 empirical studies. The analysis provided robust evidence for the effectiveness of computer-based instructional games, with 52% of the reviewed studies demonstrating significantly improved learning outcomes over traditional methods. Ke's research also identified numerous instructional assistance components in 17 of the studies, encompassing elaborative feedback, pedagogical agents, and multimodal information display. These characteristics have been demonstrated to be consistently associated with enhanced learning outcomes. Furthermore, the findings indicated that instructional computer games, which are associated with elements like self-efficacy, favorable learner attitudes toward the subject issue, and high-quality feedback integrated into gameplay, can promote greater motivation across a range of learner groups and educational environments.

Sitzmann's (2011) meta-analysis evaluated the instructional effectiveness of simulation games, synthesizing the findings from 55 empirical investigations focused on trainee learning outcomes associated with simulation-based instruction. The results revealed notable

improvements among trainees, including a 20% increase in confidence, 11% increase in declarative knowledge, 14% increase in procedural knowledge, and 9% improvement in retention.

Educational literature frequently distinguishes among the effectiveness of gamification, SGs, and game-based learning across various outcome categories. These include cognitive and affective learning outcomes (Carenys & Moya, 2016; Lamb et al., 2018) motivational outcomes (Sailer & Homner, 2020) or both (Connolly et al., 2012).

A substantial body of research has affirmed the effectiveness of gamification and gaming elements in instructional design and learning processes. A detailed systematic review of 118 empirical studies, examining the theoretical mechanisms by which gamification, social media, and game-based learning influence motivational, affective, behavioral, and cognitive learning outcomes, has been conducted by Krath and colleagues (2021). The results indicated that the theoretical underpinnings of these interventions originated from diverse disciplinary backgrounds, including human-computer interaction, social psychology, and cognitive psychology. The first category of theoretical foundations centers on affect and motivation. Prominent theories in this domain include self-determination theory (Ryan & Deci, 2017), self-efficacy theory, referring to individuals' beliefs in their capacity to perform specific tasks (Bandura, 1982) and the aforementioned flow theory (Csikszentmihalyi, 1990).

The second category pertains to theories explaining behavioral outcomes. These include the theory of reasoned action (Ajzen & Fishbein, 1980), the theory of planned behavior (Ajzen, 1991) and the technology acceptance model (Davis et al., 1989), outlining the influence of attitudes, subjective norms, and perceived behavioral control on behavioral intention and subsequent action. Cognitive load theory (Sweller, 1988) and the cognitive theory of multimedia learning (Mayer, 2005) are concerned with mental processing capacity and the mental processes involved in organizing and linking learning content with prior knowledge. Finally, the third category of theoretical foundations is concerned with the determinants and processes of learning. Many of these theories originate from social psychology and emphasize the significance of sociocultural influences and interpersonal interactions in effective learning. Notable examples include social learning theory (Bandura, 1971), social cognitive theory (Bandura, 2001), and the socio-cultural theory of cognitive development (Vygotsky, 1978)

These frameworks underscore the social nature of learning and the role of context in shaping cognitive development. Additionally, experiential learning theory (Kolb, 1984) posits that knowledge is constructed through direct personal and environmental experiences following an iterative cycle of reflection and action, rather than passive instruction.

Educational games and gamification strategies have been shown to enrich the learning experience across multiple dimensions—cognitive, affective, motivational, and behavioral. The following section will explore the educational, pedagogical, and psychological theories underpinning the integration of gamification into instructional design and learning environments.

1.3. Theories underpinning the gamification of learning processes

The theoretical foundations of gamification in educational contexts have been examined extensively by scholars and research groups. As a result, the literature presents a range of psychological and pedagogical frameworks elucidating how gamification facilitates learning, particularly through its impact on motivation, affect, behavior, and learning outcomes. These frameworks reflect diverse attempts to explain the mechanisms and effects of gamification from multiple theoretical perspectives.

Building on the systematic review conducted by Krath et al. (2021), the present work adopts the most influential theories employed in empirical research on gamification and SGs within educational settings. Drawing on findings from 118 empirical studies, the authors investigated the relationship between theoretical models of affective and motivational processes and their role in supporting learning through gamified experiences. The following theories emerged as the most frequently cited in the literature:

- **Self-determination theory (SDT):** The macro-theory of SDT explains the intrinsic motivation underlying engagement in tasks or activities (Ryan & Deci, 2000a). This framework has been applied across diverse domains, including sports, healthcare, religion, work, and education. SDT investigates the factors that facilitate or inhibit motivation and comprises several sub-theories, including cognitive evaluation theory. This sub-theory posits that conditions enhancing an individual's sense of autonomy and competence promote intrinsic motivation, whereas factors that undermine these perceptions are likely to diminish it. According to Ryan and Deci (2000b) human motivation is grounded in three basic psychological needs:

competence, autonomy, and relatedness. In the context of gamified learning environments, SDT has been widely employed to support the idea that the motivational appeal of games lies in their ability to foster these psychological needs. When games promote feelings of autonomy, competence, and relatedness, they not only encourage sustained engagement but are also perceived as contributing positively to psychological well-being (e.g. Xi & Hamari, 2019).

- **Flow theory:** Flow theory, as originally defined by Csikszentmihalyi, refers to the "holistic sensation that people feel when they act with total involvement" (1975, p. 36). The experience of flow is marked by an optimal balance between task complexity and skill, whereby the individual feels capable of successfully completing the task, assuming focused attention, the exclusion of distractions, and considerable effort. Csikszentmihalyi identified eight core elements facilitating the emergence of flow: the presence of a challenging yet attainable task, deep concentration, clear goals, immediate feedback, effortless involvement, a sense of control over one's actions, diminished self-consciousness, and a distorted sense of time.

  In gamification research, flow theory is frequently applied to evaluate the design and effectiveness of gamified interventions. Furthermore, researchers often assess the presence of flow to better understand its relationship with behavioral outcomes and user engagement (e.g. Bachen et al., 2016).
- **ARCS model**: The ARCS model, developed by Keller (1987), is a motivational framework synthesizing key variables from diverse strands of motivational research. It also includes a design process that aligns with conventional instructional design models. The acronym ARCS stands for Attention, Relevance, Confidence, and Satisfaction, four components that are considered essential for sustaining learner motivation. In the context of gamified education, the ARCS model is valuable for evaluating the motivational appeal of educational games. For example, it can be used to assess learner expectations regarding their ability to succeed in a given task (e.g. Calvo-Ferrer, 2018).
- **Goal setting theory:** Goal setting theory, originally proposed by Locke (1968), posits that challenging goals are more likely to lead to higher levels of performance than those that are easier or vague. This effect is explained through three primary

motivational mechanisms: direction of behavior, intensity of effort, and persistence over time. In the context of gamified learning, this theory has been applied to explore how goal setting within game-based environments can enhance performance outcomes (e.g. Nebel et al., 2017).

- **Self-efficacy theory:** Self-efficacy refers to an individual's belief in their ability to successfully perform the behaviors necessary to achieve a specific outcome or task (Bandura, 1982). Perceived self-efficacy has been shown to directly influence the selection of activities, underscoring its central role in motivation. In the context of gamification, research has explored whether game mechanics can enhance self-efficacy—for instance, in domains such as emergency response training (e.g. Chittaro & Buttussi, 2018) and learning tasks (e.g. Blasko-Drabik et al., 2013).
- **Social Comparison Theory (SCT):** SCT describes a fundamental human tendency to evaluate one's opinions and abilities by comparing them to others. This process serves to reduce ambiguity and foster a more coherent sense of self (Goethals et al., 1987). SCT can be viewed as a mechanism of measurement and self-assessment enabling individuals to gauge their standing in relation to internal standards and emotional perceptions of the self. Recent studies have emphasized the role of social comparison in fostering self-improvement (Buunk & Gibbons, 2007). Within gamified learning environments, SCT supports learners' efforts toward positive self-evaluation by highlighting the influence of media, social status, and competitive elements on self-esteem and emotional well-being.

The most prominent and widely applied theories supporting gamified learning in relation to behavioral processes are as follows:

- **Technology acceptance model (TAM):** TAM posits that behavioral attitude—influencing an individual's intention to use a system—is shaped by two key beliefs: perceived usefulness and perceived ease of use (Davis, 1989). TAM provides a theoretical framework for assessing how users perceive the usefulness and usability of technology. It is evident that attitudes, behavioral intentions, and behavioral results are influenced by these views. The TAM is frequently utilized in the context of gamification research to assess the impact of these beliefs on user engagement with gamified interventions.

- **Theory of Reasoned Action** (TRA): TRA posits that an individual's behavior is determined by their behavioral intention, which is influenced by two primary components: subjective norms and behavioral attitudes (Ajzen & Fishbein, 1980). Individuals are more likely to intend to perform a behavior when they view it positively and believe that others expect them to act in that manner (Ajzen, 1985). The TRA forms the theoretical foundation of the TAM and is often applied alongside it in studies examining the adoption and implementation of gamified systems (e.g. Vanduhe et al., 2020).
- **Theory of planned behavior** (TPB): The theory of planned behavior (TPB), developed as an extension of the TRA, is particularly relevant in contexts where the likelihood of success and the degree of personal control over a given behavior are limited. The TPB presents the key concept of perceived behavioral control, which is characterized as a person's assessment of the ease or difficulty involved in performing a particular behavior. In addition to the ideas of behavioral attitude and subjective norms, which are essential to the TRA, the TPB offers a comprehensive framework for understanding human behavior (Ajzen, 2002). The theoretical effects of gamification on behavior antecedents and behavioral intention are evaluated using this model.

Most prominent and influential theories linking gamification to learning processes, as identified in the literature, are as follows:

- **Social learning theory**: Social learning theory posits that individuals acquire knowledge through social contexts by observing and imitating others (Bandura, 1971). Empirical studies have demonstrated the effectiveness of social models in influencing changes in behavior, beliefs, attitudes, and both social and cognitive functioning. As outlined by Bandura, four interrelated moderating processes underpin behavioral modeling: attention, retention (both imaginative and verbal), reproduction, and motivation (or reinforcement). This theory serves as a foundational framework in the design of gamified interventions—particularly those incorporating mechanisms enabling social observation or the use of role model characters.
- **Constructivist learning theories:** Constructivist learning theories hold that learning is an active process of constructing knowledge rather than the passive receipt of information. Accordingly, education is understood as a process that supports knowledge construction, rather than the direct transmission of information (Duffy &

Cunningham, 1996). Jonassen (1999) identified three instructional strategies to facilitate learning: modeling, entailing the demonstration and articulation of reasoning; coaching, including motivational support, guidance, and opportunities for reflection; and scaffolding, involving the adaptation and restructuring of tasks to support learner progression. Learning games developed in alignment with constructivist principles typically emphasize experiential learning and active participation (e.g. Kordaki & Gousiou, 2017). Additionally, gamified interventions are often designed to encourage introspection and self-reflection (e.g. Avramenko, 2012).

- **Socio-cultural theory of cognitive development:** The socio-cultural theory of cognitive development is rooted in Vygotsky's (1978) sociocultural constructivist perspective. According to this theory, social interaction occurs on two levels: first at the social (inter-psychological) level and subsequently at the individual (intra-psychological) level. Cognitive development is facilitated by tools such as language, art, and writing, which mediate the transition from social to individual cognition (Wang et al., 2011). A central concept within this framework is the zone of proximal development (ZPD), defined as the gap between an individual's current developmental level and their potential level, achievable through guidance, collaboration, or instruction. Instructional design informed by this theory aims not only to reinforce existing skills but also to foster the emergence of new, higher levels of development. Gamified interventions based on socio-cultural theory are typically designed to provide scaffolding within the learner's ZPD. These interventions are notable for their adaptability and personalization, with the overarching goal of supporting cognitive growth and development (e.g. Davis et al., 2018).
- **Situated learning theory:** Situated learning theory posits that learning is inherently tied to authentic activities, contexts, and cultures. Pedagogical models grounded in this theory include cognitive apprenticeship, problem-based learning, learning-by-design, and case-based learning, among others. These models share a commitment to embedding learning in rich, realistic, and meaningful contexts. Additionally, they emphasize social negotiation as an essential aspect of learning, promote diverse perspectives and representations, encourage learner ownership, and foster metacognitive awareness of the learning process (Dabbagh & Dass, 2013).

Educational games and game-based learning environments are widely regarded as effective applications of situated learning, enabling learners to develop problem solving skills through immersive gameplay (Hwang et al., 2015). Accordingly, situated learning theory plays a pivotal role in guiding the design of game-based learning experiences, particularly those centered on complex, authentic problem solving scenarios (e.g. All et al., 2017).

- **Experiential learning theory:** In accordance with the experiential learning paradigm, knowledge is acquired through environmental and personal experience as an alternative to formal education (Kolb, 1984). The theoretical underpinnings of this method are comprised of four sequential stages: concrete experience, reflective observation, abstract conceptualization, and active experimentation (Kolb & Kolb, 2013). This theory views learning as a cyclical process, further elaborated from the authors into nine distinct learning styles—initiating, experiencing, imagining, reflecting, analyzing, thinking, deciding, acting, and balancing—each representing a specific stage within the broader process. Experiential learning theory is frequently applied in the field of game-based learning to guide the creation of instructional games. Additionally, it provides a framework for assessing learning results in gamified settings (e.g. Koivisto et al., 2017).
- **Multimedia learning theory:** In multimedia learning theory, developed by Mayer (2005), learners process information through two separate channels: visual and verbal. The theory asserts that each channel has a limited capacity for information processing, and effective learning occurs through active engagement. Active processing involves attending to relevant content, mentally organizing it into a coherent structure (essential processing), and integrating it with prior knowledge (generative processing). In game-based learning design, this theory is applied to reduce the extraneous processing of elements diverting attention from the core learning content, through the selection of appropriate game features and instructional strategies (e.g. Johnson & Mayer, 2010).

Gamification is a versatile and successful methodology that may be used in training and educational settings, as the sections above demonstrate. It has been shown that game mechanics improve user engagement, making them useful resources for instructional designers and teachers. SGs, as principal tool designed by the principles of gamification, must

be examined to identify the characteristics that set them apart from the more general frameworks of gamification and game-based learning. Thus, the following chapter defines the characteristics of SGs, outlines their effectiveness in educational settings, and explores the ways in which they diverge from other game-enhanced instructional strategies.

Chapter 2

Serious Games in educational and training contexts

Some sections of Chapter 2 are based on the following published paper:

Giacchi, I., Fusco, F., Vitiello, M. C., Vecchio, G.M. (2023). *Serious games nel campo educativo e formativo: aspetti teorici e applicativi.* In V. Carbone G. Carrus F. Pompeo E. Zizioli (a cura di), *Giornata della Ricerca 2021 del Dipartimento di Scienze della Formazione* (pp. 541-553). Roma : ROMA TRE-PRESS - Università degli studi Roma Tre [10.13134/979-12-5977-217-6].

2.1. Definitions of Serious Games

"Games may be played seriously or casually.
We are concerned with 'Serious Games' in the
sense that these games have an explicit and carefully thought-out educational purpose
and are not intended to be played primarily for amusement.
This does not mean that Serious Games are not, or should not be, entertaining".
(Abt, 1970)

Clark Abt is widely recognized as a pioneering figure in the field of Serious Games (SGs), having established that SGs are designed with a specific purpose beyond mere entertainment. Prensky (2001) further advanced the field by integrating digital learning into interactive experiences, introducing the concept of Digital Serious Games (DSGs). Such games synthesize entertainment and education through digital interaction, offering the potential for immersive, experiential practice.

A widely cited definition of SGs was provided by Bergeron (2006, p. 398), who described them as: "interactive computer applications, with or without a significant hardware component, that (i) have challenging goals, (ii) are fun to play with and/or engaging, (iii) incorporate some concepts of scoring, (iv) impart to the user skills, knowledge, or attitude that can be applied in the real world." Importantly, SGs are not designed solely for entertainment,

nor are they limited to children. Similar to other gamification tools, they aim to create multifaceted user experiences that are both engaging and rewarding. The value of SGs lies in their ability to promote interactive experiences that are not only functional but also emotionally engaging. Key determinants of this experience include usability, the experiences provided by technology, and the emotional responses it evokes. The potential of SGs is grounded in their capacity to elicit positive emotions and pleasant situational responses, transforming gameplay into a form of emotional expression that is often seen as the antithesis of depression (Argenton et al., 2016). The sensorial pleasure evoked by SGs derives from the graphics, usability, game aesthetic, visual and narrative stimuli that are present in the game; these elements are analyzed by emerging trends, such as engineering aesthetics (Liu, 2003).

Anolli and Mantovani (2011) identified three core dimensions of SGs. The first is the *simulation dimension*, in which SGs digitally reproduce elements of individual and collective experience, often amplifying real-world data and projecting future scenarios. Within this dimension, a distinction can be made between high-fidelity and low-fidelity SGs. High-fidelity SGs offer detailed and accurate simulations of real phenomena and are typically used in scientific and medical contexts, where the precise replication of real-world events is essential. In contrast, low-fidelity SGs only selectively represent reality, emphasizing certain elements while omitting others. These games are often designed to develop transversal skills such as leadership or problem solving.

The second is the *learning dimension*, defined as the acquisition of knowledge or skill through structured educational experiences. SGs in this category aim to provide users with instructional content and embedded “guides” that support and explain the training process. These guides facilitate metacognitive and self-reflective activities, allowing players to monitor and evaluate their learning progress. Moreover, the multi-user nature of many SGs encourages shared learning experiences, whereby players may exchange feedback and develop key interpersonal competencies, including communication, leadership, problem solving, cooperation, and teamwork.

The third is the *playful dimension*, in which game mechanics stimulate intrinsic motivation and foster further engagement. At the cognitive level, mechanisms of competition and self-competition are activated, turning gameplay into a challenge to achieve defined goals. This process generally promotes positive emotional states such as interest, curiosity, and a sense of self-efficacy.

SGs may also feature innovative approaches to evaluation. For instance, in addition to traditional assessment methods (e.g., questionnaires, interviews) SGs may measure learning during or after gameplay through built-in feedback mechanisms identifying errors or areas for improvement, thereby enabling learners to explore alternative strategies or solutions (Michael & Chen, 2006). SG designers have developed increasingly sophisticated evaluation techniques, including:

- assessment of task completion (e.g., whether players completed tasks and passed tests in the time required);
- ongoing evaluation (e.g., "Why did you choose option X instead of Y?");
- evaluation of mistakes (e.g., number, type, and recurrence of mistakes);
- behavioral assessment (e.g., risk-taking behavior, decision-making speed);
- recognition of warning signs (e.g., identifying irritation in a virtual interlocutor, evaluating the appropriateness of responses);
- learning from mistakes (e.g., the ability to learn from errors and the time taken to do so); and
- persistence and determination in completing tasks.

Thus, in SGs, learning and assessment take place simultaneously through a dynamic evaluation process in which players receive feedback during the gameplay. This process not only reinforces learning but also fosters "self-competition," promoting deeper engagement with the activity, repeated practice, and the development of new problem solving strategies.

According to Martens et al. (2008), the three core dimensions of SGs—simulation, learning, and gameplay—can be understood through the interplay of pedagogy, computer science, and game design. As illustrated in the Venn diagram below (Figure 1), each overlapping area represents a category integrating elements from two or more domains:

- **Entertainment games** lie at the intersection of learning and games. While primarily designed for fun and engagement, they often contain incidental or supplementary learning components.
- **Training simulations** emerge at the overlap of learning and simulation. These are structured to replicate real-world contexts and used to develop specific skills or knowledge in a controlled, instructional environment.

- **Simulation games** occupy the space between simulation and games. While they model real-world systems or processes, primarily for entertainment, they may also promote learning through immersive, scenario-based interaction.

At the center of the diagram is **game-based learning**, which integrates all three elements—simulation, learning, and gameplay—representing the most comprehensive application of SG

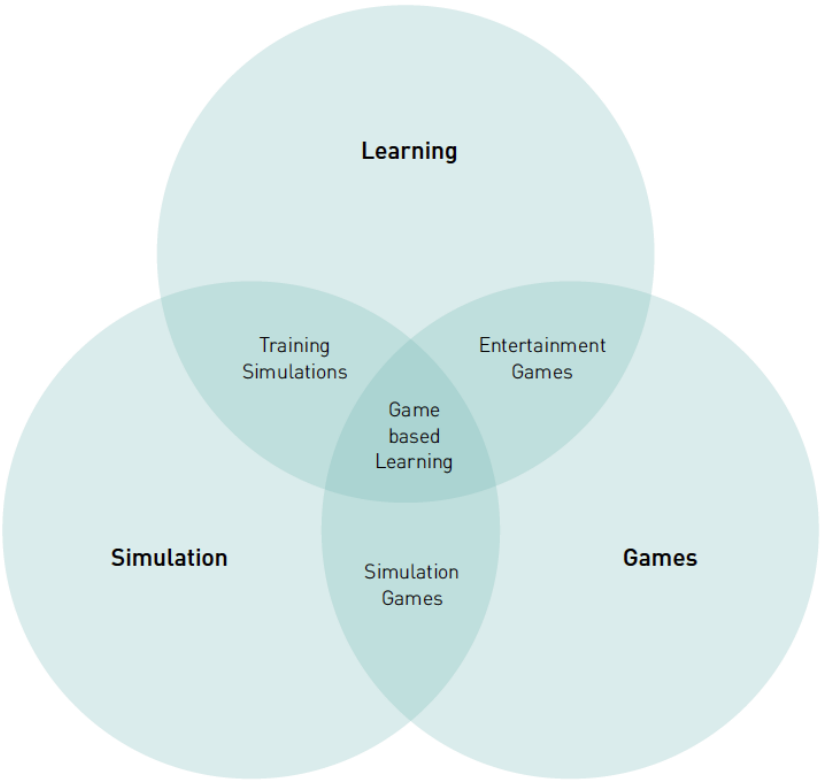


Figure 1. Interplay of Pedagogy, Computer Science, and Games (Martens et al., 2008).

principles.

2.1.1. State of the art of Serious Games in learning contexts

A fundamental distinction merits emphasis when addressing gamification and SGs in educational settings. Gamification refers to a comprehensive methodology wherein the learning process is structured according to the logic of game elements, leveraging components outlined in Section 1.1.1. In contrast, SGs are specific tools that have emerged from this broader gamification approach. Of note, SGs do not necessarily incorporate all of the game mechanics previously enumerated (Barragán-Pulido et al., 2023). Another fundamental

difference lies in their respective applications. While an SG is intentionally employed for educational purposes—often in a manner not immediately evident to the player—gamification involves the application of game-based elements to non-game contexts (Deterding et al., 2011) and does not require either a full-fledged game or an explicit educational aim. What unites both approaches is their shared goal: to foster dynamic and meaningful learning experiences that enhance learner motivation and engagement. As Kapp (2012, p. 23) wrote: "Serious games are created by using game-based mechanics, aesthetics, and game thinking to engage people, motivate action, promote learning, and solve problems. […] They are created through the gamification of traditional learning content."

SGs have proven to be highly effective and engaging educational tools, capable of influencing user attitudes across various domains. Their applications span a wide range of fields, including medicine, training, and formal education. Calderón and Ruiz (2015) in their systematic review, categorized the primary application domains of SGs as follows:

- Health and wellness: SGs designed to enhance quality of life and promote awareness of healthy practices.
- Culture: SGs developed for cultural education and awareness.
- Professional learning and training: SGs used within organizations to educate and train employees.
- Support: SGs that assist users in making everyday decisions.
- Social: SGs aimed at developing social and interpersonal skills.
- Education: SGs used to teach, support, assess, and motivate students in formal educational environments.

A recent systematic review updated the findings of Calderon and Ruiz (2015) concerning the application of SGs (Din et al., 2023), revealing a shift in emphasis: whereas Calderon and Ruiz identified health and wellness as the primary domain, Din and colleagues highlighted education and training as the foremost area of SG implementation. Moreover, SG-based learning processes are marked by innovation, representing a significant development within the broader trajectory of digital and e-learning methodologies (Prensky, 2001).

From a psychological standpoint, four core characteristics—rooted in the concept of human agency as articulated in social cognitive theory (Bandura, 2001)—are common to all SGs. First, interactivity enhances a player's sense of self-efficacy by allowing them to exert control over in-game actions. Second, SGs enable players to make choices and employ

strategies in pursuit of defined goals. Third, the presence of clear, shared rules structures players' decision-making and actions—particularly in multiplayer or collaborative contexts. Finally, the awarding of prizes or rewards according to specific rules plays a crucial motivational role (Mattiassi et al., 2021).

Educational applications

Due to their experiential value, SGs introduce innovative approaches to education, particularly by fostering users' psychological, social, and emotional well-being. A recent systematic literature review by Calvo-Morata et al. (2020) examined the use of SGs and video games in school settings to address and prevent bullying and cyberbullying, focusing primarily on students aged 6 to 16. The analyzed games typically presented bullying or cyberbullying scenarios, which players navigated via an avatar, progressing through various levels and scenarios. These simulations were particularly useful for illustrating the consequences of various behavioral responses: negative outcomes were associated with inaction or the use of verbal or physical aggression, while positive outcomes emerged from behaviors such as supporting victims and seeking external help. These game-based experiences offered players opportunities to reflect on strategies for addressing bullying, helping them build empathy and equipping them with tools to face or overcome similar challenges in real life. This, in turn, supported teachers in addressing bullying in the classroom, raised awareness among students about the impact of their actions, and fostered the development of social skills essential for building positive peer relationships—ultimately reducing the risk of victimization and aggression.

Play-based learning methodologies have also opened new avenues for interventions aimed at supporting individuals with autism spectrum disorder (ASD). A literature review by Grossard and colleagues (2017) categorized SG-based interventions into two primary types: those aimed at helping users recognize and express emotions through facial expressions, and those focused on promoting social skills in specific contexts among individuals with ASD. Most of the interventions analyzed, which targeted children and adolescents with ASD (including those with comorbidities), emphasized the development of emotion recognition skills. However, the review also identified a gap in the literature concerning the promotion of crucial

non-verbal communication skills, such as joint attention and intentional gesturing—highlighting the need for broader interventions.

Bluemink et al. (2010) further illustrated how small-group collaboration can be shaped by individual interactions within a virtual multiplayer SG. In their experiment, college students were randomly assigned to groups of four and participated in a 1-hour vocal game titled *eScape*, designed as a social action adventure. Analysis of the recorded gameplay conversations revealed that, despite notable differences in group dynamics, problem solving approaches, and the time required to complete the game, all participants engaged in sustained and intensive interaction throughout.

Similarly, Hummel et al. (2015), investigated the effectiveness of collaborative SGs in developing classroom management skills among pre-service teachers facing classroom-related dilemmas. The findings indicated that collaborative SGs—whether implemented online or in face-to-face settings—effectively promoted participant collaboration in addressing classroom challenges. However, the online format was evaluated more favorably by participants.

Training applications

Training is one of the primary purposes for which SGs are employed, due to the capacity of SGs to effectively integrate entertainment with educational objectives. More generally, the application of information and communication technologies (ICT) in education and training has yielded notable economic, social, environmental, and organizational benefits (Peters, 1998).

In corporate settings, simulation-based activities are frequently utilized to replicate and anticipate real-world processes, aiding in the development of practical skills relevant to daily work. As part of the "world of the possible," simulations allow for the exploration of alternative strategies, facilitating innovation and organizational transformation. One of the key advantages of simulation-based training is the freedom to make mistakes without incurring significant consequences (Anolli and Mantovani, 2011). A study focused on healthcare professionals (Ricciardi & De Paolis, 2014) demonstrated that simulation games may also enhance learning effectiveness and cost-efficiency. The authors highlighted that the development costs of SGs are lower than those of traditional simulators, largely due to the widespread availability and accessibility of the necessary hardware and software (e.g., SGs can be used on smartphones). The study further indicated that users trained with SGs often

exhibit superior acquisition of technical skills compared to those undergoing conventional training.

Several surveys have explored the adoption of SGs in corporate environments, finding that, within these settings, SGs are valued primarily for two purposes: employee training and human resource management. For example, a systematic literature review by Larson (2020) found that gamification and SGs are particularly effective in improving employee engagement, motivation and performance outcomes. Additionally, SGs have been shown to support processes such as employee selection and retention, contributing to the overall efficiency of internal organizational functions.

In the business context, the adoption of SGs as an innovative training methodology offers a dynamic response to ongoing technological advancements and emerging work environments. This aligns with broader global objectives, such as those outlined in the *United Nations 2030 Agenda* (United Nations, 2015a), which aims to "promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all." This vision highlights the following priorities:

- the advancement of development-oriented policies supporting productive activities, decent job creation, entrepreneurship, creativity, and innovation; and
- the pursuit of higher levels of economic productivity through diversification, technological progress, and innovation (Goal 8).

The sharing of collaborative spaces and the implementation of digital participatory processes play a crucial role in cultivating new knowledge and collective intelligence. In particular, these elements drive the generation of innovative questions and solutions tailored to both individual and organizational needs within specific social and institutional contexts.

European guidelines offer several key reflections regarding the role of training and digital competencies in the formation of intelligent communities—environments characterized by openness to knowledge sharing. Such communities are developed through the activation of collective intelligence, the promotion of information exchange networks, collaborative work practices, active participation, and responsible decision-making. A pivotal factor in this context is the empowerment of digital skills, regarded as a fundamental component of both individual learning and the fulfillment of professional potential in modern work environments. Indeed, in a labor market increasingly defined by the demand for advanced

digital competencies, such empowerment not only supports the development of soft skills and transversal skills, but also serves as a key strategy for addressing digital mismatch.

The gap between the supply and demand of professionals in the digital and ICT sectors highlights an urgent need for adequately trained individuals. In Europe, this mismatch contributes to the persistence of thousands of unfilled positions. Training, therefore, assumes a dual role: it is both a strategic investment for organizations and a vehicle for individual and societal development. From this perspective, and as previously described by Anolli and Mantovani (2011), organizational change can be examined on two levels. At the micro level, individuals—as both observers and agents of change—continually shape organizational culture through their actions and interactions. At the macro level, the organization itself guides employee thinking and behavior by defining functional goals and strategic directions aligned with its market position. Within this framework, training plays a critical role in fostering collaborative and shared knowledge, promoting critical engagement with organizational culture, and encouraging the adoption of innovative work practices. Thus, well-designed training programs may contribute to the creation of dynamic and resilient professional environments able to adapt to the ongoing technological and social transformations characterizing contemporary society.

2.1.2. Theoretical foundations of Serious Games in learning processes

The psycho-pedagogical principles underlying the design and implementation of SGs are diverse and multifaceted. Central to these principles is the notion of experience: each SG functions as a simulation of something that has been experienced, is currently being experienced, or may be experienced in the future. This mode of learning adopts a bottom-up approach, grounded in the sequential processes of observation, imagination, action, and learning (Anolli & Mantovani, 2011). At the heart of SGs lies simulation—not merely as a means of explaining system behavior, but as a mechanism for reproducing events through specific models offering valid and reliable approximations of real-world phenomena. In this context, simulation constitutes a model—be it real, virtual, mental, or neural—in which relationships are structured and evolve over time in ways that mirror the dynamics of the phenomenon being represented (Black, 1962).

The strength of simulation lies in its ability to support the exploration of real-world properties under both typical and atypical conditions. It enables an analysis of change through the manipulation of influencing variables, while also operating within a framework of

possibilities. Through the projection of future scenarios and the evaluation of hypotheses, simulation facilitates the assessment of potential benefits and limitations (James, 1890). It is this quality that renders SGs particularly effective for investigating and addressing complex problems.

Simulation theories of mind and Serious Games

Numerous neuropsychological contributions have focused on the paradigm of the simulation mind—a framework of cognitive processing that maps how the foundations of mental activity are shaped in situated and contingent contexts. The paradigm assumes that mental activity is linked to prior experiences—encompassing sensory, motor, affective, and behavioral domains—which inform the representation of phenomena.

According to the neuropsychological research of Antonio Damasio (1989; 2010), neural processing across various brain regions (including the visual, auditory, and olfactory areas) occurs via convergence zones. Each neuronal population is responsible for mapping a specific type of information, and the individual populations interact through interconnected circuits. The resulting neural activity produces a cognitive map stored in microscopic memory deposits, collectively referred to as a convergence zone. Neurons in this zone operate synergistically, enabling the representation of objects even in the absence of a dedicated processing module. Damasio further posits that culture, itself, is a byproduct of simulation. Thus, the brain's continuous interaction with the environment leads to the formation of mental maps, which support the development of models and representations essential for social interaction and the evolution of cultural structures.

In two seminal papers exploring perceptual symbol systems and mental simulators, Barsalou argued that human knowledge is fundamentally grounded in experience (Barsalou,1999; 2008). A perceptual symbol, as defined by Barsalou, is formed through the activation of a population of neurons during a perceptual or motor event. It constitutes an

unconscious neural representation, marked by schematicity, partial dynamism, and a compositional structure. These symbols are multimodal in nature, arising from diverse sensory modalities and distributed across various regions of the brain. Barsalou further elaborated on the concept of the simulator, describing it as a system with a dual-level structure, functioning as both: (a) a frame integrating perceptual symbols associated with a category, developed through repeated experiences of its instances; and (b) a generative mechanism, capable of producing an unlimited number of mental simulations based on the established frame. The simulator encompasses the knowledge components necessary for constructing mental representations of objects or events in a contextually appropriate manner. When an individual focuses cognitive resources on a specific component of an experience, a corresponding simulator is activated to represent it.

From a neuropsychological perspective, the capacity for simulation emerges from the interdependence between mind and brain. Groundbreaking research by Gallese et al. on mirror neurons (MNs) provided foundational insights into this process (Gallese, 2010; Rizzolatti et al., 1996), establishing the neural basis for simulating the intentions, anticipated actions, and emotional states of others. MNs enable individuals to understand others' intentions, dispositions, and mental states through the observation of behavior. Such simulation facilitates anticipatory responses—be they cooperative, indifferent, or defensive—and supports the adaptation of behavior. The MN system is thus integral to multiple dimensions of social cognition, including empathy and cooperation.

As Anolli and Mantovani (2011) observed, simulation plays a crucial role in supporting the development of mental representations of both the self and others (p. 125). From around the age of 3 years old, children begin not only to form mental representations of events but also to construct representations of others' mental states, thereby developing explanatory models. This developmental milestone is encapsulated in the psychological construct known as theory of mind (ToM), which refers to an individual's capacity to understand, interpret, and predict the behavior of others (Tomasello, 1999). ToM provides a cognitive framework for adopting another's perspective, highlighting the role of mentalization and shared meaning-making in the formation of simulation processes (Saxe & Wexler, 2005). This theoretical perspective emphasizes the human ability to identify with others and interpret their actions through shared conceptual structures.

Individual and social learning in Serious Games

Owing to their structural and functional potential, as well as their innovative and engaging pedagogical approach, SGs hold significant promise for transforming learning processes. The learning facilitated by SGs is inherently experiential, with each instance of gameplay constituting a unique experience. Moreover, the incorporation of play enhances learning performance, in alignment with Huizinga's (1938) assertion in *Homo Ludens* that play is a fundamental mode through which humans acquire knowledge.

Learning is generally understood as a relatively enduring change in behavior resulting from repeated experiences over time (Anolli & Legrenzi, 2012). Within this framework, SGs are recognized as effective tools for both individual and social learning. As defined by Michael and Chen (2006), SGs are "games that educate, train, and change attitude and behavior." By simulating real-world scenarios, they not only develop players' knowledge and skills but also foster adaptability and versatility.

Individual learning is grounded in direct interaction with the environment, often through a trial-and-error process (Thorndike, 1911). While this method can be highly effective due to its experiential nature, it tends to be more error-prone and offers limited opportunities for knowledge validation through comparison. In contrast, social learning—as articulated by Bandura (1971)—occurs through observation and interaction with others, particularly those regarded as role models. This form of learning typically unfolds in collaborative settings, where knowledge is co-constructed through dialogue with peers and experts. However, in complex or ambiguous environments, the reliability of social learning may be compromised, particularly when reference models lack clarity or prove inadequate.

In SGs, social learning acquires a structured form through the mechanism of scaffolding (Bruner, 1983), wherein gameplay progressively supports players in the autonomous acquisition of skill. Imitation plays a central role in this process, as repeated practice enables players to advance from an initial stage of competence to a more sophisticated level, ultimately reaching a ceiling—the point of maximum learning potential. This progression extends beyond the mere acquisition of knowledge, and also fosters *learning to learn* (Bateson, 1972), promoting metacognitive reflection on one's learning strategies and encouraging the refinement of cognitive processes.

Situated learning and Serious Games

Situated learning theory asserts that learning is inherently embedded within authentic activities, contexts, and cultural settings, thereby creating a dynamic interplay between the

individual and their environment. In this view, both the environment and the learner's perception of it represent essential elements of the learning process (Brown et al., 1989).

In SGs, the situated learning approach is grounded in specific, contextualized scenarios that imbue educational content with meaningful relevance (Anolli, 2010). The game environment acts as a matrix of meanings, allowing learners to both appreciate and transfer acquired knowledge to real-world situations. As Barsalou (2008) noted, learning in SGs involves the simulation of events and operations within defined spatial-temporal coordinates, thereby aligning closely with real-life conditions and fostering deep conceptual understanding. Moreover, SGs offer an interactive, open-ended experience characterized by discursive and argumentative complexity, supporting social comparison, collaborative problem solving, and the exchange of challenges and outcomes.

From a cognitive standpoint, learning within SGs comprises two key dimensions:

- declarative knowledge, involving the acquisition of theoretical constructions, models, and factual information; and
- procedural knowledge, referring to the development of operational skills necessary for the application of acquired knowledge in practice.

A core element of SGs is guided participation, which distinguishes between experts (e.g., developers and trainers) and novices (players), thereby promoting an engaged and informed learning experience. The dynamic interaction between these roles contributes to a structured and cooperative learning environment that supports knowledge construction and skill development.

Reflective learning and Serious Games

SGs foster learning through reflection—a process that stimulates critical thinking by encouraging learners to reconsider their in-game actions (Dewey, 1909). Uniquely, they integrate reflection with action, offering learners the ability to tailor both elements to their individual needs. This is accomplished by allowing learners to control the pacing of the simulated work process and the associated reflection phases (Pannese et al., 2013).

Within this framework, a cyclical model of learning emerges, wherein the performance of tasks is followed by a phase of evaluation and representation, which then leads back to renewed experiential engagement (Kolb & Fry, 1975). This iterative process helps reduce the influence of self-serving bias—the cognitive tendency to attribute success to personal ability and failure to external circumstances (Ross, 1977). Through simulation, SGs promote greater

awareness of habitual and routine behaviors in task execution, thereby enabling learners to identify and correct errors while exploring alternative strategies and procedures (Aldrich, 2009).

As demonstrated, simulation and SGs provide innovative opportunities for learning and training within the context of e-learning—a form of distance education supported by computer-based platforms and adaptive instructional programs tailored to users' specific needs. The following section will explore the intersection of SGs and e-learning, with particular attention to the framework of digital game-based learning.

2.2. Integration of Serious Games and game-based learning in e-learning

A substantial body of research has shown that information and communication technologies (ICTs) are challenging traditional models of knowledge organization, triggering a shift from a "sequential and single-media" approach to one described as "reticular and multimedia"—capable of reflecting both individual and collective learning experiences (Raffaele, 2000, pp. 34–39).

Importantly, the integration of digital technologies into educational and training contexts has highlighted a wide range of benefits—economic, social, environmental, organizational, and pedagogical (Peters, 1998). E-learning refers to a model of education employing digital technologies to facilitate access to knowledge and enable communication and interaction with educational content. The approach incorporates multimedia tools, online platforms, and interactive methodologies to support both synchronous and asynchronous learning experiences
(Garrison & Anderson, 2003). While the term "e-learning" originally denoted the exchange of information via email, it has progressively expanded to encompass all digitally mediated forms of knowledge transfer, facilitated by emerging technologies (Mammarella et al., 2005, p. 8). E-learning is defined by two core dimensions. First, the instrumental dimension focuses on the acquisition of digital competencies (e.g., using the internet for educational purposes). Second, technology-based learning encompasses both distance and digital learning, emphasizing the capacity to learn through interactive engagement with multimedia environments (Mammarella et al., 2005, pp. 15–18). According to Rosenberg (2001), e-learning transcends the mere digitization of instructional materials, representing a distinct mode of learning characterized by:

- accessibility and flexibility, allowing learners to overcome spatial and temporal constraints;
- personalization, enabling the adaptation of learning pathways to suit individual learner's needs;
- interactivity, facilitated by the use of forums, quizzes, simulations, and SGs; and
- collaboration, supported by learning management systems (LMS) fostering collective learning experiences.

From a theoretical perspective, e-learning is grounded in several psychological and pedagogical paradigms: *constructivism* (Vygotsky, 1978; Jonassen, 1999) emphasizes the active role of the learner and the construction of knowledge through interaction with the digital environment; *experiential learning* (Kolb, 1984) is implemented through simulations, SGs, and immersive virtual environments; and *connectivism* (Siemens, 2005) highlights the importance of digital networks and collective intelligence in knowledge construction, underscoring the role of interaction and collaboration in learning processes.

The psychological and pedagogical effectiveness of SGs and GBL can be understood through the theoretical frameworks of digital learning. According to the cognitive theory of multimedia learning (Mayer, 2014; 2020), research on GBL—including digital games, SGs, and gamification—can be categorized into three main areas:

• cognitive consequences research investigates the effects of games on cognitive processes and problem solving skills;

• media comparison research compares the effectiveness of games with traditional instructional methods, often demonstrating enhanced engagement and improved learning outcomes; and

• value-added research explores how specific design features (e.g., immediate feedback, calibrated difficulty, and immersive narratives) optimize the learning experience.

These three research streams have helped to elucidate how SGs and GBL can enhance motivation and provide more meaningful learning experiences within e-learning environments—particularly when designed to account for learners' cognitive limitations and mitigate cognitive overload (Sung et al., 2017; Woo, 2014). GBL has been shown to be an effective educational modality, provided it is grounded in solid theoretical foundations and

implemented by competent educators. It supports learners in overcoming difficulties and promotes personal and academic development.

The evolution of network-based learning toward models of community and cooperative learning has further encouraged collective knowledge construction. Within this context, the integration of simulation as a pedagogical strategy has played a key role in deepening understanding within specific knowledge domains and cultivating practical competencies such as leadership. This progression has also encompassed the development of communication skills, emotional regulation, and the refinement of organizational processes. Game-based learning can be conceptualized as an instructional approach within educational contexts employing SGs as tools to enrich the learning experience (Becker, 2021). When a specific learning objective is defined, the corresponding task is restructured to increase its appeal and effectiveness through the integration of multimedia elements. Given the significance of this interplay, a dedicated section is warranted to examine the relationship between game-based and multimedia learning.

2.2.1. Digital game-based learning

GBL, when integrated with Mayer's cognitive theory of multimedia learning, has emerged as an innovative pedagogical strategy aimed at enhancing student learning, motivation, and problem solving (Mayer, 2020). In his seminal work, Mayer (2005) proposed that multimedia learning is underpinned by three essential cognitive processes: the selection of relevant information, the organization of this information into coherent structures, and the integration of this information with prior knowledge. This theoretical model is effectively operationalized within digital game-based learning (DGBL), in which digital games—carefully designed in accordance with multimedia principles—combine verbal, visual, and interactive elements to optimize mental representation and educational impact (Schrader, 2023). Recent research has highlighted the efficacy of DGBL applications grounded in Mayer's framework, particularly in enhancing learner motivation, academic performance, and problem solving skills in complex subject areas such as mathematics (Hussein et al., 2017). For instance, a study conducted with primary school students found that use of a DGBL application led to a notable increase in motivation (+13.3% on average) and performance (+45.6%) (Loo & Mohamad Said, 2021).

As previously discussed, SGs are based on robust psychological and pedagogical foundations, which have increasingly attracted attention in contemporary educational

research. Following this overview of gamification and SGs in educational and training contexts—as well as their proven reliability as effective intervention tools—the analysis will now turn to the potential of SGs to support the development of 21st-century skills, with a particular emphasis on soft skills.

Chapter 3

Developing soft skills through Serious Games: A focus on social skills and Collaborative Problem Solving

3.1. Overview of 21st century skills

In recent decades, national and european policy documents have highlighted the importance of critical, responsible, and purposeful leveraging of digital technologies for educational purposes. The overarching aim is to cultivate competencies deemed essential for both personal and professional development, thereby supporting integrated and innovative engagement with the modern workplace. Emerging training methodologies are increasingly emphasizing the development of transversal skills, including cognitive (e.g., decision-making), social (e.g., collaboration, effective communication), and emotional competencies (e.g., empathy, emotional regulation, stress management). Within this framework, the concept of "life skills" assumes a central role. According to the World Health Organization (WHO, 1993), life skills describe the "abilities for adaptive and positive behavior, which enable individuals to deal effectively with the demands and challenges of everyday life." A lack of such soft skills, particularly among youth, is often associated with problematic behaviors reflecting underlying vulnerabilities. To address this gap, life skills education programs have been developed to foster awareness of healthy behaviors and a sense of both individual and collective responsibility. Such programs aim to enhance self-efficacy beliefs, which are recognized as strong predictors of positive behavioral outcomes (Caprara et al., 2014). By utilizing experiential and participatory approaches (e.g., peer education, educational workshops) these initiatives promote the development of risk management strategies (Lerner et al., 2015).

Concurrently, the rapid evolution of technology and the growing complexity of professional environments have necessitated the adoption of active learning methodologies such as Game-Based Learning (GBL). As noted by Romero and colleagues (2015), there has been a shift toward a competency-based educational paradigm, prioritizing practical and transferable skills over theoretical knowledge alone. Aligned with this perspective, Goal 4 of the *2030 Agenda for Sustainable Development* (United Nations, 2015b) calls for efforts to "ensure inclusive and equitable quality education and promote opportunities for lifelong learning for all." The United Nations emphasizes that quality education must extend beyond childhood, thereby endorsing a lifelong learning approach. This approach has become a cornerstone for educational reform across Europe, as reflected in the *European Universities' Charter on Lifelong Learning* (2008).

From this perspective, the evolution of European education policies has followed two primary directions. First, the development of the European community has been guided by strategic frameworks such as the Lisbon Strategy (European Council, 2000) and the Education and Training 2020 program (European Council, 2020). Second, the enhancement of higher education has been shaped by the Bologna Declaration (European Ministers of Education, 1999), which positions lifelong learning as a key mechanism for realizing individual potential. Third, the *New Skills Agenda for Europe* (European Commission, 2016), outlines three priority areas for fostering key competences essential to lifelong learning:

- enhancing the relevance and quality of skills training;
- ensuring the visibility and comparability of skills; and
- optimizing educational and vocational guidance.

Within this framework, the innovation of teaching methodologies aimed at the cultivation of soft skills is especially crucial, as these competences are deemed fundamental for addressing the multifaceted challenges of the 21st century. The Organization for Economic Co-operation and Development (OECD, 2019) defines skills as "the ability and capacity to carry out processes and to be able to use one's knowledge in a responsible way to achieve a goal. Skills are part of a holistic concept of competency, involving the mobilization of knowledge, skills, attitudes and values to meet complex demands." In particular, the OECD *Learning Compass 2030* (OECD, 2018) identifies soft skills—also referred to as transversal skills—within three broad categories: (a) cognitive and metacognitive skills, including problem solving, critical thinking, creativity, and self-regulation; (b) social and emotional

skills, such as empathy, self-efficacy, collaboration, and communication; and (c) practical and physical skills, including the effective use of digital technologies.

SGs represent innovative tools for the development and assessment of soft skills within digital learning environments. Moreover, by offering immersive and interactive experiences, they may contribute to the cultivation of complementary competencies, including decision-making, design thinking, and scientific reasoning. Thus, the integration of gamification and SGs into educational pathways represents a promising strategy for the practical implementation of innovative pedagogical models aimed at fostering 21st-century skills. In particular, emphasis is placed on soft skills deemed critical for personal and professional growth, especially during the transition from university to the workplace. In this regard, the development of collaborative and communicative abilities, along with the promotion of effective teamwork, is of paramount importance. Additionally, attention must be directed toward the advancement of a skill that is gaining increasing significance in contemporary educational and occupational contexts: collaborative problem solving. Exploration of these soft skills constitutes a core component of the present doctoral research, which aims to investigate their influence on learning processes through the use of SGs.

3.1.1. Collaboration, communication, and teamwork

The OECD has identified collaboration and communication as pivotal social skills essential for both personal and professional domains (Kankaraš & Suarez-Alvarez, 2019). Previous research in the educational field has underscored the importance of cultivating social competencies in children as a key factor in their development of relational abilities (Zheng et al., 2021). Specifically, the ability to collaborate in group settings and communicate effectively has been linked to enhanced interpersonal skills in children (Barthel et al., 2018; Collaborative for Academic Social and Emotional Learning [CASEL], 2017; Pinheiro Mota & Matos, 2013), which are often associated with greater academic engagement and improved academic performance (Chernyshenko et al., 2018; Chiteji, 2010; Duncan & Dunifon, 2012; Heckman & Kautz, 2012). Moreover, the development of enduring social skills has been shown to function as a protective factor against behavioral issues, emotional difficulties, and substance use, while simultaneously promoting emotional well-being and mental health (Campbell et al., 2010; Holopainen et al., 2012; Rose et al., 2014; Taylor et al., 2017).

In recent years, the use of SGs in social skills training within educational and training settings has grown significantly. These applications are now designed for a wide range of users, from children to adults and the elderly. The inclusion of virtual agents and realistic scenarios within SGs and game-based learning methodologies has also proven effective in enhancing user engagement (Gebhard et al., 2019; Grossard et al., 2017; Kahila et al., 2019; Qian & Clark, 2016; Romero et al., 2015). As documented in the literature, SGs represent adaptable tools that can be effectively implemented across diverse contexts and target populations while maintaining efficacy for the assessment of social skills. For instance, a recent review by Azadboni and colleagues (2024) analyzed studies focused on the use of SGs in social skills training for individuals with autism spectrum disorder (ASD). The objective was to identify and categorize key computer games used to teach social skills to individuals with ASD and evaluate their effectiveness. The review applied 104 evaluative criteria across these studies, revealing that 57 demonstrated notable improvements among participants. Additionally, 22 studies reported significant gains in one or more measured outcomes, while 13 observed substantial advancements across all assessed indicators.

Collaboration

The assessment framework developed by the OECD for its study on social and emotional skills (Kankaraš & Suarez-Alvarez, 2019) identifies collaboration as one of the "Big Five" domains for individual well-being. It is further classified within the second group of competencies—social and emotional skills—alongside empathy, self-efficacy, and communication (Chernyshenko et al., 2018).

The OECD defines collaboration as a skill demonstrated through specific behaviors, including:

- challenging assumptions;
- planning and managing time (e.g., breaking down complex tasks into smaller components and steps);
- communicating clearly (e.g., refining understanding through discussion and explanation); and
- giving and receiving feedback on performance, including self-reflection.

In further elaboration of this concept, the OECD identifies three sub-domains structuring its definition of collaboration (OECD, 2024): empathy/compassion, co-operation/relationship harmony, and trust. As stated in the framework: "individuals who score

high on empathy/compassion are described as warm and sensitive whereas individuals who score low are seen as cold, unsympathetic and insensitive. The sub-dimension, co-operation/relationship harmony, distinguishes individuals who are cordial, uncritical, kind and easy to live with. People who score high on trust tend to assume the best about people and to act in a trustful way" (Kankaraš & Suarez-Alvarez, 2019, p. 39). Collaboration involves a concern for others' well-being, as individuals capable of effective collaboration are able to sustain positive relationships and reduce interpersonal conflict (Soto & John, 2017). The ultimate goal of collaboration is to coordinate efforts in support of meaningful results and collective benefits, thereby contributing to broader societal outcomes (Mattessich & Monsey, 1992). In this regard, cooperative learning is of critical importance. In many cases, the benefits gained by individuals and groups through collaborative engagement are exceeded by the value of the outcomes produced by the group as a whole (Wood & Gray, 1991).

To comprehensively define the concept of collaboration, it is essential to identify its key characteristics:

- **Adaptability:** Collaboration enhances the capacity for compromise by fostering both individual and collective flexibility and adaptability (Rosen, 2014).
- **Conflict resolution:** Effective collaboration requires individuals and groups to manage social dynamics and build consensus through the understanding of divergent perspectives via dialogue, compromise, and negotiation (Fawcett & Garton, 2005).
- **Empathy:** A crucial component of collaboration, empathy involves recognizing and appreciating the viewpoints and thought processes of others, thereby strengthening team cohesion and effectiveness (Young, 2015).
- **Proactiveness:** Participation in collaborative efforts encourages proactive citizenship by nurturing mutual respect, understanding, and trust. It supports the establishment of clear, attainable goals and facilitates ongoing, transparent communication and information sharing (Mattessich & Monsey, 1992).

Communication

Communication is a fundamental component of the construction of relationships, beginning at an early age. The ability to express one's perspective appropriately according to context, engage in active listening, respond assertively, and utilize effective strategies in conflict situations are all essential competencies that enable authentic interaction with others.

These skills also play a protective role, allowing individuals to safeguard themselves in potentially risky situations.

The capacity for communication arises through interaction with others via a dynamic and ongoing sequence of exchange, reflecting the inherently social nature of human beings (as articulated by Vygotsky in 1978). Thus, the reduction of communication to a mere transfer of information between entities fails to capture its full depth. In fact, effective communication involves not only the transmission of information but also the capacity to express oneself verbally and non-verbally, to listen actively, and to consider both intrapersonal and interpersonal dimensions in this exchange. It is a complex, context-dependent process of reciprocal influence and meaning-making between interlocutors.

In this light, the concept of communicative skills has gained prominence, referring to competencies that support the effective production and interpretation of messages, fostering positive interpersonal relationships (Caprara et al., 2014, p.58). Communication skills encompass both intrapersonal and interpersonal dimensions. The intrapersonal component refers to internal dialogue, self-awareness, and the ability to identify one's communicative goals—both verbal and non-verbal—and adjust one's behavior according to the situation (Ricci Bitti & Bonfiglioli, 2011). The interpersonal dimension involves actively listening to others and effectively conveying one's thoughts, emotions, intentions, and desires to another person or group. Through communication, individuals construct their sense of self and form networks of interpersonal relationships, which may include cooperation as well as conflict (Bateson, 1972).

Clear and context-appropriate communication fosters constructive and harmonious relationships. Conversely, ambiguous or imprecise communication can undermine trust and compromise psychological well-being. Disagreements are a natural aspect of interpersonal interaction, and their effective management is crucial. Flexible communicative strategies (e.g., learning to say "no," negotiating, responding assertively) are especially important. Assertiveness, in particular, enables individuals to express their thoughts and emotions clearly and effectively while maintaining respect for others' viewpoints.

Albert Bandura (2006) emphasized the significant role played by communication skills in shaping life choices. He argued that such skills equip individuals (and particularly adolescents) with the ability to resist harmful peer influences and assert control over their social interactions, thereby protecting themselves from social risk.

Teamwork

In the 21st-century workplace, a critical dimension of social competence is the ability to foster and maintain a positive group dynamic (Oliveri et al., 2017). Accordingly, effective teamwork is recognized as a core component of interpersonal skills and is increasingly being integrated into educational and training programs.

One of the earliest and most influential studies to define teamwork-related competencies was conducted by Stevens and Campion (1994), who developed a foundational model identifying the knowledge, skills, and attitudes (KSAs) relevant to teamwork. This innovative framework facilitated the identification of barriers to collaborative problem solving and clarified the appropriate levels and types of individual participation. It also marked a shift in focus toward analyzing specific team behaviors. Rather than focusing solely on team dynamics, the authors emphasized the role played by the individual in team performance. Their work significantly contributed to the creation of tools for evaluating individual contributions within a team, and they identified several transferable teamwork skills, including conflict management, collaborative problem solving, communication, goal setting, and the planning and coordination of tasks.

Chiu's (2000) taxonomy builds upon the foundational work of Stevens and Campion, analyzing group collaboration and problem solving. However, Chiu's model places greater emphasis on the individual's role within the team and the nature of social interactions. Notably, it introduces observable and measurable behaviors, making it particularly relevant for use in educational assessment. According to Chiu, students exhibit specific forms of social interaction during problem solving activities, such as: (a) alternating leadership and collaborative work, (b) demonstrating concrete solutions to problems, and (c) engaging in active listening.

An additional model for understanding observable aspects of group behavior is based on the team dimensional training (TDT) framework developed by Smith-Jentsch and colleagues (2008), which organizes teamwork into four primary dimensions:

- **Information exchange:** This dimension concerns what information is shared, with whom, and in what manner. It is fundamental for building and maintaining shared situational awareness (e.g., passing relevant information to the appropriate teammate at the right time; gathering input from all relevant sources).

- **Communication:** This factor focuses on the transmission of information among team members, emphasizing clarity, accuracy, and appropriateness (e.g., using standardized terminology, minimizing unnecessary chatter, speaking clearly and audibly).
- **Supporting behavior:** This aspect highlights the ways in which team members assist and compensate for one another in pursuit of shared goals (e.g., offering, requesting, and accepting support; identifying and correcting errors; accepting constructive feedback).
- **Initiative and leadership:** This dimension encompasses the proactive leadership and executive functions exercised by team members (e.g., articulating priorities, offering guidance and suggestions, directing others as needed).

The topic of group leadership holds particular significance in the management of collective initiatives, representing a fundamental prerogative within workplace contexts. The model developed by Zaccaro and colleagues (Zaccaro et al., 2001) identifies four primary components essential to the integration of group leadership: (a) information search and structuring, (b) effective communication, (c) mutual support, and (d) the management of initiative and leadership.

In connection with this theme, the literature emphasizes the importance of shared mental models as a critical factor in enhancing team performance. In this context, the Teamwork Competency Test (Aguado et al., 2014) has emerged as a novel assessment tool supporting the formation of a shared vision among team members, particularly in the areas of resource management and decision-making—both of which are foundational to effective collective problem solving (Cooke et al., 2000).

3.1.2. Collaborative Problem Solving

This paragraph is based on the following published paper:

Giacchi, I. (2023*). Il Collaborative Problem Solving: un costrutto per lo sviluppo di competenze collaborative nel contesto universitario*. In C. Angelini, C. La Rocca (a cura di), *La Serie del Dottorato TRES*. Collana Quaderni del Dipartimento di Scienze della Formazione (pp. 35-46). Roma : RomaTrE-Press.

Recent educational and training reforms have focused on the cultivation and assessment of 21st-century skills (National Research Council, 2011). Surveys conducted through the Programme for the International Assessment of Adult Competencies (PIAAC) have

highlighted the critical role played by collaboration, communication, and problem solving in the effective use of digital tools, particularly within technologically advanced learning environments (OECD, 2009).

In response to these findings, the OECD introduced the concept of collaborative problem solving (CPS)—an innovative construct with both social and cognitive dimensions. CPS emphasizes the ability to achieve common solutions to problems within a group setting through shared understanding and coordinated efforts (OECD, 2017). In this framework, interaction is not limited to human participants but also encompasses "agents" (e.g., digital tools, intelligent systems), reflecting the evolving dynamics of digital learning contexts.

The Programme for International Student Assessment (PISA)—the largest international educational research initiative, coordinated by the OECD—has provided a systematic theoretical and practical foundation for the evaluation of CPS. In PISA 2015, CPS was formally assessed for the first time, with a focus on the establishment of a shared group objective (i.e., a construct resulting from the integration of individual problem solving and collaborative skills). The cognitive components of problem solving involve understanding and representing the problem context, applying appropriate strategies, and using self-regulation and metacognitive processes to monitor progress toward the goal (O'Neil et al. 2003). Collaborative engagement, however, necessitates additional cognitive and social skills, such as facilitating shared understanding, enabling knowledge and information flow, developing an effective team structure, and executing coordinated actions to achieve a solution (Dillenbourg, 1999; Fiore et al., 2010).

Beginning with the OECD's (2010) definition of problem solving skills—described as "the capacity to engage in cognitive processing to understand and resolve problem situations where a method of solution is not immediately obvious. It includes the willingness to engage with such situations in order to achieve one's potential as a constructive and reflective citizen" (OECD, 2010, p. 12) —this skill has been conceptually integrated into the CPS framework across three dimensions: (a) the problem context, representing the degree of difficulty posed by a problem, depending on the individual's familiarity with the context; (b) the nature of the problem situation (i.e., whether the information provided is complete or incomplete at the time it is presented to the problem solver); and (c) the problem solving process, defined by the cognitive processes involved in individual problem solving (i.e., exploring and understanding,

representing and formulating, planning and executing, monitoring and reflecting) (OECD, 2010, p. 20–21).

The PISA 2015 framework expands on this by emphasizing the collaborative dimension, identifying the core components of CPS and the interrelationships among them. The framework defines CPS as "the ability of an individual to participate effectively in a process in which two or more actors seek to solve a problem by sharing the understanding and effort required to arrive at a solution and by pooling their knowledge, skills, and efforts to achieve that solution" (OECD, 2017, p. 134). Thus, success in CPS depends on active cooperation and a shared understanding among group members, facilitating the collective achievement of a common goal (Graesser et al., 2017).

CPS is assessed from the perspective of the individual working within a group and interacting with "agents"—be they human or computer—capable of generating goals, taking actions, sending and receiving messages, perceiving the environment, and adapting to change. To operationalize CPS assessment, PISA 2015 introduced a matrix of 12 competencies (see Figure 2), formed through the intersection of three principal CPS processes (1, 2, 3) with the four problem solving processes (A, B, C, D) established by PISA 2012.

	(1) **Establishing and maintaining shared understanding**	(2) **Taking appropriate action to solve the problem**	(3) **Establishing and maintaining team organisation**
(A) Exploring and understanding	**(A1)** Discovering perspectives and abilities of team members	**(A2)** Discovering the type of collaborative interaction to solve the problem, along with goals	**(A3)** Understanding roles to solve the problem
(B) Representing and formulating	**(B1)** Building a shared representation and negotiating the meaning of the problem (common ground)	**(B2)** Identifying and describing tasks to be completed	**(B3)** Describing roles and team organisation (communication protocol/rules of engagement)
(C) Planning and executing	**(C1)** Communicating with team members about the actions to be/being performed	**(C2)** Enacting plans	**(C3)** Following rules of engagement, (e.g. prompting other team members to perform their tasks)
(D) Monitoring and reflecting	**(D1)** Monitoring and repairing the shared understanding	**(D2)** Monitoring results of actions and evaluating success in solving the problem	**(D3)** Monitoring, providing feedback and adapting the team organisation and roles

Figure 2. Matrix of Collaborative Problem-Solving Skills in PISA, 2015.

The three principal processes are as follows:

(1) **Establishing and maintaining shared understanding:** This process involves developing a common understanding of the problem state and associated actions, recognizing what each team member knows about the problem (i.e., mutual knowledge), and acknowledging the perspectives of other collaborating agents.

(2) **Taking appropriate action to solve the problem:** This process consists of identifying the appropriate CPS strategies required to address the issue and implementing suitable actions. It includes understanding the problem's constraints, setting collective goals, assuming responsibility for specific tasks, and evaluating outcomes in relation to both the problem and group objectives.

(3) **Establishing and maintaining team organization:** This process involves structuring and, when necessary, adapting the team's organization to support effective problem solving. Group members must be aware of their own roles and those of peers, as well as the functions of other agents in the group. They must also monitor group organization, adhere to engagement norms, and facilitate adjustments to address communication breakdowns, problem solving obstacles, and performance inefficiencies. The ability to manage and adapt the group structure in alignment with the problem solving objective is essential for overall team success.

Each of these three core competencies is underpinned by specific skills that can be individually assessed within collaborative tasks.

Existing theoretical models for the definition and evaluation of Collaborative Problem Solving

The OECD undertook a comprehensive review of existing models and frameworks to conceptualize the key processes underlying CPS. This body of research spanned multiple domains within the social sciences, particularly communication, individual and group problem solving, computer-supported cooperative work, and team assessment.

The literature on CPS reflects several decades of investigation, with its theoretical foundations rooted in the work of Vygotsky (1978). Vygotsky emphasized that the potential for individual development is significantly enhanced through interaction with and support from the social environment. This perspective is closely tied to the concept of the zone of proximal development (ZPD), whereby social engagement is thought to foster the acquisition of strategies for tool use and the attribution of social meaning to actions and interactions. Although there is a notable lack of validated national and international standards for the assessment of collaborative problem solving skills, several smaller-scale studies have developed reliable instruments for the evaluation of these competencies.

While conceptualizations of collaborative skills differ across theoretical models, several points of convergence can be identified. In the CPS construct, a common distinction is made between skills associated with collaboration (i.e., social skills) and those related to problem solving (i.e., cognitive skills). According to Griffin and colleagues (2011), the Assessment and Teaching of 21st-Century Skills (ATC21S) framework conceptualizes CPS as multi-dimensional, spanning both social and cognitive domains. The social skills cluster includes participation and cooperation, perspective-taking, and social regulation, while the cognitive skills cluster encompasses task regulation and knowledge building—processes by which distinct contributions of information, skills, and resources are integrated to address a given problem. As discussed earlier, the five-component model of teamwork developed by Stevens and Campion (1994) within the KSA framework also supports this dual perspective, evaluating competencies such as conflict resolution, collaborative problem solving, communication, goal setting, performance management, planning, and task coordination.

In their study, O'Neil and colleagues (2003) proposed a framework for assessing group problem solving and decision-making skills, based on a diverse set of competencies: information integration, sound judgment, alternative identification, optimal solution selection, and consequence evaluation. The framework was later expanded to include adaptability,

defined as the ability to monitor nature and source of problems, provide appropriate feedback, and clarify or acknowledge issues as they arise.

Zhuang and colleagues (2008) emphasized the role of leadership competence in CPS, and particularly the ability to influence team members through social support and encouragement. Meanwhile Collazos and colleagues (2007) focused on process monitoring and group performance evaluation, analyzing both the quality of the final product and the time required to complete tasks. More recent work has built upon and extended these foundational models. For example, epistemic network analysis (ENA) offers a methodological approach to examining group communication by analyzing how individual contributions are interconnected within collaborative discourse (Swiecki et al., 2020).

3.2. The role of Serious Games in the Collaborative Problem Solving framework

The emergence of digital technologies has progressively enabled the integration of Computer-Based Assessments (CBA) into educational and training systems, thereby opening new avenues for the evaluation of both individual and collaborative competencies. The PIAAC framework for Problem Solving in Technology-Rich Environments (OECD, 2009) identifies a range of skills relevant to CPS, defining problem solving in such environments as: "using digital technology, communication tools and networks to acquire and evaluate information, communicate with others and perform practical tasks." It further emphasizes the ability to "solve problems for personal, work and civic purposes by setting appropriate goals and plans, and accessing and using information through computers and computer networks" (OECD, 2009, p. 9). From this perspective, the assessment of transversal competencies (e.g., group communication, collaborative problem solving) can be operationalized through the collection of digital trace data. Applications of CBA range from the digitalization of traditional paper-based tests to more innovative formats, including video games and hypermedia environments (Perry et al., 2022; Timmis et al., 2015).

Communication and CPS stand out as key competencies assessable via CBA, with data collected through digital platforms such as forums, interactive environments, and SGs. Analysis of user interactions within these contexts enables the mapping of specific skills to operational processes, as defined in CPS assessment models. Ongoing research continues to explore CPS assessments, including the use of CBA for this purpose (Chai et al., 2024). In the future, this field may offer innovative methodologies for evaluating the collaborative skills fostered by SGs in digital settings.

Overall, digital technologies have introduced new methods for evaluating social and cognitive competencies, offering fresh perspectives for the analysis of CPS-related skills, particularly in group contexts. In particular, CBA facilitates the collection of rich data on participant interactions, thereby supporting more nuanced evaluations of team-based dynamics. Digital tools and gamified methodologies—such as forums, interactive platforms, and SGs—are especially effective in assessing and enhancing the interpersonal skills foundational to CPS.

Given these premises, the aim of this doctoral research is to identify innovative methodologies for the assessment of teamwork competencies, with a particular emphasis on the collaborative and interpersonal skills essential for group problem solving. The analysis of data produced in technologically advanced environments facilitates the identification of changes in cooperative behavior and fosters the development of innovative technical solutions to enhance the effectiveness of teamwork. In this context, SGs represent key instruments for the assessment and development of teamwork skills. Such games immerse players in realistic scenarios that require them to navigate complex challenges, manage conflicts, communicate effectively, establish shared goals, build group cohesion, and provide constructive feedback. Training interventions utilizing SGs may significantly benefit from the incorporation of CPS to evaluate group competencies and soft skills—especially in the context of adult learning, as this combination may best support the development and refinement of skills deemed crucial for both professional and social domains, as highlighted by the PIAAC surveys.

To assess the current landscape, a literature review was conducted on the use of DSGs for the development of soft skills, examining the extent to which collaborative and teamwork skills are addressed in existing applications. The first study aimed to determine the degree to which these technologies are currently being employed to assess and enhance collaborative skills, and whether established models exist for their effective implementation in educational and professional settings.

SECOND PART: EMPIRICAL CONTRIBUTIONS

Chapter 4

Digital Serious Games for the promotion of soft skills and learning in educational contexts: A Systematic Review

This chapter is based on the following paper:

Giacchi I., Lonigro, A., Zava, F. & Vecchio, G.M. (under review). Do Digital Serious Games promote Collaboration in learning contexts? A Systematic Review. *Educational Research Review*.

Introduction

The first empirical contribution of doctoral project presents a systematic review of the international literature concerning SGs, with particular attention to the digital dynamics and learning processes activated through their use in educational and training contexts. Given the growing relevance of SGs in promoting soft skills and experiential learning, this review aims to provide a structured synthesis of the current state of art of the research, as well as to identify key findings, methodological trends, and gaps that needed of further exploration.

Systematic reviews represent a rigorous research method designed to ensure a transparent, objective, and replicable analysis of existing scientific contributions on a specific topic. Contrasting narrative reviews, which may be influenced by the author's perspective, systematic reviews follow a predefined protocol that enhances the reliability and generalizability of the findings (Bushman & Wells, 2001). They play a pivotal role in scientific advancement for several reasons. First, they offer a comprehensive and up-to-date overview of the available evidence on a given research area. Second, when conducted by domain experts, they contribute to the consolidation and refinement of theoretical and practical knowledge. Third, they serve as a valuable reference point for scholars and practitioners seeking to orient their research or intervention strategies in a fast-evolving field (Crocetti, 2016).

In light of the multidisciplinary and relatively recent nature of SGs, a systematic review was deemed the most appropriate approach to map the academic discourse and empirical findings related to their application. Therefore, the present review adopts an integrative perspective, combining both quantitative indicators and qualitative insights in order to better evaluate the pedagogical potential of DSGs for soft skills development. Particular attention is

given to variables such as user engagement, satisfaction, usability, and learning outcomes, which are increasingly recognized as crucial factors in the effectiveness of digital learning tools.

This review contributes to the doctoral research by establishing a theoretical and empirical foundation for subsequent experimental studies and by clarifying the extent to which SGs have been validated as tools for developing soft skills such as communication, collaboration, problem-solving, and teamwork.

4.1. Serious games to enhance soft skills

The use of DSGs to enhance collaborative learning and promote cognitive, emotional and social skills is growing. Evidence on the impact of the use of DSGs on development collaboration in learning contexts remains limited. We conducted a systematic review focusing on the use of DSGs to promote collaborative skills and learning.

New opportunities for innovative approaches to learning are opening up through the integration of Serious games (SGs) in collaborative and digital settings. In recent years, there has been a growing interest in the use of SGs in educational contexts (Kara, 2021) with a particular focus on their potential to enhance learning. According to Bergeron's (2006) definition, SGs are immersive simulations that utilize digital devices and game mechanics to simulate real-world scenarios and increase the perception of reality, as well as to anticipate potential future developments. More in detail, Prensky (2001) integrates digital learning into interactive experiences, defining DSGs as a fusion of entertainment and learning that occurs through digital interaction. In the field of simulation, a well-designed SG allows for more immersive practice. This type of practice could serve as the foundation for the implementation of application processes in the context of collaborative distance learning. According to Dillenbourg's definition (1999, pp. 1-19), collaborative learning is "a situation in which two or more people learn or attempt to learn something together". Despite considerable attention to the topic, evidence specifically addressing the psychosocial constructs through which SGs facilitate collaboration in digital learning environments is currently lacking.

In SGs, the gaming experience is presented as an engaging and valid alternative to traditional learning (Altomari & Valenti, 2023). The employment of game mechanisms, including narrative, feedback, Virtual Reality (VR), storytelling, and other interactive elements, has been demonstrated to be an effective method of assessing participants' soft skills (Georgiou et al., 2019). SGs have proven to be highly motivational and effective

behavioral change training tools in many fields (Calderón & Ruiz, 2015) and a potent instrument for enhancing learning outcomes in students, fostering the growth of constructive attitudes such as motivation and cognitive skills (Hämäläinen et al., 2006; Ke, 2008; Oksanen, 2013). Research on SGs has also highlighted the impact of games on participants' cognitive and emotional processes (Hamari et al., 2014), showing that they can effectively improve soft skills such as problem solving, communication, collaboration and critical thinking about real-world problems (Anolli & Mantovani, 2011; Mavridis et al., 2016).

The evaluation of soft skills presents challenges in terms of discerning their manifestation within the context of the utilization of SGs. The Organization for Economic Cooperation and Development (OECD, 2019) provides a categorization of soft skills in the "Learning Compass 2030", identifying three different types of skills: (1) cognitive and meta-cognitive skills, which include problem solving, critical thinking, creative thinking, learning-to-learn and self-regulation; (2) social and emotional skills, which include empathy, self-efficacy, responsibility, and collaboration; and (3) practical and physical skills, which include the use of new information and communication technology devices. In this framework, SGs represent a possible alternative tool for developing, evaluating and quantifying soft skills in various digital learning contexts.

According to the study by Krath and colleagues (2021), research that separate cognitive learning outcomes from affective outcomes—or both—are frequently categorized (Carenys & Moya, 2016; Lamb et al., 2018). The lack of uniformity in the constructs used to assess the effectiveness of SGs for learning presents a challenge for researchers when interpreting the results, particularly with regard to the collaborative aspect (van Laar et al., 2020).

The aim of this review is to examine the state of art of the dimensions in which SGs enhance interpersonal experiences, as well as on the development of social skills to enhance collaboration. We will analyze the cognitive, affective and social skills, as well as the group processes that SGs promote to facilitate collaborative learning in digital environments.

4.1.1. Related works

In recent years, several empirical studies have investigated the impact of SGs on a range of cognitive, affective and social skills (Din et al., 2023; Kara, 2021). Early research in this field has focused on the resume of theoretical frameworks that facilitate collaborative learning and game mechanics that encourage collaboration (Wang & Huang, 2021). As demonstrated in the work by Salen and Zimmerman (2004), SGs can also be effective for enhance

teamworking, fostering the development of effective group processes. Through this research work, some implications can be drawn: (1) the evaluation of the disadvantages and advantages of the integration of SGs in educational contexts in terms of engagement and learning (Zhonggen, 2019; Kara, 2021); (2) the importance of game mechanics in supporting collaborative learning (Wang & Huang, 2021; Rocha et al., 2008); (3) the efficacy of questionnaires and interviews as effectiveness tools in evaluating the impact of SGs, in addition to the utilization of a pre- and post-intervention procedure (Din et al., 2023); (4) the advantages of incorporating gamification into online learning environments (Antonaci et al., 2019); (5) the necessity of addressing challenges presented by SGs, that motivate participants to enhance learning (Dondlinger, 2007).

The present paper examines the existing literature focusing on empirical studies documenting evidence on the impact of DSGs when implemented in group context. This study builds upon two systematic reviews on the topic of learning supported by SGs. The first, conducted by Wang & Huang (2021), analyzes the game dynamics within collaborative SGs and theoretical approaches to collaboration. Nevertheless, a lack of empirical evidence exists to substantiate the efficacy of SGs in facilitating learning and the development of psychosocial dimensions in digital environments. Furthermore, the study encompasses both SG and traditional board games. In their review, Connolly and colleagues (2012) focus on the empirical studies concerning the effects and outcomes of learning, including motivational and affective aspects, with the use of SGs and computer games. However, this review is not specifically focused on collaborative aspects and instead considers not only SGs, but also games developed for entertainment purposes. Furthermore, the results of this paper indicate the lack of empirical evidence supporting the efficacy of SGs using quantitative methodologies and tools. In sum, the Wang & Huang's review provides a detailed perspective on the dynamics of collaborative gameplay; however, it lacks significant empirical evidence on general soft skills. At the same time, Connolly et al.'s review provides a solid empirical base, but it does not exhaustively address collaborative aspects, including games more related to fun and entertainment than to learning.

4.2. Research questions

The purpose of this study is twofold: firstly, to identify the domains that support collaborative learning using DSGs in a collaborative setting, by examining the theoretical frameworks, practical applications and outcomes of the studies selected for the systematic review. Moreover, our analysis examines the effectiveness of DSGs in group-based learning environments, with a particular focus on their impact on learning outcomes and the development of cognitive, social and affective skills.

Four research questions have been formulated for the purpose of the study:

- *RQ1: What theoretical frameworks do the authors of the selected studies use to promote collaboration with Digital Serious Games?*
- *RQ2: In which learning contexts are Digital Serious Games employed to enhance collaboration? What is the target considered?*
- *RQ3: Does any learning evidence exist with respect to specific domains?*
- *RQ4: Which cognitive, affective or social skills, and group processes do Digital Serious Games promote?*

4.3. Method

The following paragraphs describe the methodology used to search scientific papers related to primary studies. A comprehensive search of relevant databases and electronic resources was conducted to ensure the replicability of the process, with particular attention given to search terms and areas of investigation. In addition, Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Moher et al., 2009) was employed to enhance the clarity of the information concerning the study selection process.

4.3.1 Inclusion and Exclusion Criteria

In order to identify which records were eligible for selection, the following inclusion criteria were utilized. The records included empirical and applied DSG studies in learning contexts, with empirical results and quantitative and/or qualitative data. The records included DSGs, in accordance with the Bergeron (2006) definition. Therefore, by DSG, we mean that the SG has a digital format, which can be implemented in face to face or in distance collaboration (virtual collaboration). Additionally, the integration of Virtual Reality (VR) or Artificial Intelligence (AI) agents in a SG was also considered. Moreover, DSGs in the

articles must be utilized in a collaborative setting (in groups or pairs). Only academic publications were selected, excluding book chapters, proceedings, and dissertations. Reviews of the literature were rejected. Only publications in English, Italian, or Spanish were considered, given the language spoken by authors.

Details regarding the Exclusion Criteria were displayed in Table 2.

Table 2. Summary table of the Exclusion Criteria

Exclusion Criteria	Description
EC1	Absence of empirical studies on SGs in learning contexts
EC2	Absence of quantitative and qualitative results
EC3	Absence of digital SGs
EC4	Dissertation /book chapter /proceedings /report/ commentary
EC5	Reviews of the literature
EC6	Publications in languages other than Italian, English and Spanish
EC7	The SG is not used in collaborative settings (groups or pair)

Note. EC= Exclusion Criteria

4.3.2. Literature search

Research articles were identified and selected from the following databases: *APA PsycArticles, EBSCO, Education Research Complete, ERIC, Psychology and Behavioral Sciences Collection, SCOPUS* and *Web of Science.* A combined search was conducted using the following keywords:

("serious game" AND "learning" AND "collaborate*" OR "cooperat*").*

A total of 162 records were identified after duplicates were removed using the exclusion criteria. The initial research was conducted in October 2022. Further research was initiated in April 2024 to update the published records. An additional 16 records were identified through keyword search of the same databases and included in the 162 records. No restrictions were placed on the year of publication. The records were examined according to the inclusion criteria applied to the titles and abstracts in the first screening, and this process was repeated for the full text in the second screening. A flow diagram based on the PRISMA (Moher et al., 2009) has been created to illustrate the search and selection process in Figure 3.

In order to calculate interrater reliability, two researchers independently rated the same records. The percentage of agreement (Cohen's K) was then calculated based on the number

of agreements and disagreements. In cases of conflicting ratings, the articles were subsequently discussed among all the authors until consensus was reached. Following an initial screening of the title and abstract, 85 records were excluded. The level of agreement was notably high, with a Cohen's K value of .889 ($p < .001$).

Following a comprehensive evaluation of the full texts of the 77 papers, the evaluators selected 29 studies for inclusion. The level of agreement for the full texts was high, with a Cohen's K of .864 ($p < .001$).

4.3.3 Data extraction and PRISMA model

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Moher et al., 2009) is a framework designed to guide authors in enhancing the reporting phase of systematic reviews and meta-analyses. The overarching objective of PRISMA is to enhance the clarity, transparency, and accuracy of these studies, ensuring a comprehensive and standardized presentation of findings. As illustrated in Figure 3, the PRISMA model is presented alongside a visual representation of the selection process employed to identify the primary study.

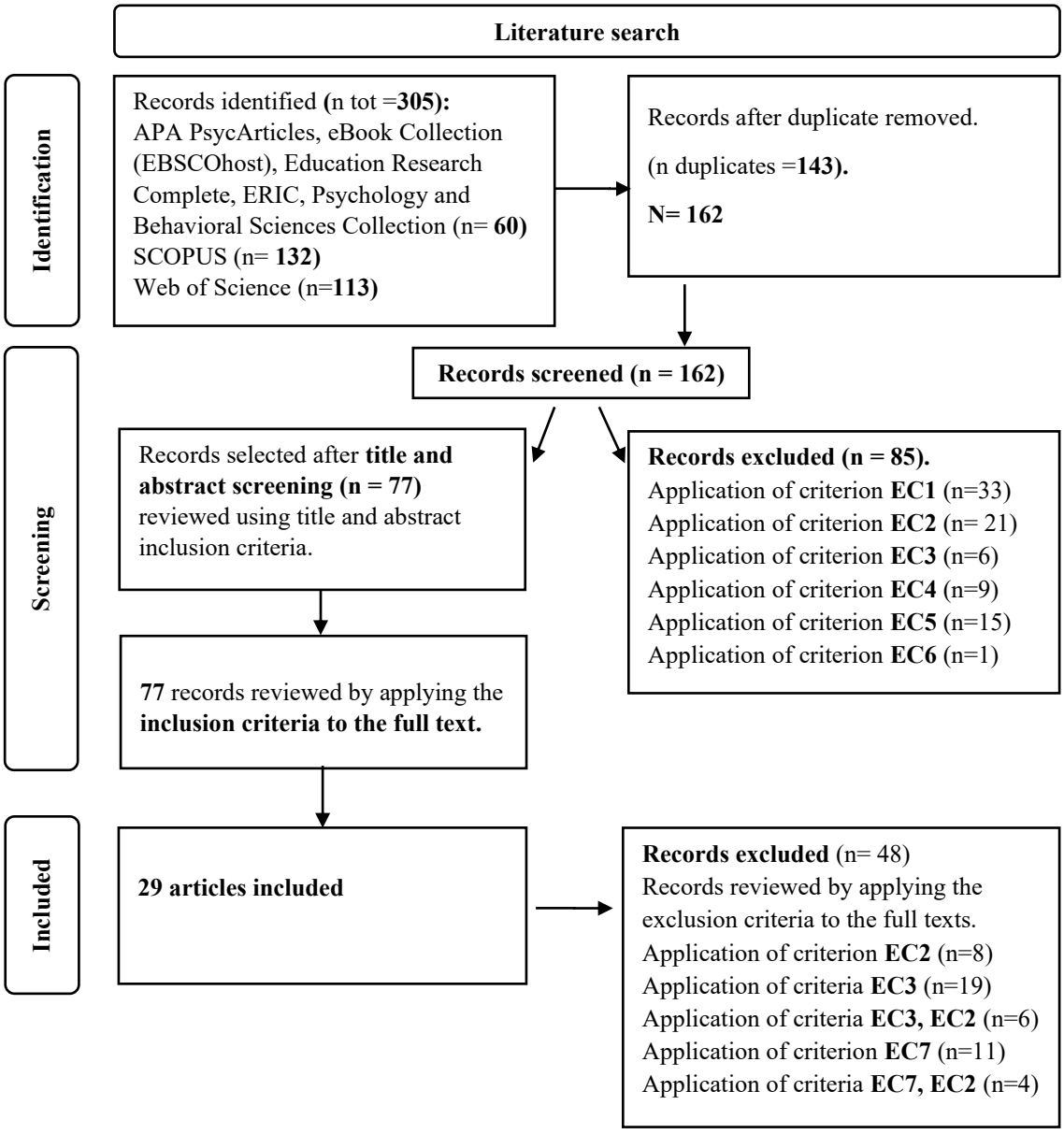


Figure 3. PRISMA flow diagram outlining the search and study selection process.

Note. EC= Exclusion Criteria.

4.4. Results

Selected studies were published between the years 2011 and 2023. From 2018 (see Figure 4) there was a notable increase in the number of studies that incorporated a collaborative construct within their theoretical approach in conjunction with SGs. The general characteristics of the selected studies, illustrated in Appendix A, will be described in the following section.

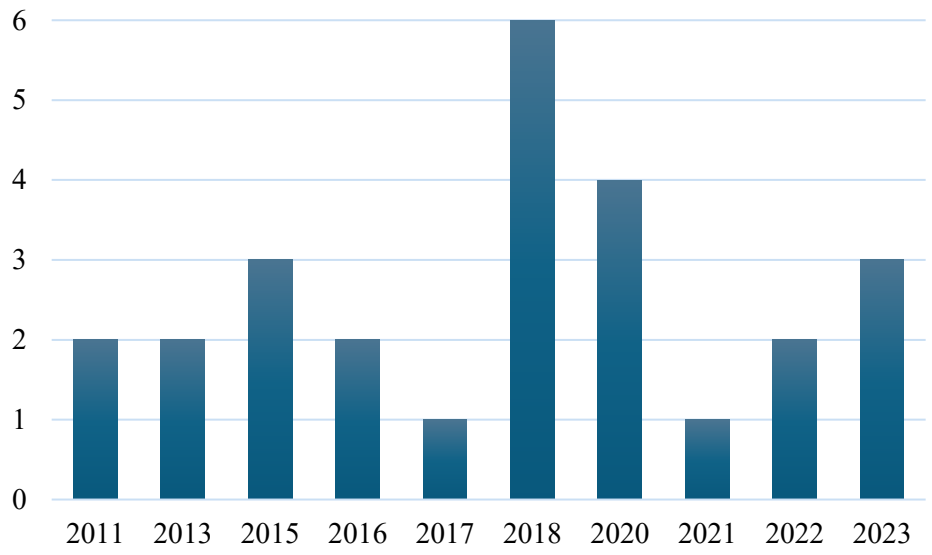


Figure 4. Articles by year of publication

RQ1: What theoretical frameworks do the authors of the selected studies use to promote collaboration with Digital Serious Games?

Selected articles report the presence of theoretical frameworks reflecting a wide range of psycho-pedagogical approaches that support the development of collaborative learning through the implementation of SGs. Seven studies (Calabor et al., 2018; D'Aprile et al., 2015; den Haan et al., 2020; Luz et al., 2016; Pellas, 2014; Saitua-Iribar et al., 2020; Wong et al., 2022) refer to theories of Experiential Learning and Social Constructivist Theories, where games become facilitators of active learning through interacting and problem solving in simulated contexts, reflecting theories such as those of Papert and Harel (1991) on knowledge construction. We also found theories of learning by doing (Cuccurullo et al., 2013), narrative-

centered learning (Malegiannaki et al., 2020), and the Social Emotional Learning approach - SEL (Collaborative for Academic Social and Emotional Learning CASEL, 2015; Xavier et al., 2023), which highlight the relationship between the development of socio-emotional skills in the school environment and the learning experience through SGs.

The Computer-Supported Collaborative Learning (CSCL) framework Fare clic o toccare qui per immettere il testo. places significant emphasis on the utilization of technology environments to facilitate collaboration and, in turn, to enhance learning interactions. This framework has been referenced in eight studies (Goumopoulos et al., 2023; Hummel et al., 2011, 2015; Meij et al., 2020; Oksanen & Hämäläinen, 2013; Perry, 2021; Terzidou et al., 2016; Wendel et al., 2013) and underpins with collaborative learning theories in which the group is central for learning, with sharing and direct interaction leading to greater knowledge assimilation and application. Indeed, some studies integrate into theories of collaborative learning approaches to Participatory Design (Bossavit & Parsons, 2018) and Collaborative Problem Solving (CPS) (Capatina et al., 2018; de Beer et al., 2023; Sánchez et al., 2009; Sánchez & Olivares, 2011), where the main variable is the ability of an individual to participate effectively in a process in which two or more agents try to solve a problem by sharing the understanding and effort required to reach a common solution (OECD, 2017).

In four studies, specific models are used for the development of collaborative learning with the support of SGs, such as the FRECH model (Andreoli et al., 2017), Keller's (1987, 2008), ARCS model in Terzidou et al. (2016), the motivational theories of Malone & Lepper (1987) (Buchinger & da Silva Hounsell, 2018) and the Csikszentmihalyi's Flow theory (2000) in Jouan et al. (2020). The objective of these studies is to increase the engagement and motivation of participants who use a SG, thus facilitating a deeper and more permanent learning experience. Two articles employed the Game-Based Learning approach (GBL) for designing SGs (Cuccurullo et al. 2013; Romero & Usart, 2013).

The studies conducted by Nicolaidou et al. (2015) and Oo and Vallabhajosyula (2022), indicate that SGs have proven effective in fostering teamwork skills in adult medical education supported by the Problem Based Learning (PBL) approach. In their study, Nicolaidou et al. (2015) used a SG as a pedagogical instrument in the context of emergency cardiology to validate the SG as a tool for healthcare education. Oo and Vallabhajosyula (2022) examine the use of SGs in surgical training, with a particular emphasis on the

development of Non-Technical Skills (NTS), which are crucial for the consolidation of group skills in high-pressure surgical contexts.

RQ2: In which learning contexts are Digital Serious Games employed to enhance collaboration? What is the target considered?

Regarding the context of application considered in the selected studies, they can be summarized as follows: university (n=12); school (n=8); healthcare training and medical education (n=5); business school (n=1), training context (n=1) and elderly care (n=1). With regard to the target groups considered in the examined studies, it is evident that a significant number of studies involved university students (n=16) and eight studies involved students from primary to secondary schools. Three studies included healthcare workers, paramedics and medical researchers (n=1), experts from professional working groups (n=1) and general voluntary people (n=1). In addition, SGs have been shown to be successful in non-formal learning settings. One study focused on the general population of museum visitors, while only one study targeted a clinical population, specifically teenagers with high-functioning Autism Spectrum Disorder (ASD) (see Appendix A.).

A total of six studies implemented an experimental research approach with control and intervention groups (Goumopoulos et al., 2023; Meij et al., 2020; Sanchez & Olivares, 2011; Sanchez et al., 2009; Terzidou et al., 2016; Xavier et al., 2023). Among the experimental studies, we found two Randomized Control Trial (RCT) designs (Goumopoulos et al., 2023; Xavier et al., 2023) and two pre-experimental designs (Buchinger & da Silva Hounsell, 2018; Hummel et al., 2015). The remaining studies utilized a research design that did not include control condition. Quasi-experimental (n=11) and experimental designs (n=6) were most common, while only three studies reported qualitative study (see Figure 5). Four studies use surveys. Five studies use mixed methods, including both quantitative and qualitative data.

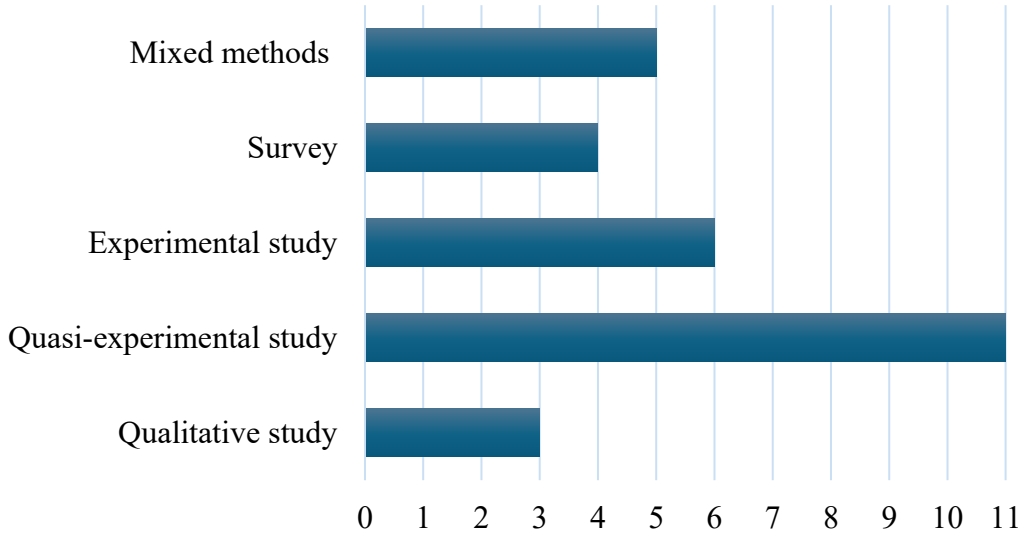


Figure 5. Study design of the selected article.

RQ3: Does any learning evidence exist with respect to specific domains?

To address the third research question, we considered the variables related to the presence or absence of evidence of learning using collaborative and DSGs: eighteen studies evaluated learning in terms of knowledge acquisition within specific domains, while eleven studies evaluated the development of knowledge along with soft skills.

Application domains of the selected studies

As shown in Table 2, eighteen studies used SGs to facilitate knowledge acquisition in a specific application domain. The domain of sustainability was identified as the most popular application domain in the articles selected (N=6) (see Tab. 2). Two studies focused on Cultural Heritage (CH) (Andreoli et al., 2017; Malegiannaki et al., 2020), two on river and water management (den Haan et al., 2020; Hummel et al., 2011), and two on surgical ability and medical knowledge (Oo & Vallabhajosyula, 2022; Wong et al., 2022). Some studies have a clear application theme for each case: the focus areas span a range of disciplines, including geographic content (Bossavit & Parsons, 2018), dengue fever knowledge (Buchinger & da Silva Hounsell, 2018), management accounting (Calabor et al., 2018) and marketing (Capatina et al, 2018), nutrition and healthy lifestyles (D'Aprile et al., 2015), classroom management dilemmas (Hummel et al., 2015), agroecology (Jouan et al., 2020), neglected tropical disease prevention (Luz et al., 2016), emergency assessment and management

(Nicolaidou et al., 2015), language learning (Perry, 2021) and financial literacy (Romero & Usart, 2013).

Conversely, another set of studies (de Beer et al., 2023; Terzidou et al., 2016; Wendel et al., 2013; Xavier et al., 2023) used SGs mainly to develop cooperation, communication and social skills. Two studies investigated cognitive skills (Goumopoulos et al., 2023; Pellas, 2014).

Table 3. Number of studies per application domain

Number of studies	Domain	Study
2	Cultural Heritage	Andreoli et al., 2017; Malegiannaki et al., 2020.
1	Geography content	Bossavit & Parsons, 2018.
1	Dengue fever	Buchinger & da Silva Hounsell, 2018.
1	Management accounting	Calabor et al., 2018.
1	Marketing	Capatina et al., 2018.
6	Sustainability	Cuccurullo et al., 2013; Meij et al., 2020; Oksanen & Hämäläinen, 2013; Saitua-Iribar et al., 2020; Sanchez & Olivares, 2011; Sanchez et al., 2009.
1	Nutrition and healthy lifestyle	D'Aprile et al., 2015.
4	Collaboration, communication or other soft and social skills	de Beer et al., 2023; Terzidou et al., 2016; Wendel et al., 2013; Xavier et al., 2023.
2	River and water management	Den Haan et al., 2020; Hummel et al., 2011.
2	Cognitive skills	Goumopoulos et al., 2023; Pellas, 2014.
1	Classroom management dilemmas	Hummel et al., 2015.
1	Agroecology	Jouan et al., 2020.
1	Prevention of neglected tropical diseases	Luz et al., 2016.
1	Assessment and management of emergency cases	Nicolaidou et al., 2015.
2	Medical knowledge and surgical ability	Oo & Vallabhajosyula, 2022; Wong et al., 2022.
1	Learning a language	Perry, 2021.
1	Financial literacy	Romero & Usart, 2013.

Learning outcomes

Eighteen of the twenty-nine studies reviewed indicate a positive impact on learning, as evidenced by an elevated post-game score compared to the pre-game score (see Appendix B). Questionnaires were the most common tool used to assess learning outcomes; others tools concern the analysis of data related to participants' login time, number of decisions made and activity on the platform (Capatina et al., 2018; Romero & Usart, 2013), interviews (Goumopoulos et al., 2023) and the evaluation of group reports (Hummel et al., 2015; Hummel et al., 2011). A number of studies include a variety of measures of knowledge acquisition, for example, the confidence dimension (Buchinger & da Silva Hounsell, 2018) refers to participants' self-assessment of their knowledge of dengue fever (rating on a Likert scale of 0 to 10).

Four studies (Cuccurullo et al., 2013; Meij et al., 2020; Oksanen & Hämäläinen, 2013; Saitua-Iribar et al., 2020) report evidence of learning on issues related to environmental sustainability with the support of collaborative SGs in the field of school education and higher education. Evidence of learning through the use of collaborative SGs in CH domain is reported in studies by Andreoli et al. (2017) and Malegiannaki et al. (2020). The first study showed that the game was effective in terms of knowledge acquisition about the archaeological site in different historical periods (i.e. Roman, Longobard, Norman and Angevin) in groups of tourists. The second study reports a positive outcome in the enhancement of historical and cultural knowledge following the utilization of SG in a secondary educational institution and among participants with a university degree.

Some SGs have been created specifically to support course requirements at schools, universities or other institutions (Buchinger & da Silva Hounsell, 2018; Capatina et al., 2018; Pellas, 2014). In the study of Calabor et al. (2018), groups of undergraduate finance and accounting students enrolled in the annual Management Accounting course, used the SG “Platform Wars Simulation” to gain knowledge of business accounting topics. The findings indicate that 82.5% of participants reported an improvement in their capacity to assess and comprehend business costs.

Hummel and colleagues (2011) investigated the pedagogical implications of integrating SG in virtual collaboration in the classroom. The quality of the learning was found to have been enhanced by a comparative analysis of the group reports submitted before and after the

virtual collaboration. Cuccurullo et al. (2013) demonstrated that there was a notable increase in teacher and student awareness of environmental sustainability matters between pre- and post-game assessments using the SG "Pappi World". D'Aprile et al. (2015) examined the SG "Cibopolis," which facilitates learning through online social networking. They found a strong correlation between the SG and participants' views and behaviors on healthy lifestyle.
Goumopoulos et al. (2023) observed that the intervention group required less time to complete the game task than a control group when assessed for cognitive functions such as memory, attention and executive function using the SG "COGNIPLAT". Luz et al. (2016) demonstrated the effectiveness of games in increasing knowledge of neglected tropical disease prevention by evaluating a virtual social networking SG among health professionals, "Dr Ludens' LSG," and found a significant increase in post-test scores using an ad hoc questionnaire. In contrast, Wong and colleagues (2022) used an assessment technique that depended on accurate responses in a collaborative SG. The results indicate that there was no difference in the clinical skills performance of medical and nursing students (intervention and control groups).

RQ4: Which cognitive, affective or social skills, and group processes do Digital Serious Games promote?

This section addresses the fourth research question *"Which cognitive, affective or social skills, and group processes do digital serious games promote?".* The synthesis of results is illustrated in Appendix C.

Cognitive skills

Among the twenty-nine selected studies, six report evidence of effectiveness on cognitive dimensions. As reported by Calabor et al. (2018), university students who participated in the study perceived SG as a beneficial tool for enhancing their capacity to make decisions and solve problems. It has been demonstrated that SGs present intricate and realistic scenarios that require students to engage in information analysis, problem identification and collaborative problem-solving.

Capatina et al. (2018) required students to apply marketing theories in a practical and dynamic SG, which helped to consolidate their understanding and improve their analytical and decision-making skills. The number of decisions made, and the activities undertaken by members of the platform community were quantified using the Qualitative Comparative

Analysis (QCA) method. Goumopoulos et al. (2023) demonstrated the efficacy of SG "COGNIPLAT" in enhancing cognitive functioning, particularly memory, attention, and other executive functions, as assessed by a standardized pre- and post-operative neuropsychological questionnaire in elderly individuals diagnosed with Mild Cognitive Impairment (MCI).

Sánchez and Olivares (2011) examined the efficacy of a Mobile Serious Game (MSG) in enhancing students' teamwork and problem-solving skills. The results demonstrated that the experimental group exhibited statistically significant improvements in problem-solving abilities when compared to the control group. In particular, they reported significant improvements in the dimensions of work responsibility and work goals, playing a MSG working in 4-member groups. Sánchez et al. (2009) employed the same scale, design, dimensions, and goals. The researchers observed that the experimental group exhibited a significantly higher score in the execution of strategies than the control group. This indicates that the students who participated in MSG-based activities were able to examine the strategic details more accurately than controls, thus ensuring the accuracy of the steps performed.

Terzidou et al. (2016) demonstrated that the utilization of agent-supported SG can significantly enhance students' cognitive abilities, particularly their disposition towards the course and games.

Affective and social skills.

The review identified fourteen studies that demonstrated the effectiveness of SGs related to the affective and social dimensions in improving collaborative soft skills. Bossavit and Parsons (2018) discovered that SG enhanced social interactions among children with ASD. The game was found to enhance social awareness and encourage positive behaviors. The improvement in social interaction was evident in the behaviors that demonstrated the players' awareness of and responsiveness to each other. D'Aprile et al. (2015) found that social aspects within the SG had a moderate impact on players' opinions. Although not a primary factor, social presence had a significant influence on participants' perspectives regarding the game and their lifestyle choices. The capacity of the game to foster social dynamics, including cooperation and competitiveness, has been identified as a key element in participant involvement. In addition, the social component promotes goal-oriented activities, social networking, and cognitive and metacognitive development.

The social dimension in collaborative SGs and its measurability is an issue of common interest for researchers: in the study by Oksanen and Hämäläinen (2013), perceived sociability

and social presence in the DSG “Game Bridge” were identified as factors influencing the emergence of social interactions. The findings indicate that players' socio-emotional processes were effectively facilitated by the game environment, resulting in enhanced perceptions of social presence and sociability in the virtual world. The survey data revealed particularly favorable outcomes in these areas, indicating that players' cooperation and social engagement were effectively promoted by the game. Perry (2012) described a variety of social mechanisms that occur throughout the course of the game, such as co-regulation and individual adaptation at different stages of content processing. Over the course of the sessions, there was a discernible increase of co-regulation, which is indicative of effective collaborative learning. The players exhibited their capacity for adaptation and collaboration in response to the challenges presented by the game.

Den Haan et al. (2020) used an environmental management SG to promote social learning among experts and non-experts involved in river management. They considered the construct of social learning highlighting the relational nature that occurs in gaining a deeper understanding of the views and mindsets of others, and the cognitive nature, characterized by acquiring new or reorganizing existing knowledge. Hummel et al. (2011) employed the scripted collaboration approach to develop an online SG. This entailed groups of students engaged in water management tasks working in collaboration with their virtual peers to address an authentic case problem, both prior to and subsequent to the case problem's occurrence. The efficacy of scripted collaboration within a SG was also examined in the study of Meij et al. (2020), which employed the use of "Enercities," a simulation game designed to facilitate the development of a sustainable urban environment. The study's findings indicated that the quality of communication between pairs of eighth-grade participants exhibited an improvement in conditions where the collaboration was scripted.

Luz et al. (2016) observed significant behavioral changes among citizens and health workers using SGs for Leishmaniasis sensibilization. There has been an increase in the use of repellents and environmental management techniques for the prevention of illness among the population. To observe these results, the Knowledge, Attitudes and Practices (KAP) (Kleba & Wendausen, 2009; Launiala, 2009) survey was used before and after the intervention. The DSG introduced players to a simulated real-world scenario in which the spread of disease depends on group efforts. There were both individual and collaborative tasks, but players received bonus points for working together and collaborating.

Sanchez and colleagues (2009) implemented three DSGs for students, who worked in teams of four and were required to collaborate in order to solve the problems presented in the games' activities. The experimental group exhibited a greater willingness to collaborate with one another than the control group. The self-report questionnaire includes a scale for the perception of collaborative work (Driscoll & Vergara, 1997; Johnson et al., 1994; Sánchez, 2001). The analysis of the five dimensions included in the scale (leadership, work responsibility, work objective, tutor's role, willingness to work in a group) revealed that the differences between both groups were significant in three of them: work responsibility, work objectives and leadership.

Terzidou (2016) conducted a study to investigate the social cohesiveness, cooperation and involvement promoted by "OSgame". The study employed a questionnaire to assess students' perceptions of the classroom environment before and after the game (Fraser, 1998). The results indicated there were statistically significant differences between the pre- and post-game perceptions of "cohesiveness", facilitating the development of connections, support and helpfulness among students.

Wendel et al. (2013) demonstrated that the use of a SG can facilitate the promotion of collaborative behaviors. This was assessed through the analysis of recorded data and the observation of coordination between players and dialogues. In order to overcome the game's obstacles, players demonstrated successful collaboration by planning their moves, talking to each other, and offering help. The results showed that teams with a clear leader performed better.

Teamwork skills were investigated by Wong et al. (2022), who assessed the impact of a virtual emergency SG with learning style through a pre- and post-measurement survey. The results indicated that students with an "Activist" and "Pragmatist" learning style exhibited higher improvement in their teamwork attitudes compared to students identified as "Theorists" and "Reflectors", who conversely did not demonstrate a statistically significant change in their attitudes.

Again, Xavier et al. (2023) demonstrated that students participating in the intervention group exhibited significant increases in calm and motivational emotions, as assessed using the Emotional Climate in the Classroom Scale – Children (ECCS - C; Albuquerque et al., 2019[1])

[1] Unpublished Instrument by Albuquerque, I., Matos, M., Cunha, M., Galhardo, A., Palmeira, L., & Lima, M. (2019). Emotional Climate in the Classroom Scale - Children (ECCS - C). University of Coimbra, Portugal.

in comparison to control groups. These improvements in emotion regulation contributed to an enhanced emotional environment in the classroom, which also favored cognitive learning.

Enjoyment, satisfaction, engagement and usability

A total of twenty-two out of twenty-nine studies reported evidence of the effectiveness of SGs in relation to the variables as enjoyment, satisfaction, engagement and usability. In these studies, the validity of the use of SGs has been often evaluated with ad hoc questionnaires created by the researchers. Several scales measure levels of enjoyment and satisfaction in participants' perceptions about the use of SGs (i.e. "Did you enjoy the game?", "Would you recommend this game to a friend?") (Andreoli et al., 2017; Cuccurullo et al., 2013; Oo & Vallabhajosyula, 2022; Malegiannaki et al., 2020; Nicolaidou et al., 2015; Sanchez & Olivares, 2011; Wendel et al., 2013; Wong et al., 2022).

Other studies have evaluated satisfaction and engagement by measuring time in games (Capatina et al., 2018), using post sessions de-briefing (Den Haan et al., 2020) or interviews and video analysis of game sessions (Perry, 2021). Hummel et al. (2015) reports positive results in terms of participants' satisfaction with the game's cooperative approach.

The direct involvement of students with high-functioning autism in the design of a SG and the learning materials has led to a greater sense of ownership and personal satisfaction, which in turn has increased the interest and enjoyment of the learning experience (Bossavit & Parsons, 2018).

Some studies have utilized validated scales for the assessment of engagement, enjoyment and usability, as perceived by participants during the use of SGs (D'Aprile et al., 2015; Goumopoulos et al. 2023). The "EGame Flow Scale" (Fu et al., 2009) was employed in the study of Jouan et al. (2020) to assess the dimensions of concentration, clear goal, feedback, challenge, autonomy, immersion, social interaction and knowledge acquisition. The results indicated that students perceived high levels of immersion, autonomy and social interactions during the game.

Pellas (2014) used the "Questionnaire on Student Engagement" (Kong et al., 2003) that measures the student's engagement levels of programming courses. In this approach, the concept of engagement is closely related to the cognitive, behavioral and emotional dimensions. The results shows that Behavioral Engagement component exhibited the highest value. Through exploration and collaborative activities, an increase in social and emotional competence was accompanied by a corresponding increase in the Cognitive Engagement

index. Within the context of an organizational constructivist framework, there was a linear relationship between Behavioral Engagement and Emotional Engagement, which highlighted users' feelings of sociality and increased students' initiatives, thereby facilitating students' learning of programming structures.

Other variables

We use the variable "Other" to indicate those constructs that could not be categorized within the dimensions of cognitive, social, affective skills, and the variables of enjoyment, satisfaction, engagement, and usability, in relation to collaborative DSGs. In the study by de Beer and colleagues (2023), the CPS variable demonstrated improvements in problem-solving and collaborative skills among nursing students. The focus group reported that students from both participating district teams indicated that they had experienced a positive learning effect on the development of their CPS skills. This effect was attributed to taking time to consciously consider their CPS development in several situations. Qualitative analysis revealed insights into three key themes: the first theme, which encompasses the processes of collaboration, consulting with each other, and capitalizing on each other's qualities and strengths, was not statistically demonstrated to have undergone growth in the group. The second theme, which encompasses the process of problem solving, was also not demonstrated to have undergone growth in the group. This theme encompasses quicker and easier problem solving, allocating assignments, coming to a joint solution, and problem-solving methods. The third theme, which encompasses learning from each other's knowledge and experience, and from each other's ideas, was also not demonstrated to have undergone growth in the group.

Romero & Usart (2013) introduce the Time Perspective (TP) (Zimbardo & Boyd, 1999) as a variable in the degree of predicting students' temporal perspective has an impact on learning performance and time-on-task. This study aims to analyze the relation between these variables in the SG "MetaVals". The results indicate that students with a future-oriented time perspective exhibited slightly higher scores in the collaborative phases of the game than students with a present-oriented time perspective or those with a balanced time perspective. Nevertheless, the differences observed were not statistically significant, indicating that TP did not directly affect individual or collaborative performance in the game.

In the study by Buchinger and da Silva Hounsell (2018), the variable of "confidence" in the game was examined. The results indicated a significant increase in students' confidence in their post-test compared to their pre-test knowledge.

Teams' structure and group process

The existence of teams, and the group process derived from them, have been identified as a fundamental inclusion criterion for the selection of studies. In two studies (Bossavit & Parsons, 2018; Buchinger & da Silva Hounsell, 2018), participants were permitted to engage in either a cooperative or competitive mode of interaction. These interactions occurred in pairs or in groups of four players. The integration of competitive and collaborative elements has been demonstrated to enhance motivational factors among the participants. Three studies (Hummel et al., 2015; Malegiannaki et al., 2020; Meji et al., 2020) have demonstrated that the scripted roles inherent to the CSCL approach within SGs can facilitate the evolution of group processes, by orienting players at various stages of the game. Conversely, Calabor et al. (2018) illustrated the emergence of groupings during the SG without any form of pre-game selection.

In the SG "Pappi World" (Cuccurullo et al., 2013), the social elements of the game were highly motivational for students, fostering a sense of individual responsibility regarding recycling. D'Aprile et al. (2015) created the SG "Cibopolis," which uses the network as a game environment to promote virtual collaboration. According to the results of the study, the combination of face-to-face and computer-mediated communication modes can improve teamworking skills. Goumopoulos et al. (2023) divided the participants into small groups for the SG "COGNIPLAT," which has been demonstrated to facilitate social interaction, thereby reducing the risk of social isolation and enhancing emotional well-being.

In the DSG "SEGAE" (Jouan et al., 2020), students were divided into smaller teams based on academic and disciplinary background, which enhances multidisciplinary comprehension and learning experience. Capatina et al. (2018) improved a DSG with an online mode facilitating access in a digital learning environment. A physical game board, connected to computer models, was implemented in den Haan et al. (2020): participants were divided into three teams of two persons and engaged in collaborative gameplay. The game facilitated the participants' capacity to assess and debate the implications of potential interventions within a context that was both realistic and immersive.

It has been shown that the use of SG in nursing and medicine improves the ability to collaborate in a virtual emergency situation. Participants in Oo and Vallabhajosyula (2022) were divided into groups of three and played a multiplayer strategy game on the Android

platform. This SG was designed to give a surgeon a bird's eye view of internal organs while performing minimally invasive procedures. Participants improved their NTS, including communication and teamwork skills. Research has shown that the PBL approach is a useful tool for developing both technical competence and teamwork in making critical decisions.

The PBL methodology was applied in the work of Nicolaidou et al. (2015) to promote technical skills and teamwork in the management of virtual medical emergencies. The SG was used in presence with the digital device, in small groups. Each group worked together to manage emergencies, simulating real-life medical teamwork. Wong et al. (2022) employed the "Virtual ER" simulation as a pedagogical tool to facilitate interdisciplinary collaboration between medical and nursing students in an online setting, enabling them to reach clinical conclusions. The findings of the study indicated that the capacity for collaboration was enhanced. De Beer et al. (2023) demonstrated that nursing students were able to diagnose and treat virtual patients in small groups using a hybrid simulation that combined online and in-person interactions. Furthermore, Romero and Usart (2013) employed a blended approach, integrating an SG with individual and group work.

In Perry (2021), two location-based augmented reality SGs were employed for the purpose of French Second Language (FL2) learning. Each session of the games began in a classroom setting and subsequently proceeded to various locations, guided by the gamified system. This approach fostered active participation and collaboration among teams of students. Oksanen and Hämäläinen (2013) employed online multiplayer SG with groups of four to five participants. The multiple game levels were designed to facilitate collaborative tasks, which were intended to promote socio-emotional processes and active social interactions.

The study by Andreoli et al. (2017) employs a collaborative group learning approach, wherein a group of tourists visiting an archaeological site collectively re-experience the past through the SG. The learning objectives are met when players feel a sense of presence, thereby enabling them to collaborate with other players in an ancient environment through virtual reality. The platform facilitates collaboration among players, each of whom employs a distinct input device, including a keyboard, joypad, Oculus Rift (via head movements), and Kinect, thereby promoting collaborative learning in CH.

The implementation of SGs has been evidenced to constitute an efficacious methodology for the sustenance of students' engagement and facilitation of group discussions

and emotional learning activities, which foster emotional understanding and awareness of sadness, fear, anger, and general emotions relevant to life (Xavier et al., 2023). In the SGs utilized in Sanchez and Olivares (2011) and in Sanchez et al. (2009), students responded to individual and group questions to resolve issues pertaining to the evolution of species and fossilization processes. In teams comprising three or four students, the games improved students' collaboration in real-time to address diverse challenges associated with species evolution. In the study by Luz et al. (2016), a considerable number of tasks within the multiplayer SG are designed with a collective purpose. The tasks encourage the players to cooperate with others to reduce the spread of Leishmaniasis in the urban or rural environment in which they live. The 3D multi-user virtual world SG (Pellas, 2014) offers users the chance to engage in interactive learning and participate in collaborative processes related to the acquisition of fundamental programming skills. In the study conducted by Saitua-Iribar et al. (2020), the DSG involved students in 16 groups. These groups collaborated to reach a consensus regarding the construction of additional housing units. To inform their decision, they had to select from a range of housing types, each with distinct energy efficiency characteristics.

Two studies have identified an additional "agent" within the SG. This intelligent interface is designed to fulfill a variety of pedagogical roles, including the provision of motivation and facilitation of gameplay, as well as the transformation of the game space into an intelligent virtual learning environment. Terzidou et al. (2016) employed the SG to facilitate collaboration among students through a three-dimensional representation of the collaborative game. In groups, users are represented by avatars. For their interaction, SG provides a variety of communication channels, including open text chat (referred to as "local chat"), private text chat for personal and team use, Voice over IP (VoIP) chat, and non-verbal communication through avatar gestures. Players take on the role of third-person characters in a 3D role-playing game in the SG developed by Wendel et al. (2013). The story of the game takes place on a deserted island, and players must work together to build a raft to escape. The design of the game strongly stresses communication, cooperation and teamwork.

4.5. Discussion

The study confirms the recent and substantial interest in the development of SGs for educational purposes (Kara, 2021), with a particular focus on enhancing soft skills and group processes. The findings report the massive use of theoretical frameworks reflecting a wide range of psycho-pedagogical approaches to support the development of collaborative learning through the implementation of SGs. This suggests that SGs can effectively enhance the pedagogical effectiveness of theoretical frameworks by promoting collaboration among users (Wang & Huang, 2021).

The studies selected reflected the interdisciplinary nature of the field and the diversity of theoretical frameworks employed. Additionally, the studies differed in terms of their respective aims and methodologies. The collaborative SGs for learning utilized in the studies embrace a multitude of domains for knowledge acquisition. The fields of application encompass a range of contexts and target populations, including primary school students, university students and volunteers from various groups of visitors to a museum. Only one study has a target population of clinical individuals in educational context (Bossavit & Parsons, 2018).

The quasi-experimental and experimental research designs were the most prevalent types encountered. Connolly's observation about the prevalence of single-condition research designs in SGs studies is similarly confirmed. This raises concerns about the applicability of the results to clinical populations and the appropriateness of an experimental study approach.

The systematic review collects several theories accessible in existing literature and demonstrates that SGs have a beneficial effect on a wide range of psychosocial dimensions. These include cognitive skills such as decision-making, problem-solving, and attitude, as well as social skills such as social behaviors, social presence, communication, collaboration, social regulation, teamwork, perceived sociability and team performance. The dimensions of satisfaction, enjoyment, usability, engagement, and perceived usefulness are the most common dimensions that have been empirically demonstrated to be effective in using SGs. In the medical field, there is a growing interest not only in the development of technical skills but also in the promotion of collaboration in critical decision-making situations.

In addition, the current study also identified the variables of CPS, time perspective and confidence. The CPS represents a novel variable and theoretical framework that demonstrates

its potential for innovation in collaborative DSGs. The Program for International Student Assessment (PISA) proposed an acceptable definition of CPS skills as "the capacity of an individual to effectively engage in a process whereby two or more computer agents attempt to solve a problem by sharing the understanding and effort required to come to a solution and pooling their knowledge, skills, and efforts to reach that solution" (OECD, 2017). New studies on the assessment of CPS are currently being conducted, which systematically review empirical research on assessing CPS skills with computer-based assessment (Chai et al., 2024). This field of research may demonstrate an innovative methodology and approach to evaluating the collaborative skills promoted by SGs in digital contexts.

The outcomes of the studies were evaluated using different qualitative and quantitative methods, confirming the findings of Connolly et al. (2012). This observation suggests that there is no single interpretation of the evaluation process of the effectiveness of the use of SGs to promote collaborative learning in digital context, in line with the work of Krath et al. (2021). The review confirmed that SGs foster interpersonal communication, emotional control and teamwork among members, creating a dynamic and engaging learning atmosphere. However, a major barrier to comparing the results of different studies is the lack of consistency in the definitions and assessments of social skills. This variation underscores the need to standardize research methods to ensure reliability and comparability of results.

As previously indicated by Rocha et al. (2008), the importance of team involvement in the design and implementation of SGs is identified as a relevant factor influencing the effectiveness of these educational tools. The findings of this paper indicate that the efficacy of SGs in enhancing group dynamics and fostering collaborative learning can be markedly influenced by the involvement of teams. The formation of game-based learning communities that enhance learning processes through collaborative engagement in socio-educational activities can be achieved by integrating computer-mediated and face-to-face communication strategies.

4.5.1. Limitations and conclusions

The review is subject to several limitations that must be addressed. In order to ensure the reliability of the study, publications such as books, book chapters, dissertations and conference proceedings were excluded. These forms of publication lack a rigorous review process, which makes it difficult to ascertain their scientific rigor. For the same reason, grey literature was also omitted.

Regarding study selection, a major limitation is the fragmented terminology used to describe the different dimensions analyzed by SGs. For instance, some authors include the term “enjoyment” under “engagement”, while others treat these as separate aspects. This inconsistency complicates the study of constructs that often lack a unified interpretation, as confirmed by Connolly et al. (2012), and the examined studies show significant variability in definitions and measurements of soft skills promoted by SGs. Therefore, a meta-analysis of the literature was not conducted due to the absence of standardized terminology and methodologies, which results in an absence of uniformity across the various dimensions under consideration. This complicates the aggregation and synthesis of results drawn from disparate studies. The inherent variability makes it challenging to interpret the findings, as the same variable may be identified and assessed in disparate ways across the studies. The final limitation pertains to the language of the selected studies, although English and Spanish are the most prevalent languages utilized for scientific publication.

The current review contributes to the advancement of research reporting positive effects on collaboration and learning through the use of DSGs. The importance and significance of the development of psychosocial constructs are taken into account as factors that can improve the development of soft skills. Collaborative learning, also thanks to the introduction of new technologies, is a construct of growing interest and research focus. It is also clear that there is a need for greater consistency in the definition and assessment of the constructs studied: this is particularly evident when considering the range of terms and methods used by the researchers in the selected studies. In the absence of standardization, the interpretation of the results will remain fragmented and subject to differing interpretations.

CPS framework provides a new theoretical and application approach for the assessment of cognitive and social skills in digital learning contexts using SGs, where the group variable is valued for the purpose of collaborative learning.

The outcomes of the systematic review indicate that DSGs are effective tools for fostering learning and developing soft skills. Nevertheless, the lack of definitive guidelines continues to impede the establishment of an unambiguous methodological framework for their implementation.

The objective of empirical research is to propose a prototype intervention that offers concrete methodological insights for teachers, trainers, and researchers.

The subsequent chapters present experimental studies to evaluate the effectiveness of interventions based on a SG applied in a university context, to identify the implications that experimentation could have for future skill formation, and as a bridge to the employment world.

Chapter 5

Cooperative Learning and Digital Serious Games: a Design-Based Research study on improving students' learning in higher education.

This chapter is based on the following published paper:

Giacchi, I., Lonigro, A., Zava, F., Vecchio, G.M. (2023). Cooperative learning in the university context: a workshop experience using Serious Games. *Q-TIMES WEBMAGAZINE,* 2, 192-205.

Introduction

This chapter presents the findings of a study that examined the implementation of an education intervention using a Digital Serious Game (DSG) to improve students' learning outcomes in a higher education context. The study was framed within a Design-Based Research (DBR) methodology (Collins et al, 2004), which guided the iterative development, implementation, and refinement of the intervention over two academic years. The two iterations employed a Cooperative Learning (CL) (Kagan et al, 2000) approach within a quasi-experimental research design to assess the intervention's impact on learning outcomes. Participants were 435 undergraduate students enrolled in an educational psychology course as part of a five-year master's degree program in *Science for Primary School* at the University of Roma Tre. In the second year, the study design was further refined through DBR principles, specifically applying the technique of *conjecture mapping* (Sandoval, 2014) to align theoretical assumptions with practical design decisions.

The assessment of learning outcomes was conducted through a rigorous evaluation of the products resulting from group work activities undertaken during the intervention period. These products were meticulously reviewed by two independent evaluators.

This chapter explores the methodological choices and findings of the research. It further considers the role of DSG in fostering advanced learning skills for future educators, with a focus on enhancing their design abilities and teamwork skills. The discussion encompasses the contributions of DBR methodology in the iterative enhancement of instructional design and its relevance in educational research.

5.1. Framing the research problem

In the last decades, the training of pre-service teachers has become a central theme in the landscape of pedagogical research within the context of higher education (Chen et al., 2022; Dos Santos, 2020; Flores et al., 2014; Smith & Hodson, 2010). In addition to the acquisition of theoretical and practical knowledge, training programs should prioritize the development of transversal skills, such as cooperation, negotiation or the ability to manage complex classroom scenarios (Garbin & Oliveira, 2024), according to the international guidelines for the development of 21st century skills (OECD, 2019). Furthermore, according to Goodwin and colleagues (2023), the efficacy of teacher training programs is currently regarded as a crucial factor that exerts a direct influence on a nation's long-term educational competitiveness and its capacity for renewal. Previous studies have shown that collaborative activities in pre-service teacher education programs in higher education can promote the development of knowledge, attitudes and behaviors (Phuong et al., 2018; Steinert et al., 2016; Vreekamp et al., 2025). Upon entering the workplace following their graduation, students frequently discern numerous benefits associated with academic group work experience (Kalfa & Taksa, 2017).

Within this framework, co-designing skills — "the team-based process in which teachers, researchers, and developers work together in defined roles to design an educational innovation, realize the design in one or more prototypes, and evaluate each prototype's significance for addressing a concrete educational need" (Roschelle et al., 2006, p.1) — are emerging as essential abilities for future teachers, who are expected to work in teams, contribute to school innovation, and expand their ability in the process of improving teaching and learning strategies through co-design practices (Penuel et al., 2007; Severance et al., 2016). To effectively cultivate this ability, it is fundamental that teacher education programs incorporate collaborative, project-based learning, that should allow students to co-construct knowledge, reflect on practice, and simulate real-world teaching challenges (Vreekamp et al.,

2025). Pre-service teachers often lack opportunities to participate in authentic co-design processes during their training programs (Cober et al., 2015), despite the important role such experiences play in their professional development, especially when the goal is to connect academic knowledge with practical work (Hummel et al., 2015).

The present investigation sought to address the identified gap by exploring teaching and learning methodologies that promote effective teamworking. Furthermore, the investigation also sought strengthening the team building phase prior to beginning a group task. The study examined learning methodologies that could integrate the assessment of co-design skills within a structured approach in higher education.

5.2. Integrating Cooperative Learning and Serious games in learning experiences

As previously discussed, some SGs contain stimulating activities requiring cooperative and/or collaborative efforts to transform a complex situation into a game scenario and achieve a common goal. In recent years, there has been an increasing interest in the use of SGs for educational purposes (Tazouti et al., 2019) and their effectiveness in promoting collaborative learning (Mavridis et al., 2016). The combination of SGs within collaborative learning methodologies in online learning environments has emerged as a promising approach for cultivating innovative learning strategies that are tailored to the needs of "digital natives" (Prensky, 2001; Wang & Huang, 2021). A recent study demonstrated that students generally perceive collaborative group work as beneficial, despite the challenges posed by online learning during the pandemic caused by the COVID-19 pandemic (Mckay & Sridharan, 2024).

In pursuit of the research objectives, a group work methodology was investigated that could integrate the assessment of teamwork, soft skills and learning within a structured approach. The goal was to identify a method that incorporated blended learning techniques in group settings and included the use of SG in the training process aimed at the participants.

The Cooperative Learning (CL) approach (Kagan et al, 2000) provides both a theoretical and methodological foundation that facilitates the management and development of work groups in multimedia learning environments, making it an effective approach in both school and university contexts (Cacciamani, 2008). In this methodology, group members benefit from each other's knowledge, encourage mutual sharing, and work synergistically toward a common goal (Johnson & Johnson, 1999). David and Roger Johnson, two of the primary

developers of the CL approach, identified five basic elements necessary for effective cooperative work:

1. **Positive interdependence**: is defined as a dynamic wherein individual members engage in collaborative behaviors, driven by the shared belief that collective success is contingent on collaborative efforts. This notion underscores the conviction that individual achievements are inextricably linked to the success of the group, and vice versa, fostering a symbiotic relationship between personal and collective goals. The authors propose that the establishment of strength-based positive interdependence is achievable also through the implementation of shared rewards, the division of resources, and the assignment of roles.
2. **Individual accountability:** this element emphasizes the concept of individual accountability, particularly in contexts where each person's performance is assessed both individually and within the group. While the proposed activities are carried out in a group setting, each individual has a specific task and role, and their performance can either contribute to or hinder the group's work. To ensure fair preparation and reinforcement, the authors suggest administering individual learning assessments or randomly selecting a student's contribution from the group for presentation to the class.
3. **Face to face promotive interaction:** in effective cooperative work, individuals encourage one another and promote collective efforts to complete tasks and achieve the common goal. The authors further suggest that, to ensure all members feel a sense of participation, the group size should be limited to between two and four individuals.
4. **Social skills**: the presence of interpersonal skills within a group can also enhance cooperative efforts. These skills include the ability to communicate effectively, make group decisions, manage conflicts, distribute leadership, and solve problems collectively.
5. **Group processing:** group processing primarily occurs during collective reflections on the execution of a task. To foster improvement, the group engages in discussions about which actions helped or hindered the achievement of objectives, what can be improved, and how. The challenges encountered during the group process help

strengthen relationships among group members and enable them to identify, define, and solve problems that arise while working together.

From this perspective, the CL approach has been shown to be effective on an individual level, as it fosters intrinsic motivation and personal well-being (Johnson & Johnson, 2003; Pearce et al., 2009). Specifically, a meta-analysis conducted by Johnson and colleagues examined the relationship between the CL methodology and student achievement (Johnson et al., 2014). The findings indicated that cooperative learning may contribute to a reduction in the number of students dismissed from universities due to academic failure. Moreover, the observed increase in academic success among students may serve to reduce their uncertainty regarding the relevance of their university experience. Achievement in this domain is associated with enhancements in students' sense of intellectual membership, intellectual adjustment, integration into academic life, commitment to completing their studies, and perception of the curricula's relevance to their needs.

From a social and interpersonal skills perspective, within a collaborative/cooperative learning environment, students provide mutual assistance, assume personal responsibility for their own learning and that of their peers, engage in group activities designed to enhance social skills, and assess group progress. Learning autonomy is also promoted by collaborative and cooperative efforts (Lopes & Silva, 2020; Zimmerman, 2000).

Evidence has demonstrated the efficacy of the peer feedback phase in cultivating skills associated with diagnosis, evaluation, synthesis, and communication (Bauer et al., 2009). According to Karandinou (2012), empirical research has demonstrated that students assume an active role in their collective learning process by engaging in the assessment of their colleagues' work. A number of operational actions are associated with the process of peer review and feedback. These include:

- engaging with a variety of perspectives and opinions
- conducting critical analyses of ideas
- providing comments and comparisons on work
- offering and receiving feedback that can be used to enhance one's own work
- providing peer feedback on students' activities.

In order to enhance our comprehension of the efficacy of feedback implementation in contemporary learning environments, both academic and vocational training alike, it is important to consider the students' perspectives and their experiences with feedback. This

approach will facilitate a more profound and nuanced understanding of the challenges and benefits associated with feedback strategy adoption (Winstone & Carless, 2020).

5.2.1. Peer feedback in promoting soft skills and learning outcomes

The role and influence of peer feedback within cooperative groups is therefore of significant importance to facilitate a comprehensive understanding of the group processes, dynamics, and associated benefits (Silva et al., 2016). Peer feedback is defined as "the mutual process through which students learn and cooperate through shared dialogue. Discourse is recognized as a platform for co-constructing knowledge, with students using various written, oral and visual communication and conversation strategies to appraise performance and standards" (Ardill, 2025, p. 5).

It is necessary to acknowledge that peer reviews or feedback may be partially accurate, entirely incorrect, or even misleading. For instance, it can happens when there is a significant disparity in competence levels among peers, or when those receiving feedback do not perceive their partner as an authoritative figure on the subject (Day et al, 2022; Gielen & De Wever, 2015), which may lead to a greater reluctance to accept their judgments or suggestions (Gielen et al., 2010). Nevertheless, this evaluative methodology holds significant potential to surpass instructor-based assessment, which is often influenced by power dynamics between teacher and student (Silva et al., 2016).

Evidence has demonstrated the efficacy of the peer feedback phase in cultivating skills associated with diagnosis, evaluation, synthesis, and communication (Bauer et al., 2009). According to Karandinou (2012), empirical research showed that students assume an active role in their collective learning process by engaging in the assessment of their colleagues' work. Several operational actions are associated with the process of peer review and feedback. These include engaging in a variety of perspectives and opinions; conducting critical analyses of ideas; providing comments and comparisons on work; offering and receiving feedback that can be used to enhance one's own work; providing peer feedback on students' activities.

Peer review and feedback have been identified as learning facilitators in educational contexts, including in CL methodology (Yu & Wu, 2016). The positive impact of CL strategies on the development of structured working groups among students has been evidenced in the research conducted by Gillies (2004). The research has demonstrated a higher level of interaction among teams and a greater social willingness to accept responsibility for mutual teaching. When this method is combined with peer review, students

find themselves accountable to evaluate their individual progress in relation to the team's overarching objectives. This integration introduces news dynamics, offering a novel perspective of collaborative learning.

In Silva and colleagues' work (2016), feedback allowed students to contact with general and specific analysis of their work and the feedback quality in the research was generally considered as good as the one provided by the teacher. From this perspective, recent studies demonstrated that encouraging structured peer feedback effectively enhances interaction, self-reflection and learning outcomes in higher education (Ardill, 2025; Boud et al., 2018).

Research highlighted that competency-based learning activities and formative assessment feedback techniques can effectively support students in developing personal, social, and methodological skills (Alt et al., 2023). It has been demonstrated that the engagement of students in the provision of formative feedback as collaborative partners in the learning process, through techniques such as group quizzes, student conferencing, and collaborative blogs, can enhance instruction, student learning, and classroom climate (Fluckiger et al., 2010). Moreover, collaborative peer review activities between cooperative groups promote critical thinking skills by introducing students to various perspectives and fostering critical analysis (Silva et al., 2016; Dominguez et al., 2015).

In the context of higher education, researchers have underscored the beneficial impacts of peer feedback on direct learning improvements, as compared to academic feedback alone (Colthorpe et al., 2014). Findings indicated that providing peer feedback can prompt students to reevaluate their own work and identify areas that required enhancement (Lopes, 2022).

Recent research highlights the integration of peer feedback and active learning techniques as a key strategy for enhancing learning outcomes in higher education, address specifically to pre-service teachers. The efficacy of these methods in cultivating critical soft skills and facilitating cross-disciplinary professional development has been demonstrated. Consequently, they play a significant role in improving students' preparedness for the workplace.

5.3. Design-Based Research (DBR) methodology in educational studies

Design-Based Research (DBR) methodology has emerged as an effective approach in educational research, particularly in complex learning environments (Cacciamani et al., 2021; Zhang et al., 2009). DBR integrates the development of theoretical insights with iterative

cycles of design, implementation, and refinement of educational interventions in authentic settings (Collins et al., 2004). This methodology is predicated on an iterative design of situational interventions, with a particular emphasis on educational interventions (DBR Collective, 2003). The DBR methodology is founded on iterative cycles of design, implementation, and review, incorporating the use of *conjecture mapping* technique. This technique facilitates the elucidation of the theoretically salient features of a learning environment design and the mapping of the ways in which these elements integrate to generate the expected outcomes (Sandoval, 2014). The DBR methodology is centered on the design of learning environments based on *theoretical conjectures*, which are assumptions in principle about how to support a specific form of learning.

The initial design of learning environment is formulated in some *high-level conjecture(s)* to support the kind of learning we are interested in developing; subsequently the *high-level conjecture(s)* becomes "reified" —that is, made operational— and articulated within an *embodiment* in a concrete intervention (Sandoval, 2014). Conjectures are *embodied* in specific elements of the design of the learning environment, which may concern four fundamental dimensions: *tools and materials*, *task structure, participant structures* and *discursive practices.*

Tools and materials feature refer to instruments used in the design experiment, such as software programs, manipulable materials, media and other resources. *Task structure* element pertains to the configuration of learning tasks to be completed by learners, encompassing the goals, evaluation criteria, standards, structure of the course organization, etc...

Participant structures refer to the manner in which study participants are expected to engage in the specified tasks, such as role and responsibilities.

Discursive practices refer to the desirable discursive modes that participants assume during interactions with others.

After defining the *embodiment* of high-level conjecture, the next step is to define the *mediating processes* that the researcher hypothesizes will produce the intended *outcomes*. In his work, Sandoval shows two types of ways to understand mediating processes: *observable interactions* and *participants artifacts.* The former encompasses observable interactions between participants and the designed environment. Observable interaction directly indicates how embodied elements of a design mediate participants' interactions and, consequently, their

learning. The second way, encompass the analysis of the artifacts produced by learning during the activities. Indeed, they are indicators of the learning process.

The last step in the conjecture map is to define the *outcomes* that *mediating processes* intend to produce. Researchers are tasked with formulating the desired outcomes in a manner that is specific and concrete. They must also specify how these outcomes will be measured.

The objective of this study's intervention was to enhance learning outcomes by integrating a DSG into an educational pathway. Conducted over two academic years, the study followed two iterative cycles, allowing for the continuous refinement of the instructional design based on empirical evidence and contextual feedback. This methodological approach enabled researchers to evaluate the intervention's effectiveness and to generate both practical and theoretical insights into achieving high levels of learning through game-based methods in higher education. DBR served as the guiding framework for designing, implementing, and refining the blended learning intervention. The high-level conjecture of the study posits that incorporating a DSG in a collaborative setting can improve learning outcomes. The full procedure and the implementation of the iterative design, as structured by the DBR methodology, are detailed in section 5.4.3.

5.4. Aims of the study

The present study combined the Collaborative Learning (CL) approach with a DSG to examine its impact on learning outcomes within student work groups involved in a higher education intervention. The dependent variable was the quality of learning, assessed through the evaluation of group reports produced by participants over two academic years. The feedback phase, introduced in the second academic year, was also examined as a potential factor influencing the quality of these outputs.

To investigate these aspects, the following research questions were formulated and explored:

- RQ1*: Can the introduction of a DSG in a CL environment lead to improving the quality of group reports in the intervention groups compared to the control groups?*
- RQ2: *Did the introduction of a structured peer feedback phase, introduced in the second academic year, influence the quality of group reports compared to the first academic year?*

In accordance with the high-level conjecture formulated, the study tested the following hypotheses:

- H1: *The introduction of a DSG in a CL environment leads to better outcomes in the quality of group reports compared to the CL environment alone. Thus, the intervention groups achieve significantly higher evaluations of group reports compared to their respective control groups*.
- H2: *The introduction of a structured peer feedback phase in the second academic year exerts a positive influence on group reports in comparison to the first academic year.*

5.5. Method

To evaluate the intervention's impacts, a quasi-experimental randomized design with a control group was used. A grid for evaluating final products was utilized at the end of the intervention, with assessments spaced three months apart. Information regarding the students' social and demographic status were collected one week prior to the interventions via email, through the online Survey Roma 3 RC platform, which automatically assigned each participant a unique alphanumeric code. The final products then underwent a rigorous evaluation by two independent evaluators using a specialized evaluation grid. This ensured a comprehensive and objective assessment.

The study received favorable consideration and approval from the University Ethics Committee on February 22, 2023. This approval covered the research protocol, informed consent procedures, and data processing, all in accordance with Legislative Decree 101/2018.

5.5.1. Participants

Participants were undergraduate students enrolled in the course *Developmental Psychology for Inclusion*, part of the five-year master's degree program in *Science for Primary School*. The course was offered during the 2022–2023 and 2023–2024 academic years, in the second semester (from January to May). Table 4 shows the enrollment of the two cohorts of students who participated in the study during each academic year.

Table 4. Number of students attending the "Developmental Psychology for Inclusion" course over the two academic years.

Course of "Development-Psychology for Inclusion"	1st academic year: 2022-2023	2nd academic year: 2023-2024	Total
N participants	221	214	435

A total of 435 undergraduate university students participated in the study, of which 94.2% were female. Participants were between the ages of 21 and 48 years old (M = 26.97, SD = 6.30). Additional details pertaining to the sample are shown in Table 5.

Table 5. Descriptive characteristics of participants.

Variables	**Statistics (%)**
Place of birth	99.1% of participants were born in Italy
Year of study	77.8% are in the fourth year (on track with the standard academic timeline) 14.1% are in the fifth year 7.9% are behind schedule in their studies
Socio-economic status	85% report a socio-economic status in line with the national average
Employment status	44.3% have a part-time or occasional job 28.4% have full-time employment 27.3% are not employed
Course attendance (last 6 months)	46.2% did not attend any courses 15.2% attended three courses 14.1% attended two courses
Laboratory attendance (last 6 months)	26.1% attended at least three laboratories 25.2% attended at least four laboratories 18% attended at least two laboratories 17.8% attended at least five laboratories

5.5.2. Course organization and procedure

The laboratory was attended by teachers in training enrolled in the "Developmental Psychology for Inclusion" course. The laboratory was structured into three temporal groups per academic year, corresponding to three periods of participation: December – February, March – May, and May – July.

Each group is subdivided into smaller subgroups composed of 4, 5, or 6 participants. These subgroups were subsequently and randomly assigned to either intervention or control groups (see Table 6).

In particular:

- in the first academic year (2022–2023), in Group 1 (December 2022 – February 2023), 90 students participated; 9 intervention subgroups (total of 45 people) and 9 control subgroups (total of 45 people) were randomly created.
- In the first academic year (2022–2023), in Group 2 (March 2023 – May 2023), 59 students participated; 6 intervention subgroups (total of 30 people) and 6 control subgroups (total of 29 people) were randomly created.
- In the first academic year (2022–2023), in Group 3 (May 2023 – July 2023), 70 students participated; 8 intervention subgroups (total of 35 people) and 8 control subgroups (total of 35 people) were randomly created.
- In the second academic year (2023–2024), in Group 1 (December 2023 – February 2024), a total of 72 students participated; 9 intervention subgroups (total of 39 people) and 8 control subgroups (total of 33 people) were randomly created.
- In the second academic year (2023–2024), in Group 2 (March 2024 – May 2024), a total of 78 students participated; 9 intervention subgroups (total of 39 people) and 9 control subgroups (total of 39 people) were randomly created.

In the second academic year (2023–2024), in Group 3 (May 2024 – July 2024), a total of 64 students participated; 8 intervention subgroups (total of 33 people) and 8 control subgroups (total of 31 people) were randomly created.

Table 6. Structure and participants of the Laboratory of "Developmental Psychology for Inclusion"

Academic Year	Group	n Intervention	n Control	n Total

Year 1 (2022–2023)	Group 1 (December – February)	45 (9 subgroups)	45 (9 subgroups)	90
	Group 2 (March – May)	30 (6 subgroups)	29 (6 subgroups)	59
	Group 3 (May – July)	35 (8 subgroups)	35 (8 subgroups)	70
Year 2 (2023–2024)	Group 1 (December – February)	39 (9 subgroups)	33 (8 subgroups)	72
	Group 2 (March – May)	39 (9 subgroups)	39 (9 subgroups)	78
	Group 3 (May – July)	33 (8 subgroups)	31 (8 subgroups)	64

The laboratory aimed at designing educational paths for prosocial education in primary school according to the CEPIDEAS model (Caprara et al., 2014; Vecchio et al., 2017; Zava, 2021). The model is divided into five components, which constitute the determinants of prosocial behaviors: 1) prosocial values and motivations; 2) emotional regulation skills; 3) empathy and ability to take the perspective of others; 4) communication and behavioral self-regulation skills; 5) precursors of civic commitment. The primary objective of the course was to collaboratively design an educational intervention in prosocial education, targeting kindergarten or primary school students, in accordance with the CEPIDEAS framework (as part of the course program). The course activities were structured into two parts: classroom-based laboratory sessions, and remote group activities, facilitated through the Moodle *Formonline* (e-learning platform) and Microsoft Teams (videoconferencing platform).

The training program was delivered over a three-month period to each student subgroup, following the phases outlined below:

- **Phase A: three face-to-face meetings.** In the initial phase of the laboratory, three face-to-face meetings were held over a total duration of 8 hours. During the first meeting, the theoretical framework of the CEPIDEAS model was introduced, and the objectives and activities of the laboratory were presented. The subgroups were formed. During the second and third meetings, design activities were conducted in subgroups. In the first phase of these activities, subgroup members discussed ideas and proposals for designing a laboratory and a learning unit focused on prosocial education.

In the final phase (lasting 30 minutes), each subgroup engaged in a comparative analysis of their work with that of another group, seeking feedback and suggestions for refining the final design. The groups were provided with a template for drafting and finalizing their reports. The feedback phase was further strengthened through a second iteration implemented during the second academic year (see paragraph 5.4.3).

- **Phase B: online DGS sessions with final debriefing and feedback for the intervention groups** (see Figures 6 and 7). The online sessions were conducted during the initial phase of the pathway with subgroups from the intervention groups, and after a three-month period—coinciding with the submission of the final project—with the control groups. Each session lasted two hours. *Microsoft Teams* was used as the platform to conduct online training sessions with the DSG. At the beginning of each session, the trainer introduced the game to the subgroup and provided the necessary instructions for its execution (10 minutes). Only one participant was responsible for screen sharing and accessing the DSG website, the link to which was shared by the trainer in the chat. The rest of the group actively contributed to the gameplay through open microphones and webcams. During the game, participants collaborated as a team, while the trainer observed the process, intervening only at the end for a debriefing session. Below is a description of the game:

> "ZooTeams" was the DSG utilized for the educational intervention (Diella et al., 2022). It was designed and created by Studio Saperessere Srl[2], a training company that offers training, communication and business consulting services. The game's narrative progresses through three distinct levels: the *Maze, the Island* and the *Totem*, each offering a unique collaborative challenge. Players assume the role of five fictional characters, each with a distinct physical profile, personal background, and a combination of strengths and weaknesses. The team is tasked with navigating the three levels within a 90-minute time limit. They will encounter a series of puzzles and challenges designed to simulate unexpected problems and team-based reasoning. These challenges engage a wide range of cognitive skills, including logical reasoning, visual-spatial processing, memory, and numerical aptitude. Success requires cooperative decision-making and strategic use of character abilities. If the character/clue match is determined to be wrong, participants are not allowed to take the test, and minutes are deducted from the total time. In the event of a

[2] *Studio Saperessere Srl* is the training partner and co-financer of the industrial doctorate project.

correct match, participants proceed to challenges, which consist of mini games with varying levels of difficulty and typology. The game culminates when the players utilize the clues to guess the final word.

The final part of each session was dedicated to a structured debriefing, conducted in three phases (20 minutes):

(a) an immediate group discussion of the experience following the gameplay session.

(b) A reflective group discussion held one week later, guided by a group-assessment grid (see paragraph 5.3.4).

(c) The provision of standard collective feedback by the trainer on Moodle, offering an overall evaluation of the game processes for each group.

Figure 6. Visual interface of "ZooTeams".

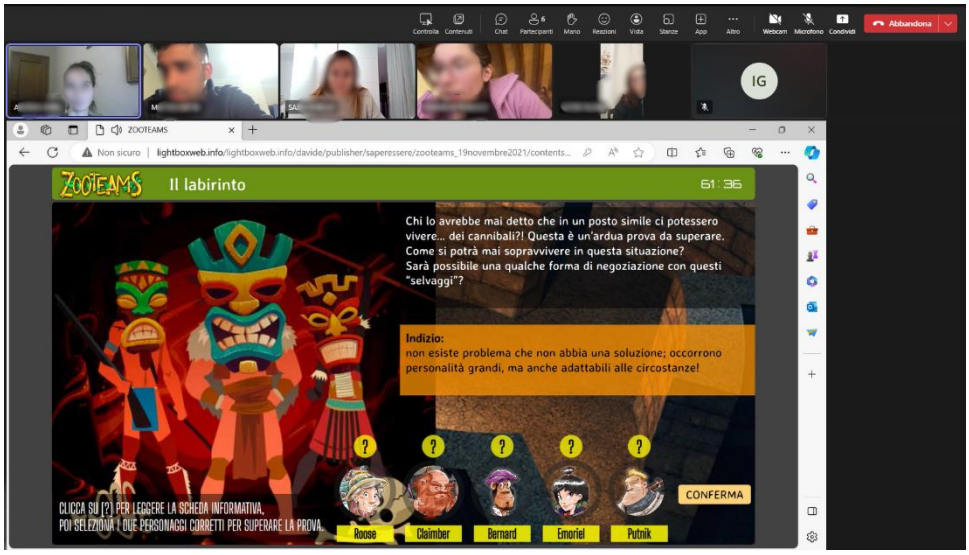


Figure 7. Participants during the online DSG session with "ZooTeams"

- **Phase C: online design activities and organization of the works using the forum**. This phase ensured the continuity of the remote subgroup design activities through the discussion forum on the university *Formonline* platform. In these forums, the subgroups engaged in continuous discourse, deliberated on concepts and proposals for the project, and obtained feedback from their peers.
- **Phase D: implementation of subgroup project and delivery of the final report.** At the conclusion of the project, each subgroup prepared a report that included a theoretical introduction, the design of the laboratory activity and a learning unit devoted to students at primary school. At the conclusion of the three-month period, the subgroups were required to upload the document to the designated space on the *Formonline* platform.
- **Phase E: online DSG sessions with final debriefing and feedback for the control groups** (this phase mirrors Phase B).

One week before the intervention, all the students completed the online self-report questionnaire (via email).

5.5.3. Iterations of the study design through the Design-Based Research (DBR) methodology

The present study employed a Design-Based Research (DBR) methodology, undertaking iterative and situated design experiments to enhance an education and training

intervention. The primary hypothesis of this study is that the combination of a DSG within an academic course can enhance the overall learning outcome. The iterative designs are intended to facilitate the achievement of learning outcomes associated with the CEPIDEAS model in educational design, as operationalized within the "Developmental Psychology for Inclusion" course, where the experimental implementation took place. In the following sections, the course design and the experimental intervention are presented, based on two iterative cycles carried out over two consecutive academic years.

Course design implemented over the two iterations

In accordance with the DBR approach, the high-level conjecture was identified on the premise that the incorporation of a DSG into a collaborative learning intervention setting can enhance learning outcomes.

First Iteration: Cooperative Learning and Serious Game intervention to enhance learning outcomes

The first iteration of the intervention was structured following the Design-Based Research (DBR) framework, with reference to Sandoval's *conjecture mapping* model, which articulates the design on three interconnected levels: **embodiment, mediating processes,** and **intervention outcomes.**

At the **embodiment level**, the intervention involved the use of specific tools, materials, task structures, participant structures, and discursive practices.

The *tools and materials* included: the theoretical handbook for the CEPIDEAS model's reference; slide presentations with laboratory content; expert guest contributions; a template for structuring the final project; the Moodle forum hosted on the *Formonline* platform; the DGS "ZooTeams"; a structured debriefing grid to guide post-game reflection.

The *task structure* was designed around (a) the collaborative development of a group project focused on prosocial education in preschool or primary education settings, guided by the CEPIDEAS model; (b) participation in three in-person meetings during the initial phase of the laboratory; and (c) participation at online training sessions with the DSG.

The in-person meetings were organized as follows:

- in the first meeting (2 hours), the theoretical model and objectives of the laboratory were introduced; working groups were formed.

- The second and third meetings (6 hours) focused on subgroup-based design work, with each subgroup—composed of four or five randomly assigned students—developing either a training laboratory and a learning unit. Each session concluded with a 30-minute feedback phase, during which groups engaged in peer review and received input for improvement. At the end of the meetings, three volunteer subgroups were expected to present their project ideas to the whole class.
- Online SG sessions were held at two distinct time points: at the outset of the intervention for the experimental group, and three months later—coinciding with the final project submission and the administration of the post-test—for the control group. Each two-hour session comprised three structured debriefing phases: (1) an immediate post-game discussion; (2) a reflective discussion held one week later, guided by a group self-assessment grid (see paragraph 5.3.4); and (3) general feedback provided by the trainer via the *Formonline* forum.

The *participant structures* included the creation of working groups, in-person collaborative discussions on the selected project topic, and asynchronous exchanges on the Moodle forum where participants shared and discussed ideas, independently managing the organization of their group work.

Discursive practices were embedded across three structured in the face to face meeting: (1) a brainstorming and ideation phase for defining the project theme; (2) a peer-feedback phase in which groups paired up to exchange feedback; and (3) a plenary sharing session where three volunteer groups presented their project ideas to the class.

In accordance with *conjecture mapping*, these design elements were expected to trigger **mediating processes** such as *observable interactions*—particularly through face-to-face feedback exchanges—and participant-generated artifacts, including (a) the final group project and (b) the DSG debriefing grid.

These processes were hypothesized to contribute to **intervention outcomes** by enhancing learning, as reflected in the quality of the subgroups' final products.

Innovations for the second iteration: Cooperative Learning and Digital Serious Games enhancing learning outcomes through structured feedback phase.

In the second iteration, key refinements were made to the embodiment and mediating processes components—specifically focusing on a structured peer feedback phase. In the transition from the first to the second year of the research design, there was a need to

systematically strengthen the peer feedback phase within the cooperative groups involved in co-design. In the first academic year, although feedback was present, it was not systematically planned or monitored. This approach gave rise to concerns regarding phase traceability and monitoring, with the objective of ascertaining the impact of the feedback process on the final group outcomes. The revised design encouraged groups to actively request, provide, and integrate feedback, supported by new tools to collect and track how suggestions were addressed. Innovations included:

- *Tools and materials*: introduction of a “feedback grid” and a “summary sheet of changes made”, where each group documented how feedback was incorporated into the initial project prototype, guided by specific prompts. The "feedback grid” was developed to facilitate peer feedback regarding project ideas generated during in-class activities, thereby fostering discussion and refinement within subgroups. In particular, the following dimensions were examined: clarity of objective, innovation and creativity, adequacy of the target, feasibility, strengths and critical issues. In Table 7, the specific questions concerning each dimension are reported.

Table 7. Categorizations for the "feedback grid"

Categories	Guiding questions	Feedback
Clarity of objective	*Is the project's objective clear?*	…
Innovation and creativity	*Does the idea introduce innovative elements?*	…
Student age/grade level	*Is the project idea appropriate for the selected target audience? Could any constraints or limitations emerge during its implementation?*	…
Feasibility	*Is the idea achievable within the foreseen timelines and methods? Are there any potential problematic obstacles?*	…
Strengths	*What are the main strengths of the idea?*	…
Critical issues	*Are there any critical issues in the idea that should be addressed? Which elements need to be strengthened?*	…

The "Summary sheet of changes made" was to be completed by all subgroups, reflecting on the feedback received from the peer groups. The summary sheet included the following questions: *(a) Which of the suggestions received were accepted? (b) What changes do you plan to make to the initial project idea? (c) Did you find the feedback from the peer group useful? If so, why?*

- *Discursive practice*: the introduction of the structured peer feedback phase in subgroups, aimed at organizing peer review during face-to-face meetings and supporting critical reflection. Working in pairs of subgroups, during the second and third meetings, each group presented their project idea prototype to their counterpart subgroup (5 minutes), and in turn received the "Feedback grid" related to the evaluated project idea (10 minutes total).

- *Participants artifacts*: the integration of these tools as new artifacts designed to strengthen collaboration and enhance the quality of final outputs. This material was included in the final project deliverable submitted at the end of the laboratory.

The primary distinction between the two iterations lies in the structured peer feedback phase management model employed within the CL model. While both iterations incorporated a feedback phase, including group discussions and collaborative evaluations, the second iteration reinforced the peer feedback phase. This allowed for a more transparent, traceable, and pedagogically effective integration of peer suggestions. This design choice is expected not only to improve the quality of student's learning outputs, but also to promote deeper reflection on collaborative dynamics and the learning process itself. The conjecture map of the two iterations is presented in Figure 8.

High level conjecture: integrating a Serious game into a collaborative learning environment can enhance learning outcomes.

Target: undergraduate students enrolled in the course "Developmental Psychology for Inclusion," part of the five-year Master's Degree Program in Primary Education Sciences, across two academic years (2022-2023 and 2023-2024).

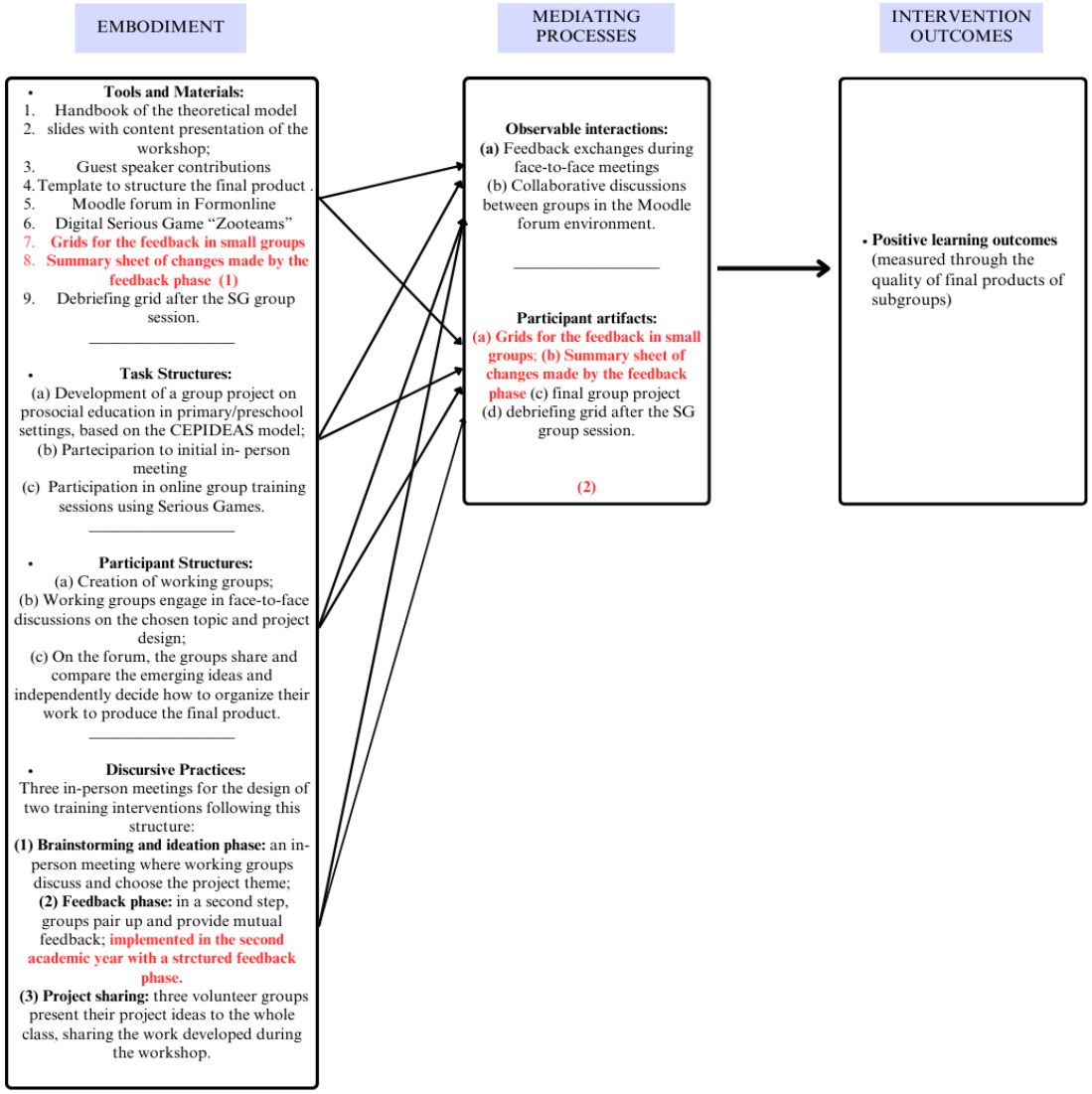


Figure 8. Conjecture mapping of the design iterations. Elements highlighted in red represent the implementation of the second iteration during the second academic year.

5.5.4. Measures

Socio-demographic information: The survey encompasses a wide range of demographic and socioeconomic factors, including gender, age, country of birth, economic status, educational level, current employment status, university enrollment, and questions related to course and laboratory attendance as part of the academic program.

Quality of group report. The final reports submitted by the participants were subjected to a rigorous evaluation process using a specialized assessment grid (see the evaluation grid in APPENDIX D). Two independent raters conducted this evaluation to ensure objectivity and consistency in scoring. The evaluation grid was designed to assess the overall quality of the final group reports based on originality, level of articulation of the project, and adherence to the theoretical model. Each criterion was rated on a five-point scale, with detailed descriptors ranging from 1 (minimum score) to 5 (maximum score). The grid was used by two independent evaluators. To define the final score, inter-rater agreement was assessed by calculating Cohen's kappa coefficient (k= .70), which indicated an adequate level of agreement between raters (Landis & Koch, 1977; Sim & Wright, 2005). Subsequently, the individual scores were summed.

5.5.5. Data analysis

To investigate the effects of DSG in CL environment, the following analytic procedure was conducted. First, group affiliation (1 = Intervention group; 2 = Control group) and academic year (1 = 2022–2023; 2 = 2023–2024) were treated as independent variables, while the quality of the group report was considered the dependent variable.

To address the first research question, we aimed to evaluate whether there were significant differences in group report quality based on group type and academic year, considered separately. For this purpose, a 2×2 ANOVA design was used to compare group differences based on the factors of group affiliation and academic year. Specifically, ANOVA was employed to evaluate the main effects of each independent variable on quality of group reports.

To address the second research question, we investigated whether the introduction of structured peer feedback, implemented only during the second academic year, had a measurable effect on quality of group report. Therefore, a second ANOVA model was run focusing on the interaction effect between group affiliation and academic year, under the assumption that only the

intervention group in 2023–2024 received structured peer feedback. All statistical analyses were performed using jamovi.

5.6. Results

To answer to the first research question "Can the introduction of a DSG in a CL environment lead to improving the quality of group reports in the intervention groups compared to the control groups?", the first ANOVA considered only the main effects of the academic year and group affiliation. Results revealed significant differences for both academic year, $F(1, 430) = 24.6$, $p < .001$, $\eta^2 = .05$, and group affiliation, $F(1, 430) = 88.2$, $p < .001$, $\eta^2 = .16$. Tukey post hoc tests indicated that the intervention group achieved significantly higher evaluation scores in quality of group report compared to the control group (*Mean difference* = 3.55, *SE* = 0.38, $p < .001$). Additionally, students in the first academic year received significantly lower evaluation scores than those in the second academic year (*Mean difference* = -1.88, *SE* = 0.38, $p < .001$.

To answer to the second research question, "Did the introduction of a structured peer feedback phase, introduced in the second academic year, influence the quality of group reports compared to the first academic year?", the second ANOVA included the interaction effect between groups and academic years. Results shown that, group affiliation and academic years significantly interact, $F(1, 429) = 18.9$, $p < .001$, $\eta^2 = .03$. Further, Tukey post hoc were conducted (Table 4). Specifically, in academic year 1, the intervention group received significantly higher scores on final reports compared to the control group; in academic year 1, the intervention group received significantly higher scores on final reports compared to the control group of academic year 2; in academic year 2, the intervention group received significantly higher scores on final reports compared to the control group of academic year 1; in academic year 2, the control group received significantly higher scores on final reports compared to the control group of academic year 1; in academic year 2, the intervention group received significantly higher scores on final reports compared to the control group; no significant difference was found between the intervention groups of academic year 1 and academic year 2 (Table 8).

Table 8. Post hoc interaction Academic year × Group

Groups comparisons			Mean difference	SE	df	t	*p*
Academic year 1 - Intervention	vs	Academic year 1 - Control	5.140	0.521	429	9.872	<.001
Academic year 1 - Intervention	vs	Academic year 2 - Intervention	-0.300	0.518	429	-0.578	.939
Academic year 1 - Intervention	vs	Academic year 2 - Control	1.620	0.528	429	3.068	.012
Academic year 1 - Control	vs	Academic year 2 - Intervention	-5.440	0.519	429	-10.472	<.001
Academic year 1 - Control	vs	Academic year 2 - Control	-3.520	0.529	429	-6.649	<.001
Academic year 2 - Intervention	vs	Academic year 2 - Control	1.920	0.527	429	3.643	.002

5.7. Discussion

The objective of the present study was to examine the impact of the implementation of an educational intervention with a DSG and a structured peer feedback phase in a CL environment on the development of co-design skills in pre-service teachers. This investigation was based on the evaluation differences in the quality of final reports between the intervention and control groups across two academic years. This methodological approach allowed for the examination of two distinct aspects: the effectiveness of the DSG-based intervention and the influence of the structured peer feedback phase, designed and implemented through the DBR methodology (DBR Collective, 2003; Sandoval, 2014).

In relation to the first research question, the findings indicate that in both academic years, the intervention groups achieved significantly higher scores in group report evaluations compared to the control groups. This outcome suggests a positive impact of DSG intervention. A substantial body of research has demonstrated the efficacy of DSGs in enhancing learning and soft skills (Connolly et al., 2012; Wang & Huang, 2021). The present findings are consistent with this literature and extend this knowledge to the context of pre-service teacher education.

Regarding the second research question, the structured peer feedback phase was implemented in the second academic year for both groups. ANOVA results indicated that the control group from the first academic year scored significantly lower than the control group in the second year. This difference may be attributed to the introduction of the structured peer feedback phase, which was absent in the first-year research design. Additionally, overall scores for the second academic year were higher than those of the first year, suggesting that structured peer feedback positively influenced the quality of group reports. Consistent with Silva and colleagues (2016), our study confirms that structured peer feedback can reach a level of quality comparable to teacher feedback. It also supports prior evidence that such feedback enhances student engagement and fosters more effective group dynamics by establishing responsibility mechanisms (Gillies, 2004). In these settings, students are encouraged to engage more meaningfully with peers, fostering mutual support and shared responsibility for group learning processes.

Further analysis revealed no significant interaction between the intervention groups across the two academic years. This suggests that the DSG intervention maintained a consistently positive effect regardless of the presence or absence of the structured peer feedback phase. Therefore, DSG implementation may have exerted a stronger influence on learning outcomes than the addition of peer feedback. These findings align with prior literature, highlighting the value of cooperative environments enhanced by DSGs in promoting motivation, engagement, and the development of collaborative skills (Wang & Huang, 2021; Zheng et al., 2021).

Moreover, DSG appears to have supported the development of effective social and team-building skills, crucial to achieving shared goals and fostering group cohesion (Johnson et al., 2014; Lopes & Silva, 2020; Zheng et al., 2021; Zimmerman, 2000). The intervention groups demonstrated higher performance in the co-design tasks, particularly in the coordination of design and writing activities. The lack of opportunities for informal, game-based comparisons in the control groups likely hindered their performance. The added value of DSGs lies in their capacity, documented in the literature, to increase motivation and engagement, while fostering reflection and internalization through experiential learning (Anolli & Mantovani, 2011; Breuer & Bente, 2010; Nadeem et al., 2023; Söbke et al., 2020).

Another key finding concerns the performance of the control groups across the two academic years. In the second year, the control group performed better than in the first year. This improvement is likely due to the structured peer feedback activity introduced in the second

year, which was previously unstructured. This interpretation is consistent with findings by Yu and Wu (2016), who emphasized the central role of feedback in collaborative learning environments. It also aligns with literature on the role of feedback in promoting self-reflection, metacognition, and academic performance, even when delivered by peers (Ardill, 2025; Boud et al., 2018). Again, in line with Silva et al. (2016), our results support the conclusion that structured peer feedback can match the quality and impact of teacher-provided feedback. It also contributes to a more engaged and accountable group dynamic (Gillies, 2004).

The main findings of this study suggest that when team building is proactively fostered through a DSG, the necessity for a formal feedback structure to support collaboration may be reduced. Conversely, in scenarios where this initial phase has not been undertaken, the implementation of structured peer feedback is recommended. This improvement can be attributed, at least in part, to the structured peer feedback process introduced in the second iteration of the design. In this regard, the use of conjecture mapping (Sandoval, 2014) proved effective in identifying key design components and their role in supporting targeted learning outcomes.

5.7.1. Limitations and conclusions

The results of this study offer encouraging insights into the potential of DSG in fostering co – design practices in CL environments, with the aim of enhancing learning outcomes in pre-teacher programs. Moreover, a comprehensive examination of the methodology employed in the research design enhancements, utilizing the DBR approach, was stressed.

Nevertheless, it is important to acknowledge several limitations to facilitate effective guidance of future research and interpretation. First, it must be noted that the present study captures the short-term impact of the DSG-based intervention on students' learning outcomes. Despite the findings indicating a beneficial effect, the limited period of the experimental study precludes an evaluation of the sustained retention of the learning outcomes. A longitudinal research design involving repeated measures, with the same cohort of participants across two or more academic years, would be beneficial in understanding how the effects of the intervention evolve over time and whether they contribute to maintaining learning improvements.

Secondly, the study design did not include a pre-collaboration evaluation of the learning outcomes. Incorporating assessments both before and after the group collaboration phase would provide a more nuanced understanding of how the cooperative process of co-design contributes to the final outcomes (Hummel et al., 2015). This addition would help distinguish between first baseline competence and the added value of group work with DSGs.

Lastly, the role of group composition is another salient issue that this study does not specifically address. The effectiveness of CL methodologies may be significantly influenced by team collaboration characteristics, including prior experience and interpersonal skills. To optimize group functioning and educational impact, future research should examine the interactions between these characteristics and interventions with DSG.

The institutional context is another crucial point to consider in a critical analysis of the study's observed results. The university setting, particularly the laboratories within the Masters's Degree in *Science for Primary School,* strongly emphasizes cooperative and laboratory-based learning. These elements may have facilitated the integration of DSGs into learning environments and amplified their effects. In work contexts, less open to methodological experimentation or with a less collaborative culture, the effectiveness of DSGs might be reduced.

From an applied perspective, the results of this study offer significant insights into the enhancement of cooperative educational practices in higher education, particularly in courses designed for future educators and teachers. Through participation in activities that involve DSG, they not only can experience an innovative tool for learning but become active agents in the process of construction of learning. Concurrently, cooperative group work facilitates the experiential acquisition of the benefits inherent in a methodology that fosters shared responsibility, comparison, critical reflection, and positive interdependence. The educational efficacy of DSGs surpasses the mere entertainment value or digitization of training materials, encompassing the establishment of learning environments where collaborative problem-solving, co-design, and active engagement become indispensable practices. Consequently, DSGs have emerged as instruments that bridge the gap between academic and professional contexts. This development affords students a substantial opportunity to cultivate practical competencies within authentic contexts.

In conclusion, the integration of cooperative methodologies, structured peer feedback phase, and DSG offers a promising strategic direction for innovating higher education,

thereby empowering pre-service teachers' skills to take active roles and develop greater awareness of their own learning processes.

Chapter 6

Correlational study of game experience and soft skills development through the Digital Serious Game *ZooTeams*

Introduction

This chapter presents the concluding study of the doctoral thesis and is focused on the use of DSGs in education, particularly regarding their potential to promote the development of soft skills. In line with the trajectory outlined in preceding empirical studies, the present investigation examines the impact of the DSG "ZooTeams", which was previously employed in initial phases of research, on participants' perceptions of soft skills development. The aims of this study are twofold. Firstly, it seeks to identify which dimensions of gaming experience are most associated with a perceived improvement in soft skills. Secondly, it aims to evaluate the effectiveness of "ZooTeams" from an applicative and methodological perspective.

Csikszentmihalyi's Flow Theory (1990), which explains the psychological state of intense involvement that might arise throughout the game, provides the theoretical framework of reference. According to this theory, optimal learning occurs when there is a balance between challenge and perceived competence.

The study employs the *EGame Flow* (EGF) scale to assess the quality of the gaming experience. The EGF scale is a validated and multidimensional tool, based on the *Flow Theory*, which evaluates seven fundamental aspects of the user experience*: concentration, clear goals, feedback, challenge, autonomy, immersion,* and *social interaction* (Chen et al., 2018).

The methodology involves a statistical analysis of the relationships between measured constructs and participants' perceptions of soft skills development. Correlation analyses were carried out to explore the associations between variables, followed by regression models to investigate how different dimensions of gaming experience affect perceptions of improving soft skills.

The chapter is structured as follows: the initial paragraph examines the extant literature on the use of the EGF scale in relation to the development of soft skills, with a literature review of studies already conducted and the primary findings. The following paragraph delineates the design and structure of the DSG "ZooTeams," which were developed by the partner of the doctoral project to understand the educational objective. The final section of this study is an in-depth examination of the methodological framework and the results that emerged from the statistical analyses. This investigation aims to identify which game experience dimensions, measured via the EGF scale, are most strongly linked to students' perceived growth in psychosocial skills.

6.1. Game experience and perception of psychosocial skills: an evaluative approach using the EGameFlow Scale.

Recent studies have demonstrated the considerable potential of SGs as both an educational instrument and a vehicle for the development of psychosocial skills. As discussed in preceding chapters, a substantial body of research has underscored the potential of games, particularly SGs, as instruments capable of facilitating learning and fostering responses from cognitive, affective, and social perspectives (Connolly et al., 2012; Kara, 2021). The integration of digital technologies in the field of education has emerged as a subject of increasing interest, giving its potential to enhance the learning experience for students. Digital educational games represent a promising field of research for understanding the influence of gaming experience on the development of psychosocial dimensions.

In this context, the *flow theory* proposed by Csikszentmihalyi (1990) serves as a foundational theoretical framework for understanding gaming experience. This theory delineates a psychological state characterized by complete immersion and intrinsic gratification, which occurs when an individual is profoundly engaged in an activity, even in the absence of immediate achievement of a specific objective. This state, motivated by pure pursuit of enjoyment, encompasses elements of exploration, creativity, learning, and entertainment. This supports the idea that the motivations of play are predominantly intrinsic (Keller & Bless, 2008; Thomas & Macredie, 1994). Subsequent studies (Abrantes, 2012; Buckley & Anderson, 2006) have confirmed that the positive emotions generated by gaming are essential to foster user engagement and persistence. In educational and gaming contexts, the concept of *flow* holds relevance. Research has demonstrated that students who experience

flow during educational games tend to demonstrate more positive learning outcomes (Abrantes, 2012). This is attributed to their increased sense of involvement, satisfaction, and motivation to participate.

In order to support this perspective, researchers have employed different evaluation instruments, such as the *Gameplay Scale* (Zurita Ortega et al., 2020), as well as the *System Usability Scale* – SUS- (Tolentino et al., 2011), for the purpose of measuring usability, satisfaction, and enjoyment in players. The findings with the use of these instruments indicated that emotional and cognitive engagement during play can enhance the quality of the educational experience.

In this scenario, the EGameFlow (EGF) scale is employed, which was developed by Fu and colleagues (2009) based on the GameFlow checklist of Sweetser & Wyeth (2005), and subsequently validated by Chen and colleagues (2018). This latest version of the scale encompasses 31 items. Confirmatory factor analysis and reliability tests are among the statistical methods used in these studies to empirically validate the scale. These analyses confirmed the methodological reliability of the scale in measuring the online gaming experience.

The scale includes 7 dimensions, described as below (Espinosa Curiel et al., 2020):

- *concentration:* games should require concentration, and the player should be able to concentrate on the game;
- *goal clarity:* games should provide the player with clear goals at appropriate times;
- *feedback:* players must receive appropriate feedback at appropriate times*;*
- *challenge:* games should be sufficiently challenging and match players' skill levels.
- *autonomy*: players should feel a sense of control over their actions in the game.
- *immersion:* players should experience a deep but effortless involvement in the game.
- *social interaction*: games should support and create opportunities for social interaction.

Although the EGF scale was originally developed to assess player experience, few studies have explored its potential as a tool for investigating psychosocial skill development. A study on nutrition education in children (Espinosa Curiel et al., 2020) found a significant correlation between the flow dimension of the *challenge* and the perceived *improvement in knowledge* (the improvement in knowledge was measured using the EGF scale, which included an additional eighth dimension related to knowledge acquisition in Fu and colleagues work, in 2009). The regression model explained 27% of the variance in learning

results, suggesting that specific flow dimensions may serve as reliable predictors of educational outcomes.

A recent study by Pacheco-Velázquez and colleagues (2025) employed the EGF scale to assess game experience among engineering students. The findings indicated that the dimensions of *autonomy, feedback,* and *concentration* were associated with the development of complex knowledge, which is essential to the logistics sector. Additionally, these dimensions were found to enhance critical thinking and complex problem-solving skills.

Similarly, a study by Eckardt and Robra-Bissantz (2019) investigated the experience of playing the SG "Lost in Antarctica", designed to support computer literacy learning. To evaluate both learning and gameplay experience, the authors employed the EGF model, developed specifically to measure the enjoyment of digital learning games, including the achievement of learning objectives. In this study, the *knowledge improvement* dimension was directly linked to participants' perception of increased skills and understanding. This dimension, along with *concentration, clear goals, feedback, challenge,* and *autonomy*, received positive evaluations and remained consistent even when the learning content was adapted. These dimensions were identified as fundamental to a learning-supportive gaming experience.

Despite the paucity of studies that have employed the EGF scale to directly assess the development of psychosocial skills, extant evidence suggests that its dimensions, which are closely tied to cognitive, affective, and social domains, can serve as significant indicators for evaluating the impact of DSGs on personal and social development. In this context, the EGF scale has the potential to contribute to the advancement of the current body of research by offering novel insights into the way SG can promote psychosocial dimensions through the flow experience. The same scale was employed in some studies included in the systematic review cited in Chapter 4.

The objective of the following sections is to examine the way certain components of the EGameFlow scale may facilitate the cultivation of psychosocial skills through the utilization of a DSG. The dimensions of the game may have the potential to positively influence cognitive and social skills in both educational and professional contexts.

In light of the extant literature on this subject, and in accordance with the findings outlined in the systematic review of Chapter 4, the following categories of variables were considered*: self-efficacy in problem solving* (for intend the cognitive domain), *interpersonal skills* (for the

social domain, incorporating soft skill like communication, conflict resolution, and collaborative problem solving), and *collaborative work orientation* (defined here as the frequency and preference for group work, and referred also to the group work processes).

6.1.1. EGF dimensions and problem-solving self-efficacy

The *Flow Theory* and the subsequent dimensions of the EGF scale can significantly contribute to fostering *problem-solving self-efficacy.* According to Bandura's theory of self-efficacy (1997), individuals develop a stronger belief in their competencies when they successfully overcome challenges. Games that offer finely calibrated levels of difficulty facilitate experiences of mastery, which are recognized as fundamental sources of self-efficacy. The EGF scale evaluates the extent to which a game provides such optimal levels of challenge, enough to stimulate engagement without causing frustration, thus facilitating the emergence of these mastery experiences. Moreover, the perceived autonomy in decision-making during gameplay enhances intrinsic motivation and the feeling of personal responsibility for outcomes (Zimmerman, 2000; Bandura, 1997). These are both essential components in the development of self-efficacy. Autonomy encourages experimentation, initiative, and risk-taking, key aspects of effective problem-solving self-efficacy.

Feedback, which helps learners understand the consequences of their actions and refine their strategies, accordingly, is another essential element to develop in a game. Ke (2009) conducted a qualitative meta-analysis, synthesizing data from 65 empirical studies. The identified game elements encompass elaborative feedback, pedagogical agents, and multimodal information display. These elements have been demonstrated to be consistently associated with enhanced learning outcomes. Furthermore, the findings indicated that instructional computer games, which are associated with elements like self-efficacy, favorable learner attitudes toward the subject issue, and high-quality feedback integrated into gameplay, can promote greater motivation across a range of learner groups and educational environments.

As Hattie and Timperley (2007) emphasize, *feedback* is among the most powerful influences on self-regulated learning and efficacy beliefs. The reflective process made by the

feedback supports both cognitive flexibility and adaptive learning, contributing directly to improved problem-solving skills and a stronger sense of self-efficacy.

Empirical support for this relationship can be found in the study by Perlwitz and Stemmann (2022), which explored the impact of SGs on self-efficacy expectations in STEM education. Given the implications of self-efficacy on academic persistence and career paths, the authors proposed SG as a potential intervention. Their study, which involved SG and used a pre-post design, revealed that flow experiences mediated a positive effect on self-efficacy. The results highlighted the critical role of game elements such as *challenge* and *autonomy* in producing this effect, aligning closely with the dimensions assessed by the EGF scale.

6.1.2. EGF dimensions and interpersonal skills development

The EGF can enhance and support the development of *interpersonal skills*: *clear goals* help players coordinate their actions and understand group objectives, which is critical for shared task execution. Effective *feedback* allows teams to monitor their interactions and adjust behaviors collaboratively, thereby enhancing group decision-making and interpersonal awareness. These elements align with constructivist learning theories (Bruner, 1961), which emphasize the learner's active role in constructing knowledge through social negotiation and meaningful feedback.

While *autonomy* typically relates to individual decision-making, in collaborative environments it fosters shared leadership and mutual respect. This dimension refers to Ryan and Deci's Self-Determination Theory (2000a), which posits that autonomy enhances intrinsic motivation and cooperative behavior when individuals feel a sense of agency in their actions. Players experience ownership of their roles, which encourages open communication and equitable participation.

The dimension of *social interaction* directly addresses the quality and frequency of interaction among players. According to Vygotsky's (1978) sociocultural theory, learning is fundamentally social and occurs through interaction with others in shared contexts. Collaborative games that encourage peer interaction, indeed, promote communication (verbal and non-verbal), conflict resolution (through negotiation and consensus-building), team-based problem solving (by distributing tasks and co-constructing solutions).

6.1.3. EGF dimensions and collaborative work orientation

The EGF scale provides a useful framework for examining how specific elements of game design can support the development of *collaborative work orientation*, defined as the tendency to prefer and effectively engage in team-based tasks (Lower et al., 2017). Among the scale's dimensions, *feedback* can emerge as an influential factor in fostering collaboration. Immediate and constructive feedback, especially when it reflects group-level performance, reinforces mutual accountability, and facilitates learning from both successes and failures. It helps players reflect on the effectiveness of their team strategies and encourages the adjustment of roles, communication styles, and cooperation methods. According to Hattie and Timperley (2007), feedback plays a critical role in guiding learning and reinforcing collective responsibility, especially when it is timely and task focused.

Within the EGF framework, the dimensions of *immersion* and *social interaction* can play a central role in affecting learners' attitudes toward collaborative teamwork orientation. High levels of *immersion* during gameplay can facilitate the emergence of shared flow experiences, a psychological state in which team members become fully engaged, cognitively synchronized, and emotionally aligned in the pursuit of a common objective (Sawyer, 2007). Referred to as group flow, this phenomenon can directly impact the effectiveness and satisfaction of collaboration among group members. According to Sawyer (2007), group flow not only enhances the quality of game performance but also increases individual satisfaction with team dynamics. Similarly, Csikszentmihalyi (1990) posits that shared flow experiences can strengthen interpersonal bonds and foster intrinsic motivation, prompting participants to associate teamwork with positive emotions and successful outcomes. As a result, learners who experience this deep level of collaborative engagement are more likely to develop a preference for teamwork, perceive it as more enjoyable than working alone.

The EGF dimension of *social interaction* is connected to the development of collaborative orientation. Foundational theories of learning support this perspective: Vygotsky (1978) emphasized the pivotal role of social interaction in cognitive development, arguing that knowledge is co-constructed through dialogue and shared activity. In educational settings, Johnson and Johnson (2009) further demonstrated that cooperative learning environments significantly enhance motivation, foster mutual respect, and improve outcomes by cultivating positive interdependence among learners. Games that actively promote frequent, meaningful, and constructive interaction among participants help normalize the experience of working in a

team (Lower et al., 2017). This positive reinforcement can lead to a stronger preference for group work, increased motivation to participate in team-based tasks, and a greater probability of seeking collaborative opportunities in future academic or professional contexts.

The extant literature on this subject is limited. However, as demonstrated in the systematic review of Chapter 4, it can be concluded that cognitive, affective, and social processes within learning settings supported by DSG can be effectively measured by psychological survey tools, based on well-established theoretical frameworks. The subsequent paragraph will focus on describing the process of birth, design, and deployment of DSG "ZooTeams", which is the subject of our research, to clearly outline the processes it intends to stimulate and the learning objectives it sets itself.

6.2. "ZooTeams": design process and educational objectives

"ZooTeams" is an educational e-learning tool developed by *Studio Saperessere Srl,* a partner in the doctoral project. *Studio Saperessere Srl* is a micro-enterprise with a core team of eight employees, supported by a network of over 100 professionals. The company specializes in providing customized solutions in training design, organizational innovation, multimedia learning tools, and human resources assessment. Its mission is to support corporate growth by enhancing human capital and fostering innovation.

The DSG was developed in a multidisciplinary team of psychologists and digital designers in response to the challenges of online training that emerged during the COVID-19 pandemic. Integrated into a structured training program, the game was designed to provide companies with an effective solution for delivering remote learning experiences. Main goal of this collaboration was to empirically validate the effectiveness of the educational programs by implementing "ZooTeams".

The primary objective of "ZooTeams" is to cultivate essential soft skills, particularly problem-solving, communication, and collaboration, within immersive and interactive learning environments. This tool was specifically designed to support both individual and group learning processes: initially, the DSG "ZooTeams" was implemented in corporate training programs aimed at enhancing key competencies such as evaluative and decision-making abilities, time management, and strategic action planning to overcome shared challenges. More broadly, the game was conceived as a means to stimulate cultural change within organizations, drawing on principles of social and situated learning (Bandura, 1977) and game-based learning methodologies (Hamari et al. 2014).

In the academic context, the game was reframed as a tool for developing pre-professional skills to guide students in their transition from university to the workplace. In particular, its use within teacher training programs aimed to promote the development of a skill set aligned with the demands of today's complex and dynamic work environments, including:

- *self-efficacy in problem-solving,* by strengthening both analytical and creative approaches to complex scenarios;
- *interpersonal skills,* including communication (e.g., using decentralized communication networks when possible, applying open and supportive communication techniques, practicing non-evaluative listening, aligning verbal and non-verbal cues, and engaging in small talk comfortably), conflict resolution (e.g., encouraging functional conflict, avoiding dysfunctional dynamics, applying appropriate conflict resolution strategies, and using integrative negotiation methods), and collaborative problem solving (e.g., employing effective group decision-making and identifying/removing barriers to team-based problem solving);
- *team orientation and collaborative work*, by promoting cooperation and shared task achievement.

As highlighted by Maestri, Sassoon, and Polsinelli (2018), SG should not be seen as the final objective of a training process, but rather as a tool to explore individual and group dynamics within the context of organizational learning. Accordingly, "ZooTeams" has been integrated into a broader learning framework consisting of the following components: (a) a theoretical introduction, which lays the groundwork for the learning objectives, explains the game mechanics, and supports the participants' initial decision-making processes; (b) an experiential phase, in which teams collaboratively tackle tasks, allowing them to identify roles and observe team dynamics in action; and (c) a guided application phase, based on a structured delivery model (as detailed in paragraph 5.5.2).

Building on this collaboration, the present study integrates "ZooTeams" into a structured research framework, with the aim of exploring its game dimensions and evaluating its effectiveness in fostering psychosocial skill development. In this study, the EGF scale was used to assess both the effectiveness of the game experience provided by "ZooTeams" and the soft skills the game aims to develop.

6.3. Aims of the study

To gain a deeper understanding of the theme, the next phase of the research aimed at exploring the impact of the DSG utilized in the study described in chapter 5 on the development of psychosocial skills. Main objective of this study was to identify which dimensions of the game experience, measured by the EGF scale, are most significantly associated with the acquisition of psychosocial skills. Based on the existing literature and theoretical framework, the following research hypotheses have been formulated:

- H1: The EGF dimensions of *challenge, autonomy,* and *feedback* are positively correlated with the perception of self-efficacy in problem-solving.
- H2: The EGF dimensions of *goal clarity, feedback, autonomy,* and *social interaction* are positively correlated with the perceived development of interpersonal skills.
- H3: The EGF dimensions of *feedback, immersion, and social interaction* are positively correlated with the perceived development of collaborative work orientation.

6.4. Method

The present study employs the same research method delineated in paragraph 5.5, with data collection and procedure described in detail in paragraphs 5.5 and 5.5.2, respectively. The present analysis is an examination of previously unanalyzed data, thus offering a novel perspective on the previously investigated experimental intervention.

6.4.1. Participants

The participants included in this study correspond to those previously detailed in Section 5.5.1, as the analysis presented herein offers a distinct analytical perspective on the data obtained from the same experimental intervention.
Among the 435 participants, 420 completed the EGF scale questionnaire after the DSG session.

6.4.2. Measures

The questionnaires administered to the sample encompassed the following variables (the whole questionnaire is reported in Appendix E):

- **Problem Solving Self-Efficacy Scale** (APSP: Pastorelli et al., 2001). It's a self-report scale designed to assess self-efficacy beliefs related to problem solving. The scale consists of 14 items measuring three core areas: *problem-solving efficacy* (e.g., "I *am*

able to identify positive alternative solutions when facing problems"), *critical thinking* (e.g., *"I am able to recognize the principles underlying a line of reasoning*"), and *creative thinking* (e.g., "*I am able to find different ways to do the same things to avoid repetition and boredom*"). Responses are rated on a 7-point Likert scale, ranging from 1 = "Not at all capable" to 7 = "Fully capable" (Cronbach's alpha =.86)

- **Teamwork Scale for Youth** (TSY: adapted from Lower et al., 2017). It is a self-report scale designed to evaluate individuals' orientation toward teamwork. It consists of 10 items, such as *"I'm good at communicating with my team members".* Responses are rated on a 5-point Likert scale, from 1 = "Strongly disagree" to 5 = "Strongly agree" (Cronbach's alpha = .78).
- **Teamwork KSA Test** (KSA: Stevens & Campion, 1994; adapted fromVan Krevelen, 2020). The scale includes 15 items. The taxonomy developed by Stevens and Campion (1994) consists of two main dimensions of teamwork KSAs*: Interpersonal KSAs* and *Self-Management KSAs.* Interpersonal KSAs consist of specific knowledge, skills, and abilities that facilitate interpersonal interaction, namely *conflict resolution, collaborative problem solving* and *communication.* Self-management KSAs are comprised *of goal setting and planning/coordination.* An example of item is: "*During group activities, I have often involved other working groups to solve specific problems".* Responses are rated on a 6-point Likert scale, ranging from 1 = "Strongly disagree" to 6 = "Strongly agree". The internal consistency values for these factors were: α = .79 (goal-setting), α = .80 (conflict resolution), and α = .76 (communication).
- **E-GameFlow Scale** (EGF Scale; Fu et al., 2009; adapted from Chen et al., 2018). The EGF Scale is designed to assess participants' experience of a Serious Game through 31 items (post-game survey) covering seven dimensions: *concentration* (items 1-5, α =.74), *clear goals* (items 6-10, α =.83), *feedback* (items 11-14, α =.75), *challenge* (items 15-19, α =.87), *autonomy* (items 20-23, α =.85), *immersion* (items 24-27, α =.66), and *social interaction* (items 28-31, α =.93). An example item is: "*The game captures my attention*." Responses are rated on a 7-point Likert scale, ranging from 1 = "Strongly disagree" to 7 = "Strongly agree".

6.4.3. Data analysis

The statistical analysis was conducted using *jamovi* statistical software. In order to explore the relationships between variables, bivariate correlation analyses were performed.

Multiple regression models were then employed to examine how the dimensions of the E-GameFlow Scale (Fu, Su & Yu, 2009; adapted from Chen et al., 2018) influenced specific psychosocial skills, which included the dependent variables of *problem-solving self-efficacy,* measured with the Problem Solving Self-Efficacy Scale (Pastorelli et al., 2001), *interpersonal skills*, measured with the Teamwork KSA Test (Stevens & Campion, 1994; adapted from Van Krevelen, 2020), and *collaborative work orientation*, measured with the Teamwork Scale for Youth (Lower et al., 2017).

6.5. Results

6.5.1. Relationship between EGame Flow scale dimensions and psychosocial domains

The relationship between the dimensions of the EGF scale, which assesses game experience, and the three examined psychosocial dimensions (collaborative work orientation, problem-solving self-efficacy, and interpersonal skills) was analyzed. The correlation analysis was conducted at T2 for all participants concerning the psychosocial variables.

As shown in Table 9, all Pearson's *r* coefficients were positive and statistically significant, indicating that a higher perceived quality of the game experience is associated with higher levels of *collaborative work orientation, problem solving self-efficacy* and *interpersonal skills.* In particular, *collaborative work orientation* showed significant correlations with all EGF dimensions, with coefficients ranging from r = .20 (concentration) to r = .29 (social interaction). The strongest associations were found with social interaction (r = .29, $p < .001$) and immersion (r = .27, $p < .001$). *Problem solving self-efficacy* also showed significant, however slightly weaker, correlations with all EGF dimensions (*r* between .10 and .22). The highest correlations were observed with goal clarity, feedback, and autonomy (all *r* = .22, $p < .001$). Lastly, *interpersonal skills* were significantly correlated with all EGF dimensions, with the strongest relationships observed for goal clarity, autonomy, concentration, and social interaction (*r* ranging from .24 to .26, $p < .001$).

Table 9. Correlation analysis between EGame Flow scale dimensions and psychosocial domains.

	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
(1) Concentration	—									
(2) Goal clarity	.48***	—								
(3) Feedback	.41***	.58***	—							
(4) Challenge	.59***	.57***	.60***	—						
(5) Autonomy	.45***	.63***	.52***	.62***	—					
(6) Immersion	.48***	.30***	.33***	.45***	.38***	—				
(7) Social interaction	.56***	.30***	.43***	.56***	.46***	.48***	—			
(8) Collaborative work orientation	.20***	.22***	.24***	.25***	.23***	.27***	.29***	—		
(9) Problem solving self -efficacy	.11*	.22***	.22***	.15**	.22***	.10*	.10*	.37***	—	
(10) Interpersonal skills	.26***	.26***	.17***	.25***	.25***	.16**	.24***	.42***	.37***	—

*Note. *p < .05, **p < .01, ***p < .001*

6.5.2. Influence of EGF dimensions on psychosocial domains

To analyze the associations between characteristics of the gaming experience and the perceived development of soft skills, three multiple linear regressions were conducted, using *problem solving self-efficacy, interpersonal skills,* and *collaborative work orientation* as the respective dependent variables (see Table 10).

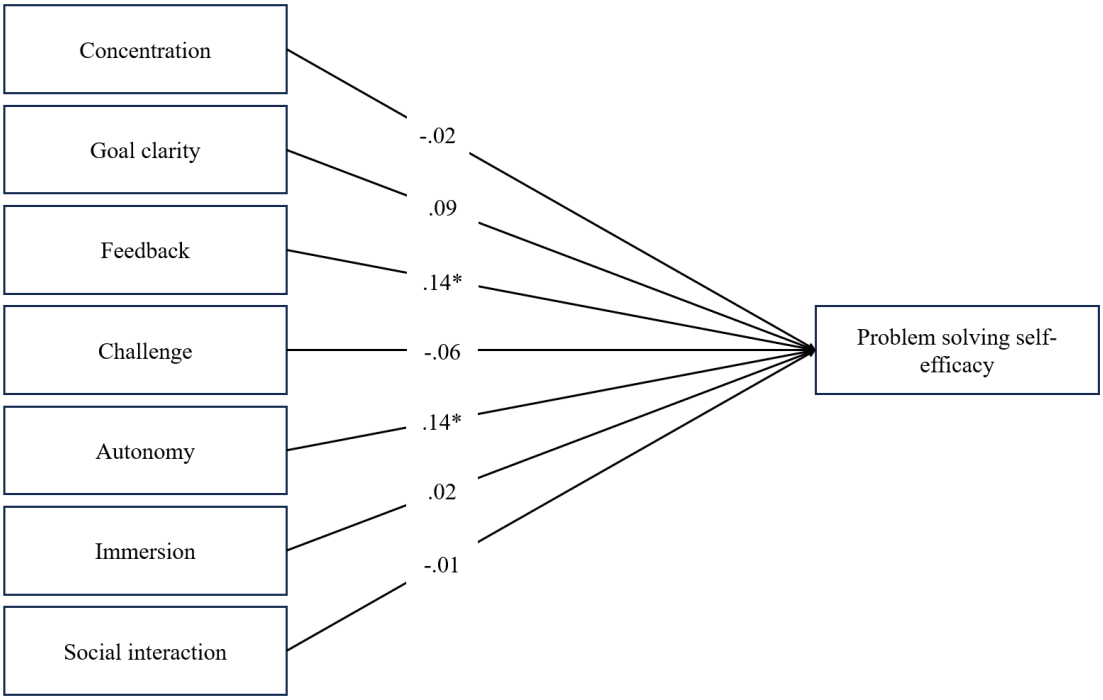
In the first model, which focused on *problem solving self-efficacy,* the regression was statistically significant overall ($R^2 = .07$), although the coefficient of determination indicated a rather modest amount of explained variance. Among the dimensions included, only *feedback* ($\beta = .14$, $p = .032$) and *autonomy* ($\beta = .14$, $p = .049$) showed significant and positive associations with *problem solving self-efficacy*. None of the other dimensions were significantly associated with this domain (see Fig. 9).

The second model examined the influence of *interpersonal skills* ($R^2 = .11$). In this case, the explained variance was modest, though slightly higher than in the previous model. *Goal clarity* ($\beta = .15$, $p = .027$) emerged as a significant and positive influence of *interpersonal skills*, suggesting that greater clarity in the tasks perceived during the gaming experience is associated with higher perceived development of these skills. In addition, *social interaction* also showed a significant positive association ($\beta = .13$, $p = .046$), indicating that the social dynamics of the game may play a role in the development of relational skills. The remaining variables did not reach statistical significance (see Fig. 10).

Finally, the model related to *collaborative work orientation* explained 12% of the variance in the outcome ($R^2 = .12$), representing the model with the highest explained variance among the three. Two dimensions were significantly associated with *collaborative work orientation*: *immersion* ($\beta = .15$, $p = .008$) and *social interaction* ($\beta = .18$, $p = .005$), both showing positive effects. These results suggest that greater engagement in the game and interaction with other players may foster the development of a stronger collaborative work orientation. The remaining dimensions of the gaming experience did not influence the model (see Fig. 11).

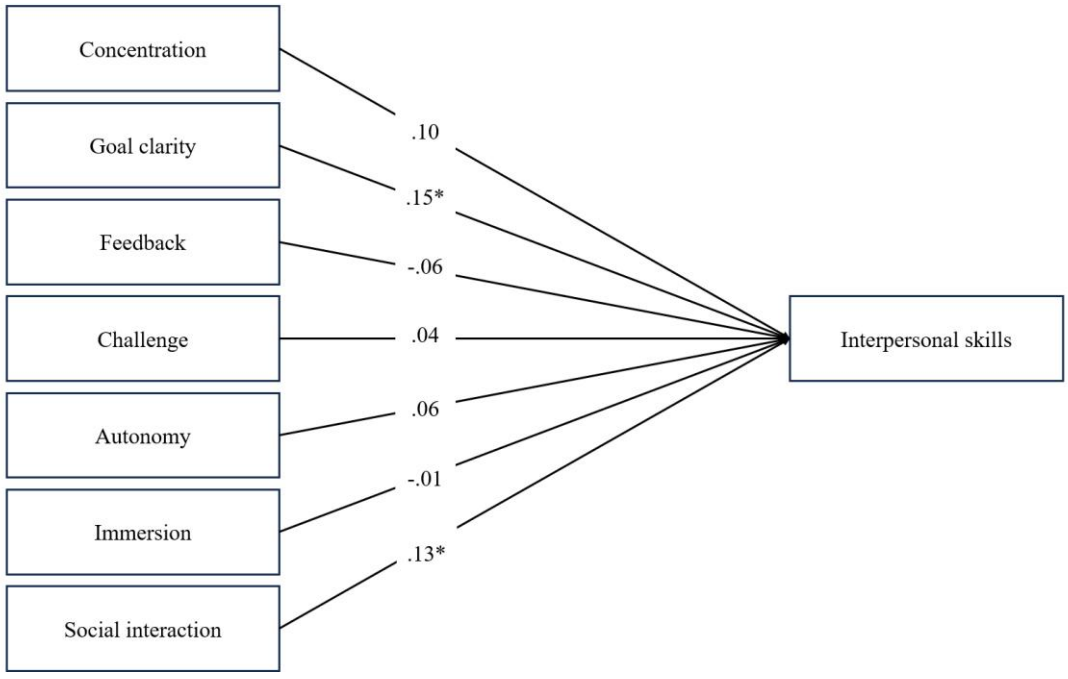
Table 10. Multiple linear regressions

Outcome	Dimension	β	SE	t	*p*
Problem solving self-efficacy	Concentration	-.02	0.04	-0.35	.731
	Goal clarity	.09	0.04	1.27	.206
	Feedback	.14*	0.04	2.15	.032
	Challenge	-.06	0.05	-0.77	.441
	Autonomy	.14*	0.04	1.97	.049
	Immersion	.02	0.03	0.27	.788
	Social interaction	-.01	0.04	-0.16	.876
Interpersonal skills	Concentration	.10	0.06	1.50	.135
	Goal clarity	.15*	0.06	2.22	.027
	Feedback	-.06	0.05	-0.92	.356
	Challenge	.04	0.06	0.49	.625
	Autonomy	.06	0.05	0.85	.396
	Immersion	-.01	0.04	-0.22	.829
	Social interaction	.13*	0.05	2.00	.046
Collaborative work orientation	Concentration	-.06	0.03	-0.96	.340
	Goal clarity	.10	0.03	1.44	.149
	Feedback	.07	0.03	1.07	.287
	Challenge	.02	0.04	0.23	.817
	Autonomy	.01	0.03	0.12	.901
	Immersion	.15**	0.02	2.65	.008
	Social interaction	.18**	0.03	2.84	.005



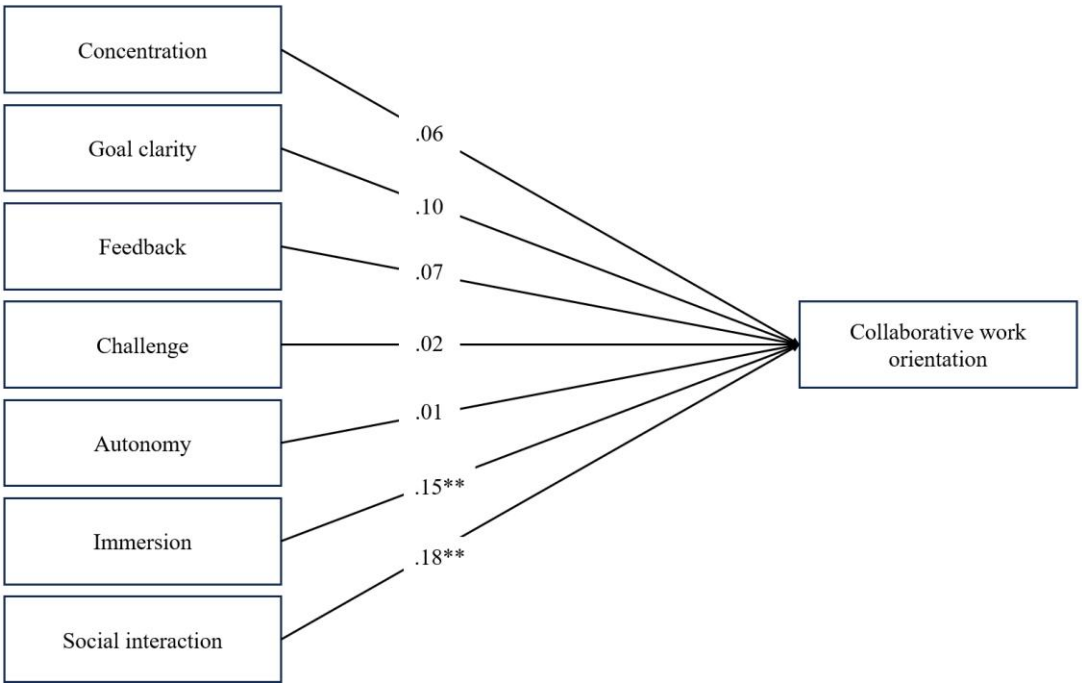
*Note. *p < .05, **p < .01, ***p < .001*

Figure 9. Standardized beta coefficients from the first multiple linear regression model influencing problem-solving self-efficacy based on game experience dimensions.



*Note. *p < .05, **p < .01, ***p < .001*

Figure 10. Standardized beta coefficients from the second multiple linear regression model influencing interpersonal skills based on game experience dimensions.



*Note. *p < .05, **p < .01, ***p < .001*

Figure 11. Standardized beta coefficients from the third multiple linear regression model influencing collaborative work orientation based on game experience dimensions.

6.6. Discussion

The first hypothesis is partially supported: results from the first regression model indicate that the *feedback* and *autonomy* dimensions of the EGF scale are significantly associated with perceived self-efficacy in problem solving. Consistent with literature, perceived autonomy in decision-making during gameplay enhances intrinsic motivation and fosters a sense of personal responsibility for outcomes (Zimmerman, 2000). *Autonomy* supports experimentation, initiative, and risk-taking, core components of effective problem-solving behavior. *Feedback*, on the other hand, helps learners understand the consequences of their actions and refine their strategies accordingly. This reflective process fosters cognitive flexibility and adaptive learning, thereby enhancing problem-solving skills and a strong sense of self-efficacy (Hattie & Timperley, 2007).

Nevertheless, no other dimensions were found to be positively associated with this domain, contrary to the initial hypothesis, which had anticipated a significant contribution from the *challenge* dimension. This result could be attributed to the game not being perceived as adequately challenging, especially concerning its collaborative elements.

The second hypothesis is also partially supported: results from the second regression model indicate that the *clear goals* and *social interaction* dimensions of the EGF scale are positively associated with the development of *interpersonal skills*. Constructivist learning theory (Bruner, 1961) emphasizes the learner's active role in constructing knowledge through negotiation and interaction. In this sense, the DSG "ZooTeams" may have provided players with *clear goals,* enabling them to coordinate their actions effectively and understand shared group objectives, an essential condition for successful task execution in collaborative settings. The need to engage in teamwork may have allowed groups to monitor their collective actions and promote collaborative behavior, thereby enhancing communication and interpersonal awareness (Stevens & Campion, 1994).

However, contrary to the initial hypothesis, *feedback* and *autonomy* were not significantly associated with interpersonal skills. Regarding *feedback,* it is possible that the game did not provide sufficient or timely information to facilitate meaningful peer comparison or group reflection. Alternatively, *feedback* may not have allowed adequate time or space for team discussion and adjustment. As for *autonomy,* the DSG may have offered limited opportunities for decision-making within a collaborative environment, potentially leading to confusion or uncertainty regarding group and individual strategies.

The third hypothesis proposed that the EGF dimensions of *feedback*, *immersion*, and *social interaction* would positively influence collaborative work orientation. Based on the results of the third regression model, only *immersion* and *social interaction* were found to be significantly and positively associated with *collaborative work orientation.*

In the case of *immersion*, the flow experienced during gameplay may have generated a deep sense of engagement that involved all group members (Csikszentmihalyi, 1990). According to Sawyer (2007), group flow not only enhances the quality of joint performance but also increases individual satisfaction with team dynamics. This suggests that students who experience a high level of collaborative engagement are more likely to develop a preference for teamwork, perceive it as more rewarding than working individually, and retain positive memories related to cooperative learning contexts.

Social interaction can also be linked to this outcome, as the DSG may have enhanced motivation for solving problems collectively, fostering a preference for working in teams rather than alone. Moreover, the game was implemented within an educational setting grounded in cooperative learning principles (Johnson & Johnson, 2009), where such

environments have been shown to significantly boost motivation, promote mutual respect, and improve outcomes by fostering positive interdependence among learners.

However, contrary to the third hypothesis, *feedback* did not show a significant relationship with *collaborative work orientation*. This suggests that, in this context, feedback did not contribute meaningfully to the development of a team-oriented mindset. An explanation may lie in the nature of the feedback provided in the DSG, which may not have been sufficiently timely or task-specific (Hattie & Timperley, 2007) to encourage meaningful reflection on group strategies for achieving shared goals.

Overall, the findings suggest that certain specific characteristics of the gaming experience — such as *feedback*, *autonomy*, *goal clarity*, *immersion*, and *social interaction* — may contribute to the perceived development of soft skills. However, the strength of these effects is moderate, and the proportion of explained variance remains relatively low.

6.6.1. Limitations and conclusions

The identification of specific dimensions of gaming experience (with EGF scale) that can influence the perceived development of soft skills is a recent area of interest within the field of educational research. Therefore, the existing literature is currently limited. This study contributes to advancing this evolving field by highlighting how the design and delivery of DSG, characterized by well-structured and clearly defined game elements, such as *autonomy, feedback, challenge, and social interaction*, can enhance the effectiveness of interventions aimed at fostering the development of psychosocial skills, both of cognitive and relational nature.

Nevertheless, this study presents some limitations. A primary concern relates to the proportion of explained variance (R^2), which remains relatively modest across all three dependent variables. However, this finding is consistent with what is often observed in educational and psychological research, where individual behaviors and perceptions are shaped by a complex interplay of personal, contextual, and social factors that cannot be fully captured by a single theoretical model. Indeed, the *flow* dimensions considered in this study represent only a subset of the many variables that may influence the perceived development of soft skills.

Furthermore, the model examined in this study is exploratory in purpose. The aim was to examine relationships between selected components of the subjective flow experience and self-assessed soft skills, rather than to construct an exhaustive model. Considering this, the

relatively low R^2 values do not undermine the relevance of the findings. On the contrary, they offer valuable insights that may inform future research, particularly longitudinal or experimental studies, designed to investigate the underlying causal mechanisms more thoroughly at play.

A final constraint pertains to the limited duration of the intervention (one session of play). The temporal constraints imposed do not allow for the cultivation of soft skills to be adequately fostered. In light of these considerations, future implications necessitate the development of extended training pathways that would be tailored to the specific soft skills under examination.

In conclusion, this study reports contributions to the expanding field of educational research on DSGs by exploring how particular game elements may support the development of soft skills. While the findings offer only partial support for the initial hypotheses, they underscore the potential of dimensions such as *autonomy, feedback, goal clarity, immersion,* and *social interaction* in influencing students' perceived growth in problem-solving self-efficacy, interpersonal skills, and collaborative work orientation.

While certain anticipated associations were not observed, including the role of *challenge* or *feedback* in specific domains, the study offers substantial evidence that the design of DSG can influence psychosocial skills. The relatively low explained variance is indicative of the complexity of human behavior in educational contexts and underscores the necessity for more comprehensive and longitudinal investigations.

General conclusions and future directions

The present thesis explored the potential of DSGs as innovative tools for learning, supporting the development of key 21st-century competencies (OECD, 2019), with particular emphasis on soft skills, through a comprehensive theoretical and empirical investigation. The research was grounded in psycho-educational foundations, with the aim of providing concrete and pragmatic solutions to the challenges posed by digital transformation in education and training contexts (Raffaele, 2000).

The first part of the thesis clarified the definitions of "gamification" (Deterding et al., 2011) and SGs (Bergeron, 2006), emphasizing their increasing diffusion across multiple sectors (Kara, 2021), including education, health, marketing, and engineering. It reports also that the game design elements are employed in the educational field as strategies that can support the design of interventions to achieve an effective learning experience that combines fun and learning (Kapp, 2012). In particular, SGs have proven effective in combining the emotional and motivational aspects of play with specific learning objectives, thereby promoting active, reflective, and experiential learning experiences (Anolli & Mantovani, 2011).

Drawing upon the PIAAC framework (OECD, 2009) and the Collaborative Problem Solving framework (PISA, 2015), the research identified key cognitive, communicative, and relational skills, which can be effectively enhanced through DSGs. Specific indicators and assessment tools were proposed to evaluate these skills, although the lack of consistency and standardization in definitions and measurement methods remains a major limitation, as confirmed by the first study in the systematic literature review. The results of the systematic review also demonstrated the general effectiveness of DSGs in improving learning outcomes and supporting the development of psychosocial skills. However, it also revealed significant fragmentation in terminology and assessment approaches, which undermines the comparability and generalizability of findings across different studies, highlighting the urgent need for shared frameworks and methodological coherence.

The second empirical study confirmed the positive impact of DSGs on learning within structured cooperative learning environments. This study combined the Collaborative Learning (CL) approach (Kagan et al., 2000) with the use of the DSG "ZooTeams" to examine its effect on learning outcomes within student work groups involved in a higher education intervention. The intervention groups demonstrated significantly better performance

than control groups, supporting the hypothesis that integrating DSGs into collaborative settings enhances academic output. The consistency of these results, even in the absence of structured feedback phase in the second year, suggests that DSGs maintain their efficacy as educational tools across different implementation modalities, although further investigation is warranted to understand the specific contribution of each instructional component. A particular emphasis is placed on the Design-Based Research (DBR) methodology (DBR Collective, 2003; Collins et al., 2004; Sandoval, 2014) for conducting the two iterative design stages of the intervention. This approach has been demonstrated to be a particularly effective methodology for identifying key design elements and their functionality in supporting educational research.

The final study broadened the analysis by providing additional insights into a specific aspect of the DSG "ZooTeams," focusing on participants' perceptions of soft skill development as influenced by the game experience (Csikszentmihalyi, 1990), measured using the EGameFlow scale (Chen et al., 2018). This study makes a significant contribution to the advancement of this evolving field by highlighting the potential of DSG. When characterized by well-structured and defined game elements, such as *autonomy, feedback, challenge, and social interaction*, DSGs can enhance the effectiveness of interventions aimed at fostering the development of psychosocial skills, both of cognitive and relational.

Beyond the academic context, DSGs also demonstrate significant potential in professional and corporate training environments. In such environments, characterized by specific needs related to talent development, change management, and competitiveness, DSGs can be an effective tool for the strengthening of transversal skills, including collaboration, communication, and teamwork. DSG's experiential and engaging format has been shown to promote individual learning while also stimulating collective dynamics that encourage organizational innovation and knowledge sharing. The structured and evidence-based model presented in this thesis is also adaptable to these contexts, where attention is often focused on measurable results. In this regard, DSG functions as a passage between training and practice, providing professionals with the opportunity to cultivate skills in simulated but realistic environments, that mirror the tangible challenges of the contemporary world of work.

The proposed model of experimentation is also innovative in comparison with traditional methods of intervention in lifelong learning and adult education. DSGs and gamification represent the new frontiers of the digitization of training processes. These methodologies can

offer concrete solutions for organizational improvement, the exploitation of talent, and the effectiveness of training interventions. Furthermore, the transferability of the proposed intervention model warrants consideration. The intervention under discussion was developed and implemented in a university setting characterized by a robust presence of laboratories, in addition to the habitual use of digital platforms such as Moodle and Teams. The replicability of the model in different contexts—for example, courses with less technological equipment, less homogeneous student populations, or in different disciplinary fields—could encounter critical issues that were not addressed in the present study. Moreover, the collaboration with *Studio Saperessere Srl* facilitated the utilization of the DSG "ZooTeams" instrument for experimental purposes. This initiative was guided by expert trainers who have previously been employed and facilitated the execution of training utilizing the game, debriefing and feedback phases.

The research conducted in the university context has supported a new method for supporting the training of future educators and trainers, thereby transforming them into active agents in learning processes, fostering the acquisition of professional skills, and strengthening the relationship between academia and the workplace. The importance of meticulous validation, grounded in evidence-based methodologies, is revealed as a fundamental strength. This approach facilitates the development of a replicable and accessible model across diverse contexts, thereby contributing to the establishment of a comprehensive system of good practices. The integration of e-learning and the strategic use of digital technologies in training interventions set ambitious goals, which span technological and pedagogical dimensions. These goals are designed to address learners' specific needs in a targeted way.

The consolidation of the relation between university and company, facilitated by the use of applied research, has given rise to virtuous collaborations between the educational system and the workplace. The networking of these experiences has been shown to promote the emergence and strengthening of an innovative ecosystem that is accessible and spread across the territory. This environment aims not only to develop skills, but also to foster a digital citizenship that is aware of the opportunities offered by a networked society and recognizes its risks. This synergistic process supports the creation of territorial networks, oriented towards digital transformation, sustainable development, and widespread innovation.

Furthermore, the research findings have revealed novel perspectives that warrant further exploration. A more in-depth analysis of the individual characteristics of participants is

imperative to comprehend the influence of motivation, prior experience, and learning styles on the efficacy of DSG in training contexts. In a similar vein, it will be important to broaden the scope of observation to include the long-term implications of DSG use. This will entail a thorough assessment of learning retention and the sustained development of acquired transversal skills over time. A critical yet unresolved issue concerns the lack of standardization in the evaluation methodologies used to assess soft skills within digital environments. The absence of shared criteria and validated instruments limits the ability to compare studies, revealing a systemic weakness in the field that calls for targeted methodological interventions grounded in interdisciplinarity. Subsequent research endeavors could concentrate on DSG's participatory design, which entails the active involvement of teachers, designers, and students in the development process to guarantee enhanced pedagogical coherence and elevated levels of engagement. Another promising area of research concerns the study of organizational and cultural contexts in which learning experiences with DSG are embedded. The aim could be to analyze how group dynamics, leadership styles, and institutional environments can influence learning outcomes.

In conclusion, this doctoral thesis stressed the necessity for critical reflection on the role of technology in education. The DSG should not be conceived of as an auxiliary instrument, but rather as a pivotal element of a pedagogical approach that prioritizes student-centered, cooperative learning. The conscious integration of these elements into learning interventions represents a promising direction for innovation in higher and vocational education. This approach promotes student autonomy and fosters the development of transversal skills that are now essential in a complex, interconnected, and constantly changing society.

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Appendix A.

Characteristics of the selected studies of the systematic review.

Study (country)	Presence of control group (Yes/No)	Theoretical framework	Context	Target (N=)
Andreoli et al., 2017 (Italy)	No	FRECH model: collaborative learning and Serious game in Cultural Heritage.	Educational context: cultural heritage	Common groups of visitors to a museum in an archaeological site in Salerno (N=72)
Bossavit & Parsons, 2018 (United Kingdom)	No	Participatory Design (PD) approach. Learner-centered design approach via the 3T "sandwich model" proposed by Parsons and Cobb (2014; Parsons, 2015). Holt and Yuill's (2014) framework for collaborative technology-based interactions.	Educational institution: special education	Teenagers with high functioning Autism Spectrum Disorder (ASD) (N=6)
Buchinger & da Silva Hounsell, 2018 (Brazil)	No	Collaborative-Competitive Serious Games (CCSG) for learning. Motivational theories of Malone & Lepper (1987), Dweck (1986), and Keller (1987, 2008).	Educational institution: school and university	Students from junior high school (41%), high school (16%) and post-secondary education: undergraduates (32%) and postgraduates (11%) students from Computer Science and Informatics courses. (N=63)
Calabor et al., 2018 (Spain)	No	Serious games as educational tools and experiential learning.	Educational institution: university	Students enrolled in a Management Accounting course in higher education. (N=80)
Capatina et al., 2018 (Italy, Franch, Romania)	No	Learning analytics. Serious games in business to promote collaborative problem solving skills.	Educational institution: business schools	Master's students enrolled in programs at three European universities (University of Milano-Bicocca, Grenoble Alpes University and University of Galati) (N=75)
Cuccurullo et al., 2013 (Italy)	No	Serious games and game-based learning (GBL). Learning by doing and learning-through-playing.	Educational institution: school	Children between 9 to 10 years randomly selected from the primary school of the town of Baronissi (Italy) and some voluntary teachers. (N=24)
D'Aprile et al., 2015 (Italy)	No	Socio-constructivist learning approach; Digital serious games and experiential learning.	Educational context: young learners	People aged between 14 and 32. (N=65)

de Beer et al., 2023 (Netherlands)	No	Collaborative learning and Collaborative Problem Solving (CPS).	Medical Education	Second year undergraduate nursing students at Saxion University of Applied Sciences, aged between 18 and 27 years. (N= 110)
den Haan et al., 2020 (Netherlands)	No	Learning-based interventions. Participatory environments and social learning.	Professional context	Experts from professionals working in Dutch river management and non-experts (design researchers and game designers) (N=26)
Goumopoulos et al., 2023 (Greece)	Yes	Computer - based cognitive training.	Elderly care context	People aged 65 and over, with Mild Cognitive Impairment (MCI) (N=10/11)
Hummel et al., 2015 (Netherlands)	No	CSCL (Computer-Supported Collaborative Learning) with scripted collaboration	Educational institution: university	Student teachers: third-year students at the NHL University of Applied Sciences (N=19)
Hummel et al., 2011 (Netherlands)	No	Collaboration within Technology-Enhanced Learning (TEL); CSCL (Computer-Supported Collaborative Learning) and CSCW (Computer Supported Collaborative Work) with scripted collaboration.	Educational institution: university	Water management students of the HZ University of Applied Science in the Netherlands (N=12)
Jouan et al., 2020 (Italy, France, Belgium, Poland)	No	Active-learning tools. Flow theory (Csikszentmihalyi,1990).	Educational institution: university	Students from the partner universities of the University of Bologna (UNIBO). The sample ranged from first year Masters students to PhD students, with the majority of students in their second year of a Master's course. (N=52)
Luz et al, 2016 (Brazil)	No	Game-based learning. Serious games for health education. Constructivist model.	Healthcare: community of healthcare professionals	Participants include medical researchers, veterinarians, health service administrators and community health workers. (N=20)
Malegiannaki et al., 2020 (Greece)	No	Narrative-centered learning.	Educational institution: school and university	The first study was carried out by students in an Ancient Greek language and history course at a high school in Greece. The second study was carried out by postgraduate students at the University of Piraeus. (N=33)
Meij et al., 2020 (Spain)	Yes	CSCL (Computer-Supported Collaborative Learning). Scripted collaboration. Serious games as learning tool.	Educational institution: school	Students from an eighth-grade classroom in Valencia. (N=16/16)

Nicolaidou et al., 2015 (Cyprus)	No	Problem-Based Learning (PBL). Virtual Patients in Medical Education**.** Serious Games in emergency cardiology.	Medical Education	Paramedic nurses with specialization in the assessment and management of pre-hospital emergencies. Cardiology with emphasis on emergency care. University of Cyprus. (N=90)
Oksanen & Hämäläinen, 2013 (Finland)	No	CSCL (Computer-Supported Collaborative Learning).	Educational institution: university	Vocational students and teachers at the College of Jyväskylä. (N=69)
Oo & Vallabhajosyula, 2022 (Singapore)	No	Gamification for the development of soft skills in minimally invasive surgical training. Non-Technical Skills (NTS) in surgical training (Gjeraa et al., 2016).	Medical Education	House officers and junior doctors from the Department of Surgery at Tan Tock Seng Hospital in Singapore. (N=9)
Pellas, 2014 (Greece)	No	Constructionism (Papert & Harel, 1991) and experiential learning.	Educational institution: school	Voluntary students aged 15-16, from three different high schools in Greece. (N=55)
Perry, 2021 (Canada)	No	CSCL (Computer-supported collaborative learning). Situated Learning Theory (Dunleavy & Dede, 2014). Volet et al. 's framework for socially-regulated learning (2009).	Educational institution: university	Voluntary students of three cohorts of FL2 Franch (University of Victoria Campus - Canada) (N=58)
Romero & Usart, 2013 (Spain)	No	Game Based Learning (GBL). Time Perspective (TP) and time on task. Academic Learning Time (ALT) model.	Educational context: adult postgraduate education	Post-secondary students of executive Master in Marketing and Sales (EMMV) in ESADE Business and Law School (Barcelona) (N=24)
Saitua- Iribar et al., 2020 (Spain)	No	2030 Agenda; 17 Sustainable Development Goals (SDGs). Experiential learning. Design thinking methodology and the use of Serious Games.	Educational institution: university	Undergraduate students in primary education (University of the Basque Country). (N=47)
Sanchez & Olivares, 2011 (Chile)	Yes	Mobile devices for educational collaborative problem solving. Mobile Serious Games (MSGs).	Educational institution: school	8th grade students from 5 Chilean schools, with high and low degree of socioeconomic vulnerability. Science classes. (N= 373)
Sanchez et al., 2009 (Chile)	Yes	Mobile serious games for collaborative problem solving. Effects of ICT on student learning.	Educational institution: school	8th grade students from 5 Chilean schools. (N=206/167)
Terzidou et al., 2016 (Greece)	Yes	The ARCS Model (Keller, 1987) to support CSCL (Computer-supported collaborative learning).	Educational institution: university	Undergraduate students enrolled in the Multimedia Systems course. (N= 20/14)

Wendel et al., 2013 (Germany)	No	Computer-supported collaborative learning (CSCL), Game-based Learning and Digital Educational Games (DEGs).	Educational field	Volunteers in the field of education (N=23)
Wong et al., 2022 (China)	No	Constructivist learning. Input-Process-Output (IPO) model (Garris R. et al, 2016).	Medical Education	Interprofessional education to medical and nursing undergraduates, University Grant Committee, Hong Kong. (N=62)
Xavier et al., 2023 (Portugal)	Yes	Social-emotional learning (SEL) programs into school curriculums. Serious games for learning.	Educational institution: school	Pupils from 3rd and 4th grade classes (N=89/75)

Appendix B.

Evidence of knowledge acquisition

Study (country)	Name of the Digital Serious Game	Teams' structure	Knowledge acquisition		
			Presence (Yes/No)	Measures	Results
Andreoli et al., 2017 (Italy)	Hippocratica Civitas Game	Groups of tourists	Yes	Ad hoc questionnaire	$P_{post} > P_{pre}$
Bossavit & Parsons, 2018 (United Kingdom)	No name	Three teams of two players	Yes	Ad hoc questionnaire	$P_{post} > P_{pre}$
Buchinger & da Silva Hounsell, 2018 (Brazil)	Sherlock Dengue 8	Teams of four players	Yes	Ad hoc questionnaire	$P_{post} > P_{pre}$
Calabor et al., 2018 (Spain)	Platform wars simulation	The formation of working teams takes place automatically.	Yes	Ad hoc questionnaire	$P_{post} > P_{pre}$
Capatina et al., 2018 (Italy, Franch, Romania)	Simbound	Students grouped into five teams for country	Yes	Game data analysis	Enhanced learning through play, increased areas of strategic planning, marketing campaign execution and performance analysis.
Cuccurullo et al., 2013 (Italy)	Pappi World	Social networking in the game (virtual collaboration)	Yes	Ad hoc questionnaire	$P_{post} > P_{pre}$
D'Aprile et al., 2015 (Italy)	Cibopolis game	Social networking in the game (virtual collaboration)	Yes	Ad hoc questionnaire	Significant relationship between the serious game *Cibopolis* and the learner attitudes and behaviors of nutrition and healthy lifestyle.
de Beer et al., 2023 (Netherlands)	Carion	Two teams of five students	No	/	/

Den Haan et al., 2020 (Netherlands)	Virtual River Game	Three teams of two people.	Yes	Ad hoc questionnaire	The acquisition of new knowledge and restructuring existing ones has enabled non-expert participants to achieve a more nuanced understanding of the functioning of the river system.
Goumopoulos et al., 2023 (Greece)	COGNIPLAT	Small groups of four to six	Yes	Evaluated by platform data. Tendency of the completion time of the game task over time.	$P_{post} > P_{pre}$ INT>CTL
Hummel et al., 2015 (Netherlands)	Mastership' game'	Teams of four or five people	Yes	Evaluation of the groups' reports.	There was no significant difference in learning between the online groups and the face-to-face groups.
Hummel et al., 2011 (Netherlands)	Aquaculture game	Social networking in the game (virtual collaboration)	Yes	Evaluation of the groups' reports before and after virtual collaboration.	Virtual collaboration using SGs improves learning effect.
Jouan et al., 2020 (Italy, France, Belgium, Poland)	SEGAE	Small groups of students	Yes	Ad hoc questionnaire	$P_{post} > P_{pre}$
Luz et al, 2016 (Brazil)	Dr. Ludens' LSG	Social networking in the game (virtual collaboration)	Yes	Ad hoc questionnaire	$P_{post} > P_{pre}$
Malegiannaki et al., 2020 (Greece)	Tracers of the Past	Five teams (teenagers) and four teams (adults)	Yes	Ad hoc questionnaire	$P_{post} > P_{pre}$
Meij et al., 2020 (Spain)	Enercities	16 pairs	Yes	Ad hoc questionnaire	Learning outcomes: the experimental group (scripted collaboration) significantly outperformed the control group (non-scripted collaboration in the knowledge test.
Nicolaidou et al., 2015 (Cyprus)	Virtual Emergency TeleMedicine (VETM)	Teams of two people	No	/	/
Oksanen & Hämäläinen, 2013 (Finland)	Game Bridge	14 teams of four to five people	No	/	/

Oo & Vallabhajosyula, 2022 (Singapore)	Protectors of Eshana	3 teams of three people to match the number of players in the game.	No	/	/
Pellas, 2014 (Greece)	Co.Co.I.A.	Teams of 5 people	No	/	/
Perry, 2021 (Canada)	Explore" and VdeUVic	Three teams	No	/	/
Romero & Usart, 2013 (Spain)	MetaVals	Three teams (in dyads)	Yes	Data from the MySQL database platform	The participants' scores in finance literacy: the individual phase of the game did not differ significantly across the three Time Perspective groups.
Saitua-Iribar et al., 2020 (Spain)	The Island	Teams of three people	Yes	Ad hoc questionnaire.	$P_{post} > P_{pre}$
Sanchez & Olivares, 2011 (Chile)	Evolution BuinZoo and Museum	Teams of four students	No	/	/
Sanchez et al., 2009 (Chile)	Evolution BuinZoo and Museum	Teams of four students	No	/	/
Terzidou et al., 2016 (Greece)	OsGame	15 teams of 2-3 people	No	/	/
Wendel et al., 2013 (Germany)	Escape from Wilson Island	Small teams of up to four players (one group with only three players)	No	/	/
Wong et al., 2022 (China)	Virtual ER	Teams of 4 or 5 players	Yes	Clinical skills: evaluated by a scoring system based on correct answers in the game.	INT=CTL
Xavier et al., 2023 (Portugal)	No name	Teams in classroom	No	/	/

Note. $P_{post:}$ Post evaluation. $P_{pre:}$ Pre evaluation. Ad hoc questionnaire: the questionnaire was developed by the researchers of the study and refers to knowledge related to the topic of learning, assessed pre and post measurement. INT: intervention group. CNT: control group.

Appendix C.

Typology, measures, and results of psychosocial constructs.

Study (country)	Constructs	Measures	Results
Andreoli et al., 2017 (Italy)	Cognitive: /	/	/
	Affective: /	/	/
	Social: /	/	/
	Enjoyment, satisfaction, engagement, usability: **satisfaction, enjoyment, usability.**	Ad hoc questionnaire.	Participants rated the level of engagement and immersion highly. Overall satisfaction with the game experience and usability was high.
	Other: /	/	/
Bossavit & Parsons, 2018 (United Kingdom)	Cognitive: /	/	/
	Affective: **motivation**	Questionnaire: *Intrinsic Motivation Inventory* (IMI) (Ryan & Deci, 2000)	The results indicated that participants found the game intrinsically motivating.
	Social: **social behaviors and engagement**	Observation of participants' behavior using the *'active other awareness'* and *'attentional other awareness'* approaches of Holt and Yuill (2014): interactions between children with ASD when completing a computer-based collaborative task and the behaviors that support (or do not support) task completion.	The game improved social interactions, particularly in cooperative modes where participants collaborated rather than competed. This improvement in social interaction was evident in behaviors that showed players were aware of and responsive to each other. Despite this, participants' overall engagement in game activities decreased over time, even though their disengagement or withdrawn behavior decreased across sessions.
	Enjoyment, satisfaction, engagement, usability: **enjoyment**	Questionnaire: *Scenario Experience Feedback Questionnaire* (SEFQ) (Weiss et al., 2011). Participants completed the questionnaire after the final session.	They reported high levels of interest and enjoyment, felt competent while playing, and perceived a good amount of choice in how they engaged with the game, despite some feeling pressure or tension during play.
	Other: /	/	/
Buchinger & da Silva Hounsell, 2018 (Brazil)	Cognitive:	/	/
	Affective: /	/	/
	Social: /	/	/

	Enjoyment, satisfaction, engagement, usability: /	/	/
	Other: **confidence**	Ad hoc questionnaire pre and post measurement	The confidence level in post-test was higher than in pre-test.
Calabor et al., 2018 (Spain)	Cognitive: decision **making and problem solving.**	Ad hoc questionnaire	Students perceive the serious game as useful to improve their profile in generic competences. Decision making (about 79%) and problem solving (76%) are the most practiced in the game.
	Affective: /	/	/
	Social: /	/	/
	Enjoyment, satisfaction, engagement, usability: /	/	/
	Other: **/**	/	/
Capatina et al., 2018 (Italy, Franch, Romania)	Cognitive: **decision-making skills**	*Qualitative comparative analysis* (QCA): time spent logged in by each student; number of decisions made; activity in the platform community (information gathered directly from *Simbound*).	Through the serious game, students are able to apply marketing theories in a practical and dynamic context, which helps to consolidate their understanding and improve their analytical and decision-making skills.
	Affective: /	**/**	**/**
	Social: /		**/**
	Enjoyment, satisfaction, engagement, usability: **engagement**	*Qualitative comparative analysis* (QCA*):* time spent logged in by each student; number of decisions made; activity in the platform community (information gathered directly from *Simbound*).	High levels of participation were generally associated with better performance, but some teams performed well with moderate levels of involvement, suggesting that the quality of decisions can compensate for less time spent on the platform.
	Other: /	/	/
Cuccurullo et al., 2013 (Italy)	Cognitive: /	/	/
	Affective: /	/	/
	Social: /	/	/
	Enjoyment, satisfaction, engagement, usability: **satisfaction and usability.**	Ad hoc questionnaire	Student survey: easy to use (70%); Easy to learn (100%); Very satisfied (100%); 100% of respondents would recommend the game to a friend; Express interest in future use (88%) Teacher survey: over half of respondents 'strongly agreed' that Pappi World was easy to play, with almost all others 'agreeing'. Similarly positive results were obtained when teachers were asked if they agreed with the game dynamics designed to motivate students to play Pappi World. This indicates teachers' interest in such educational tools and their intention to incorporate the game into their teaching.

	Other: /	/	/
D'Aprile et al., 2015 (Italy)	Cognitive: /	/	/
	Affective: /		/
	Social: **social presence**	Ad hoc questionnaire	Social aspects within the game had a moderate impact on players' opinions. The presence of social aspects supports clearly goal-oriented activities, to enhance social networking and to promote the acquisition of problem solving and communication, and metacognition.
	Enjoyment, satisfaction, engagement, usability: **usability and enjoyment**	Questionnaire*: System Usability Scale* (SUS) (Brooke, 1996) and items ad hoc built.	*Cibopolis* scored 75.22 out of 100 on the SUS scale, exceeding the average threshold of 68 and indicating an above-average ease of use. This suggests that the game is generally well received in terms of usability. Enjoyment was significantly influenced by ease of use and multimedia adequacy.
	Other: /	/	/
de Beer et al., 2023 (Netherlands)	Cognitive:	/	/
	Affective: /	/	/
	Social: /	/	/
	Enjoyment, satisfaction, engagement, usability: /	/	/
	Other: **Collaborative Problem Solving (CPS)**	Focus group on three main themes: collaboration, problem solving and learning from each other.	Qualitative method: students from both participating district teams indicated that they had experienced a positive learning effect on the development of their CPS skills, this came by taking time to consciously consider their CPS development on several occasions.
		Ad hoc questionnaire pre and post measurement	Quantitative method: no significant difference between pre and post measurements.
Den Haan et al., 2020 (Netherlands)	Cognitive: /	/	/
	Affective: /	/	/
	Social**: cooperation**	Ad hoc questionnaire, pre and post measurement	The results show that the game stimulated social learning. Participants reported an increased understanding and awareness of the dynamics of river management and the importance of cooperation between different stakeholders.
	Enjoyment, satisfaction, engagement, usability:	Post session de-briefing	The results indicate that the game was perceived as a useful participatory tool, which improved the quality of decisions and

	engagement Other: /	/	increased the acceptance of the proposed strategies. /
Goumopoulos et al., 2023 (Greece)	Cognitive: **cognitive functioning as memory, attention and executive functions.**	Neuropsychological standardized questionnaires, pre and post measurement.	Improvements in cognitive function were observed in the intervention group compared with the control group, demonstrating the effectiveness of the game in cognitive training. No significant differences were found for the CTL in any of the metrics.
	Affective: /	/	/
	Social: /	/	/
	Enjoyment, satisfaction, engagement, usability**: engagement and usability.**	Questionnaire*: System Usability Scale* (SUS) (Brooke, 1996)	High levels of engagement in the intervention group, with positive feedback on the game. The game received an average SUS score of 68, which is in the middle of the usability scale. This indicates that users found the platform usable.
	Other: **/**	/	/
Hummel et al., 2015 (Netherlands)	Cognitive: /	/	/
	Affective: /	/	/
	Social: /	/	/
	Enjoyment, satisfaction, engagement, usability: **satisfaction**	Ad hoc questionnaire	Students expressed a high level of satisfaction with the collaborative approach of the game. However, the online version required improvements to the game structure and instructions to increase clarity and reduce interaction complexity.
	Other: /	/	/
Hummel et al., 2011 (Netherlands)	Cognitive: /	/	/
	Affective: /	/	/
	Social: **collaboration**	Ad hoc questionnaire, pre and post measurement	Students showed a medium to low appreciation of virtual collaboration, with some finding online collaboration less rewarding than face-to-face. The results of the questionnaires showed an average for various aspects of collaboration, such as improved flexibility and relationship quality.
	Enjoyment, satisfaction, engagement, usability: /	/	/
	Other: **/**	/	/
Jouan et al., 2020 (Italy, France, Belgium, Poland)	Cognitive: /	/	/
	Affective: /	/	/

	Social: /	/	/
	Enjoyment, satisfaction, engagement, usability**: enjoyment and flow experience.**	E-Game Flow Scale (Fu et al., 2009)	Students perceive high levels of immersion, autonomy and social interaction during game play.
	Other: **/**	/	/
Luz et al, 2016 (Brazil)	Cognitive: /	/	/
	Affective: /	/	/
	Social: **behavioral change**	Questionnaire pre and post measurement. Knowledge, Attitudes and Practices surveys (KAP) (Launiala, 2009; Kleba & Wendausen, 2009).	Behavioral changes were evident, with an increase in the use of preventive measures such as the use of repellents and environmental management to reduce the presence of vectors.
	Enjoyment, satisfaction, engagement, usability: /	/	/
	Other: **/**		/
Malegiannaki et al., 2020 (Greece)	Cognitive: /	/	/
	Affective: /	/	/
	Social: /	/	/
	Enjoyment, satisfaction, engagement, usability: **engagement, enjoyment and usability**	Ad hoc questionnaire	The overall experience and story of the game were generally rated higher by adults. Adults also found the game easier and less complicated than teenagers, although their impressions of the length of the game were similar. The game was generally well received by teenagers. In terms of usability, the difficulty and perceived length of the game were rated quite low, but the confusion caused by the rules was rated moderate.
	Other: **/**	/	/
Meij et al., 2020 (Spain)	Cognitive:/	/	/
	Affective: **motivation**	FAM questionnaire (Rheinberg, Vollmeyer, & Burns, 2001; Vollmeyer & Rheinberg, 2006) before and after gameplay.	No difference between the conditions for challenge after gameplay.
	Social: **communication**	Dialogue communication: dialogues were recorded. De-briefing.	The higher frequency of upper-level (third and fourth level) dialogue acts in the scripted condition suggests deeper and more focused exchanges about important game mechanics.
	Enjoyment, satisfaction,	/	/

	engagement, usability: / Other: /	/	/
Nicolaidou et al., 2015 (Cyprus)	Cognitive: /	/	/
	Affective: /		/
	Social: /		/
	Enjoyment, satisfaction, engagement, usability: **engagement and usability**	Ad hoc questionnaire	The game's user interface was positively rated by players as user-friendly and straightforward, and the difficulty level was considered appropriate, although there were some less intuitive aspects. Despite the occasional misunderstanding, the feedback was found to be helpful for learning, and the game's educational value for emergency medical training was acknowledged. While there was room for improvement in the accuracy and clarity of medical terminology, user engagement was noticeably high.
	Other: /	/	/
Oksanen & Hämäläinen, 2013 (Finland)	Cognitive: /	/	/
	Affective: /	/	/
	Social: **perceived sociability and social presence**	Questionnaire included: 1) the sociability scale (Kreijns et al., 2007), and 2) the social presence module of the game experience questionnaire (Poels et al., 2008).	The results show that players' socio-emotional processes were effectively supported and facilitated by the game environment, which increased their sense of social presence and sociability in the virtual world. The information gathered from the surveys showed particularly positive results in these areas, suggesting that the game effectively promoted players' cooperation and social engagement.
	Enjoyment, satisfaction, engagement, usability: /	/	/
	Other: /	/	/
Oo & Vallabhajosyula, 2022 (Singapore)	Cognitive: /	/	/
	Affective: /	/	/
	Social: **communication and collaboration**	Ad hoc questionnaire, pre and post measurement	There was no significant difference in pre-test and post-test scores on communication and collaborative skills
	Enjoyment, satisfaction, engagement, usability: **usability and engagement**	Ad hoc questionnaire	Evaluation of the easy of use, usefulness of the application and effectiveness of application as an education tool. Seven out of nine participants agreed or strongly agreed with the fun factor associated with the game. The qualitative feedback indicates the potential for

			enhanced efficacy in the prototype through the incorporation of improved graphics, a more intuitive tutorial run, a user-friendly interface and controls, and an enhanced 3D environment
	Other: /	/	/
Pellas, 2014 (Greece)	Cognitive: /	/	/
	Affective: /	/	/
	Social:/	/	/
	Enjoyment, satisfaction, engagement, usability: **engagement**	Questionnaire on Student Engagement (Kong et al., 2003)	The *Behavioral Engagement* component had the highest value, according to the average engagement indicators, which were almost at a high level. Through exploration and collaborative activities, increasing social and emotional competence in an activity led to a corresponding increase in the *Cognitive Engagement* index. Within an organizational constructivist framework, there was a linear relationship between *Behavioral Engagement* and *Emotional Engagement*, which highlighted users' feelings of sociality and increased students' initiatives, making it easier for students to learn programming structures.
	Other: /	/	/
Perry, 2021 (Canada)	Cognitive: /	/	/
	Affective: /	/	/
	Social: **social regulation and interaction**	Ad hoc interviews, questionnaires pre and post measurement, and video analysis of game sessions	Throughout the game, interactions demonstrated a variety of social control strategies, including co-regulation and individual adaptation at different stages of content processing. High levels of co-regulation, indicative of successful collaborative learning, gradually increased over the course of the sessions, demonstrating participants' improved flexibility and ability to collaborate within the constraints of the game.
	Enjoyment, satisfaction, engagement, usability: **engagement**	Ad hoc interviews, questionnaires pre and post measurement, and video analysis of game sessions	The students showed a high level of engagement. They enjoyed the opportunity to communicate in a real environment and to use language in an immersive game environment. They discussed meanings and worked together to complete objectives and obstacles presented by the game in many rich and engaging interactions.

	Other:/	/	/
Romero & Usart, 2013 (Spain)	Cognitive: /	/	/
	Affective: /		/
	Social: /		/
	Enjoyment, satisfaction, engagement, usability: /	/	/
	Other: **temporal perspectives on time on task**	Zimbardo Time Perspective Inventory (ZTPI) (Zimbardo, & Boyd, 1999).	Future-oriented students showed slightly higher scores in the collaborative phases of the game than present-oriented students or those with balanced TP. However, the differences were not statistically significant, suggesting that TP did not directly affect individual or collaborative performance in the game.
Saitua- Iribar et al., 2020 (Spain)	Cognitive: /	/	/
	Affective: /	/	/
	Social: /	/	/
	Enjoyment, satisfaction, engagement, usability: /	/	/
	Other: **/**	/	/
Sanchez & Olivares, 2011 (Chile)	Cognitive: **problem solving**	Self-report questionnaire: scale for the perception of problem solving skills (Polya, 1957).	All students showed an increase in their problem solving skills, but only on the dimension of "strategy execution" did the experimental group outperform the control group in terms of statistical significance.
	Emotional: /	/	/
	Social: **collaboration**	Self-report questionnaire: scale for the perception of collaborative work (Johnson et al., 1994; Driscoll & Vergara, 1997; Sánchez, 2001).	Students in the experimental group showed improved perceptions of their collaborative skills compared to the control group. In particular, they reported significant improvements in the dimensions of work responsibility and work goals.
	Enjoyment, satisfaction, engagement, usability: **enjoyment and engagement**	Ad hoc questionnaire	Students in the experimental group were more positive about science lessons, finding them more enjoyable and stimulating than their peers in the control group. This suggests an improvement in motivation to learn science among students who participated in MSG-based activities.

	Other: /	/	/
Sanchez et al., 2009 (Chile)	Cognitive: **problem solving**	Self-report questionnaire: scale for the perception of problem solving skills (Polya, 1957).	The experimental group demonstrated superior performance to that of the control group, although the observed differences were not statistically significant.
	Affective: /	/	/
	Social: **collaboration**	Self-report questionnaire erception of collaborative work (Johr ; Driscoll & Vergara, 1997; Sánchez, 2001).	The experimental group demonstrated a greater willingness to collaborate with one another than the control group. The analysis of the five dimensions included in the scale (leadership, work responsibility, work objective, tutor's role, willingness to work in a group) revealed that the differences between both groups were significant in three of them: work responsibility, work objectives and leadership.
	Enjoyment, satisfaction, engagement, usability: /	/	/
	Other: /	/	/
Terzidou et al., 2016 (Greece)	Cognitive: **attitude and motivation**	Questionnaire pre and post measurement: A*ttitude towards course* in terms of course-value, course-enjoyment and course-motivation; *Attitude Towards Games* in terms of game-value, game enjoyment and game-motivation (Sisson, 2011).	The findings showed that before and after the intervention, there were no discernible systematic variations in the attitudes of the students between the two groups. However, attitudes about the course before and after the intervention, as well as attitudes toward the games before and after the intervention, showed statistically significant differences between the groups. No significant differences between the two groups' attitudes towards games before and after (M=Post: 3.84, SD=0.47) the intervention. However, there were significant differences between participants' enjoyment of games before (M=Pre: 3.70, SD=0.44) and after (M=Post: 3.98, SD=0.40) the intervention.
	Affective: /	/	/
	Social: **cohesiveness cooperation and involvement**	Questionnaire pre and post measurement: S*tudents' perception about their classroom environment* (Fraser, 1998). *Perceived Usefulness of the hypothetical use of agent* (Davis, 1989).	The results showed that there was no discernible difference between the two groups' perceptions of their learning environment. There were differences between pre and post 'cohesiveness' that were statistically significant. After the game is over, an intelligent gaming environment helps students to become more connected, supportive and helpful to each other. Students in the experimental group liked the pedagogical agents and said they helped during game sessions.

	Enjoyment, satisfaction, engagement, usability: /	/	/
	Other: /	/	/
Wendel et al., 2013 (Germany)	Cognitive: /	/	/
	Affective: /		/
	Social: **collaboration**	Analysis of recorded ion of collaborative behavior (team play, coordination between players, communication).	The results showed that the game effectively promotes collaborative behavior. To overcome the game's obstacles, players demonstrated successful collaboration by planning their moves, talking to each other and offering help. Teams with a clear leader tended to perform better, highlighting the value of coordination and leadership in group projects.
	Enjoyment, satisfaction, engagement, usability: **engagement and usability**	Ad hoc questionnaire	The post-game questionnaires showed that participants were highly motivated and engaged, indicating that they found the serious game enjoyable and challenging.
	Other: /	/	/
Wong et al., 2022 (China)	Cognitive: /	/	/
	Emotional: /	/	/
	Social: **teamwork**	Questionnaire pre and post measurement: *Human Factors Attitude Survey* (HFAS) (Helmreich, 1990).	The virtual emergency department significantly improved attitudes to teamwork. The mean pre-test HFAS score was 91.26 (SD 8.75), which increased to 94.27 (SD 10.46) at post-test, a significant improvement of 3.02 points. Notably, students with Activist and Pragmatist learning styles experienced significantly greater improvements in teamwork attitudes. Conversely, students identified as theorists and reflectors did not show statistically significant changes in their attitudes.
	Enjoyment, satisfaction, engagement, usability: **satisfaction**	Ad hoc questionnaire	With an high average game satisfaction score, the students demonstrated a significant level of satisfaction with Virtual ER. Most of the 62 players had positive things to say about the game.
	Other: /	/	/
Xavier et al., 2023 (Portugal)	Cognitive: /	/	/
	Affective: **emotional climate**	Questionnaire pre and post measurement: Emotional Climate in the Classroom Scale – Children (ECCS – C) (Albuquerque et al., 2019).	Calm and motivational emotions: only in the intervention group showed a significant increase from pre- to post-measurement and were stable in future assessments. Threat emotions: from post-measurement to 6-month follow-up,

			threat emotions decreased in both groups, indicating a reduction in stress over the academic year. Empathy: the children in the intervention group demonstrated a statistically significant increase in empathy from pre-measurement to all subsequent assessment points..
	Social: **social behaviors and collaboration**	Social-Emotional Skills: subscales from the Social and Emotional Skills (SSES) survey (OECD, 2019b). Questionnaire pre and post measurement + 2 follow up measurements (after 3 and 6 months).	In both the intervention and control conditions, the effect of time showed an average increase in cooperation from pre to post measurements. This increase may be related to the regularity of the school year, which provides more opportunities for this type of interaction.
	Enjoyment, satisfaction, engagement, usability: /	/	/
	Other: /	/	/

Note. The term "Ad hoc questionnaire" is employed in studies that utilize a single post-measurement. In the study conducted by De Beer et al. (2023), the CPS construct is classified as comprising cognitive skills pertaining to problem-solving and social skills, including collaboration, participation, perspective taking, and social regulation. The constructs identified in the study have been highlighted in bold.

Appendix D.

Assessment grid structure and criteria, independently applied by two evaluators to rate sub-group final reports (1–5 scale per criterion).

Criteri	*Descrittori e punteggi*	*Gruppo 1*	*Gruppo 2*	*Gruppo 3*
Originalità	1: L'elaborato è essenziale, senza contributi critici, risente di stereotipie. Le informazioni riportate mostrano un livello superficiale di rielaborazione dei contenuti. Non replicabile sul piano reale. 2: L'elaborato è svolto in modo semplice, con linguaggi/tecniche appropriati e arricchiti di qualche spunto critico. I contenuti sono affrontati con un approccio mediamente originale. Le informazioni riportate mostrano un livello superficiale di rielaborazione dei contenuti. Scarsamente replicabile sul piano reale. 3: L'elaborato è svolto in modo articolato, con buona varietà di contenuti e particolari che lo arricchiscono. Sono presenti buoni contributi personali le informazioni riportate mostrano un adeguato livello di rielaborazione. Mediamente replicabili sul piano reale. 4: L'elaborato è svolto in modo molto originale; le informazioni riportate mostrano un adeguato livello di rielaborazione e approfondimento dei contenuti. Replicabile sul piano reale. 5: L'elaborato prodotto risulta essere significativo ed originale, corretto e ben strutturato. Riflette criticamente sui contenuti riportati. Le informazioni riportate mostrano un ottimo livello di rielaborazione e approfondimento dei contenuti. Altamente replicabile sul piano reale.			
Livello di articolazione del progetto	1: L'elaborato prodotto presenta varie imperfezioni e una struttura poco coerente rispetto ai requisiti della consegna. 2: L'elaborato presenta contenuti organizzati e articolati in modo poco chiaro. L'organizzazione e strutturazione del lavoro risulta essere semplice, essenziale ed abbastanza corretta. 3: L'elaborato presenta contenuti organizzati e articolati in modo efficace. Ordine ed			

	equilibrio dell'organizzazione del testo nella strutturazione delle sue parti. 4: L'elaborato prodotto risulta essere ben sviluppato ed in gran parte corretto rispetto all'organizzazione degli argomenti e struttura del prodotto. 5: L'elaborato presenta contenuti articolati in modo efficace e coerente. Le parti sono correlate in modo congruo alle conoscenze richieste. Le sezioni del progetto sono state approfondite e articolate in modo chiaro e definite in ogni parte.			
Aderenza al modello CEPIDEAS	1: L'elaborato risulta insufficiente nella produzione: aderenza al modello, accuratezza nei linguaggi e nelle tecniche. I riferimenti al modello risultano frammentari e/o carenti. Le fonti selezionate risultano inappropriate o scarse. I collegamenti al modello di riferimento mostrano una scarsa conoscenza del tema. 2: L'elaborato è sufficiente nella produzione: aderenza al modello, accuratezza nei linguaggi e nelle tecniche. Presenti i riferimenti al modello e con poche fonti. I collegamenti al modello di riferimento mostrano una bassa conoscenza del tema. 3: L'elaborato è di livello discreto nella produzione: aderenza al modello, accuratezza nei linguaggi e nelle tecniche, completezza nella produzione. Le fonti risultano presenti e coerenti al modello. I collegamenti al modello di riferimento mostrano una adeguata conoscenza del tema. 4: L'elaborato è di buon livello nella produzione: aderenza al modello, accuratezza nei linguaggi e nelle tecniche, completezza nella produzione. Buon livello di padronanza della competenza richiesta. I collegamenti al modello di riferimento mostrano una buona conoscenza del tema. 5: L'elaborato è di livello eccellente nella produzione: aderenza al modello, accuratezza nei linguaggi e nelle tecniche, completezza nella produzione. Il lavoro risulta approfondito in tutte le sue parti. Presenza di fonti appropriate alla tematica trattata. I collegamenti al modello di riferimento mostrano un'ottima conoscenza del tema.			
Totale		***Nr***	***Nr***	***Nr***

Appendix E.

Questionnaire items and corresponding scales used to collect data in the third study.

Ricerca Team building_ SFP_ T1_23/24

Gentile studente/studentessa,

La invitiamo a partecipare ad una ricerca sull'esperienza universitaria. Attraverso il presente questionario, intendiamo verificare l'incremento delle competenze collaborative di studenti/studentesse universitari/e attraverso un approccio esperienziale e gamification, e analizzare l'attuale esperienza di studio in Università, al fine di promuovere modalità didattiche innovative. Ecc….

APSP

Le affermazioni del questionario descrivono alcune situazioni che si presentano comunemente all'università e/o nella vita di tutti i giorni. Leggi attentamente ogni affermazione e indica quanto ti senti in grado di affrontare ciascuna situazione descritta, scegliendo la risposta che meglio descrive la tua esperienza, da 1 =“Per nulla”, a 4= “Del tutto”.

1. Individuare soluzioni alternative positive di fronte ai problemi.
2. Anticipare le possibili conseguenze delle diverse alternative individuate di fronte ad un problema.
3. Generare e discutere soluzioni prima di prendere una decisione.
4. Affrontare qualcosa di nuovo senza che qualcuno ti spieghi come procedere.
5. Andare controcorrente e pensare in modo diverso dagli/dalle altri/e.
6. Essere un “vulcano” di idee.
7. Accertare la credibilità delle fonti di informazione.
8. Distinguere tra contenuto di un'informazione e le intenzioni di chi la trasmette.
9. Riconoscere i principi che stanno alla base di un ragionamento.
10. Inventare nuove procedure anziché limitarti a seguire quelle stabilite da altri/e.
11. Trovare modi diversi per fare le stesse cose per evitare la ripetizione e la noia.
12. Affidarti all'intuito.
13. Fare più cose contemporaneamente.

    Cercare ulteriori informazioni quando hai dei dubbi su quelle che possiedi.

TSY

Di seguito troverai elencate alcune affermazioni. Valuta quanto sei d'accordo con ciascuna di esse scegliendo la risposta che meglio descrive quello che pensi, da 1 =''Pienamente in disaccordo'' a 5 ''Pienamente in accordo''. Non esistono risposte giuste o sbagliate.

1. Penso che il lavoro di squadra sia importante.
2. Le persone che lavorano in gruppo imparano di più rispetto alle persone che lavorano da sole.
3. Mi sento in grado di lavorare in gruppo.
4. So come dare ai membri del mio gruppo un feedback che non ferirà i loro sentimenti.
5. Chiedo agli/alle altri/e componenti del gruppo dei feedback.
6. Faccio uno sforzo per includere altri membri nel mio gruppo.
7. Apprezzo i contributi dei membri del mio gruppo.
8. Tratto tutti i membri del mio gruppo in egual modo.
9. Riesco a comunicare bene con i membri del mio gruppo.
10. Sento di avere le capacità per essere un leader.

KSA

Le seguenti affermazioni si riferiscono a come generalmente lavori in gruppo. Da 1="Fortemente in disaccordo" a 6="Fortemente in accordo", indica il tuo grado di accordo/disaccordo con ciascuna di queste affermazioni.

1. I/le colleghi/e mi dicono spesso che sono aperto/a e accogliente con le altre persone
2. I/le miei/mie colleghi/e mi dicono spesso che hanno la sensazione che io rispetti la loro opinione
3. Nelle attività di gruppo mi è capitato spesso di chiedere supporto agli altri membri del gruppo nella soluzione di un problema
4. Durante le attività di gruppo mi è capitato spesso di coinvolgere altri gruppi di lavoro per risolvere problemi specifici
5. Durante le interazioni in un lavoro di gruppo ho cercato sempre di garantire che ciascun componente potesse condividere il proprio punto di vista
6. I membri del mio gruppo mi hanno spesso chiesto di aiutarli a risolvere conflitti con altri colleghi/e.

7. Quando si è verificato un conflitto tra colleghi/e, ho saputo cosa fare per risolvere la situazione.
8. Spesso sono riuscito a risolvere conflitti con i colleghi/e
9. Ho dato spesso feedback costruttivi sulla performance ai membri del gruppo di lavoro
10. Nell'impostazione di un nuovo lavoro di gruppo, ho definito chiaramente i compiti, in modo che il gruppo sapesse esattamente cosa fare
11. All'inizio di un nuovo lavoro di gruppo, mi sono sempre assicurato/a che i ruoli e le responsabilità dei membri del gruppo fossero chiare e comprese
12. Quando mi sono posto/a degli obiettivi, mi sono sempre assicurato/a che fossero sfidanti ma realistici
13. Quando ho definito degli obiettivi per il mio gruppo di lavoro, mi sono assicurato/a che fossero sfidanti ma raggiungibili
14. Quando ho impostatogli obiettivi per il mio gruppo di lavoro, ho stabilito tempi specifici per il loro completamento
15. Per aumentare il rendimento dei/ delle miei/mie colleghi/e, ho fornito periodicamente feedback specifici rispetto a ciò che era stato fatto bene

EGAMEFLOW Scale

Valuta il tuo grado di accordo/disaccordo con le seguenti affermazioni riferite all'esperienza di gioco con l'utilizzo del Serious Game "Zooteams", da 1= "Completamente in disaccordo" a 7 = "Completamente in accordo".

1. Il gioco ha catturato la mia attenzione.
2. Il gioco ha fornito contenuti che hanno stimolato la mia attenzione.
3. Durante il gioco non mi sono distratto/a.
4. In generale, sono riuscito/a a rimanere concentrato/a sul gioco.
5. I compiti di gioco sono stati adeguati per me
6. Ho capito gli obiettivi di questo gioco fin dall'inizio.
7. Gli obiettivi complessivi del gioco sono stati chiari per me.
8. Ho capito la progressione complessiva del gioco.
9. Sono riuscito/a a capire cosa sarebbe successo nei passaggi successivi del gioco.
10. Ho capito cosa fare per vincere/completare la partita.
11. Il gioco ha fornito feedback sui progressi nel corso della partita.

12. Il gioco ha fornito feedback immediati sulle azioni svolte.
13. Il gioco forniva immediatamente informazioni sulle prestazioni.
14. Sono stato/a sempre a conoscenza del tempo di gioco.
15. Il livello di difficoltà in questo gioco è adatto a me.
16. Le mie abilità miglioravano gradualmente nel corso del gioco.
17. Sono stato/a motivato/a dal miglioramento delle mie abilità.
18. Il gioco propone nuove sfide ad un ritmo adeguato.
19. Il gioco offre tipologie di sfida adatte a giocatori diversi.
20. Ho sentito di avere il controllo sul gioco.
21. Ho sentito di avere il controllo sulle azioni da compiere durante il gioco.
22. Ho sentito di avere il controllo sulle mie interazioni con il gioco stesso.
23. Ho sentito di poter usare strategie liberamente.
24. Non mi sono accorto/a del tempo che passava durante il gioco.
25. Durante il gioco mi sono estraniato/a da ciò che mi circondava.
26. Sono riuscito/a ad immergermi profondamente nel gioco.
27. Mi sono sentito/a emotivamente coinvolto/a nel gioco.
28. Mi sono sentito/a connesso/a agli altri/e giocatori/trici quando giocavo.
29. Il gioco ha sollecitato l'interazione tra i/le componenti del gruppo.
30. Il gioco ha stimolatolo spirito di squadra durante la partita.
31. La relazione con gli/le altri/e giocatori/trici mi ha aiutato a migliorare le mie abilità di gioco.