Contemporary Educational Technology, 2026, **18**(2), ep659
ISSN: 1309-517X (Online)

OPEN ACCESS

Review Article

Do digital serious games in collaborative settings promote learning and psychosocial skills? A systematic review

Isabella Giacchi [1*]
0009-0005-7675-4081

Antonia Lonigro [2]
0000-0001-9280-4302

Federica Zava [1]
0000-0003-4007-535X

Giovanni Maria Vecchio [1]
0000-0001-6452-4995

[1] Department of Education, Roma Tre University, Rome, ITALY
[2] Department of Developmental and Social Psychology, Sapienza University of Rome, Rome, ITALY
[*] Corresponding author: isabella.giacchi@uniroma3.it

Citation: Giacchi, I., Lonigro, A., Zava, F., & Vecchio, G. M. (2026). Do digital serious games in collaborative settings promote learning and psychosocial skills? A systematic review. *Contemporary Educational Technology, 18*(2), Article ep659. https://doi.org/10.30935/cedtech/18599

ARTICLE INFO

Received: 12 Jan 2026
Accepted: 22 Apr 2026

ABSTRACT

Digital serious games (DSGs) in collaborative settings are increasingly explored for their potential to support 21st century skills, particularly collaboration. However, existing literature still offers a fragmented picture of their impact on collaborative competences. Thus, this study aims to (1) map empirical research on DSGs in collaborative contexts—highlighting theoretical frameworks, application fields, and assessment methods for knowledge acquisition and psychosocial skills—and (2) examine their effectiveness, identifying which components of collaborative competence and group dynamics are supported. Following PRISMA guidelines, the literature search identified 29 studies reporting empirical evidence on the use of DSGs in collaborative settings, using the search terms "serious game*" AND "learning" AND "cooperat*" OR "collaborat*." The studies selected are highly heterogeneous in frameworks, aims and methods, reflecting the multidisciplinary nature of DSG research. Main findings show that research on DSGs in collaborative contexts is highly heterogeneous and predominantly based on experimental and quasi-experimental designs, with a strong focus on short-term outcomes such as knowledge acquisition and user satisfaction. Results indicate also that DSGs mainly support collaboration through interconnected cognitive, affective, and social mechanisms, particularly when embedded within structured frameworks such as computer-supported collaborative learning. However, evidence on longitudinal effects and deeper group processes remains limited, revealing a gap between short-term learning outcomes and the analysis of sustained group dynamics. Future research on DSG interventions aiming to more effectively capture group processes should adopt standardized definitions, use validated instruments for assessing collaboration, and implement longitudinal designs grounded in structured collaborative methodologies.

Keywords: digital serious games, collaboration, systematic review, learning outcomes, psychosocial skills

INTRODUCTION

The integration of digital serious games (DSGs) into collaborative settings has opened new opportunities for the development of 21st century skills. DSGs can be defined as interactive digital applications designed with both entertainment and educational purposes, engaging learners in simulated scenarios that foster

active knowledge experience (Bergeron, 2006; Prensky, 2001). Their adoption is growing across a wide range of contexts, including formal education, vocational training, and professional development (Kara et al., 2020; Laamarti et al., 2014). The provision of dynamic experiences has been demonstrated to be effective in promoting motivation and engagement, which are critical factors in facilitating effective learning (Breuer & Bente, 2010; Dondlinger, 2007; Ke, 2016; Lim-Fei et al., 2016; Nazry & Romano, 2017; Wouters et al., 2013; Zhonggen, 2019). Through the use of game mechanisms such as narrative structures, performance feedback, and the integration of advanced digital technologies (e.g., virtual reality [VR]), DSGs provide alternatives to traditional instructional methods while enabling the assessment of soft skills in authentic-like situations (Altomari & Valenti, 2023; Georgiou et al., 2019; Rocha et al., 2008).

Concurrently, the recent challenges posed by the post-pandemic context have accelerated the integration of experiential practices in education, expanding research on computer-supported collaborative learning (CSCL) due to its potential in digital learning to promote online social interaction (Cesareni & Cacciamani, 2015; Selwyn, 2012). In this perspective, collaboration emerges as a core social skill required for success in contemporary academic and professional environments, defined as a socio-emotional competence involving constructive interaction, shared responsibility, and coordinated effort to achieve common goals (Mattessich & Monsey, 1992; OECD, 2019; Oliveri et al., 2017). Moreover, collaboration is a socio-cognitive construct shaped by the interplay of various elements, including personal competencies and dispositions, team dynamics, interpersonal relationships, mutual trust, and contextual factors such as the nature of the task and the tools involved (Andrews-Todd & Forsyth, 2020; Patel et al., 2012). In this regard, DSGs implemented in group contexts are posited to be especially effective to enhance collaboration, teamwork, and communication skills, reinforcing the social dimension of learning (Martí-Parreño et al., 2021). DGSs require individuals to coordinate actions and engage in joint decision-making (Salen & Zimmerman, 2004), negotiation and conflict resolution, thereby maximizing the development of collaboration and teamwork—a critical element where the value of collaborative outcomes often surpasses individual gains (Hamalainen et al., 2006; Wood & Gray, 1991; Zichermann & Cunningham, 2011). Moreover, research on soft skills in digital environments is undergoing rapid expansion, leading to the emergence of novel approaches to how to assess them with and through digital technologies (Chai et al., 2024). However, the assessment of outcomes in collaborative settings using DSGs poses significant methodological challenges: variability in the use of measures for assessing soft skills hinders the comparison of impact and outcomes across research studies (Carenys & Moya, 2016; Krath et al., 2021; Lamb et al., 2018; van Laar et al., 2020).

Previous Works

Previous studies on serious games (SGs) and collaboration have provided valuable, but limited, insights into this research area. One of the most important studies is that of Connolly et al. (2012). This systematic review offered insights into empirical evidence regarding computer games and SGs in relation to the dimensions of learning, engagement, and skills acquisition. While their multidimensional framework usefully categorized cognitive, affective, motivational, and social outcomes, collaboration was treated as a generic or secondary outcome rather than as a distinct construct. Furthermore, the review combined studies conducted at the individual level with those involving group interaction without explicitly examining outcomes from collaborative digital environments. Additionally, the review covered not only SGs, but also computer games that were not intended for educational purposes.

Another relevant study is the systematic review by Wang and Huang (2021), which focuses on collaboration by examining theoretical frameworks, game mechanics, and design features that encourage collaboration. Their contribution significantly advances our understanding of *how* to design collaborative games. However, the review places limited emphasis on evaluating learning and psychosocial outcomes arising from collaborative gameplay. It relies predominantly on self-report measures and pays less attention to the effectiveness of outcomes across studies.

Din et al. (2023) updated mappings of SGs by examining application domains, evaluation methods, and quality attributes across disciplines. However, collaboration was not conceptualized as a focal dimension of analysis, nor were collaborative learning processes or group-level outcomes systematically distinguished from individual learning effects. As a result, insights into how DSGs support collaboration—and which collaborative processes are empirically assessed—remain fragmented.

To address this gap, the present review proposes an investigation of DSGs in collaborative settings, with a particular emphasis on their impact on knowledge and psychosocial outcomes associated with them, as well as related attention to group composition and processes. Building on the outcome categorization proposed by Connolly et al. (2012), this review aims

(1) to identify the theoretical frameworks underpinning studies on DSGs in collaborative settings,

(2) to analyze the overall effectiveness of the interventions presented in the literature, and

(3) to examine which aspects of collaboration are targeted or neglected.

Research Questions

The purpose of this study is twofold. First, it aims to systematically map the landscape of empirical research on DSGs in collaborative settings, examining the theoretical frameworks, contexts of application, and the assessment of knowledge and soft skills outcomes. Second, it seeks to critically evaluate the evidence of effectiveness, specifically identifying which aspects of collaborative competence and group dynamics are supported or not.

Based on these objectives, four research questions (RQs) were formulated:

1. **RQ1.** Which theoretical frameworks are used in selected studies involving DSGs in collaborative settings?
2. **RQ2.** In which learning contexts are DSGs implemented, and which learner populations are targeted?
3. **RQ3.** What is the reported effectiveness of DSGs in collaborative settings on cognitive, affective, social, and knowledge acquisition outcomes in the included studies?
4. **RQ4.** Which specific aspects of collaborative competence and group dynamics are supported by DSGs, and which remain underexplored?

METHOD

Analytical Approach

Preliminarily, inclusion criteria (IC) and exclusion criteria (EC) were established. Then, the identification and selection of articles were conducted following the PRISMA model (Moher et al., 2009), which included the calculation of inter-rater reliability among evaluators. After establishing the final set of articles included in the review, the data were analyzed using a qualitative content analysis approach (Elo & Kyngäs, 2008). Extracted data were organized into thematic tables and examined through a combined deductive-inductive approach. An initial coding framework was developed inductively based on the data from the selected studies. Subsequently, further categorizations were guided deductively by the classification proposed by Connolly et al. (2012). The resulting categories were iteratively refined and used to synthesize the findings. To ensure the reliability of the analysis, peer debriefing was conducted, with coding decisions and category development regularly discussed among the authors.

Inclusion and Exclusion Criteria

To determine which records were eligible for selection, the following IC were applied.

1. **IC1.** Studies were eligible for inclusion if they involved DSG, defined according to Bergeron (2006) as digital games developed for educational purposes. The term “serious games” was deliberately used during the search process to retrieve as many relevant studies as possible, as it is more commonly adopted in the literature than the more specific label “digital serious games.” During the selection phase, only studies explicitly using DSGs, applicable in face-to-face and/or remote mode, were retained.
2. **IC2.** Only empirical studies reporting original research were considered, including those with quantitative and/or qualitative data, to ensure a comprehensive assessment of outcomes. Eligible studies were within formal or informal learning contexts, including educational, vocational, and professional training environments.

Table 1. Summary table of the exclusion criteria

Exclusion criteria	Description
EC1	Absence of empirical studies on DSGs in learning contexts
EC2	Absence of quantitative/qualitative outputs
EC3	The DSG is not used in collaborative settings (groups or pair)
EC4	Dissertation/book chapter/conference proceedings/report/commentaries
EC5	Reviews of the literature
EC6	Publications in languages other than Italian, English, and Spanish

3. **IC3.** A core requirement was that the DSGs were implemented in collaborative settings, either in groups or pairs, to investigate the influence of the group context. Studies integrating advanced technologies, such as VR or similar, as support of collaborative DSGs, were also considered eligible.
4. **IC4/IC5.** Only peer-reviewed academic publications were included. This decision was made to ensure methodological rigor, transparency, and the inclusion of empirically grounded evidence. Dissertations, book chapters, conference proceedings, report and commentaries were excluded due to their potential variability in methodological quality, lack of formal peer-review processes, and/or absence of empirical findings. Literature reviews were excluded to avoid overlapping with primary studies.
5. **IC6.** Finally, given the authors' language capabilities, only publications available in English, Italian, or Spanish were considered.

Details regarding the corresponding EC are presented in **Table 1**.

Literature Search and Inter-Rater Reliability

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. Keywords were selected from our theoretical framework to align with the research objectives and included domain-specific terms ("serious game*" AND "learning" AND "collaborat*" OR "cooperat*"). The search was performed by "abstracts" only, in each database. No restrictions were placed on the year of publication to ensure a comprehensive retrieval of all relevant evidence.

The search, performed in April 2024, initially yielded a total of 305 records. Following the removal of duplicates, 162 records remained for systematic screening against the predefined IC. The screening process was conducted in two sequential stages: first, a review of titles and abstracts to establish initial eligibility; second, a full-text screening of those records retained from the previous stage. This comprehensive search and selection process is illustrated in a flow diagram constructed according to the PRISMA model (Moher et al., 2009), presented in **Figure 1**. To calculate inter-rater reliability, two independent researchers screened the records. Agreement between raters was assessed using Cohen's kappa (Cohen's K), which was calculated based on the number of concordant and discordant ratings. In cases of disagreement, the articles were discussed among researchers until a consensus was unanimously reached.

The screening process involved two main stages: firstly, title and abstract screening, following the initial screening of titles and abstracts, 85 records were excluded. The inter-rater agreement for this stage was notably high, with a Cohen's K value of .889 ($p < .001$). Secondly, full text screening: the remaining 77 papers proceeded with a comprehensive full-text evaluation. The inter-rater agreement for the full-text screening remained high, with a Cohen's K of .864 ($p < .001$). Following this final assessment, 29 studies were selected for inclusion in the systematic review (**Figure 1**).

RESULTS

General Characteristics of the Selected Studies

Years of publication

Selected studies were published between the years 2011 and 2023. From 2018 there was a notable increase in the number of studies that incorporated collaborative DSGs in educational and training interventions (**Figure 2**).

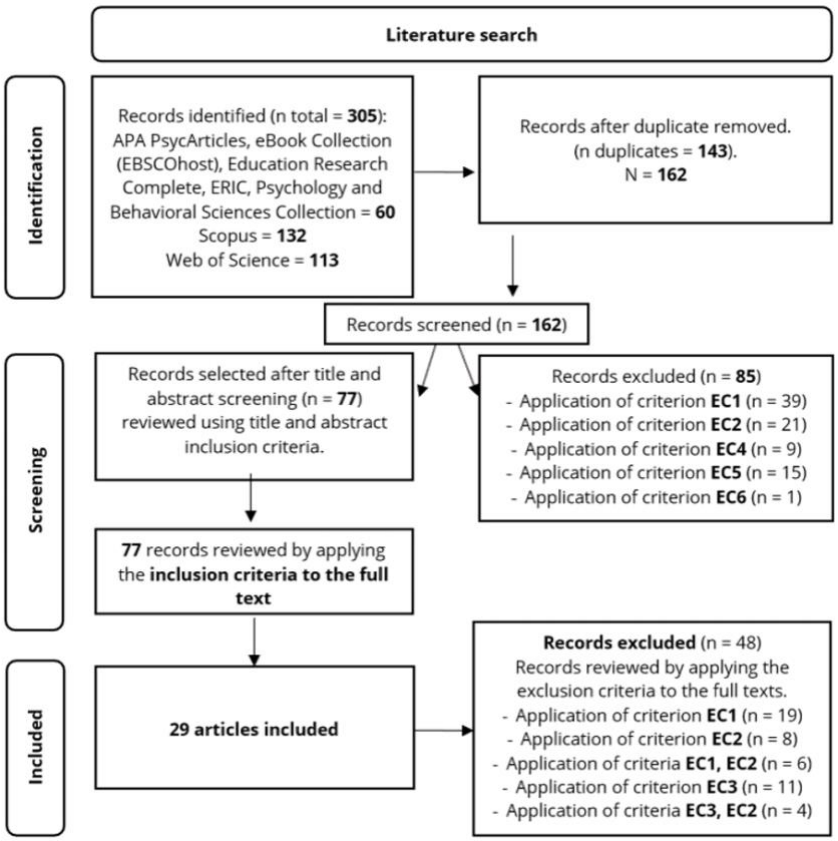

Figure 1. PRISMA flow diagram outlining the search and study selection process (as reported in **Table 1**) (Source: Developed by the authors based on the PRISMA guidelines, Moher et al., 2009)

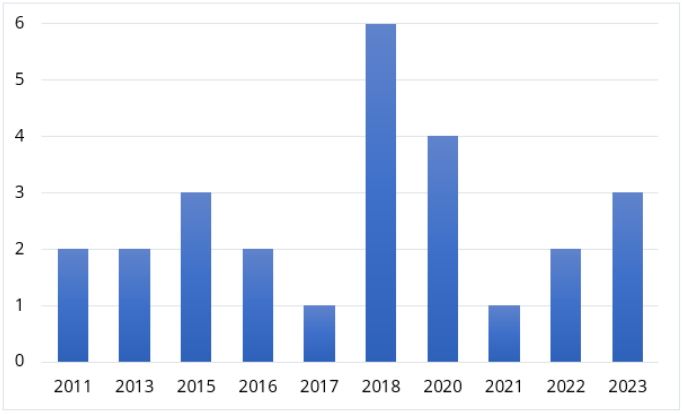

Figure 2. Articles by year of publication (Source: Developed by the authors)

Study design

Seventeen of the twenty-nine studies utilized experimental or quasi-experimental research designs, with some explicitly noting specific pilot studies for testing the DSGs in collaborative settings (Bossavit & Parsons, 2018; Buchinger & da Silva Hounsell, 2018; Cuccurullo et al., 2013; D'Aprile et al., 2015; Jouan et al., 2020; Meij et al., 2020; Oksanen & Hämäläinen, 2013; Oo & Vallabhajosyula, 2022; Pellas, 2014; Romero & Usart, 2013; Saitua-Iribar et al., 2020; Sánchez & Olivares, 2011; Sánchez et al., 2009; Terzidou et al., 2016; Wong et al., 2022). Only two of these were randomized controlled trials (Goumopoulos et al., 2023; Xavier et al., 2023). Eight studies employed a mixed-methods approach, combining qualitative and quantitative analyses (De Beer et al., 2023; Den Haan et al., 2020; Hummel et al., 2011, 2015; Malegiannaki et al., 2020; Nicolaidou et al., 2015; Perry, 2021; Wendel et al., 2013). The remaining four studies consisted of three qualitative research designs (Calabor et al., 2018; Capatina et al., 2018; Luz et al., 2016) and a single case study (Andreoli et al., 2017).

Table 2. Number of studies per application field

n	Application field	Study
2	Cultural Heritage	Andreoli et al. (2017), Malegiannaki et al. (2020)
1	Geography content	Bossavit and Parsons (2018)
1	Dengue fever	Buchinger and 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 and Hämäläinen (2013), Saitua-Iribar et al. (2020), Sanchez and 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 and Vallabhajosyula (2022), Wong et al. (2022)
1	Learning a language	Perry (2021)
1	Financial literacy	Romero and Usart (2013)

Note. n: Number of studies

Application field of the selected studies

As shown in **Table 2**, most studies adopt DSGs in collaborative settings primarily to support knowledge acquisition within specific subject areas. Sustainability emerges as the most frequently addressed field. Other fields of application, such as cultural heritage, river management, and medical training, are frequently mentioned in studies. Despite this diversity, the distribution remains highly fragmented, with several topics mentioned by only one or two studies (e.g., geography, financial literacy, and neglected tropical diseases). A smaller yet relevant group of studies focuses instead on skills-oriented outcomes, including collaboration, communication, social competence and cognitive skills. These studies shift the emphasis from discipline-specific content toward the development of soft skills increasingly required in both educational and professional settings. Nevertheless, these contributions persist in being underrepresented in comparison to knowledge-driven approaches.

RQ1. Theoretical Framework Involving DSGs in Collaborative Settings

Selected studies report the presence of theoretical frameworks reflecting a wide range of psycho-pedagogical approaches that were adopted in the research on DSGs in collaborative settings (**Appendix A**). CSCL framework (Gunawardena et al., 1997; Kagan et al., 2000; Van Bruggen et al., 2002) places significant role in the utilization of digital environments to facilitate collaboration and, in turn, to enhance learning interactions. This framework has been referenced in eight studies (Hummel et al., 2011, 2015; Goumopoulos et al., 2023; Meji et al., 2020; Oksanen & Hämäläinen, 2013; Perry 2021; Terzidou et al., 2016; Wendel et al., 2013), which lend support to the theory that group is central for learning. In particular, the framework posits that sharing and direct interaction lead to greater knowledge assimilation and application. This is achieved by guiding the interacting partners through a sequence of interaction phases with designated activities and roles. These studies provide evidence of the effectiveness of assigning roles within collaborative groups to promote participation and collaborative learning. 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., 2013; Wong et al., 2022) refer to theories of experiential learning and social constructivist theories using DSGs, 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 studies that implemented theories of learning by doing (Cuccurullo et al., 2013), narrative-centered learning (Malegiannaki et al., 2020) and the social emotional learning approach (Collaborative for Academic Social and Emotional Learning [CASEL], 2015; Xavier et al., 2023).

Five studies report framework related to participatory design (PD) (Bossavit & Parsons, 2018) and collaborative problem-solving (CPS) (Capatina et al., 2018; De Beer et al., 2023; Sánchez & Olivares, 2011; Sánchez et al., 2009). Four studies use specifics theoretical frameworks: the FRECH model in Andreoli et al. (2017), the ARCS model of Keller (1987, 2008) in Terzidou et al. (2016), the motivational theories of Malone and Lepper (1987) in Buchinger and da Silva Hounsell (2018) and the Csikszentmihalyi's (1990) flow theory in Jouan et al. (2020). The objective of these studies was to increase the engagement and motivation of participants who use a DSG, thus facilitating a deeper and more permanent learning experience.

The studies conducted by Nicolaidou et al. (2015) and Oo and Vallabhajosyula (2022) are based on problem-based learning approach to create and implement DSGs to foster teamwork skills in adult medical education for healthcare education and non-technical skills (NTS). Two articles (Cuccurullo et al., 2013; Romero & Usart, 2013) adopted the game-based learning (GBL) approach to enhance the potential of a gamified environment to promote learning, focusing on specific areas of intervention, such as time perspective (TP).

RQ2. Learning Contexts and Populations

Regarding the context of application considered in the selected studies, they can be summarized as follows: higher education (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). About 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. Some studies included healthcare workers, paramedics and medical researchers, experts from professional working groups and general voluntary people (n = 3). Furthermore, studies have demonstrated the efficacy of DSGs in non-formal learning environments. 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) (**Appendix A**).

RQ3. Effectiveness of DSGs in Collaborative Settings on Outcomes Related to Knowledge Acquisition and Psychosocial Outcomes

Knowledge-related outcomes: Emerging trends and gaps

To address the **RQ3**, we considered the variables related to the presence or absence of evidence of knowledge acquisition (**Appendix B**) and psychosocial outcomes (**Appendix C**) in the selected studies that use DSGs in collaborative settings. A prevailing tendency has been observed, suggesting that the implementation of DSGs in collaborative environments tends to promote learning enhancement. Out of twenty-nine studies, eighteen reported a significant positive impact on learning outcomes, reflected in higher post-test or post-game scores compared to pre-test measures. Most studies assessed learning through self-report questionnaires, complemented by behavioral data (e.g., login time, decision counts, and platform activity) and performance evaluations such as group reports. The divergence in measurement tools signals a clear trend toward the multi-dimensional evaluation of learning outcomes.

DSGs applied in collaborative settings demonstrate positive learning outcomes across diverse fields. Several studies (Cuccurullo et al., 2013; Meij et al., 2020; Oksanen & Hämäläinen, 2013; Saitua-Iribar et al., 2020; Sánchez & Olivares, 2011; Sánchez et al., 2009) reported increased awareness and understanding of environmental sustainability among school and university participants. In cultural heritage, studies by Andreoli et al. (2017) and Malegiannaki et al. (2020) highlighted improved historical and cultural knowledge, indicating that DSGs can foster situated learning and contextual understanding. In health education, DSGs such as "Cibopolis" (D'Aprile et al., 2015) and "Dr Ludens' LSG" (Luz et al., 2016) effectively supported knowledge acquisition and behavioral awareness related to health promotion and disease prevention. In business and professional education, studies by Calabor et al. (2018) and similar studies (Capatina et al., 2018) suggest DSGs facilitate conceptual understanding and applied knowledge in business, accounting, and management contexts.

A number of studies have indicated that the process of learning may extend beyond the mere recall of content, potentially impacting participants' awareness, decision-making skills, and self-perceived competence (e.g., Buchinger & da Silva Hounsell, 2018). This reflects a trend toward transformative learning outcomes,

where DSGs support both cognitive and behavioral dimensions of knowledge application. While most studies have reported positive outcomes, it is important to note that a minority of studies (Hummel et al., 2015; Wong et al., 2022) have found no significant differences in learning outcomes. These findings were attributed to two factors: the absence of a control group and the unclear instruction of the use of the game.

Psychosocial outcomes: Emerging trends and gaps

In the analysis of psychosocial outcomes, we identified the cognitive, affective, and social dimensions (Connolly et al., 2012) highlighted in the selected studies (**Appendix C**). Six studies (Calabor et al., 2018; Capatina et al., 2018; Goumopoulos et al., 2023; Sánchez & Olivares, 2011; Sánchez et al., 2009; Terzidou et al., 2016) reports evidence in DSGs used in collaborative settings stimulating analytical reasoning, decision-making, and problem-solving. Games designed around authentic and complex scenarios (e.g., Calabor et al., 2018; Capatina et al., 2018) required participants to apply theoretical knowledge in dynamic environments, promoting deep learning through situated cognition. Evidence from Sánchez and Olivares (2011) and Sánchez et al. (2009) further indicates measurable improvements in strategic thinking and teamwork-related cognitive performance, with experimental groups outperforming controls. Additionally, Goumopoulos et al. (2023) demonstrated that DSGs can foster cognitive rehabilitation, enhancing executive functioning among older adults with mild cognitive impairment (MCI).

Fourteen studies provided evidence that interventions with DSGs are associated to the affective growth and social competence, particularly by facilitating cooperation, empathy, and social awareness. In interventions involving both neurotypical and special populations (Bossavit & Parsons, 2018), DSG enhanced social responsiveness and peer interaction. Several studies (e.g., Oksanen & Hämäläinen, 2013; Perry, 2012; Wendel et al., 2013) report that DSGs fostered social presence, co-regulation, and collaborative adaptation. Findings also suggest that structured collaboration mechanisms (e.g., scripted roles or goal-oriented tasks) enhance communication quality and cooperative behaviors (Hummel et al., 2011; Meij et al., 2020). Moreover, games integrating real-world social learning contexts (e.g., Den Haan et al., 2020; Luz et al., 2016) produced behavioral changes extending beyond gameplay—such as increased use of preventive health practices and more reflective environmental management attitudes**.**

Twenty-two studies reported strong evidence that enjoyment, satisfaction, and engagement are the most common dimensions found in interventions with DSGs. Participants frequently rated DSG as highly enjoyable, immersive, and usable, according to both researcher-developed measures and validated assessment tools, e.g., *E-game flow scale* (Fu et al., 2009) or *Questionnaire on student engagement* (Kong et al., 2003). These dimensions were often correlated in the studies with increased motivation and cognitive engagement, underscoring their mediating role between emotional involvement and learning performance.

A smaller set of studies examined additional dimensions such as confidence, TP, and CPS (OECD, 2017). While confidence tended to increase following gameplay (Buchinger & Da Silva Hounsell, 2018), other variables such as time orientation (time-on-task) (Romero et al., 2013) and CPS (De Beer et al., 2023) produced non-significant effects. In the first case, the lack of effectiveness can be addressed to the size of the sample (24 students) while in the second case, the effectiveness of the qualitative data isn't confirmed by the quantitative data. These results suggest that DSGs in collaborative settings demonstrate potential for short-term efficacy on soft skills, but their long-term impact remains undemonstrated.

RQ4. Collaboration and Group Dynamics in DSGs

In order to respond to the **RQ4**, the reviewed studies reveal patterns to analyze how DSGs used in collaborative settings can support collaborative competence and group dynamics. **Appendix B** specifies the structure of the teams employed in the studies. Overall, the groups across the 29 studies ranged in size from two to six players.

The first trend concerns the integration of cooperative and competitive modalities, used to balance motivation and collaboration. Studies by Bossavit and Parsons (2018) and Buchinger and da Silva Hounsell (2018) show that both interaction types, typically among 2-4 players, stimulate engagement and social regulation.

A second group of studies adopted scripted roles derived from the CSCL framework (Hummel et al., 2015; Malegiannaki et al., 2020; Meji et al., 2020), demonstrating that pre-defined roles orient players' participation and enhance coordination. Conversely, Calabor et al. (2018) observed that collaboration can also emerge spontaneously, suggesting that structured and self-organized mechanisms may coexist.

Communication emerged as a key facilitator of group processes. Hybrid modalities combining face-to-face and digital communication (D'Aprile et al., 2015; De Beer et al., 2023; Romero & Usart, 2013) improved teamwork and reflection. Similarly, the DSG "SEGAE" (Jouan et al., 2020) highlighted how multidisciplinary grouping enhances cross-domain understanding, while agent-based and avatar-mediated designs (Terzidou et al., 2016; Wendel et al., 2013) supported coordination and presence through multimodal interaction.

Most DSGs fostered communication, coordination, and joint decision-making. In medical and nursing education (Nicolaidou et al., 2015; Oo & Vallabhajosyula, 2022; Wong et al., 2022), problem-based and simulation-based games improved NTS such as teamwork and shared decision-making. Socio-emotional collaboration was promoted with the use of COGNIPLAT (Goumopoulos et al., 2023) and Pappi World (Cuccurullo et al., 2013), which enhanced social engagement and individual responsibility, while Xavier et al. (2023) demonstrated that group play fosters emotional understanding and empathy.

In other fields, the use of DGSs supported by VR or 3D multiplayer environments encouraged experiential and situated collaboration (Andreoli et al., 2017; Pellas, 2014; Perry, 2021). DGSs implemented to promote sustainability education (Luz et al., 2016; Saitua-Iribar et al., 2020; Sánchez et al., 2009, 2011) showed that collaborative competences such as collective reasoning and consensus-building are increased.

Overall, DSGs were shown to support short-term, task-oriented collaboration dynamics, such as communication and coordination, through synchronous and multimodal interaction; role distribution and accountability, via scripted or emergent roles; joint problem-solving, through interdependent tasks; socio-emotional engagement, enhancing empathy and group cohesion.

Despite these positive outcomes, several aspects remain not enough examined. Research in the field of conflict resolution has primarily focused on short-term forms of collaboration, neglecting both negotiation dynamics and conflict resolution processes within groups. A notable gap in the extant literature pertains to the underutilization of DSGs in the context of group formation and the analysis of group dynamics in extended temporal frames. Consequently, although DSGs foster teamwork and task-oriented cooperation in the short term, the evolutionary and normative dimensions of group dynamics observable in the long term remain largely unexplored.

DISCUSSION

The reviewed studies are highly heterogeneous in frameworks, aims, field of applications and methods, reflecting the multidisciplinary nature of DSG research (Kara et al., 2020; Laamarti et al., 2014). This variability is also consistent with previous systematic reviews in digital GBL, which report different research focuses and methodological approaches across domains (Dan et al., 2024). In recent years, however, a growing interest has emerged in DSGs applied to collaborative educational and professional contexts, with a marked increase in publications since 2018, as also confirmed in previous systematic reviews (Wang & Huang, 2021).

In this review, the CSCL framework emerged as the most common framework that supports the use of DSGs in collaborative contexts, confirming its value in encouraging knowledge co-construction, peer interaction, and social regulation (Cesareni & Cacciamani, 2015; Selwyn, 2012). Studies adopting CSCL framework often integrated role assignments and scripted collaboration to balance individual accountability and shared responsibility. In line with previous studies (Wang & Huang, 2021), these findings suggest that DSGs can act as digital mediators of collaboration, particularly when the game design mechanisms explicitly model coordination and communication processes among learners.

Most studies adopted quasi-experimental or experimental designs, indicating commitment to methodological rigor. Some qualitative studies are oriented to underpin the validation of the DSG used, analyzing the dimensions of satisfaction and enjoyment. This methodological diversity reflects the field's evolving research practices. Indeed, in accordance with previous reviews, quantitative and experimental approaches remain predominant, often relying on tests and self-report instruments to assess learning

outcomes (Dan et al., 2024). The predominance of short-term post-intervention assessments (e.g., self-report questionnaires and usability surveys) shows that evaluation efforts are still concentrated on immediate learning or satisfaction outcomes, rather than on longitudinal or process-based effects. This indicates a field still in development, where controlled studies offer initial insights but rarely capture the dynamic evolution of collaboration.

As previous studies have highlighted (Connolly et al., 2012), empirical evidence spans multiple learning outcomes, from knowledge gains and motivation to social and affective skills. Knowledge and satisfaction results are most common, confirming that DSGs are still primarily used for acquisition of contents and to enhance engagement. This pattern is consistent with prior systematic reviews, which highlight a strong emphasis on cognitive and motivational outcomes, with comparatively limited attention to social skills (Dan et al., 2024). It is important to note that not all studies provide evidence regarding the efficacy of DSGs in learning outcomes. This finding underscores the heterogeneity of DSGs, emphasizing that their efficacy may be contingent on the methodology used.

A significant contribution of this review lies in the synthesis of findings regarding psychosocial and group-based outcomes of DSGs in collaborative settings. The evidence suggests that DSGs enhance such outcomes through three interrelated mechanisms: *cognitive activation*, supported by problem-solving, analytical, and decision-making tasks; *engagement,* fostered by enjoyment, immersion, and satisfaction; *social interaction*, enabling cooperation, coordination, and shared regulation within groups, as supported by the literature (Salen & Zimmerman, 2004; Wood & Gray, 1991; Zichermann & Cunningham, 2011). From this perspective, it is important to consider that these mechanisms may be influenced by learners' different levels of digital learning inclination (Yoo & Pyon, 2026). This inclination encompasses preferences for digital media, engagement in informal learning practices, and access to various information sources. This suggests that the effectiveness of DSGs may partially depend on users' pre-existing digital dispositions, highlighting an interaction between game design and learner characteristics. Together, these mechanisms outline a multidimensional model in which cognitive, affective, and social processes converge to support collaborative competence (Salen & Zimmerman, 2004; Wood & Gray, 1991; Zichermann & Cunningham, 2011). Indeed, studies employing scripted collaboration or hybrid interaction formats (e.g., Hummel et al., 2011; Oksanen & Hämäläinen, 2013) were particularly effective in promoting effective communication, interdependence, and socio-emotional cohesion.

Although the findings strongly support the role of DSGs in facilitating short-term, task-oriented teamwork (e.g., effective communication and coordination), a critical gap remains in the analysis of longitudinal group development and conflict resolution. Given its developmental nature, the extant evidence base for collaboration is, as of yet, limited to its immediate success in specific contexts. This stands in contrast to the broader, sustained development and transferability of collaborative competence that is an essential component of its evaluation. Consistent with previous literature, research implementations of DSGs have remained focused on individual learning outcomes, while collaborative dimensions and group processes have been under-explored (Dan et al., 2024).

Therefore, while DSGs mediate initial interaction effectively, their capacity to foster long-lasting group dynamics remains an open question that future research must address.

Despite the generally positive findings, the results also suggest that, as previously noted in the literature (Ke, 2009), DSGs in collaborative settings remain fragmented in their assessment and lack coherence. Many studies describe teamwork qualitatively but do not assess specific group processes such as conflict resolution or decision-making processes. Similarly, few studies investigate how motivation and engagement operate at both the individual and collective levels during gameplay. Rather than viewing these as limitations, these observations point to emerging areas of inquiry: the need for deeper process-oriented research capable of capturing the evolving nature of group interaction in game-based environments.

Limitations

This review is subject to several limitations that should be recognized. First, our methodological choice to include only peer-reviewed publications (excluding proceedings, dissertations, and book chapters) increases

the risk of omissions of studies that have found no or a negative effect, artificially inflating the overall perceived effectiveness of DSGs in this context.

The categorization of measures, such as satisfaction and enjoyment, proved to be a complex undertaking. This complexity stemmed from the utilization of disparate terminologies by various studies to denote concepts that were, in essence, substantially similar. This heterogeneity posed a significant challenge in synthesizing the results. Consequently, although positive trends regarding satisfaction are recurrent in this field, they should be interpreted with caution: for this reason, measures related to satisfaction have been grouped separately in the tables. This allows for adequate recognition of the contribution of the studies without forcing their categorization according to the terms employed by Connolly et al. (2012). This is due to the limited comparability and generalizability resulting from the different measurement methods and research designs adopted.

Despite these constraints, this review offers a critical mapping of the literature, indicating that collaborative DSGs hold the potential to support learning, psychosocial outcomes, and group dynamics. The synthesized evidence suggests a positive trend in supporting coordination, communication, and shared problem-solving, particularly when CSCL principles are implemented.

CONCLUSION AND FUTURE DIRECTIONS

In conclusion, this systematic review highlights the heterogeneity and multidimensional nature of studies on DSGs in collaborative contexts. The findings show that DSGs are most investigated using experimental and quasi-experimental designs, and are primarily associated with knowledge acquisition, satisfaction, and engagement outcomes. The review suggests also that DSGs supports collaboration through interconnected cognitive, affective, and social mechanisms, particularly when involved by structured or scripted interaction frameworks such as CSCL framework. Overall, this review contributes to the field by integrating fragmented evidence into a coherent analytical framework and by highlighting gaps regarding longitudinal effects and group development processes in game-based collaborative learning.

Future investigations could increase the use of DSGs in collaborative settings by using CSCL framework to explore how digital role distribution and task interdependence foster teamwork and collective problem-solving in digital learning environments. Furthermore, the research should aim to standardize definitions, adopt validated instruments for assessing collaborative competence, and include longitudinal and mixed-method designs capable of capturing both outcome- and process-level dynamics.

Author contributions: IG & GMV: conceptualization and writing–original draft; **IG:** writing–review & editing; **AL & FZ:** data curation and methodology; & **GMV:** supervision. All authors approved the final version of the article.

Funding: The authors received no financial support for the research and/or authorship of this article.

Ethics declaration: The authors stated that no ethical approval was required for this study.

AI statement: The authors used ChatGPT (OpenAI) during the final stage of manuscript preparation for English language editing and stylistic revision. The authors take full responsibility for the content of the manuscript.

Declaration of interest: The authors declared no competing interests.

Data availability: Data generated or analyzed during this study are available from the authors on request.

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APPENDIX A

Table A1. Characteristics of the selected studies

Study (country)	Y/N	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 and Parsons (2018) (United Kingdom)	No	PD approach. Learner-centered design approach via the 3T "sandwich model" proposed by Parsons and Cobb (2014) and Parsons (2015). Holt and Yuill's (2014) framework for collaborative technology-based interactions	Educational institution: special education	Teenagers with high functioning ASD (N = 6)
Buchinger and da Silva Hounsell (2018) (Brazil)	No	Collaborative-competitive serious games for learning. Motivational theories of Malone and 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 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 CPS (OECD, 2017)	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 MCI (N = 10/11)
Hummel et al. (2015) (Netherlands)	No	CSCL 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, CSCL and 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. The sample ranged from first year master's 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	GBL. 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)

Table A1 (Continued).

Study (country)	Y/N	Theoretical framework	Context	Target (N)
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. Scripted collaboration. Serious games as learning tool	Educational institution: school	Students from an 8th grade classroom in Valencia (N = 16/16)
Nicolaidou et al. (2015) (Cyprus)	No	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 and Hämäläinen (2013) (Finland)	No	CSCL	Educational institution: university	Vocational students and teachers at the College of Jyväskylä (N = 69)
Oo and Vallabhajosyula (2022) (Singapore)	No	Gamification for the development of soft skills in minimally invasive surgical training. 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. Situated learning theory (Dunleavy & Dede, 2014). Volet et al.'s (2009) framework for socially-regulated learning	Educational institution: university	Voluntary students of three cohorts of FL2 French (University of Victoria Campus–Canada) (N = 58)
Romero and Usart (2013) (Spain)	No	GBL. TP and time on task. Academic learning time model	Educational context: adult postgraduate education	Post-secondary students of executive master's in marketing and sales in ESADE Business and Law School (Barcelona) (N = 24)
Saitua-Iribar et al. (2020) (Spain)	No	2030 agenda; 17 sustainable development goals. 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 and Olivares (2011) (Chile)	Yes	Mobile devices for educational collaborative problem-solving. Mobile serious games	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	Educational institution: university	Undergraduate students enrolled in the multimedia systems course (N = 20/14)
Wendel et al. (2013) (Germany)	No	CSCL, GBL, and digital educational games	Educational field	Volunteers in the field of education (N = 23)
Wong et al. (2022) (China)	No	Constructivist learning. Input-process-output model (Garris et al., 2002)	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 programs into school curriculums. Serious games for learning	Educational institution: school	Pupils from 3rd and 4th grade classes (N = 89/75)

Note. Y/N: Presence of control group (yes/no); N: Participant number; & In Sanchez and Olivares (2011) the number of intervention and control groups was not available

APPENDIX B

Table B1. Typology, measures, and results of knowledge outcomes

Study (country)	Name of the serious game	Team structure	Knowledge outcomes		
			Y/N	Measures	Results
Andreoli et al. (2017) (Italy)	Hippocratica civitas game	Groups of tourists (number not detailed)	Yes	Ad hoc questionnaire	$P_{post} > P_{pre}$
Bossavit and Parsons (2018) (United Kingdom)	No name	Three teams of two players	Yes	Ad hoc questionnaire	$P_{post} > P_{pre}$
Buchinger and 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 a 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

Table B1 (Continued).

Study (country)	Name of the serious game	Team structure	Knowledge outcomes		
			Y/N	Measures	Results
Nicolaidou et al. (2015) (Cyprus)	Virtual emergency TeleMedicine	Teams of two people	No	/	/
Oksanen and Hämäläinen (2013) (Finland)	Game bridge	14 teams of four to five people	No	/	/
Oo and 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 and 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 TP groups
Saitua-Iribar et al. (2020) (Spain)	The Island	Teams of three people	Yes	Ad hoc questionnaire	$P_{post} > P_{pre}$
Sanchez and 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. Y/N: Presence (yes/no); 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

Table C1. Typology, measures, and results of psychosocial outcomes

Study (country)	Psychosocial dimension	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 and Parsons (2018) (United Kingdom)	Cognitive: /	/	/
	Affective: **motivation**	Questionnaire: *Intrinsic motivation inventory* (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* (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 and da Silva Hounsell (2018) (Brazil)	Cognitive:	/	/
	Affective: /	/	/
	Social: /	/	/
	Enjoyment, satisfaction, engagement, usability: /	/	/
	Other: **confidence**	Ad hoc questionnaire pre- and post-measurement	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*: 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:* 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 have 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

Table C1 (Continued).

Study (country)	Psychosocial dimension	Measures	Results
			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: **CPS**	Focus group on three main themes: collaboration, problem solving and learning from each other. Ad hoc questionnaire pre- and post-measurement	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. 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: **engagement**	Post-session de-briefing	The results indicate that the game was perceived as a useful participatory tool, which improved the quality of decisions and increased the acceptance of the proposed strategies
	Other: /	/	/
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: /	/	/

Table C1 (Continued).

Study (country)	Psychosocial dimension	Measures	Results
	Cognitive: /	/	/
	Affective: /	/	/
Hummel et al. (2011) (Netherlands)	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: /	/	/
	Cognitive: /	/	/
	Affective: /	/	/
Jouan et al. (2020) (Italy, France, Belgium, Poland)	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: /	/	/
	Cognitive: /	/	/
	Affective: /	/	/
Luz et al. (2016) (Brazil)	Social: **behavioral change**	Questionnaire pre- and post-measurement. Knowledge, attitudes, and practices surveys (Kleba & Wendausen, 2009; Launiala, 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: /		/
	Cognitive: /	/	/
	Affective: /	/	/
	Social: /	/	/
Malegiannaki et al. (2020) (Greece)	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: /	/	/
	Cognitive:/	/	/
Meij et al. (2020) (Spain)	Affective: **motivation**	FAM questionnaire (Rheinberg et al., 2001; Vollmeyer & Rheinberg, 2006) before and after gameplay	No difference between conditions for challenge after gameplay
	Social: **communication**	Dialogue communication: dialogues were recorded. De-briefing	The higher frequency of upper-level (3rd and 4th level) dialogue acts in the scripted condition suggests deeper and more focused exchanges about important game mechanics
	Enjoyment, satisfaction, engagement, usability: /	/	/
	Other: /	/	/
	Cognitive: /	/	/
	Affective: /	/	/
	Social: /	/	/
Nicolaidou et al. (2015) (Cyprus)	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: /	/	/

Table C1 (Continued).

Study (country)	Psychosocial dimension	Measures	Results
	Cognitive: /	/	/
	Affective: /	/	/
Oksanen and Hämäläinen (2013) (Finland)	Social: **perceived sociability and social presence**	Questionnaire included: the sociability scale (Kreijns et al., 2007) and 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: /	/	/
	Cognitive: /	/	/
	Affective: /	/	/
	Social: **communication and collaboration**	Ad hoc questionnaire, pre- and post-measurement	There was no significant difference in pre- and post-test scores on communication and collaborative skills
Oo and Vallabhajosyula (2022) (Singapore)	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 participants out of nine 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: /	/	/
	Cognitive: /	/	/
	Affective: /	/	/
	Social: /	/	/
Pellas (2014) (Greece)	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 exploratory 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: /	/	/
	Cognitive: /	/	/
	Affective: /	/	/
Perry (2021) (Canada)	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: /	/	/
	Cognitive: /	/	/
	Affective: /	/	/
	Social: /	/	/
Romero and Usart (2013) (Spain)	Enjoyment, satisfaction, engagement, usability: /	/	/
	Other: **temporal perspectives on time on task**	Zimbardo TP inventory (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

Table C1 (Continued).

Study (country)	Psychosocial dimension	Measures	Results
			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 and 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 (Driscoll & Vergara, 1997; Johnson et al., 1994; 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: scale for the perception of collaborative work (Driscoll & Vergara, 1997; Johnson et al., 1994; 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: *attitude 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. But 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. But 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: /	/	/

Table C1 (Continued).

Study (country)	Psychosocial dimension	Measures	Results
	Cognitive: /	/	/
	Affective: /	/	/
Wendel et al. (2013) (Germany)	Social: **collaboration**	Analysis of recorded data: observation 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: /	/	/
	Cognitive: /	/	/
	Emotional: /	/	/
Wong et al. (2022) (China)	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) on 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 a 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: /	/	/
	Cognitive: /	/	/
Xavier et al. (2023) (Portugal)	Affective: **emotional climate**	Questionnaire pre- and post-measurement: 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 survey (OECD, 2019). 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**