IEEE Access
Multidisciplinary ⋮ Rapid Review ⋮ Open Access Journal

Received 22 August 2024, accepted 3 October 2024, date of publication 10 October 2024, date of current version 21 October 2024.

Digital Object Identifier 10.1109/ACCESS.2024.3477465

TUTORIAL

Exploring Collaboration in Multiplayer Gamification: A Systematic Literature Review

HERYANTO, FERI HIDAYATULLAH FIRMANSYAH, AND YUSEP ROSMANSYAH
Bandung Institute of Technology, Coblong, Bandung, West Java 40132, Indonesia

Corresponding author: Heryanto (23222077@mahasiswa.itb.ac.id)

This work was supported by a sponsorship from the Ministry of Communication and Informatics of the Republic of Indonesia through the Domestic Master's Scholarship Program. The authors also acknowledge the support of Institut Teknologi Bandung (ITB) for providing institutional facilities and resources.

ABSTRACT This article is a systematic literature review that explores aspects of collaboration in the context of gamification in multiplayer gaming environments, highlighting the potential of gamification to increase engagement and intrinsic motivation in various sectors through the application of game elements, and identifying research needs on gamification that support collaboration. The main focus of this literature review is to gain a deep understanding of the concept of gamification, particularly in multiplayer environments that support collaboration between players. To clarify this research, we formulate it into three research questions. RQ1: What are the latest trends in gamification, particularly in a multiplayer context? RQ2: What are the most commonly used methods for developing gamification in multiplayer environments? RQ3: How is gamification used in collaborative aspects of multiplayer environments? A formal protocol was followed to perform an automated search for relevant articles published between January 2018 and October 2023, adopting the Kitchenham method. The result obtained 44 selected articles for further study. Through systematic analysis of the relevant literature, this article identifies domains, technologies, theories, frameworks, models, gamification elements, impacts, and other key findings related to gamification that support collaboration aspects in multiplayer environments. The findings of this review are expected to provide a solid knowledge base for further research in developing more effective and engaging gamification strategies to foster collaboration between players.

INDEX TERMS Systematic literature review, gamification, gamified, multiplayer, collaboration.

I. INTRODUCTION

Gamification is a concept that can take the form of a product, idea, procedure, experience, design method or system, and all of them simultaneously [1], [2]. However, in general, the accepted definition is the concept of using game elements in a non-game context [1], [3]. Gamification has been applied in various fields such as education, business, marketing, and many others. Gamification is a highly flexible tool that aims to improve the user experience and provide benefits in various contexts. The broad impact of the implementation of gamification in sectors has transformed our traditional ways of interaction, particularly in the educational context [4].

In the context of education, gamification plays a crucial role in enhancing students' learning experiences. Through the use of gamification, students can experience learning with a sense of enjoyment, similar to when playing a game [5]. The environment created when gamification is implemented has the potential to develop communication skills, share ideas, and set goals [6]. Gamification can also increase student engagement in the learning process, improve the level of interactivity, and stimulate problem-solving skills [7]. This is the pedagogical aspect that educators often overlook because they are too focused on knowledge transfer. Based on this, gamification has the potential to support Smart Learning Environments (SLE).

SLE is a learning system that combines traditional learning elements with technology to create an engaging learning experience for students and stakeholders while achieving learning goals through the use of smart tools and methods [8]. SLE encompasses various aspects of the learning environment, including infrastructure, technological

The associate editor coordinating the review of this manuscript and approving it for publication was Daniela Cristina Momete.

devices, pedagogical approaches, and student profiles, using smart devices efficiently [9]. The integration of gamification into this learning environment adds a new dimension to pedagogical approaches, fostering deeper engagement and a more immersive learning experience.

The concept of gamification has evolved over time. Early gamification focused on basic and commonly used elements, such as points, badges, and leaderboards [10], [11], [12]. However, as the field of gamification matures, the elements of the game design are evolving, such as the storyline, competition, collaboration, negative experience, and other complex elements emerging, in line with intrinsic motivation [13]. The current trend highlights an increased emphasis on creating immersive experiences, integrating and combining gamification with advanced technologies such as augmented reality (AR) that provide positive benefits to users, especially in the education sector [14], [15], the integration of gamification with virtual reality (VR), which tends to focus on learning [16], [17] and the integration of gamification with artificial intelligence (AI) that promotes engagement and interactivity of participants in the learning process [18]. Although early gamification focused on basic elements used for individual player journeys, the rise of online platforms has sparked a new phase, driving the emergence of gamified multiplayer environments where users interact, collaborate and compete in virtual landscapes together.

Multiplayer games are games that involve multiple players, either as opponents or as standalone teams. Games with many players who are not bound to any specific coalition make it more complicated to formally analyze using game theory, as these players have the ability to form or change coalitions as needed [19]. Gamified multiplayer environments represent the intersection between social interaction and game mechanisms, providing a rich platform for experiences that may be collaborative and competitive in nature.

The gamification environment often prioritizes the competitive aspect, with previous research primarily uses game elements such as leaderboards and badges, both in the context of competing with others and individual challenges [20], [21]. Michaels views a competitive environment in the context of learning as occurring when students' achievements are negatively related to each other, for example, if one student achieves their goal and another student competing with them fails to achieve theirs [22]. In gamified learning situations, competition occurs when individuals or teams compete to obtain initial resources such as levels, badges, and points [22]. The competitive aspect applied in the gamification context is achieved through the evaluation of the student's rankings using leaderboards and the announcement of one winner at the end of the game [23]. Although the competitive element in gamification has been widely studied, focusing on individual achievements and leaderboards, the collaborative aspect is equally important.

A collaborative environment refers to a condition in which individuals work together to achieve a common goal [22]. According to Michaels, a collaborative environment occurs when the achievements of students are positively interdependent, meaning that the success of one student also contributes to the success of other students working with them [22]. This indicates that a collaborative environment in gamification will involve cooperative tasks, shared goals, group challenges, and team-building elements. Collaboration in gamification is achieved by setting common goals for group members and rewarding the entire group with badges rather than rewarding specific individuals [23]. Therefore, more research is needed to explore how gamification can support collaborative aspects and understand its impact on users.

Although interest in gamification is increasing, there are still many research gaps that need to be addressed. In recent times, research on gamification has focused on exploring how gamification can motivate individuals through design features that are individualistic and competitive. These studies specifically emphasize individual engagement and competitive elements in gamification [24], without exploring the dynamics of groups involved in multiplayer contexts. This raises questions about how gamification can be used to optimize cooperation and interaction between players. More research is needed on the effectiveness of various gamification strategies in multiplayer environments, particularly in terms of collaboration. Furthermore, more research is needed on the impact of collaborative gamification on user behavior and outcomes.

The previous literature review conducted by [25] investigated the use of gamification in the context of collaboration, highlighting how gamification motivates cooperation and collaboration in various domains such as education, crowdsourcing, and others. They developed a framework for cooperative gamification and identified three gamification design approaches: individualistic, collective, and hybrid. The study also identified the psychological and social impacts of gamification in collaboration and recommended future research directions, including exploring new domains related to collaborative gamification, the negative impacts of collaborative gamification, gamification features that foster collective sentiment and their implementation effects.

Based on these recommendations and the need to explore collaboration within multiplayer gamification, a systematic literature review (SLR) is required to identify current trends and research gaps in multiplayer gamification that support collaborative aspects. This SLR will address three Research Questions: (1) trends in multiplayer gamification, including publication years, domains, and technologies used; (2) multiplayer gamification strategies, including models/frameworks and interaction dynamics; (3) gamification elements that support collaboration and their psychological impacts, both positive and negative. The primary contribution of this SLR is to provide a comprehensive understanding of the current state of multiplayer collaborative gaming, trends, and technological developments, as well as the methods used. It will also offer insight into the design and implementation of collaborative gamified systems, potentially influencing future developments in this field.

II. THEORETICAL BACKGROUND

Gamification, as an approach to integrating game elements in non-game contexts [3], has garnered significant attention in recent years. In the context of multiplayer gaming, research on collaboration within gamification has become increasingly relevant. Collaboration in multiplayer games can play a key role in enhancing the user experience, motivating participation, and creating a dynamic interactive environment. This chapter aims to provide a comprehensive theoretical foundation to support an SLR. The discussion includes key concepts such as gamification, multiplayer games, collaboration, motivation, frameworks, technology, and relevant previous research.

A. GAMIFICATION

Nick Pelling is often credited with coining the term 'gamification', precisely in 2002, during a presentation at TED (Technology, Entertainment, Design). Nick Pelling defined gamification as the application of elements of the design of game-like user interfaces to enhance the speed and enjoyment of electronic transactions [26], [27]. However, the broader concept of gamification involves the application of game elements in non-game contexts [3]. These elements include points, badges, leaderboards, levels, and more challenging aspects such as game elements, curiosity, challenge, sense of control, and storytelling [3], [7] designed to improve user engagement and motivation.

Gamification is different from games in general. Games are characterized by providing enjoyment, being bound by rules, being fictional and non-productive [11], [28]. Gamification not only involves the application of elements of enjoyment, engaging interactions, and pleasant design with predefined goals [3], [11]. Beyond that, gamification is a strategic step in improving systems, services, companies, and other activities, by creating experiences similar to those encountered when playing games with the goal of engaging users and motivating them [29]. Gamification is a method that can be used to improve motivation, engagement, behavior change, friendly competition, and cooperation in various situations, such as increasing employee productivity, strengthening social relationships, engaging customers, or achieving academic success [30].

In recent years, the popularity of gamification has inspired its implementation in various fields such as health, education, business, community, tourism, and many others [30]. Examples of its application include the education sector, which integrates game elements with the 'Quizizz' application to enhance student engagement [31]; the health sector, which uses gamification to encourage engagement and motivation, behavior change, emotional well-being and physical activity [32], [33]; and the business sector, which uses gamification to increase understanding of the underlying mechanisms impacting employee and customer attitudes and behaviors [34]. According to a report by [25], the education sector is the most popular for implementing gamification to improve student engagement and motivation, followed by the crowdsourcing sector.

B. MULTIPLAYER GAME

Multiplayer games are a concept in the world of video games that allows players to interact with other players in the same game, either as allies in one group or opponents [19]. In multiplayer games, two or more people play together in the same game session, and players have the ability to play synchronously or asynchronously [35], [36].

According to Zagal et al. [36], [37], multiplayer games have six different characteristics: (1) varying degrees of social interaction, with some games having no social interaction at all, while others have high levels of social interaction, (2) a mix of competition and cooperation, (3) the determination of synchronous or asynchronous in player participation in the game, (4) the need for coordination of social interactions among players, (5) dependence on specific equipment and tools because the game cannot continue without certain display elements, and (6) the presence of meta-gaming elements, where not all players have the same information in the game, but they still adhere to the same rules. For example, in card games, players cannot see each other's cards and may bluff, which can affect the course of the game but does not change its basic rules.

Multiplayer games have been extensively studied in two main contexts, namely competition and collaboration [38]. Competitive games can be defined as a social process in which individuals participate in activities involving rewards based on their performance compared to others in the same task or event [39]. Collaborative games refer to the type of game in which individuals or groups work together to achieve a common goal or outcome [22], [40]. In both competitive and collaborative multiplayer modes, they offer a deep social experience, allowing players to interact, communicate, and shape player characters [22], [39].

An interesting aspect of multiplayer games is their ability to build strong communities around the game. Multiplayer games create communicative situations in which players share experiences with each other [41], [42]. In such situations, the collaborative and teamwork aspects are necessary to succeed in playing the game, making the interaction between players one of the key aspects of these multiplayer games [42], [43].

We have not found a standard term for multiplayer gamification, but based on the definition of gamification as the application of game elements to non-game contexts [3], and the term ''multiplayer'' referring to games played by multiple players either as teammates or opponents [19], [35], [36], it suggests that multiplayer gamification refers to the application of game elements that support something outside the game context, played by multiple players either as individuals competing against each other or as friends in a group collaborating and working together.

C. COLLABORATION

Collaboration is the act of participants working together to share knowledge, skills, and data to achieve a common goal [44]. Collaboration refers to the interdependence in the activities of the participants, which is the main attribute of collaborative interaction [45]. It involves sharing knowledge and resources, coordinating strategies, and making collective decisions to address the challenges that the game poses. In collaborative games, the mechanisms of the game are designed so that optimal gameplay depends on coordination and good decision-making between participants, often requiring communication and joint problem-solving efforts [46].

Collaboration is a key element in generating new knowledge through social learning, integrating insights from various knowledge systems, and enhancing participant engagement in achieving their goals. Collaboration can be distinguished into symmetric and asymmetric collaboration, where symmetric collaboration involves relationships without hierarchy and active participation of participants, while asymmetric collaboration features hierarchical relationships with participants having a lower status, often found in traditional teacher-student dynamics [47].

Collaboration in gamification is a concept that integrates game elements into teamwork or collaborative projects. In this context, collaboration becomes more engaging and productive because game elements, such as points, challenges, and rewards, are used to encourage active participation. For example, in a work environment, teams can collaborate on projects with a points system that rewards team members who achieve specific goals. This will enhance team members' motivation to collaborate more effectively, as they can see their progress in the form of points that can be exchanged for desired rewards.

One real-world example of collaboration in gamification is the application of collaborative learning. Collaborative learning is a method in which learners work in small groups to achieve a common goal [48]. In a gamified environment, collaborative learning can be implemented in various ways. For example, the study by [49] integrates collaborative learning with gamification through the development of a Web-based collaborative reading annotation system (WCRAS) equipped with point elements (intensive quality annotation and active participation), badges, levels and leaderboards. The research results show an increase in annotations, immersive experiences, student engagement, and interactions.

D. MOTIVATION IN GAMIFICATION

Motivation is a complex phenomenon that drives action, while rewards are the outcomes obtained from those actions [1]. Gamification is closely related to human motivation, which can be understood through the concepts of intrinsic and extrinsic motivation. Extrinsic motivation is related to external rewards, such as rewards or punishments [50]. Game elements such as points, badges, and statistics can trigger extrinsic motivation and encourage user participation [51]. In contrast, intrinsic motivation indicates that individuals engage in activities for inherent satisfaction rather than external consequences. When intrinsically motivated, individuals are driven by the pleasure or challenge of the activity itself [50]. Elements such as collaboration, teamwork, and shared challenges can improve intrinsic motivation [52]. Therefore, it is essential to stimulate players' intrinsic motivation to maintain long-term engagement [3], [50]. The design of an effective gamification strategy should be based on understanding human motivation. Social Cognitive Theory (SCT) and Self-Determination Theory (SDT) are among the most widely used theories in gamification.

SCT, as proposed by Bandura [53], emphasizes the role of self-efficacy and the interplay between personal, behavioral, and environmental determinants. The theory posits that individuals exert an intentional influence over their actions and events. The research by [54] used gamification with competition to improve self-efficacy in radiology training, demonstrating increased knowledge and self-efficacy. Similarly, [55] applied SCT to understand how social environments and personal experiences influence motivation and behavior, integrating rewards, challenges, and recognition to improve motivation for active transportation to school.

In addition to the SCT developed by Bandura, Vygotsky's Sociocultural Theory also emphasizes the importance of social and cultural contexts in learning and child development [56], [57], [58]. Vygotsky argued that cognitive development does not occur in isolation but is influenced by social interactions and the use of symbolic tools, such as language and mathematical symbols. The central concept introduced by Vygotsky is the Zone of Proximal Development (ZPD), which represents the gap between a child's actual abilities and their potential when guided by an adult or more capable peers [56], [57]. Vygotsky's theory suggests that literacy and formal education have varying impacts on cognitive functions depending on the social context in which they are applied. For example, studies in West Africa indicate that literacy does not have a universal impact on problem-solving abilities but can influence specific cognitive functions depending on the social and cultural context [57]. Furthermore, the mathematics teaching programs developed by Kozulin [57] emphasize the importance of using symbolic tools to improve students' cognitive skills and problem-solving abilities.

SDT, developed by Deci and Ryan, states that intrinsic motivation is cultivated when three basic needs are met: competence, autonomy, and social relatedness [50], [59]. Competence involves feeling capable and achieving desired outcomes; autonomy refers to having control and choice over actions; and social relatedness involves feeling connected and accepted by others. Fulfillment of these needs leads to optimal performance and psychological well-being. The research by [60] applied SDT in course design, using game mechanics such as points, badges, and leaderboards to enhance engagement and task completion quality. Furthermore, [61] integrated SDT with gamification in lifelong

learning (LLL), showing an increase in intrinsic motivation and intentions to continue learning among employees.

Flow Theory (FT), developed by Abuhamdeh, describes the optimal psychological experience of being fully immersed in a challenging activity that matches one's skills [62]. A study by [63] integrated SDT, FT, and gamification using challenge-based elements such as achievement, pleasure, performance feedback, and a sense of community. The study found that such gamification programs could enhance students' intrinsic motivation and flow experience, although the difference was not significant between the control and experimental groups. These findings suggest that gamification designs that consider human motivation and relevant theories can create effective and enjoyable learning experiences.

E. FRAMEWORKS FOR GAMIFICATION

The gamification framework provides a structure and guidelines to design and implement game elements effectively. These frameworks help designers integrate game elements into various systems to achieve specific goals, such as increasing user engagement or motivating learning. Two commonly used frameworks for gamification are the octalysis and MDA frameworks.

The octalysis framework, developed by Chou [64], analyzes human motivation through eight core drives (see Table 1). The framework distinguishes between:

- White Hat Core Drives: Positive and constructive motivation, making users feel good and inspired.
- Black Hat Core Drives: Negative and urgent motivation, making users feel pressured or anxious, but effective in motivating quick action.
- Right Brain Core Drives: Intrinsic motivation, related to creativity, social relationships, and holistic thinking.
- Left Brain Core Drives: Extrinsic motivation, related to logic, ownership, and achievement.

TABLE 1. Core drives octalysis [64].

Core Drive	White Hat/Black Hat/Neutral	Left Brain/Right Brain (Motivation)
Epic Meaning & Calling	White Hat	Right Brain (Intrinsic)
Development & Accomplishment	White Hat	Left Brain (Extrinsic)
Empowerment of Creativity & Feedback	White Hat	Right Brain (Intrinsic)
Ownership & Possession	Neutral	Left Brain (Extrinsic)
Social Influence & Relatedness	Neutral	Right Brain (Intrinsic)
Scarcity & Impatience	Black Hat	Left Brain (Extrinsic)
Unpredictability & Curiosity	Black Hat	Right Brain (Intrinsic)
Loss & Avoidance	Black Hat	Left Brain (Extrinsic)

The MDA (Mechanics, Dynamics, Aesthetics) framework [65] is a conceptual model used to analyze and design games. It breaks down the game-playing experience into three main components:

- Mechanics: The rules, systems, and algorithms that form the basic structure of the game, including game rules, scoring algorithms, storylines, and interactions.
- Dynamics: The behaviors and system responses that arise from the interaction between mechanics and player actions during gameplay.
- Aesthetics: The emotional experiences players have when interacting with the game's dynamics and mechanics, such as pleasure, challenge, tension, excitement, or a sense of achievement.

Examples of gamification frameworks can be found in various fields, such as environment, education, and business. For example, [66] use octalysis to analyze user motivation and how gamification can influence pro-environmental behavior. [67] apply Octalysis to evaluate gamification approaches in education, identifying the strengths and weaknesses of these activities to motivate students. Reference [68] employ the MDA framework to enhance user engagement on donation-based crowdfunding platforms, where:

- Aesthetics refer to the player's emotional response, such as challenge and camaraderie.
- Dynamics encompass game mechanism behaviors such as time pressure and feedback systems.
- Mechanics involve specific elements, such as points, levels, and badges, designed to support dynamics and aesthetics.

These studies demonstrate that the appropriate implementation of gamification frameworks can significantly improve user engagement and motivation, contributing to achieving the desired goals.

F. ADVANCED TECHNOLOGIES IN GAMIFICATION

As discussed above, gamification trends are geared towards creating immersive experiences through the incorporation and integration of advanced technologies such as AR, VR, and AI [14], [15], [16], [17], [18]. AR technology integrates virtual objects and information with the real world, allowing users to interact with the physical environment, thereby creating an immersive and interactive learning experience [15]. AR fosters collaboration among students through activities that require teamwork in problem-solving, information sharing, and strategy discussion. Elements such as role-playing and digital storytelling in gamified AR applications allow students to act as characters in stories related to the lesson material, enhancing interaction and team collaboration. The development of AR applications often utilizes platforms such as Unity and the Vuforia Engine [14]. Research has shown that the use of AR and gamification improves not only cognitive learning outcomes, but also socioemotional development, with positive changes in behavior and attitudes [14], [15]. The integration of AR in multiplayer gamification can be an effective tool to enhance student collaboration and motivation.

VR technology enables users to experience deep sensations, creating a more profound and engaging learning experience [16], [17]. The development of VR applications often utilizes platforms such as Unity and Unreal Engine [69]. In a multiplayer gamification environment supported by VR, team elements and social graphics make users feel part of a community, contributing to a richer learning environment. These elements are essential to achieve the educational dimensions and ensure the quality of the virtual environment [70], thus enhancing teamwork, communication, and player engagement [69]. The integration of VR with gamification can also be applied in workplace settings, where the use of 3D spaces (such as 3D avatars, 3D meeting spaces, and social events) supports social cohesion among team members. User motivation is a key aspect of a gamified environment, and the main challenge is developing an efficient 3D gamification platform that addresses the elements that inspire team members [71].

Automatic question generation is one of the AI technologies integrated with gamification, which generates questions tailored to the learning stages of students, creating a more personalized learning experience [72], [73]. Intelligent Tutoring Systems (ITS) teach course content, diagnose students' strengths and weaknesses, provide automatic feedback, organize learning materials based on students' needs, and facilitate collaboration among learners [73], [74]. In the context of multiplayer gamification, the research by [75] shows that AI-powered gamified educational robots (AIER), word selection interfaces, and knowledge matching interfaces require students to answer questions cooperatively. Students can supplement this content by discussing with each other or asking questions to the robot, thus promoting cooperative learning. This integration demonstrates that AI technology in multiplayer gamification can support collaborative aspects.

G. PREVIOUS STUDY

Previous research on collaboration in multiplayer gamification environments has yielded several significant findings. A notable SLR by [25] identified how gamification can be designed to support cooperative activities and better understand the results and effectiveness of gamification in motivating collaboration. This study developed a new framework for cooperative gamification, integrating the results of the literature review to formulate three different design options to motivate collaboration through gamification, highlighting the strengths and weaknesses of each option. The framework encompasses various design approaches to motivate cooperation, including individualistic and collectivist approaches.

Reference [25] proposed several future research directions, which are relevant to our exploration of multiplayer gamification. Firstly, they noted that gamification has been used in various contexts, such as education and crowdsourcing, indicating its multidisciplinary nature for motivating collaboration. This is pertinent to the domain of multiplayer gamification we aim to explore. Secondly, they highlighted that gamification can elicit various emotional responses, such as curiosity and enthusiasm, which can shape collaborative intentions, while also noting the potential for negative emotional responses. These insights are relevant to understanding the elements of gamification that support collaboration and their psychological impacts.

The future research directions recommended by [25] inspire us to explore collaboration within multiplayer gamification environments, which we have incorporated into our SLR's research questions.

III. METHOD

The method used in this study is a SLR. SLR, also known as a systematic review, is a method to identify, evaluate, and interpret all existing relevant research related to a specific research question, topic area, or phenomenon [76]. SLR can help fully understand a topic or research question by examining various existing studies. In this study, following the guidelines established by Kitchenham and Charters [76], which are a set of rules and specific steps for conducting SLR in a structured and efficient manner. The literature review consists of three main stages as shown in Figure 1. To define the research question and protocol, identify and describe related research, systematically evaluate the research, and report the results of the review.

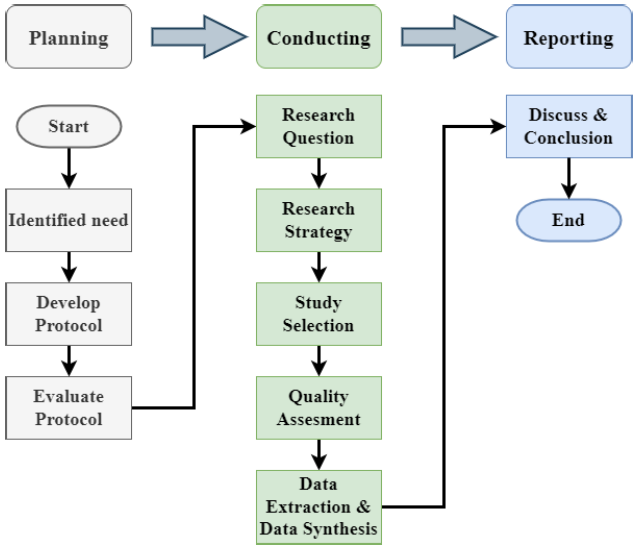

FIGURE 1. SLR step based on kitchenham [76].

Planning stage. This stage aims to (a) identify the review needs, (b) plan the research questions, (c) develop the review protocol, and (d) conduct an evaluation of the review protocol [76].

Conducting stage [76]. This stage consists of several activities:

1) Research Question (RQ): The purpose of the RQ stage is to help guide the research focus and limit the scope of the research to remain relevant to the research topic,

in this case, regarding the collaboration aspects in multiplayer gamification.

2) Search Strategy: The main goal of conducting a systematic review is to identify as many original relevant studies as possible related to a specific research question. This is achieved through the application of an objective and fair search strategy. The level of precision in the search process is one of the elements that distinguishes a systematic review from a traditional review.
3) Study Selection Criteria: The purpose of establishing research selection criteria is to identify the most relevant studies that can provide direct evidence for the research question. To avoid bias, these selection criteria should be established at an early stage when the research protocol is defined, although these criteria can be refined during the information search process. Inclusion and exclusion criteria should be based on the research question. As part of the process, the studies to be included should be tested to ensure that they can be interpreted consistently and the studies are correctly classified.
4) Quality Assessment: This stage aims to measure and assess the methodological quality and reliability of the studies included in the selected literature review. This is an important step in maintaining the integrity and validity of SLR results.
5) Data Extraction: The goal of this stage is to develop a data collection form that is used to accurately record the information obtained by the researcher from the primary studies. To reduce the potential for bias, a data collection form must be established and tested when creating the research protocol.
6) Data Synthesis: The purpose of the data synthesis process is to organize and present the findings of the selected studies in a concise way. This process involves a series of steps that must be carefully followed to enhance understanding of the synthesized data.

Reporting Stage. Reporting Stage. This stage is the final phase of the systematic review process by writing and distributing the findings of the review to interested or affected parties [76].

A. RESEARCH QUESTIONS

Formulating research questions is the most crucial aspect of any systematic study [76]. Research questions are formulated using the PICOC criteria (Population, Intervention, Comparison, Outcome, Context) [77]. For this SLR, the PICOC is shown in Table 2. Here is an explanation of the PICOC:

1) Population: The population includes specific roles, scope of use, or industrial sectors. The population in this SLR may include individual players, multiplayer players, player characteristics, etc.
2) Intervention: Intervention refers to approaches, methodologies, tools, or technologies used to solve specific problems. In this SLR, it could be gamification, gamified, gamification methods, technologies, frameworks, gamification goals, elements, and so on.
3) Comparison: The method, device, or technique used to compare with the intervention (if relevant). This SLR does not include comparison because its focus is to test and identify findings from previous studies to formulate conclusions or provide suggestions for future potential research based on scientific literature.
4) Outcome: The outcome should be related to crucial factors significant for practitioners and/or outcomes achievable through intervention, such as improving reliability, increasing motivation and knowledge, and so on. All relevant outcomes should be identified. In this study, the results include the impact of successful implementation of gamification supported by methodologies, frameworks, methods, elements, collaborative aspects, motivation theories, technologies, etc.
5) Context: Context refers to the broader perspective or domain of the involved population, including elements related to the research, such as collaboration, competition, and other factors, in the context of research on multiplayer gamification.

TABLE 2. Overview of PICOC.

PICOC	Description
Population	Number of players, multiplayer, multiuser
Intervention	Gamification, Gamified
Comparison	n/a
Outcomes	Impact gamification, framework, technology, method, elements gamification, and purpose research paper
Context	Collaboration aspect

Based on PICOC [77], research questions directly related to the research topic have been determined, such as collecting information about current gamification trends, methods, or strategies used in gamified multiplayer environments, and exploring gamification that can support collaboration aspects. The following are the research questions used in the SLR exploring collaboration with gamified multiplayer in Table 3.

B. SEARCH STRINGS

The search procedure involves selecting a digital library, determining search keywords, conducting the search, and obtaining a preliminary list of relevant primary studies. The search strategy helps determine the appropriate search string and identify suitable databases to gather relevant documents to answer the research question. One of the most effective methods for finding high-quality literature sources is using specialized library databases in the field. Literature searches were conducted on leading digital libraries in this field to find a wide range of literature studies. The digital libraries used in this research include:

1) ACM Digital Library (http://portal.acm.org)
2) IEEE Xplore (http://ieeexplore.ieee.org)

TABLE 3. Research questions.

ID	Research Questions	Motivation
RQ1	What are the latest trends in gamification, particularly in a multiplayer context?	Identify and understand the latest trends and developments in gamification, especially in the context of multiplayer. Identifying these trends will help in keeping up with changes in the gamification paradigm and understand how current practices can affect multiplayer environments.
RQ2	What are the most commonly used methods for developing gamification in multiplayer environments?	Identifying the most commonly used strategies and methods in the development of gamification in multiplayer environments. This identification will provide insight into existing best practices and allow us to identify potential enhancements in the development of gamification in a multiplayer context.
RQ3	How is gamification used in collaborative aspects of multiplayer environments?	Identifying and understanding how gamification is used in collaborative aspects within multiplayer environments. This identification will help uncover how gamification can influence and enhance collaboration among players in multiplayer environments, providing valuable insights for further development in collaborative gamification.

3) Science Direct (http://www.sciencedirect.com)
4) Scopus (http://www.scopus.com)
5) Springer Link (http://link.springerlink.com)

From that database, search strategies for conducting SLR analysis can be formulated. The main limitation is that the number of databases available is highly dependent on the search terms used. The publication date limits in each database range from January 1, 2018, to October 17, 2023, and publication types, such as journals, are included as search limitations in selected databases. In addition, all databases were accessed on October 17, 2023.

The search term development process involves several steps, including (1) identifying search terms from PICOC that focus on the population and intervention, (2) identifying search terms from the research topic and questions, and (3) finding synonyms for the identified terms. Furthermore, (4) search terms are refined by composing more complex search terms using identified terms, as well as the use of boolean logic operations 'AND' and 'OR'. The search string used in the search is shown in Table 4.

The initial search strategy employed identical keywords across all databases: (Gamification OR Gamified) AND (Multiplayer OR Multiuser) AND (Collaboration OR Competition OR Cooperation OR Teamwork). However, this approach proved ineffective for IEEE Xplore, yielding no relevant results within the specified search parameters (publication years and journal types). This discrepancy necessitated a tailored keyword strategy for IEEE Xplore: (Gamification OR Gamified) AND (Collaboration OR Competition OR Cooperation OR Teamwork OR Multiplayer OR Multiuser).

TABLE 4. Keyword search.

Database	Keyword
ACM Digital Library	(Gamification OR Gamified) AND (Multiplayer OR Multiuser) AND (Collaboration OR Competition OR Cooperation OR Teamwork)
IEEE Explore	(Gamification OR Gamified) AND (Collaboration OR Competition OR Cooperation OR Teamwork OR Multiplayer OR Multiuser)
Science Direct	(Gamification OR Gamified) AND (Multiplayer OR Multiuser) AND (Collaboration OR Competition OR Cooperation OR Teamwork)
Scopus	(Gamification OR Gamified) AND (Multiplayer OR Multiuser) AND (Collaboration OR Competition OR Cooperation OR Teamwork)
Springer Link	(Gamification OR Gamified) AND (Multiplayer OR Multiuser) AND (Collaboration OR Competition OR Cooperation OR Teamwork)

This modified strategy successfully retrieved relevant articles from IEEE Xplore.

C. STUDY SELECTION CRITERIA

At this stage, the inclusion and exclusion criteria are determined to avoid bias and focus more on the research topic. The inclusion and exclusion criteria for this SLR are shown in Table 5.

TABLE 5. Inclusion and exclusion criteria.

Criteria	Included	Excluded
Period	Publication year during the period 2018-2023	Publication year before 2018 or after 2023.
Type of Source	Type of documents journal	Type of documents not journal (conference papers, proceedings, bibliometric, meta-analytical, books, book review, book chapters, note, editorial, conference review, erratum, short survey, letter, magazines, literature review, etc.)
Language	Written language in English	Written in other languages than English
Accessibility	Full-text articles	Could not have full access to the journal source
Type of Literature	Primary paper	Not primary paper
Relevance to Topic	Focus and relevance Gamified or Gamification	Article does not focus and is not relevant to Gamified or Gamification.
Relevance to Topic	Focus and relevance Multiplayer Gamified or Multiplayer Gamification	Article does not focus and are not relevant to Multiplayer Gamified or Multiplayer Gamification.

Figure 2 illustrates the extensive search steps and the number of studies found at each step. Zotero software and the Parsifal tool were used to manage the search findings. The Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) [78] guidelines were applied in the study selection process, and inclusion and exclusion criteria are described in more detail in Table 5. As seen in Figure 2, the process is divided into several stages: first, conducting an

initial search based on the predefined keywords, according to the keyword criteria in Table 4, resulting in 550 articles from the ACM Digital Library database, 302 articles from the IEEE Xplore database, 247 articles from the Science Direct database, 1120 articles from the Scopus database and 1467 articles from the Springer Link database. Then, an automatic filtering process was conducted in each database by implementing inclusion criteria, including the publication period from January 1, 2018, to October 17, 2023, document type journal and written language in English. Finally, a total of 754 articles were obtained that met these criteria and 2932 articles were removed. The exclusion of these types of document was based on considerations of relevance and methodological rigor, as journal articles typically undergo peer review and provide detailed empirical evidence, which is crucial for the reliability of our systematic literature review.

Duplicate research screening was further conducted using the Parsifal tool to automatically identify and remove duplicate articles. This automated approach ensured a comprehensive and efficient screening process, minimizing the risk of overlooking relevant studies. The Parsifal tool employs sophisticated algorithms that compare metadata, abstracts, and full text content to identify potential duplicates with high accuracy. Through this rigorous screening process, 34 duplicate articles were successfully identified and removed from the initial dataset, resulting in a total of 720 articles to undergo screening based on inclusion and exclusion criteria. Of these, 117 articles could not be fully accessed from the journal source, 116 articles were not primary articles, 368 articles were excluded because they did not focus on or were not relevant to Gamified or Gamification, and 55 articles were relevant to gamification but were excluded because they did not focus on or were not relevant to multiplayer Gamified or multiplayer Gamification. Based on the study selection process performed, 64 articles were finally accepted that met the inclusion criteria and will proceed to the quality assessment process.

Specifically, we adhered to the PRISMA guidelines during the study selection process to ensure a systematic and transparent approach [78]. The PRISMA guidelines provide a systematic framework for identifying, screening, and including studies in a review. For the overall SLR process, including planning, conducting, and reporting the review, we followed the guidelines proposed by Kitchenham and Charters [76]. These guidelines provided a structured approach to defining research questions, developing a review protocol, conducting the review, and synthesizing the findings. By integrating the PRISMA guidelines for the study selection process and following the Kitchenham guidelines for the overall SLR, we ensured a robust and systematic approach. This methodology allows for a thorough and transparent review process, enhancing the reliability and validity of the study findings.

D. QUALITY ASSESSMENTS

The quality assessment stage helps in examining, evaluating the accuracy, and reliability of the selected articles, based on

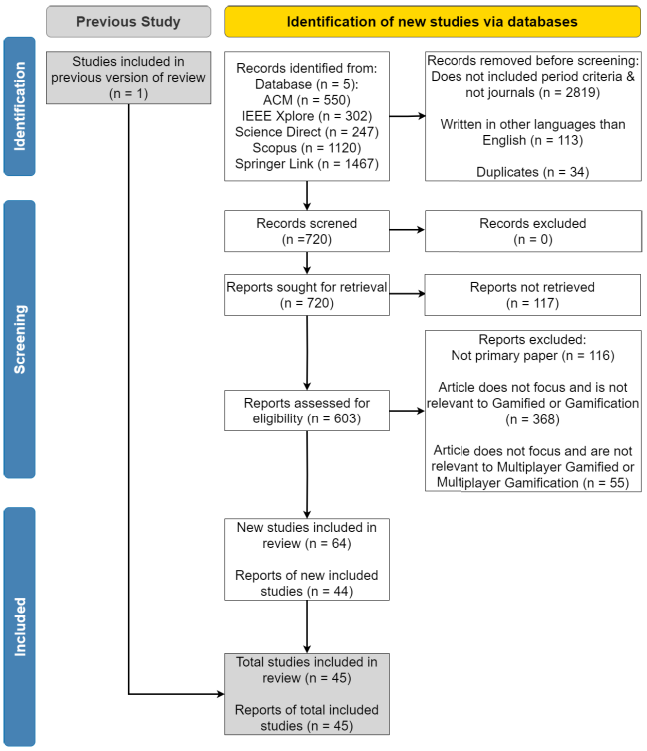

FIGURE 2. Flowchart for search and selection of literature studies.

the quality assessment reflecting the value in accordance with the quality of the article. The selection of appropriate criteria can improve the assessment of the quality of the evidence and reduce the potential bias that may arise in each study. Four questions in the form of a questionnaire are prepared in accordance with the guidelines [76], as follows:

- Does the data support the related research topic?
- Were the approach and formulation of the analysis conveyed well?
- Are the context and data sources well preserved and described?
- Are the relationships between the data, interpretations, and conclusions coherent?

TABLE 6. Cut-Off assessment.

Category	Description	Score
Yes	The information is provided clearly and explicitly	1.0
Partially	The information is provided clearly and implicitly	0.5
No, and not considered	Information cannot be inferred	0.0

Table 6. Shows the quality assessment conducted in the SLR. With a cut-off assessment criteria below or equal to 2.0, the maximum score is 4.0. After a thorough analysis of 64 articles, 20 studies were cut-off, leaving only 44 studies selected for further analysis. The final set of primary research articles included is presented in Table 7 and is categorized

according to the description categories Q (Q1-Q3) and non-indexed.

TABLE 7. Selected article.

No	Digital Library	Publications	Qty	Paper
1	Scopus	Journal Q1	25	[79]–[91]
	Science Direct			[92]–[100]
	IEEE Explore			[101], [102]
	Springer Link			[103]
2	Scopus	Journal Q2	15	[104]–[115]
	Springer Link			[116], [117]
	IEEE Explore			[118]
3	Science Direct	Journal Q3	2	[119]
	Scopus			[120]
4	ACM	Non-indexes	2	[121]
	Scopus			[122]
	Total		44	

The inclusion of research from non-indexed journal articles was a carefully considered decision made to ensure the comprehensiveness and rigor of our literature review. Although indexed journals represent a valuable source of scholarly information, they may not encompass all relevant research, particularly in emerging fields or those with limited publication opportunities.

E. DATA EXTRACTION

Data extraction was conducted in this study in order to answer research questions within the SLR framework. Data from 44 primary studies were collected in a predetermined data extraction table based on research questions and analysis of the studies. Table 8 contains the relationships between the variables and RQs. Each question represents a respective RQ, and there are those that are general in nature, meaning that even though they are not directly related to the RQ, they are still a major part of the research.

F. DATA SYNTHESIS

Data synthesis aims to combine information from various selected studies to answer the research questions posed. Sometimes, evidence from multiple sources can strengthen arguments, even if one study lacks sufficient evidence. This synthesis process involves collecting data in both quantitative and qualitative forms, then using a narrative approach to organize the data according to the research objectives. The results are presented in tables that correspond to the research questions and also use various visualization techniques such as bar graphs, pie charts, and tables to provide a clearer picture of how gamification supports collaboration.

IV. RESULT AND DISCUSSION

A. DESCRIPTIONS OF STUDIES

This section presents the results and discussion covering all the findings obtained from the literature review, which not only includes research on the aspects of collaboration in multiplayer gamification environments from January 2018 to October 2023 but also includes types of research, research methodologies, motivational theories supporting gamification, from each research article.

1) TYPE OF RESEARCH

In this section, we discuss the results of the review of 44 articles conducted, which can be grouped into two main categories: empirical research type and theoretical research type. These categories help to describe the various approaches used in the reviewed research, as well as their impact on the development of knowledge in the relevant field. The results are presented in Table 9.

Based on Table 9, it was found that 40 papers, or about 91 percent of papers discussing multiplayer gamification, predominantly used empirical research approaches over theoretical research. This indicates a strong dominance of empirical approaches in exploring the concept of gamification in multiplayer contexts. This is because multiplayer gamification involves real interactions among players in complex environments, making empirical research the primary choice to observe, measure, and understand the dynamics within it. The empirical approach also allows researchers to test the effectiveness of gamification strategies in enhancing player participation and engagement, thereby providing strong empirical evidence to support further development in this field.

2) METHODOLOGY APPROACHES

The classification of methodology approaches in conducting literature reviews is important because it serves as a framework that can help researchers or readers understand the approach used in a study or analysis. By categorizing methodologies into various approaches, such as qualitative, quantitative, and conceptual, one can quickly identify the research methods employed and how data is analyzed. This allows for the evaluation of the alignment between the research objectives and the methods applied, as well as the discovery of the strengths or weaknesses of the approach used in a paper. The classification results based on 44 selected articles are shown in Table 10. This classification allows for the use of multiple methodology approaches in a single paper.

The results of the extraction of 44 articles indicate that most studies use a quantitative approach in their methodology. Of the total of articles analyzed, 31 articles use quantitative methods, 16 articles use qualitative methods, and only two articles adopt a conceptual approach. Interestingly, some articles combine more than one approach in one study, creating complex and versatile research designs.

In this context, the predominant use of quantitative methods can be explained for several reasons. The quantitative approach tends to provide the ability to measure, identify patterns, and generate numerical data that can be statistically analyzed. In the scope of multiplayer games and gamification, these numbers can provide clear insights into the behavior, preferences, and impacts of player collaboration. The quantitative approach is often considered more objective because it relies on empirical data measurable and

TABLE 8. Property mapping data extraction.

Variable	Description	Category	Key RQs
Type of Research	Determining whether the research is empirical, theoretical, etc.	Empirical, theoretical, or others	General
Methodology Approaches	Indicating whether the study is conceptual, qualitative, quantitative, etc.	Conceptual, qualitative, quantitative, or others	General
Motivation Theories	Listing of the theories underlying the gamification strategies used in the research.	Flow, Goal, SDT, SCT, or others.	General
Publication Year	Listing the publication year of the study to identify trends in gamification over time.	2018, 2019, 2020, 2021, 2022, 2023	RQ1
Gamification Domain	Mentioning the field or sector in which gamification is applied.	Health, education, or others	RQ1
Technology Used	Listing the technologies used in the gamification solution as part of the research or in support of gamification.	Desktop, web, mobile, AR, VR, AI, or others	RQ1
Gamification Frameworks/Models	The framework or model used to develop gamification strategies.	Octalysis, MDE, MDA, or others	RQ2
Strategy	Explaining the gamification method related to multiplayer gamification interaction modes and multiplayer gamification dynamics.	1. Synchronous, asynchronous, or others. 2. Cooperative, collaborative, competitive, or others	RQ2
Gamification Elements	Explaining the gamification elements that support collaboration aspects.	Team, mission, team competition, or Others	RQ3
Psychological Impact	Describing the psychological impact of using gamification elements that support collaboration aspects.	Engagement, intrinsic motivation, emotional or others.	RQ3

TABLE 9. Mapping of research type.

No	Type of Research	Qty	Paper
1	Empirical	40	[79]–[88], [90]–[92], [94]–[112], [114]–[116], [118]–[122]
2	Theoritical	4	[89], [93], [113], [117]

TABLE 10. Mapping of methodology approaches.

No	Methodology Approaches	Qty	Paper
1	Quantitative	31	[79], [81]–[89], [91], [94]–[99], [101], [102], [105], [107]–[112], [115], [119]–[122]
2	Qualitative	16	[80], [90], [92], [93], [99], [100], [103], [104], [106], [109], [111], [113], [114], [116], [118], [120]
3	Conceptual	2	[113], [117]

statistically testable. In research involving technology, such as gamification, the use of quantitative approaches can allow researchers to measure the impact of technology in more detail, for example, its influence on the level of participation, motivation, or player achievement.

However, it is important to note that there are several articles that combine quantitative and qualitative approaches [99], [109], [111], [120], and there are also articles that combine conceptual and qualitative approaches [113], indicating an awareness of the complexity of the topic and the need to understand the phenomenon holistically. Combining methods can provide richer and deeper insights, as well as a more comprehensive understanding in the context of gamification in multiplayer environments.

3) MOTIVATION THEORIES

Out of 44 studies analyzed, only 13 articles explicitly referenced the motivation theories used by the researchers. These motivation theories were related to gamification in multiplayer environments. Although most of the studies did not directly cite motivation theories, the researchers employed gamification strategies considering various aspects, including psychological impacts related to intrinsic and extrinsic user motivation, with the goal of improving user experience, motivation, and engagement. The use of gamification in multiplayer environments involves the use of game elements, techniques, and methods in various processes that align with their respective gamification domains, while also applying relevant motivation theories. This is presented in Table 11.

SDT is a framework for human motivation that explores various phenomena in gender, culture, age, and socioeconomic status. SDT explains these phenomena by focusing on psychological levels, ignoring sociological or physiological aspects, and using human perceptions, cognitions, emotions, and needs as factors predicting regulation, behavior, development, and experience. The central point of this theory is the significant difference between two types of motivation, namely autonomous motivation and controlled motivation [123]. Similar to the research conducted by [102], the study highlights that a combination of gaming elements between competition and collaboration, informed by SDT, can enhance student engagement in learning platforms, showing that the right balance of these elements can lead to better learning.

The next theory is the FT, which is a concept in psychology designed by Mihaly Csikszentmihalyi that allows players to focus and enjoy the game as a whole. Similar to the study conducted by [94], this study observed that elementary school students were more engaged when faced with challenging tasks, but their performance decreased when the challenges became too difficult, leading to frustration. This is in line with the principle of flow theory, which states that optimal engagement occurs when there is a balance between the level of challenge and the individual's skill level. Although flow theory can guide the design of gamified learning activities to

TABLE 11. Motivation theories.

No	Paper	Theory	Definition	Motivational Outcome
1	[80], [82], [100], [102], [106], [121]	Self Determination Theory (SDT)	SDT is a motivational framework that discusses how the social environment and individual differences facilitate various types of motivation, especially autonomous and controlled motivation. SDT investigates the relationship between social contexts, individual differences, and various aspects of life such as learning, performance, experience, and psychological health. The theory states that all individuals have three basic psychological needs: the need to feel competence, autonomy, and social relatedness [50], [59]. Meeting these needs is considered a key factor for effective functioning and good mental health [123].	The use of collaborative, cooperative, competitive game elements such as group missions and guilds improves positive dependency, participation, social interaction, cognitive and emotional support [82], [102]. The use of badges and group points provides positive feedback to students [100]. The elements of avatar and profile customization have an impact on supporting autonomy, while elements such as currency, XP, and levels promote competence [80]. The other impacts are fun, playfulness, and enjoyment [106].
2	[91], [94]	Flow Theory (FT)	FT is a psychological concept developed by Mihaly Csikszentmihalyi. This theory describes the optimal psychological experience when an individual is fully immersed in an activity that is both challenging and well suited to his or her abilities [62]. Characterizes a state in which a person is fully immersed and focused on an activity, enjoying the process thoroughly. In this state, individuals often experience a sense of freedom of time, deep concentration, and intrinsic motivation, where the activity itself becomes satisfying and enjoyable. As a result, high levels of productivity and creativity can be achieved [94].	Challenge, cooperation, feedback, and fellowship, as well as fantasy and narrative, contribute to creating a positive shared experience, which benefits each other [91]. Adaptive challenges improve deep engagement and enjoyment in learning activities, provided that careful consideration is given to the dynamics of individuals and groups [94].
3	[117], [122]	Connectivism Theory (CT)	CT is a conceptual framework that views learning as a network phenomenon influenced by technology and socialization [124]. This theory was first introduced in the online publication [125] titled 'Connectivism: A Learning Theory for the Digital Age.' Connectivism is rooted in the principles explored by chaos, network, complexity, and self-organization theories [124], [125]. According to this theory, learning involves not only individual interaction with content, but also interaction with others and communities. In the context of distance learning, especially gamification, connectivism theory highlights that students are more motivated and engaged when they have autonomy in managing their learning and feel connected to their peers. Social connections and online communities are considered key components [122].	Gamification elements such as user-generated content, experience points, and interactive progress, along with collaboration, facilitate the exchange and construction of knowledge through social interaction, fostering a sense of togetherness and shared goals [117]. Gamification elements such as competition and collaboration create an online network environment where students can actively and continuously acquire new knowledge, become independent, and build their own knowledge within a learning community [122].
4	[118]	Social Cognitive Theory (SCT)	SCT explains several key functions that operate on self-regulatory mechanisms; these include self-monitoring, setting one's behavior goals, evaluating one's behavior, and affective self-reactions. The theory emphasizes the importance of observational learning, imitation and modeling [53], suggesting that people can learn behaviors and strategies by observing others [118].	The use of gamification elements such as progress, goal, feedback, cooperative and chat can reflect contributions to team goals, goal setting, encourage sustained participation, observe and learn from peer behavior, promote engagement and active participation [118].
5	[95]	Goal-Framing Theory (GFT)	GFT, as articulated by Lindenberg and Steg (2007) [126], encompasses different motivations to explain specific behaviors, particularly how goals or motivations determine individual behavioral intentions. In this context, three specific goal frames are activated: normative, hedonic, and gain frame [95]. This theory posits that these goal frames influence how people process information and act on it, with normative goals that promote pro-environmental behavior, while gain and hedonic goals often conflict with such behavior [126].	Gamified cooperative elements can stimulate normative user goals that impact the enjoyment of such behaviors and the achievement of goals by achieving benefits. Cooperative interactions in multiplayer environments create a sense of connection between players [95].
6	[84]	Social Interdependence Theory (SIT)	Social Interdependence Theory was first developed by Kurt Lewin and later refined by Morton Deutsch and David W. Johnson [127]. SIT is a framework that explains how interdependence between individuals can influence their behavior and motivation [128], particularly in terms of cooperative, competitive and team-competitive interactions. The theory of social interdependence argues that the way goals are structured within group settings can significantly influence individual interactions and their resulting outcomes [84].	Structured interdependence among individuals, whether competitive, cooperative or a combination of both in team competitions, has been shown to enhance collaboration, increase user enjoyment and participation, and the effectiveness of multiplayer gamification systems [84].

encourage engagement, this research indicates that achieving a state of flow in a collaboratively gamified environment is complex and requires careful consideration of individual and group dynamics, as well as the design of gamified learning activities.

In contrast to CT, as evidenced by the research conducted by [122], the use of 'Quizizz' as a gamified tool was positively perceived by students. It allowed them to engage in a fun and interactive manner, potentially improving their motivation, engagement, and autonomy in the learning process. Gamification elements such as competition and collaboration can be integrated into learning communities to enhance the learning experience for distance learners.

However, this research also identifies limitations in the application of gamification supported by connectivism. One of the main challenges is the high level of anxiety among distance postgraduate students due to limited study time and other life commitments, which can affect their motivation and self-confidence in collaborative tasks. Furthermore, the generation gap among students of different ages can impact the effectiveness of collaborative gamification elements, as older students may have less understanding of this technology. The geographical separation of distance learners also poses challenges in building a supportive and connected learning community, which is crucial for collaboration.

The study conducted by [118], developed Tic-Tac training aimed at promoting active transportation in the workplace. This game was designed by integrating self-monitoring, goal setting, and feedback, in accordance with the concepts described by SCT. These elements are intended to stimulate changes in health behavior by encouraging group goals and providing players with the ability to monitor progress together, creating a collaborative environment that supports these efforts. Related research on GFT, conducted by [95], found that cooperative interaction using gamification can improve user normative, hedonic, and gain users goals, causing them to adopt low-carbon actions. Meanwhile, gamified competition triggers only hedonic aspects and provides motivation for low-carbon actions without affecting environmental responsibility. This study highlights that the impact of incentives on environmental protection efforts can be temporary and that the loss of incentives can reduce behavior change or even have a negative impact on intrinsic motivation. Furthermore, the research emphasizes that the measurement of gamification interactions, especially from the perspective of interpersonal interactions, is only a small part of gamification as a whole, and future research could explore the impact of gamification from other perspectives.

Regarding SIT, as demonstrated by [84], this study indicates that competitive gamification among teams, which combines elements of competition and cooperation, is more effective in improving enjoyment and participation in crowdsourcing. Users in gamified conditions that include cooperative elements, such as cooperation and inter-team competition, reported a higher willingness to recommend crowdsourcing applications. This study suggests that gamification supported by the theory of social interdependence can enhance collaboration and enjoyment in multiplayer environments. However, it also highlights the need for more empirical research to fully understand the impact on commitment to cooperation and perceived benefits of the system.

B. RQ1: WHAT ARE THE LATEST TRENDS IN GAMIFICATION, PARTICULARLY IN A MULTIPLAYER CONTEXT?

This section will answer the research question regarding RQ1, which is related to gamification trends in multiplayer environments based on 44 accepted articles from January 2018 to October 2023. There are several topics to answer the trends in gamification in multiplayer environments by referring to the extraction table (see Table 8), namely, regarding the year of publication, the publication domain, and the supporting gamification technologies. This discussion of gamification trends focuses on gamification in multiplayer environments.

1) PUBLICATION YEAR

Figure 3 shows the trend in the publication year of multiplayer gamification from January 2018 to October 2023, focusing on 44 accepted articles that have undergone several screening processes. The results indicate an interesting dynamic in the trend in the publication year. In 2018, there were six articles that were the focus of the literature, while the number of new publications on multiplayer gamification increased to seven articles in 2019. In 2020, there was an increase, although not significant, with eight articles, reflecting the continued growing interest in this field. Although the number of recent publications remained stable with seven articles in 2021 and increased by eight articles in 2022, there was no significant change in trend in 2023 with eight articles found. This dynamic reflects the development and sustainability of research interest in multiplayer gamification, which is increasingly favored by researchers over time, with more noticeable increases in certain years, providing insight into the evolution and relevance of this topic in academic literature.

2) GAMIFICATION DOMAIN

Figure 4. Shows the analysis of the gamification trend of 44 articles accepted during the period 2018 to 2023, providing interesting information. The highest domination was found in the education domain, covering 20 studies or about 43 percent of the total. This phenomenon indicates a significant interest in implementing multiplayer gamification in the context of education. Meanwhile, the business sector contributed six studies, or about 13 percent, indicating that the use of gamification is also beginning to penetrate the business world with the aim of increasing engagement and productivity. Furthermore, the health sector drew attention with four studies, or about 9 percent, indicating that gamification has the potential to motivate and influence behavior in health

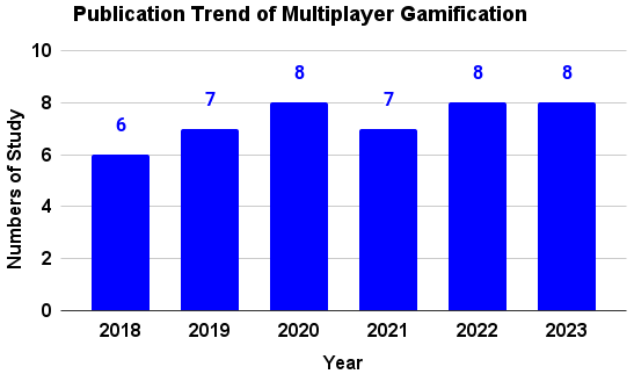

FIGURE 3. Publication trend of multiplayer gamification (January 2018-October 2023).

contexts. The use of gamification also extends to the game industry and crowdsourcing sectors, each with three studies or about 6 percent.

Then the environmental and technology sectors each had two studies, about 4 percent. Finally, in other domains, about 15 percent consisted of a collection of more specific domains, such as governance, active transport, virtual organization, cybersecurity, hospitality and tourism, online communities and network society, each contributing about one study. However, it should be noted that several articles focus on more than one domain, which explains why the number of domains exceeds the total number of articles. With this research, gamification has proven to be relevant in various domains, creating potential for broader applications and varied impacts in the multiplayer scope.

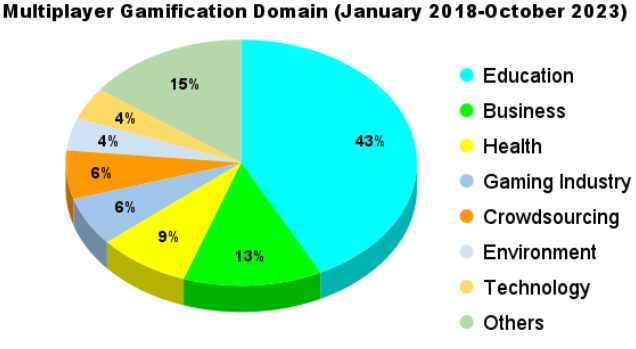

FIGURE 4. Multiplayer gamification domain (January 2018-October 2023).

The dominance of gamification in the multiplayer environment can be explained by several underlying reasons. Education emerges as a primary domain because gamification provides an innovative and engaging approach to improving the learning process. Implementing game elements, such as levels, badges, leaderboards, and teams [101], [102], creates a more interactive and motivating learning environment. This makes gamification a highly effective choice for stimulating learner participation and engagement in multiplayer contexts.

Then there is an interesting gamification domain in crowdsourcing, where crowdsourcing is a cooperative technique, but we categorize it as a domain within multiplayer gamification, because crowdsourcing has an interesting topic that we need to highlight. Crowdsourcing is a technique used in many linguistic data collection tasks, where the system is classified into four main categories: crowd-processing, crowd-solving, crowd-rating, and crowd-creating [129]. Crowdsourcing leverages the collective efforts of a large number of participants (the crowd) to perform tasks that are difficult, time-consuming, or expensive to perform. Specifically, crowd-creating solutions seek to create comprehensive artifacts (emerging) based on heterogeneous contributions [88]. Based on research conducted by [84], the crowdsourcing technique, which for us is a multiplayer gamification domain, is used for collective data collection by sharing location-based parking information, then research conducted by [107], this research explores the use of gamification to engage a broader community in the process of designing environments that are aware of crowd dynamics, presenting design problems as puzzles, and using crowd-based simulation actions as part of the game assessment mechanism. Furthermore, research in the crowdsourcing domain conducted by [88], through crowd-creating and crowd-rating techniques, aims to gamify multiplayer in the process of collecting and evaluating idiomatic expressions in various languages, which is a task in the fields of language education, computational linguistics, and natural language processing (NLP).

Research in multiplayer gamification has explored its application in various emerging domains with promising results. For example, in the environmental domain, [95] investigated low-carbon actions to combat climate change caused by excessive carbon emissions. Their study found that the application of gamification, particularly through cooperative and competitive dynamics, positively impacts user behavior and promotes low-carbon practices. Similarly, [83] implemented gamification to encourage environmentally friendly behaviors, emphasizing the importance of collaboration for complex and long-term tasks and how competition can stimulate short-term motivation. Their findings revealed a significant long-term reduction in energy consumption, highlighting the effectiveness of gamification in driving behavioral change.

In the emerging domain of virtual organizations, [93] proposed a gamification design inspired by games such as World of Warcraft (WoW) to create ''gameful organizations.'' These organizations aim to engage and empower their members by providing game-like experiences. The study identified design considerations for the application of gamification in virtual organizations, including crowd-working, virtual team collaboration, and crowdsourcing.

In the cybersecurity domain, [115] implemented game elements to simulate realistic cybersecurity scenarios, where participants faced tasks reflecting real world situations. Gamification was used to study both normal and potentially harmful user behaviors in a controlled environment.

Participants competed in teams to earn points by interacting with synthetic ''customers'' and completing specific tasks. Data collected from participant activities, such as mouse and keyboard usage, network traffic, and email logs, were used to analyze normal and malicious behaviors, which is crucial to developing insider threat detection algorithms.

In the governance domain, [79] applied gamification through 3D software and game engines to reduce the time and costs of the planning process while enhancing citizen participation. The results showed that gamification could inspire non-expert participation in planning processes (co-creation and co-evaluation), decentralizing and democratizing final planning solutions. The interactive environment provided by the game platform made urban planning issues more comprehensible. However, challenges such as compliance with legal, ethical and GDPR policies during the co-creation and co-evaluation phases were noted, which could delay the planning process. Despite these challenges, the field remains open for further research.

3) SUPPORT TECHNOLOGY GAMIFICATION

Based on 44 accepted articles, there are 12 articles that do not explicitly mention the technology supporting the implementation of gamification. It is also important to note that in one article, it is possible to use several technologies simultaneously to support gamification in a multiplayer environment. The categorization in this study is based on the technology used to implement gamification in a multiplayer environment (see Table 12). Web-based applications that integrate gamification in a multiplayer environment are the most widely used technology for this purpose. Mobile applications are becoming increasingly popular as a current technology. As a result, mobile applications may be an interesting alternative and may eventually surpass the popularity of web applications in the use of this technology, as evidenced by the research set. Due to its lack of flexibility in terms of portability, desktop technology is currently less popular.

TABLE 12. Support technology of gamification.

No	Technology	Qty	Paper
1	Web-based	15	[80], [83], [85], [87], [88], [92], [98], [100]–[102], [107], [112], [116], [118], [122]
2	Mobile	14	[81], [84], [86], [88], [94]–[99], [105], [110], [111], [116]
3	AR	5	[79], [81], [82], [110], [111]
4	Desktop	3	[88], [99], [120]
5	Robot Technology	2	[86], [98]
6	VR	1	[79]
7	Cloud (DaaS)	1	[115]
8	Edge Computing	1	[89]
9	Basic Computer Technology (camera, computer, communication device)	1	[91]

AR is becoming an increasingly popular technology in gamification within multiplayer environments, with a considerable number of studies utilizing it. However, VR technology is underutilized in this research area, with only one article found discussing its implementation. VR has the potential to be an intriguing technology in the future due to its ability to create interactive experiences and stimulate gamification in multiplayer environments across various sectors. Additionally, several other technologies were found to support multiplayer gamification, such as Cloud (DaaS), edge computing, basic computer technology, communication devices, and robot technology, providing new insights into technologies that can support gamification in multiplayer environments.

Technology in this digital era is rapidly developing, including technology that can support gamification in multiplayer environments. Researchers in this research environment are dominated by the application of web technology to support the implementation of gamification in multiplayer environments. For example, the research conducted by [122] uses an online game called 'Quizizz', which is a web-based application that allows multiplayer participation in quizzes and learning activities. The use and modification of the tic-tac training game [80], [118], the use of the Google + Communities platform [100], the use of LMS [101], [102], and many other uses related to web technology as a supporter of gamification in multiplayer environments. The use of this web technology is preferred by researchers, most likely because of its ability to reach a wide audience. Web-based applications can be accessed from various devices with internet connectivity. This accessibility is crucial to reach a large number of players, which can support the collaborative aspects of multiplayer gamification.

Some researchers also utilize mobile technology to support the implementation of gamification in multiplayer environments, such as the research conducted by [96], where participants receive personalized links on their phones, which direct them to their personal badge book displaying virtual identities, accumulated points, achievements, and additional performance statistics. The use of quizbot [86], telegram bot [88], and Kahoot [116]. Desktop technology is also still used to support the implementation of gamification, such as the use of a telegram bot [88] that can run on desktops, the Web and mobile devices, and the use of Unity3D for PC games that can also be played independently [99]. Then the utilization of robot technology, as in the research conducted by [98], where robots are equipped with RFID readers and Bluetooth sensors. The robot movement is triggered by RFID tags wrapped with expandable paddles, which participants use to interact with the robot, requiring multiple participants to control the robot with divided motion commands; this game design promotes collaboration.

The use of AR by [82], This study developed an integrated AR gamified learning approach for electronic courses to help students better understand concepts and enhance their motivation. Then, the use of AR by [110], in their research,

allows users to interact with the elements of the game overlayed on the physical point cards through AR, using their mobile devices. The implementation of AR is facilitated by Unity 3D development software and Vuforia SDK. The use of VR by [79], in their study, not only utilizes VR technology, but also employs AR, which is MR (Mixed Reality) technology. This technology is actively used to create immersive and interactive environments that facilitate community participation and collaborative decision making in urban planning.

The use of cloud technology (DaaS) by [115], in their research, participants were provided with virtual Windows machines through Amazon WorkSpaces, which is a desktop-as-a-service (DaaS) solution provided by Amazon Web Services (AWS). This setup enabled participants to engage in gamified tasks using a virtual desktop hosted in the cloud. The use of technologies such as edge computing is also intriguing, as in the study conducted by [89], which focused on the implementation of gamified incentive mechanisms in the context of edge computing. Incentives in the form of points were given to different ESP's edge servers to encourage them to share computational resources. These points acted as virtual exchange bills, recording the sharing actions of edge servers and driving cycle operations within the system, leading to increased system throughput and reduced idle resources. The points earned by edge servers ensure that they will receive assistance from other edge servers in the future, which is their practical reward. Furthermore, the utilization of Basic Computer Technology [91], such as an escape room game, includes computers and communication devices such as walkie-talkies so that the game leader can observe and interact with participants. Computer screens are also used inside the escape room to display the remaining game time.

It can be concluded that, currently, web-based applications are the most commonly used technology to support gamification in multiplayer environments. However, further research may reveal that mobile technology, AR, and VR can also be used to implement gamification in multiplayer environments. It should be noted that the use of gamification can be tailored to various types of technology, depending on its intended purpose. We did not find the use of AI technology based on the studies in the literature we found, but we have compiled a list of recommended technologies (Table 13) that includes discussions of AI, AR, VR, and Big Data mining technologies, based on the literature studies we found.

TABLE 13. Recommendation technology of gamification.

No	Technology	Qty	Paper
1	AI	5	[79], [83], [87], [97], [114]
2	AR	3	[105], [110], [112]
3	VR	1	[112]
4	Big Data Mining	1	[97]

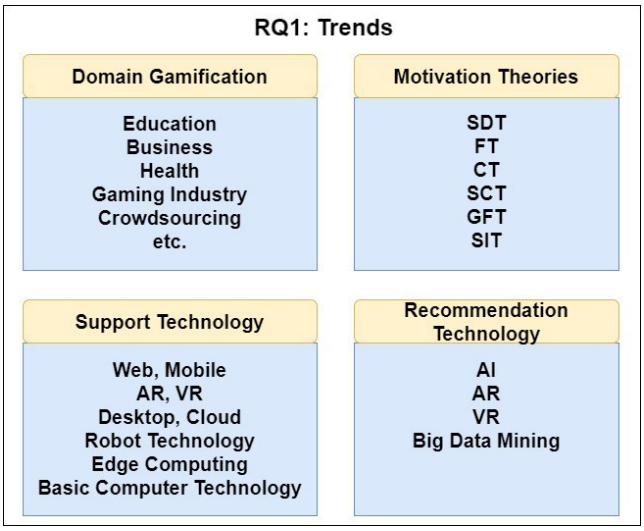

FIGURE 5. Summary of RQ1 for support gamification.

AI technology is recommended here as a fairly widely recommended technology. AI is recommended by [97] to analyze player behavior, optimize matchmaking, and improve game ecology through big data mining and machine learning. Big data mining is used to analyze attributes of smurf accounts, extract discriminative features, and calculate scores for each attribute using machine learning. This accurately identifies all the smurf accounts in the game [97]. AI for pattern recognition, predictive analysis, and automation in urban planning contexts [79], AI for creating adaptive and personalized experiences in games [83], AI technology for creating artificial characters or NPCs [114], and AI can also improve engagement in the field of education [87]. In addition, AR and VR technologies are also recommended to improve user experience [112].

Figure 5. Represents a summary of the results of RQ1, consisting of the multiplayer gamification domain, supporting technologies for multiplayer gamification, technologies recommended by researchers, and motivation theory. This motivation theory is actually of a general nature as it directly supports the application of gamification in general, but we include it in RQ1 which discusses multiplayer gamification trends.

C. RQ2: WHAT ARE THE MOST COMMONLY USED METHODS FOR DEVELOPING GAMIFICATION IN MULTIPLAYER ENVIRONMENTS?

This section will address the research question concerning RQ2, which is related to gamification methods in multiplayer environments based on 44 articles accepted from January 2018 to October 2023. There are two main discussions to answer the gamification methods in multiplayer environments by referring to the extraction table (see Table 8), namely gamification frameworks/models and multiplayer gamification strategies.

1) GAMIFICATION FRAMEWORKS/MODELS

From the 44 reviewed articles, only 12 explicitly used a framework/model for the implementation of gamification, while other articles used a direct approach by applying elements of the game without using a specific framework/model. The findings on the gamification framework/model are presented in Table 14.

TABLE 14. Gamification frameworks/models.

No	Frameworks/Models	Paper
1	Octalysis	[80], [102], [109], [118]
2	Conceptual Framework of Gamified Crowdsourcing	[84], [88]
3	Game Elements and Hierarchy	[90], [106]
4	MDA (Mechanics, Dynamics, and Aesthetics)	[108]
5	The 8-Pointed Higher Education Gamification Star	[87]
6	Smiley Model	[92]
7	Social Gamification Framework	[86]

Based on the literature, octalysis is a widely used framework in gamification. As discussed previously, Chou [64], [130] states that the primary goal of the gamification framework is to stimulate user motivation to encourage desired behaviors. Researchers have used the octalysis framework to analyze how the characteristics of various gamification interventions support the eight core gamification drivers. For example, [118] used octalysis to evaluate Tic-Tac-Training, identifying its potential as a gamification intervention and providing recommendations to enhance its core drives based on development experience. The aim was to map ideas from student groups about desired features in the Active School Transport (AST) game to the eight core drives of Octalysis, creating a roadmap for future features of Tic-Tac training [80]. Similarly, [109] applied octalysis to analyze features of the Battleship-PA game, examining how these features connect to the eight core drives of gamification to assess the potential of the game in influencing children's physical activity behaviors. Furthermore, [102] developed a new framework based on octalysis, focusing on intrinsic motivation and how game elements can support it. This user-centered gamification design aims to evaluate the sustainability of online learning experiences for undergraduate students, categorizing motivational needs based on the octalysis core drives. This framework maps the elements of the game to the motivational needs of various types of learners to support their gamified learning journey.

Furthermore, a framework specifically used for gamified crowdsourcing introduced by Morschheuser [84], [88], [129], [131], this framework combines elements such as leaderboards, rankings, badges, points, and levels to encourage competition between users, as well as cooperative elements that encourage users to work together. This framework is based on social interdependence theory, which states that the interdependence created by gamified goals can significantly influence user enjoyment and behavior in crowdsourcing activities. The study conducted by [84] explores how various types of gamification goal structures, cooperative, competitive, and competitive between teams, affect users' perceptions of enjoyment, usefulness, behavior, and willingness to recommend crowdsourcing systems.

Game Elements and Hierarchy is a framework by Werbach and Hunter, which is a structured approach to gamification that outlines how game design elements can be applied in non-game contexts to engage and motivate individuals and teams. This framework is divided into three main categories: Dynamics, Mechanics and Components [132]. The Werbach and Hunter framework is used in research [106], to engage teams in developing product or service ideas through a board game that combines various elements of the game to facilitate collaboration and innovation within the company team. In research [90], the Werbach and Hunter framework is used to identify and examine examples of gamification implementation in a company that does not explicitly mention it as gamification. The MDA framework stands for Mechanics, Dynamics, and Aesthetics. As discussed previously, mechanics are the fundamental components of the game, including rules, algorithms, and data structures. Dynamics refers to the behavioral patterns that emerge from gameplay influenced by the mechanics. The aesthetics are related to the desired emotional responses evoked in the players [65]. The MDA framework was used by [108] to improve emotional intelligence (EI), purpose in life, and learning strategies in university students through a cooperative gamification-based methodology over 15 weeks.

The 8-Pointed Higher Education Gamification Star is a framework that integrates eight elements considered crucial for the development of successful gamified experiences in higher education. These elements include points, badges, levels, leaderboards, challenges, storytelling, empowerment, and social influence [87]. The Smiley model integrates learning design with game elements to create an enjoyable environment in educational tools [133]. This Smiley model emphasizes the inclusion of various elements of the game to enhance the learning experience and is used to guide the integration of gamification into the learning design of simulators [92]. Furthermore, the Social Gamification Framework is a framework specifically designed for K-6 learning platforms [134], In research conducted by [86], this framework is used to incorporate social elements into gamification design to enhance the learning experience for children, parents and teachers, including elements such as rewards and direct feedback.

Based on the findings of the literature, the Octalysis Framework is widely used to implement gamification elements in a multiplayer environment. Regarding other gamification frameworks/models found, some are indeed created for specific purposes and used in certain domains. The application

of these frameworks/models and other gamification elements in the studies we found has the same goal, which is to create collaborative dynamics between players.

2) MULTIPLAYER GAMIFICATION STRATEGIES

In this section, we explore gamification strategies in a multiplayer environment. The strategies we are looking for lead to the framework/model used, as discussed in the previous section. Next, we examine and analyze the studies we found based on criteria such as the type of interaction over time between players (playtime interaction) and the type of interaction in game dynamics (player interaction dynamics) Presented in Table 15.

In the criteria for the type of interaction time between players, we divided them into two categories, namely, simultaneously and asynchronous. Simultaneous refers to the ability of several players to connect to the system at the same time and play simultaneously [121], while asynchronous refers to a mode in which players do not need to be present and play at the same time [118]. Studies that explicitly use simultaneous interaction include [82], [91], [98], [104], [105], and [121], Based on these studies, although explicit goals of using simultaneous interaction are not presented, some studies suggest that the use of simultaneous interaction aims to emphasize collaborative learning, ensure direct communication, cooperation and active discussion among participants. This interaction aims to maximize engagement, emotional, and social dynamics, as well as real-time learning outcomes in the context of gamification. Studies that explicitly use asynchronous interaction include [80], [88], [99], [107], and [118], Based on these studies, there are several goals and conditions for using asynchronous interaction. Asynchronous refers to conditions that can accommodate various player schedules and locations, providing the flexibility needed for participants to engage in the game, thus facilitating broader participation and engagement, which ultimately can enhance the social, collaborative, and cooperative aspects of the game without forcing users to focus solely on the game. In addition, there are also studies that use simultaneous and asynchronous game interactions in their research, such as the studies conducted by [85] and [116]. Based on this, simultaneous and asynchronous interactions can be considered in developing multiplayer gamification according to the needs and target users.

Next, we discuss dynamic interactions in multiplayer environments. Based on the studies we collected, we found several categories that included collaborative, competitive, cooperative, social, adaptive, and collective. These findings are presented in Table 15. It should be noted that in some articles, one or more aspects of dynamics can be used, and there are three articles that do not explicitly describe the dynamic aspects in their research.

Based on a review of 44 articles on the types of interaction dynamics in multiplayer gamification, the findings show variations in preferences for interaction dynamics. Collaborative aspects emerged as the dominant type of research, identified in 29 articles, emphasizing active cooperation and achieving common goals. Meanwhile, competitive aspects appeared in 24 articles, highlighting player competition to achieve specific accomplishments. Cooperative elements were present in 13 articles that focused on collaboration to achieve individual or group goals. Social aspects were identified in 11 articles, focusing on player interaction in a social context. Adaptive elements appeared in three articles, emphasizing the adjustment of gaming experiences based on player responses. Collective elements were identified in three articles that encompass the collection of individual or group outcomes. These findings show the complexity and diversity of the dynamics of interaction applied in multiplayer gamification, creating varied and engaging gameplay experiences.

The collaborative aspect is becoming more favored compared to the competitive aspect. Of 29 articles emphasizing the collaborative aspect, it is evident that researchers tend to pay more attention to active cooperation and achieving common goals among players. This reflects a trend in the development of multiplayer gamification that emphasizes positive interaction, teamwork, and the achievement of collective results. This collaborative aspect encourages more active participants [101], increases motivation and participant engagement [100], [102], [116], [117], [118], [121], improves socialization, communication, and positive psychosocial impact [98].

The preference for collaboration focuses on achieving group goals rather than individual competition. However, the dynamics of interaction among other players is equally important; for example, the competitive aspect can stimulate the desire of users to participate and contribute [88], [95], [110]. The cooperative aspect stimulates an improvement in the quality of contributions through knowledge exchange [99] and enhanced emotional intelligence [108]. The aspects of social interaction can improve collaboration, improve knowledge exchange and management [87], [90]. Adaptive aspects can create a more responsive gaming experience [83] and enhance performance [94]. Collective aspects can encourage the accumulation of diverse data, co-creation, and co-evaluation [79], [115].

It is important to combine several aspects of player interaction dynamics in the implementation of gamification in a multiplayer environment. Based on the literature study, almost several articles use collaborative and competitive aspects simultaneously in their research. Usually, these aspects are not alone, but are also combined with other aspects, such as collaborative with competitive and adaptive [94], collaborative with collective [79], or cooperative with competitive and social [110]. Furthermore, it is also necessary to understand the risks posed by the implementation of these aspects of interaction dynamics. For example, the implementation of adaptive aspects may lead to incidents of increased errors among users due to the sensitivity of the adaptive scheme to challenges.

Figure 6 illustrates a summary of the RQ2 results on the methods used for gamification in multiplayer environments,

TABLE 15. Player interaction dynamic.

No	Interaction	Description	Paper
1	Collaborative	The activity carried out by multiple players working together towards a common goal [22].	[79], [80], [82], [83], [85]–[87], [90], [91], [93], [94], [98], [100]–[102], [105]–[107], [109], [113]–[122]
2	Competitive	The activity where two or more parties strive to achieve a goal, where one party's gain is at the expense of the other [22].	[80], [81], [83], [84], [87], [88], [92]–[96], [100], [101], [104], [107], [109], [110], [113], [115], [116], [118], [120]–[122]
3	Cooperative	The activity carried out by several players working together toward individual goals [22].	[81], [84], [89], [91], [92], [95], [99], [104], [108], [110], [113], [115], [119]
4	Social	Interaction between players, in the game or in the impact of the game (game features) [118].	[80], [87], [90], [93], [96], [99], [106], [110], [111], [117], [118]
5	Adaptive	The condition of difficulty adjustment in games based on player personalization [94].	[83], [94], [121]
6	Collective	The coordinated effort of a team, where the individual contributions of each member are pooled as an effort to achieve a common goal [115].	[79], [99], [115]

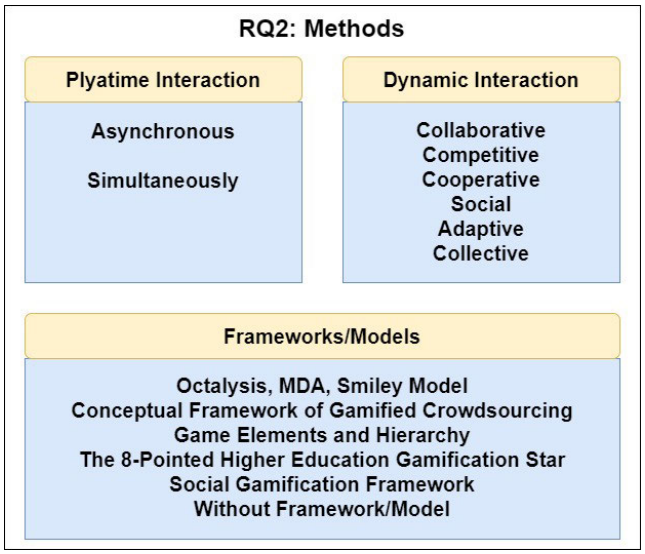

FIGURE 6. Results of RQ2 for methods multiplayer gamification.

including frameworks/models for gamification support, playtime interaction, and dynamic interaction. The top sequence represents the aspects most commonly used in the articles found.

D. HOW IS GAMIFICATION USED IN COLLABORATIVE ASPECTS OF MULTIPLAYER ENVIRONMENTS?

This section will address the research question related to RQ3, which is about gamification that supports collaboration aspects in a multiplayer environment. Based on 44 articles accepted from January 2018 to October 2023, there are two main discussions to answer RQ3 referring to the extraction table (see Table 8), namely gamification elements supporting collaboration aspects and psychological impact.

1) GAMIFICATION ELEMENTS SUPPORTING COLLABORATION ASPECTS

Recent findings from the study of game elements have provided a deep insight into various aspects, particularly those that support collaboration. The identified elements also support other aspects such as cooperation, collective efforts, and social interaction within the context of the game. However, some elements are not free from competitive impact. Previous literature, such as the study by [25], categorized game elements into three categories: individual, collective, and hybrid. This inspired us to create categories for the game elements we found. In this SLR, gamification elements that support collaborative aspects are divided into two categories: multiplayer elements and individual elements. The individual elements referred to here are elements within gamification that focus on personal contributions and the roles of players in a collaborative environment. Meanwhile, multiplayer elements are elements within gamification designed to facilitate interaction and cooperation among multiple players in a gamified environment.

Out of 44 reviewed articles, we found 29 multiplayer game elements that support collaborative aspects and nine individual game elements that support collaborative aspects (see Table 18). However, six articles did not explicitly discuss the game elements used to support collaboration in their research. Additionally, four articles discussed game elements that support collaboration but are not part of digital game features. These elements are non-digital and implemented face-to-face in learning environments, such as team elements and team competition [82], [104], [116], and discussion [104], [116], [122]. There is no explicit explanation for why these non-digital elements are used. However, as suggested by [135], non-digital elements often promote a higher face-to-face interaction among participants. This social interaction can improve student engagement and strengthen their social skills, which are crucial in collaborative learning environments. Additionally, the use of non-digital elements can reduce distractions that might arise from digital devices, thus allowing for better focus on the learning material [4].

The most dominant and frequently used multiplayer element is the 'team' aspect, which appears in 27 articles. This element highlights the importance of social interaction, collective, cooperative and collaboration among players within a team or group to achieve specific goals in the game. Whether in the form of groups or guilds, the 'team' element underscores that cooperation is a crucial element in the gaming experience. Additionally, the 'team competition' element is noted in 13 articles, indicating that competition between

teams also plays a significant role in fostering collaboration and teamwork within the game. This shows that not only is internal cooperation within a team important, but also that cooperation is required in facing challenges from opposing teams. Furthermore, the 'team challenge' elements appear in 13 articles. The 'team challenge' element emphasizes the importance of challenges that cause team members to work together and collaborate to complete the game.

For individual elements, the most dominant is the 'role player/playing' element, which appears in five articles. This element allows each team member to have different roles with specific tasks and responsibilities. This ensures that each team member contributes uniquely and importantly to achieving common goals. Additionally, the 'gift/sharing' element appears in four articles, supporting social interaction and collective among players both in the game and in learning, ultimately promoting cooperation and collaboration to achieve common goals. The gamification elements that support collaborative aspects are presented in Table 18 with the ME codes for the Multiplayer Elements and IE for the Individual Elements.

The Figure presented 7 illustrates the findings synthesized in the SLR on gamification elements that support collaboration and cooperation. These elements are presented in Table 18 along with their explanations. It is important to note that this diagram is not intended as a formal framework or model. Instead, it serves as a visual representation summarizing the pathways through which various gamification elements, identified in the literature, contribute to cooperative and particularly collaborative environments. The synthesis results in the player interaction dynamic section might differ slightly from this section because the player interaction dynamic section examines overall player dynamics, while this section focuses on the interaction dynamics resulting from specific elements. This section explains aspects based on the effect of a single element, not the combined effects of all elements and other factors that might impact player interaction dynamics.

Figure 7 categorizes elements into two main groups: multiplayer (P1-P3) and individual elements (P4-P6), each contributing to collaboration and cooperation through different pathways.

- P1: Direct Collaboration Support. Elements such as team and team mission that inherently encourage collaborative behavior. These elements consist of ME1, ME4, ME6, ME9, ME12, ME13, ME14, ME15, ME16, ME17, ME18, ME19, ME20, ME21, ME22, ME25, ME27, ME28, and ME29.
- P2: Competitive Path. Including elements that drive competitive and collaborative dynamics, team challenges and team competitions that encourage teamwork to overcome external enemies. These elements consist of ME2, ME3, ME7, ME8, ME11, ME24, and ME26.
- P3: Social Path. Elements that enhance social interaction within the team, building the foundation of collaboration through communication activities and bonding. These elements consist of ME1, ME5, ME10, and ME23.
- P4: Direct Collaboration Support. Role player specific elements that assign unique responsibilities to team members, ensuring significant individual contributions to group goals. IE1 element is included in this category.
- P5: Collective Path. Aggregation of individual efforts into cohesive group performance, fostering a sense of collective achievement. These elements consist of IE2, and IE5.
- P6: Social Path. Interactions and mutual support among individuals resulting in collaborative outcomes, facilitated by features such as gift and emotion. These elements consist of IE1, IE2, IE3, IE4, IE5, IE6, IE7, IE8, and IE9.

The role of team elements, such as team missions, team goals, and team feedback, in fostering collaborative environments has been well documented [81], [84], [91], [98], [115]. Competitive elements such as team challenges, team competitions, team points, and team leaderboards also enhance teamwork [83], [84], [87], [115], [119]. The aspects of social interaction are crucial to support collaborative efforts, both within teams (for example, chat and social communities) [101], [105], [107], [117], and between individuals outside the team (for example, integration of avatars and social media) [80], [99]. Furthermore, assigning specific roles within teams ensures unique and significant contributions toward group objectives [81], [86], [98], [113], [117]. Collective aspects in individual settings, such as point elements, are equally important in supporting collaborative efforts [89], [100].

By presenting this diagram in Figure 7, we aim to provide a concise visual summary of how various gamification elements can foster collaborative and cooperative learning environments, as identified in the reviewed literature. This diagram consolidates insights from the reviewed articles, highlighting the dominance of 'team' elements in multiplayer settings and 'role-playing' elements in individual settings. It underscores the crucial role of social and competitive interactions in transforming individual and multiplayer elements into effective collaborative experiences, thereby supporting the development of teamwork and collective problem-solving skills. This diagram also emphasizes the importance of balanced game design to cater for both individual and group dynamics. In addition, this visual representation can be used as an illustration for educators and developers to design more effective gamified learning experiences.

2) PSYCHOLOGICAL IMPACT

In the literature review that we conducted on the psychological impact of implementing gamification elements that support collaborative aspects, several interesting findings have emerged. Specifically in this section, we combine psychological impacts related to collaborative or cooperative aspects, as both collaborative and cooperative have

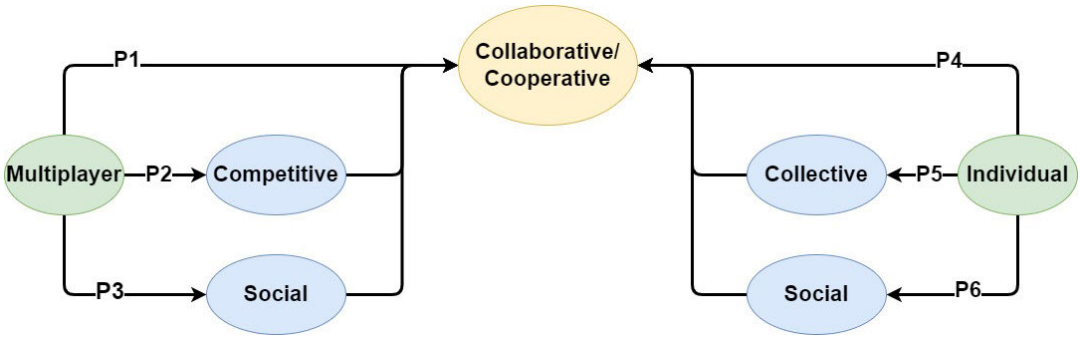

FIGURE 7. Pathways to collaborative elements in gamification.

similarities in encouraging cooperation, although some argue that the goal of collaboration is for the group while the goal of cooperation is more toward the individual [22]. Of the 44 articles that we reviewed, 14 articles did not explicitly discuss the psychological impact of implementing gamification elements that support collaborative or cooperative aspects. Furthermore, our findings indicate that the psychological impact of increased motivation emerges as the most dominant, with 25 articles discussing it. This suggests that the use of gamification elements in collaboration can significantly increase players' motivation in various contexts, such as education, business, health, and other interesting contexts. In addition, increased social interaction or social experience is prominent, with 24 articles describing how the use of gamification can enrich social interactions among players, enhance connections, and expand their social networks.

Furthermore, another positive impact revealed through the research is emotional well-being, which is found in 18 articles, as well as intrinsic motivation discussed in 14 articles, experiential well-being in 14 articles, positive behavior in 11 articles and increased learning / cognition in 10 articles. This indicates that the implementation of gamification elements not only enhances external interaction and motivation, but also can positively impact the emotional well-being and intrinsic motivation of players. However, it is important to note that in the two articles there are also indications of possible negative effects of implementing gamification elements in supporting collaboration aspects. This highlights the need for more research to fully understand the psychological impacts of gamification in the context of cooperation and collaboration and how these impacts may arise. Understanding these findings can provide a foundation for designing more effective gamification strategies that balance boosting motivation with maintaining players' psychological well-being. This is presented in Table 16.

Collaborative gamification, as discussed in [116], significantly increased motivation. Teachers reported high levels of engagement among students, even those with lower language proficiency, who participated actively. The students also showed great interest and enthusiasm for the gamified flipped classes. In the business sector, [121] found that collaborative gamification on the Wordsmith platform increased engagement. The gamified task design encouraged workers to engage deeply in tasks, regardless of monetary rewards. Social incentives, such as completing annotation tasks in pairs and encouraging colleagues to continue for mutual benefit, also increased engagement.

The success of collaborative gamification in improving social interaction is due to several factors. Shared goals between participants encouraged collaboration, while identified roles such as Brainstormer, Critic, Supporter, and Team Wrangler contributed to team dynamics and social interaction [86]. An effective gamification design in crowdsourcing that promotes promotive interaction, peer feedback, and opportunities for members to reflect on their contributions to collective goals also played a crucial role. This design increased enjoyment, participation, and user recommendations, thus enhancing social interaction [84].

In [108], collaborative gamification positively affected emotional well-being. The application of the MDA model in educational gamification improved two dimensions of emotional intelligence (emotional clarity and emotional repair), indicating a better understanding and regulation of emotional states among team members. The model encouraged changes in learning strategies and life goals, motivating students to learn. In [81], features that encouraged team achievements over individual accomplishments and transparent individual contributions to group efforts promoted cohesion, empathy, and emotional well-being through collective play.

The integration of AR technology into collaborative gamification created engaging and challenging learning environments, enhancing students' curiosity and task completion desire. SDT also played a role, suggesting that motivation can be increased if teachers create supportive learning environments with engaging activities, timely feedback, and rewards [82]. In the business context, [106] applied SDT to show that gamification offers various user benefits through hedonic (intrinsic motivators), utilitarian and social (extrinsic motivators) elements, creating enjoyable, challenging and structured environments that increase intrinsic motivation.

The successful impact of collaborative gamification on experiential well-being involves the application of FT. Group

TABLE 16. Psychological impact.

No	Psychological Impact	Description	Qty	Paper
1	Increased engagement/motivation	The psychological impact can be related to one or more categories such as increased motivation, interest, increased engagement, and increased achievement.	25	[80]–[85], [87], [91], [93], [95], [99], [101], [102], [104]–[106], [108], [109], [113], [114], [116]–[118], [121], [122]
2	Increased social interaction/social experience	The psychological impact can be related to one or more categories such as communication skills, social skills, comparison, interdependent, sense of community, community building, team spirit, we intentions, group cohesion, sense of ownership and agency, social experiences, influence, interaction, relationship, affection, fellowship, relatedness, psychosocial state, promote prosocial.	24	[80]–[87], [91], [93], [95], [98], [102], [104]–[106], [109], [113], [114], [116], [118], [120]–[122]
3	Emotional well-being	The psychological impact can be related to one or more categories such as emotional intelligence, intelligence investment, intelligence response, intelligence support, confidence and reduced anxiety.	18	[80]–[84], [86], [91], [93], [95], [98], [102], [105], [106], [108], [113], [114], [116], [122]
4	Intrinsic motivation	The psychological impact can be related to one or more categories such as intrinsic motivation, long-term motivation.	14	[80]–[85], [91], [93], [95], [102], [105], [106], [114], [121]
5	Experiential well-being	The psychological impact can be related to one or more categories such as flow experience, fun, enjoyment, satisfaction, quality of life (QOL), well-being.	14	[80], [81], [83]–[85], [87], [91], [93], [95], [98], [105], [106], [116], [121]
6	Positive behavior	The psychological impact can be related to one or more categories such as behavior, behavior change, attitude, commitment, inspiration, prosocial behavior, reduce cheating, physical activity, performance, empowerment, responsibility.	11	[81], [85], [86], [95], [98], [99], [101], [105], [106], [118], [120]
7	Increased learning/cognition	The psychological impact can be related to one or more categories such as learning, learning efficacy, learning process, learning strategies, support among learners, cognitive load, deep learning, knowledge extension, fostering, problem-solving/resolving problems, reflective thinking.	10	[82], [83], [85], [86], [102], [104], [105], [108], [120], [122]
8	Negative effect	The psychological impact can be related to one or more categories such as decreased engagement and motivation, loss of autonomy, feelings of incompetence, and feelings of isolation.	2	[94], [100]

flow significantly affects participants' revisit intentions, word-of-mouth communications, group cohesion, and subjective quality of life. Shared flow experiences, even in playful settings, positively influence group cohesion and quality of life [91]. In the health sector, [98] found that collaborative gamification improved experiential well-being by increasing positive emotions such as pleasure and improving social interactions during the game. This approach diverted children's attention from their symptoms, reducing feelings of isolation and making their hospital experience less painful.

In [118], SCT supported the impact of collaborative gamification on positive behavior, which explains self-regulation mechanisms such as self-monitoring and goal setting, helping to change health behaviors through mobile applications. Collaborative aspects in games, such as teamwork and joint task completion, also contributed to behavior changes. In the environmental sector, [95] showed that GFT explains how collaborative and competitive gamification interactions influence user low-carbon actions by activating normative, hedonic and gain motivations. Collaborative interactions enhanced users' perception of environmental responsibility and offered social and enjoyable benefits, encouraging low-carbon actions.

Collaborative gamification improves learners' cognitive resources for building conceptual models, leading to improved academic performance. Creating enjoyable learning environments also contributes [105]. In the environmental sector, [83] found that collaborative gamification improved learning through problem-solving and joint knowledge construction as a team. Its effectiveness depended on the quality of dialogue, stimulating information exchange, and constructive communication through questioning, answering, and discussing, making collaborative settings highly engaging.

Figure 8. Represents a summary of the results of RQ3 on the psychological impact of using collaborative aspects in gamification, where several positive and negative impacts were found. The negative impact of using gamification that supports collaborative aspects is discussed in two research articles.

Factors contributing to the success of collaborative gamification in various sectors include shared goals that foster collaboration, well-defined roles that improve team dynamics, and game design elements that promote social interaction and engagement. Emotional well-being is supported through improved emotional intelligence and motivation, while experiential well-being is enhanced by creating enjoyable and immersive experiences that foster group cohesion and positive emotions. The integration of technologies such as AR, the use of models such as MDA, and the application of theories such as SDT, SCT, GFT, and FT further enhance motivation, behavior change, and learning outcomes. Together, these factors create a supportive and engaging environment that leads to positive impacts in education, business, health, environmental, crowdsourcing and other sectors. It is important to note that other factors not covered in this SLR may also play a role in the successful implementation of collaborative gamification.

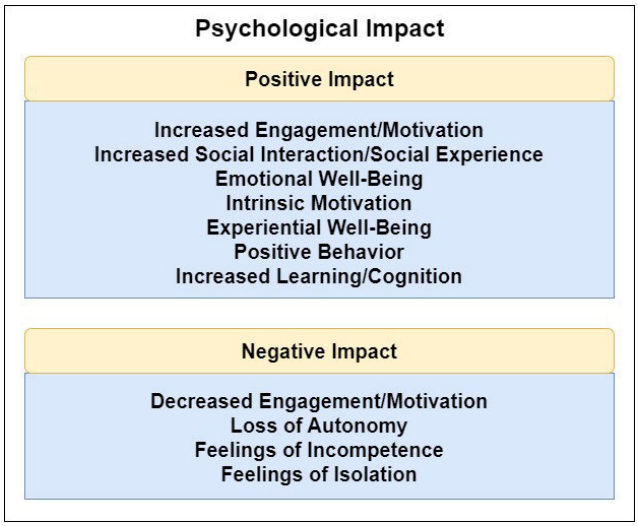

FIGURE 8. Results of psychological impact.

There are various positive impacts obtained from the application of gamification that supports aspects of collaboration, but this does not rule out the possibility that gamification in a collaborative environment can have a negative impact. As in the two articles we found, this aspect is interesting to discuss in order to understand the causes of these negative impacts. As stated in [94], the application of gamification in collaborative learning is expected to increase engagement and motivation. However, their research found that achieving group goals was not as effective as achieving individual goals, resulting in a decrease in student engagement and motivation. Then, the research conducted by [100] is about competitive games between teams that are designed to foster a sense of connection and collaboration by creating a sense of belonging in a team. The same research also reported the negative impact of implementing gamification that supports collaboration aspects in the form of decreased motivation.

Some of the factors that caused the decreased engagement and motivation have been identified by the authors in the two articles. These causal factors impact not only decreased engagement and motivation, but also loss of autonomy, feelings of isolation, and incompetence. As the results of the evaluation carried out by [100] using the theory of motivation of SDT. Here are some impacts and causes:

- **Lost of Autonomy**. This is due to the lack of a system design that can acknowledge individual contributions within the team [94], [100] so that team members feel that they have no control over the outcome of their work. The ambiguity of expectations and purposes of the collaborative gamification system also confuses users and reduces the sense of autonomy of [94]. Moreover, the design of a system that provides features for the presence of teachers on the platform also results in an limits discussion and can decreased the student's sense of autonomy because he feels supervised and afraid of making mistakes [100].
- **Feelings of Incompetence**. This happens when the team is in a low ranking that impacts the student's self-confidence by feeling that what they're doing is just futile, so making them feel incompetent and unable. In addition, the lack of useful contributions from several team mates that impacts team success, can make active contributing students feel incompetent because they are less able to team goals [100].
- **Feelings of Isolation**. This occurs when students who feel uncomfortable give feedback to teammates they do not know, promoting a sense of isolation due to a lack of effective communication and constructive feedback. Besides, students who are reluctant to share with their teammates because of the absence of a teammate's appreciated system, create a sense of isolation within their team [100].

Based on some of these negative impacts, future research opportunities have been opened, which have given rise to ideas to address these challenges. The problem is consistent with the SDT theory of autonomy that relates to the individual having full control over the actions they do; competence relating to the feeling that the individual is capable of the desired results; then social relatedness that involves the individual feeling connected to other peers and feeling accepted by colleagues [50], [59], [123]. especially when in a team in collaborative mode. The goal of a clear collaborative gamification system is a system that provides appreciation for individual contributions to enhance the sense of autonomy, considering that some of these problems do arise because of individuals who want to be appreciated for their contributions; the goal of a clear collaborative gamification system; a system that can give the right role according to individual abilities through personalized [136] can also be proposed as a solution to increase a sense of competence; systems that can make students give each other support, such as the collaborative peer learning [137], [138] gamified system, so that students can feel connected. In addition, it is equally important to consider the correct combination of gamification elements [94] and to avoid gamification elements that can drive selfishness [81]. Some of the solutions mentioned were merely hypothetical, requiring much more research and empirical evidence, not excluding the possibility that there are still many other solutions that are more effective and have been empirically proven.

3) CHALLENGES AND BARRIERS

Previous research has shown that gamification can have a positive effect in a collaborative setting. However, it is important to acknowledge that there may be challenges and barriers when implementing gamification to support collaboration in a gamified environment. Several challenges and barriers arise in the implementation of gamification in collaborative environments relating to several aspects such as the necessary game design, personal motivation, the use of technology, and gamified environment, among

others. Below are certain challenges and barriers that we have identified in the Table 17. These challenges can provide barriers to the implementation of gamification in collaborative environments if not addressed properly.

TABLE 17. Challenges and barriers in implementing collaborative gamification.

Category	Detail	Paper
Game Design	Game Elements	Interference from notifications [80], gamified environment oversimplification [93], confusing visual features and rules [109], limited element variations [114]
	Interaction	Ineffective communication features [80], [91], lack of team contribution [113], imbalance of team contribution [100], lack of individual and cooperative features [81], insufficient implementation of collaborative elements [102]
	Rewards	Ineffectiveness in achieving team goals [94]
	Sustainability	Real-world social network disruption [114], boredom and fatigue due to overuse [109], unfair peer evaluation [117], self-certification cheating [99]
Technology	Adaptation/ Acceptance	Lack of technical experience among teachers [82], attitudes toward gamification and technical infrastructure [87]
	Integration	Cognitive overload with AR support [82], integration of AR, gamification, and social aspects [110]
	Needs	Additional technology requirements [79]
Gamified Environment	Group Dynamics	Limited player time [106], dominance by higher achieving students [104], building learning communities [122]
	Traditional Learning Methods	Transition from passive learning [116]
	Needs	Additional technology requirements [79]
Motivation	Extrinsic/Intrinsic	Social loafing [81]
	Engagement	Difficulty involving remote members [93]
Regulation	Legal and Ethical Compliance	Legal and ethical compliance [79]

The challenges and proposed solutions related to the game design category regarding game elements include several aspects:

- Lack of control over notifications in the game which can affect the player's overall motivation towards the feature. Reference [80] proposed the solution of adding more types of notifications from different game events, allowing players to choose which notifications they want to receive and sending the most important notifications by email.
- The adoption of games for organizing is not always good and can result in an inappropriate simplification of the operative reality as well as a misperception that the organizational environment is similar to a game. Reference [93] states that it is necessary to carefully consider the specifics of the context to be gamified and the possible side effects of gamification interventions. In addition, the ethical responsibility of the gamification designer plays an important role. Unfortunately, ethical reflection on the use of gamification design is still underdeveloped, and this is a key line of research that should be developed in the future.
- Visual confusion and unclear game rules, which caused some participants to feel unmotivated to continue playing. Reference [109] suggested updating the visuals to be clearer and adding a way to view the visual features for the teams. In addition, they also suggested adding a tutorial for users who are not familiar with the classic game so that all users can understand the rules of the game. They also suggested a clear feedback feature to communicate with users when something is done incorrectly or something goes wrong.
- Current gamification designs still use a limited variety of game elements and struggle to understand the effects of those elements on users. Reference [114] tries to expand the catalog of social game elements available to gamification designers, shifting the attention from PBL (points, badges, leaderboards) to artificial entities, gamified temporary groups, and structured guilds. They also focus on game dynamics that differ from competition, favoring designs that support mutual cooperation, self-awareness, and empathy.

The challenges and proposed solutions related to game design with respect to interaction include several aspects.

- The use of escape rooms to support collaborative environments, some features of escape rooms, such as clear objectives, feedback, and game-leader guidance, are currently ineffective [91]. The authors suggest that features such as clear objectives, feedback, and game-leader guidance need to be improved or redesigned. For example, goals could be redesigned to be more scalable and measurable in terms of milestone achievement.
- The chat feature in the game was not widely used by the team [80], [113], a solution was proposed by [113] regarding the need to carefully think about how facilities such as chat or discussion boards would be moderated and managed. In addition, moderation by a facilitator may be required to ensure that communication between learners is appropriate and correct misunderstandings.
- The lack of useful contributions from some team members was related to the negative impact on the motivation of students who actively use the platform. This is due to the nature of the platform, which is designed to encourage group work, such as discussions. When some students stop using the platform, group work becomes less interesting, despite the efforts made by students who are still participating [100]. Reference [100] proposed a solution to consider a gamification platform based on individual ranking. In this way, students can still receive

feedback on their performance compared to their peers, without relying too much on team contributions.
- Similarly, combining individualistic and cooperative characteristics can hinder cooperative relationships, suggesting that the design of gamification should consider the balance between altruistic and egoistic motivations [81].
- Related to the lack of collaborative elements that can lead learners to become isolated, which in turn can increase the likelihood that they become unmotivated or unengaged [102]. to this challenge [102] suggest gradually reducing extrinsic motivation-based game elements and introducing game elements that support collaboration and competition. This is expected to increase learners' engagement and motivation on the learning platform.

Challenges and solutions related to the game design category of Rewards and Sustainability include several aspects

- Lack of effectiveness in achieving group goals caused by the absence of a system that rewards individual contributions. One potential solution to address the lack of effectiveness in achieving group goals is to recognize individual contributions in collaborative efforts [94].
- The highly engaging guild structure in gamification can replace users' real-world social networks, which can raise concerns. Reference [114] suggests that the design of gamification should carefully consider when and for what purpose to use 'guilds' in its design. This is to ensure that the guild structure supports the formation of affective bonds among users without replacing their real-world social networks.
- Boredom and fatigue felt by children when many gamification elements are repeated. Reference [109] propose adding motivating features, such as a social system for users, and adding common tasks such as 'walk to school' or 'bike to school' to simplify the task creation process. In addition, the authors also suggest improving the audio and visuals of the game as well as adding surprise elements such as extra experience points or cosmetic items for avatars under some tiles.
- The potential for unfair assessment by peers in a gated environment, that is, when students are assessed by their peers. There is a risk of learners receiving ''(dis)likes'' for reasons other than their contribution to knowledge acquisition, such as personal bias or cyber-bullying. Reference [117] proposed a hierarchy of classification as a solution, where peers who provide scores are also graded by peers at higher levels, but this system may still require intervention from the instructor in the event of failure in the collective classification standards.
- Participants may cheat when they are less motivated or highly motivated to optimize their progress. The solution offered by the authors regarding the cheating problem is to remove the self-certification element from progress in the next version of the software. The authors suggest that replacing self-certification with group activities, such as multiple-choice quizzes administered by staff, may be a better solution. These activities would provide credits that contribute to the game economy without significantly increasing the administrative burden [99].

The challenges and solutions related to the category of gamified environments regarding group dynamics and traditional learning include several aspects.

- Related to group dynamics in the form of time constraints faced by teams [106], domination by higher achieving students can inhibit the participation of other students, resulting in uneven distribution of learning [104], and building a learning community conducive to collaboration can be difficult, especially when learners are geographically far apart and rarely meet face-to-face [122]. Some solutions emerge from the authors such as dividing tasks fairly between group members can prevent domination by a few members and encourage equal participation [139]. Then the selection of appropriate collaboration tools to support online group projects. The use of discussion forums and synchronous communication tools, such as video conferencing tools can help facilitate communication and cooperation between group members who are separated by distance [139].
- Some students are used to passive learning where the teacher gives direct instructions, and they feel uncomfortable when not given direct instructions first. They perceive gamification activities as not real learning. Reference [116] suggested that to overcome this problem, it is necessary to provide a brief explanation of the basic knowledge that has been covered in the online learning session at the beginning of the face-to-face session when the percentage of students who show inadequate basic knowledge is quite high.

Challenges and solutions related to the motivational categories of extrinsic/intrinsic motivation and engagement cover several aspects.

- One of the challenges mentioned was overcoming 'social loafing' or a general lack of motivation to cooperate in a group context [81]. In a study by [139] the use of peer evaluation, tutor evaluation, and possibly self-evaluation could help overcome the problem of social loafing by clarifying individual contributions to the group project. designing activities that prepare students and act as a warm-up, including opportunities for self-introduction, self-presentation, and getting to know each other. In addition, the importance of activities that involve developing ground rules and sharing strategies found helpful or unhelpful in previous group projects was mentioned.
- The difficulty in engaging and motivating members to work together remotely, [93] proposes to encourage the formation of personal bonds through a game-based

environment. An engaging organization can provide gamified activities (for example, puzzles, mini-games, etc.) that workers from different virtual teams can enjoy together. In this environment, the execution of work tasks can coexist with game-like activities, so that workers can develop personal bonds with their teammates, combining their work and leisure time.

Challenges and solutions related to the Technology and Regulation category include several aspects

- Related to technology adaptation/acceptance, challenges such as lack of technical experience among teachers and resistance to the use of technology can pose a major obstacle in effectively implementing gamification strategies that require collaboration or cooperation [82]. attitudes of teachers and students towards gamification, as well as the technological infrastructure if the gamification design is based on new technology [87]. Some solutions are offered by [140] By conducting training and workshops that cover both technical and pedagogical aspects, teachers can improve their skills in using technology in learning.
- Potential cognitive overload when students are required to use complex skills such as problem-solving and collaboration in AR-supported conditions. This can be a challenge when the content of the AR system is inflexible, making it difficult to adapt teaching materials to support collaborative or cooperative activities [82]. Then how to combine AR, gamification, and social factors to increase user participation, which is considered a difficult task [110]. Some solutions related to this are offered, namely, regarding the AR application development process must involve engineers (to develop programming), educators (as thematic experts) and other specialists to produce quality educational resources [141]. In addition, when AR apps are integrated with collaborative gamification, researchers in technology education should carefully consider the design of the targeted learning content, the amount of information displayed on the mobile screen, and the ability of the learning equipment and the classroom environment to achieve appropriate learning scenarios [142].
- Regarding regulation, [79] report on the additional technology requirements and preparation needed to support the co-creation and co-evaluation phases. These additional technology requirements need to comply with legal, ethical, and GDPR policies during the co-creation and co-evaluation phases. This legal process requires time and preparation according to the country's ethics and laws, which can delay the planning process.

It should be noted that the proposed solution may still need to be proven empirically and can be material for future research. There are many other solutions that can be used and proven to be more effective than the proposed solution.

V. IMPLICATION AND FUTURE RESEARCH

This study provides valuable information on the practical applications of multiplayer gamification in various domains, with broad implications and significant potential directions for future research. The findings of this study are particularly relevant for several practical applications, including educational game design, business platform development, and healthcare applications:

- Educational game developers can leverage these findings to create games that integrate collaborative gamification elements. By incorporating features such as team-based challenges and reward systems that recognize individual and group achievements, these games can foster a more engaging and interactive learning environment. Such design strategies can improve student motivation and participation, ultimately contributing to improved learning outcomes.
- In the corporate sector, gamification can be applied to improve employee collaboration. Business platforms can be designed to allow employees to collaborate on projects with reward systems that recognize both individual and team contributions. This implementation can improve teamwork, productivity, individual skill development, and overall employee satisfaction. In addition, workplace gamification can promote knowledge sharing and skill development among employees.
- In the healthcare sector, gamification can be used to encourage collaboration between patients and healthcare providers. Applications that allow patients to track and share their progress and receive support from peers can improve motivation and health outcomes. For example, collaborative health applications can be designed to promote healthy competition and mutual support among patients, thereby fostering a supportive community and improving patient adherence to treatment plans.

The implications of this research extend beyond immediate practical applications and contribute to theoretical development and policy formulation:

- This study reaffirms that collaboration is a key element that not only enhances the gaming experience in gamification but also has broader applications beyond the gaming context, such as in education, business, and healthcare. The findings indicate that collaborative elements in gamification can significantly enhance social interaction and cooperative behavior, which are crucial to achieving success in various scenarios.
- By highlighting the importance of collaborative elements, this study contributes to the advancement of gamification theory. These findings can guide researchers and practitioners in designing more effective gamification systems by integrating collaborative dynamics. Understanding how collaboration influences motivation and engagement allows developers to create more impactful gamification experiences.

- Educational institutions may consider integrating gamification into their curricula to enhance student engagement and facilitate collaborative learning. The use of gamification elements in educational settings can transform traditional learning approaches, making them more interactive and student-centered, which in turn can improve student motivation, material comprehension, and collaborative skills.

To build on the insights gained from this study, future research may explore several avenues:

- Future research could focus on longitudinal studies to evaluate the long-term impact of gamification on collaboration and player engagement across various contexts, including education, business, and healthcare. Such studies would provide in-depth insight into how collaborative gamification influences behavior and outcomes over time.
- Emerging technologies such as Artificial Intelligence (AI), Augmented Reality (AR) and Virtual Reality (VR) have significant potential to further enhance collaboration in multiplayer gamification. Future research should explore how these technologies can create more immersive and interactive environments, as well as the challenges that may arise in their implementation.
- It is important to analyze player behavior in the context of gamification to understand the factors driving collaboration. Research can focus on intrinsic and extrinsic motivations that influence cooperative behavior, which will aid in designing more effective gamification systems that promote collaboration and achieve desired outcomes.
- Finally, future research could focus on developing more comprehensive theoretical models for gamification, with a particular emphasis on collaborative aspects. These models would serve as frameworks for researchers and practitioners, providing guidance in designing and implementing gamification systems that maximize collaboration and engagement.

The findings of this study lay a solid foundation for practical applications, theoretical development, and future research in multiplayer gamification. By emphasizing the role of collaboration, stakeholders in education, business, and healthcare can design more engaging and effective systems. The continued exploration of new technologies and the analysis of collaborative behavior will drive innovation in gamification, providing impactful solutions in various industries.

VI. LIMITATION

This SLR can provide a deep understanding of multiplayer gamification focusing on collaborative aspects. However, there are several limitations to consider in interpreting the findings of this research. One limitation is the limited number of 44 articles that met our inclusion criteria. As a result, more research is needed to fully understand the scope and exploration of collaboration in multiplayer gamification. Second, the research time frame between January 2018 and October 2023 may have overlooked important contributions published before or after this period. Relevant research outside this time frame may have a significant impact on understanding multiplayer gamification. It is important to note that this review does not ignore potential bias in study selection. The search process did not involve manual reading of all published papers in the journals. Additionally, reliance on specific databases for literature search may have missed works not indexed in those sources, reducing the completeness of the review. Furthermore, this review may have a language bias as it only includes articles published in English. This selection was made because English serves as the lingua franca in international scientific publications, making the articles published in this language more broadly accessible and widely disseminated within the global scientific community. Furthermore, the authors' limited proficiency in languages other than English influenced this decision, ensuring the accuracy and reliability of the analysis and interpretation of the reviewed studies. However, to minimize publication bias, this study exclusively incorporates studies from journal articles that have undergone rigorous peer review by field experts through no-reference review procedures, with impact factor as a measure of research quality. As a result, research from conference proceedings is excluded from this review as journal articles are considered more reliable sources, having undergone strict evaluation before publication.

Third, the review's focus on multiplayer gamification in a collaborative context may have implications for generalizing findings to other gamification applications. Although collaboration is an important aspect in many multiplayer game contexts, there is a possibility that different gamification strategies or other game contexts also have valuable implications. Thus, there is a need to broaden the perspective to thoroughly understand the impact of gamification in various fields. Fourth, this SLR methodology provides a strong structure for investigating the relevant literature. However, there is the possibility that in-depth qualitative insights from case studies or practitioner reports may be overlooked. A more in-depth analysis of specific cases or practitioner experiences can provide a more contextual and detailed understanding of the implementation and impact of multiplayer gamification in real-world situations. Fifth, the evolving nature of the gamification technology and methodology suggests that the findings of this review may have limitations in terms of novelty and relevance. New innovations in technology or gamification approaches can quickly change the landscape, making existing findings obsolete or requiring a revision. Therefore, more research and periodic updates are needed to refresh the understanding of multiplayer gamification.

Taking these limitations into account, this document still provides a valuable contribution to understanding multiplayer gamification and collaboration. Although it cannot cover all relevant contributions and aspects, this review provides

TABLE 18. Gamification elements support collaboration aspect.

Code	Element	Qty	Motivation Supporting Collaboration	Paper
ME1	Teams/Group/Guild	27	Groups of players working together towards common goals. Encourage teamwork, shared responsibilities, and collective problem-solving.	[80], [81], [83]–[87], [90], [91], [93], [95], [98]–[102], [105], [106], [108], [109], [113]–[115], [118]–[121]
ME2	Team Challenge	13	Challenges designed for teams to overcome together. Promotes strategic planning and joint efforts to achieve common objectives.	[81], [85]–[87], [90], [91], [98], [102], [106]–[108], [115], [120]
ME3	Team Competition	13	Teams competing against each other. Stimulates motivation through healthy competition, pushing teams to perform better.	[83], [84], [87], [90], [95], [100], [109], [113], [115], [118]–[121]
ME4	Team Mission/Quests/Tasks	10	Specific tasks or missions assigned to teams. Fosters cooperation and collaboration in task completion.	[81], [83], [90], [93], [99], [101], [102], [105], [109], [114]
ME5	Chat/Communication/Discuss	9	Communication tools for team discussion. Enhances coordination and sharing of ideas, crucial for collaborative problem-solving.	[81], [101], [106], [108], [113], [114], [118], [119]
ME6	Team Goal	7	Common goals set for the team to achieve. Aligns team efforts towards a unified objective, reinforcing collaboration.	[81], [84], [86], [91], [98], [115], [118]
ME7	Team Point/Incentive/Score	7	Points or incentives awarded based on team performance. Motivates teams to work together for higher rewards.	[81], [83], [84], [87], [106], [115], [119]
ME8	Team Leaderboard	5	Ranking of teams based on their performance.. Drives the competitive spirit and aims for higher collective achievement.	[83], [84], [87], [94], [100]
ME9	Team Feedback	4	Feedback given to teams about their performance. Provides constructive insights for improvement, fostering better teamwork.	[84], [91], [98], [115]
ME10	Narrative/Theming/Storytelling	4	Storylines or themes that enhance the gaming experience. Engages players in a shared narrative, encouraging collaboration through immersion.	[83], [87], [91], [108]
ME11	Team Rewards	3	Rewards given to teams for their achievements.. Incentivizes collective efforts and celebrates team success.	[93], [115], [120]
ME12	Generated Content	2	Content created by players with in-game teammates. Encourages creativity and joint creation of content, enhancing team collaboration.	[117], [118]
ME13	Replays	2	Ability to replay and review game sessions. Allows teams to analyze performance and strategize improvements collaboratively.	[86], [98]
ME14	Visualization/3D/2D	2	Visual elements that enhance understanding of game dynamics. Aids in team comprehension and strategic planning.	[79], [107]
ME15	Choice	1	Options or choices given to teams. Empowers teams to make decisions together, fostering collaboration.	[86]
ME16	Co-creation	1	Collaborative creation of game content or strategies. Encourage joint efforts and creative collaboration.	[79]
ME17	Co-evaluation	1	Teams evaluating each other's performance. Provides mutual feedback, improving collaborative improvement.	[79]
ME18	Dice	1	Use of dice to introduce elements of chance. Encourages team strategy and decision making.	[106]
ME19	Explore	1	Opportunities for teams to explore game environments. Promotes team-based discovery and problem-solving.	[86]
ME20	Guide	1	Guidance provided to teams for task completion. Supports collaborative learning and problem-solving.	[91]
ME21	Player matching	1	Matching players into teams. Facilitates the formation of balanced and effective teams.	[99]
ME22	Question Cards	1	Cards with questions for team discussion. Stimulates team discussion and collective problem-solving.	[106]
ME23	Social Communities	1	Platforms for social interaction among players. Enhances social connections and fosters a sense of community.	[117]
ME24	Team Badges/Medals	1	Badges or medals awarded to teams for achievements. Recognizes team achievements, motivating ongoing collaboration.	[87]
ME25	Team Progress	1	Tracking the progress of the team. Keeps teams informed about their collective progress, encouraging continuous effort.	[86]

TABLE 18. *(Continued.)* **Gamification elements support collaboration aspect.**

Code	Element	Qty	Motivation Supporting Collaboration	Paper
ME26	Team XP/Level	1	Experience points or levels gained by the team. Rewards collective efforts and progress, promoting further collaboration.	[87]
ME27	Timer	1	Time constraints for completing tasks. Promotes efficient teamwork and time management.	[106]
ME28	Usability	1	Ease of use of game features. Supports smooth collaboration by minimizing technical barriers.	[98]
ME29	Voting	1	Teams voting on decisions. Facilitates democratic decision-making and team consensus.	[106]
IE1	Role Player/Playing	5	Players trying different roles without long-term commitment. Encourages flexibility and understanding of the role within the team.	[81], [86], [98], [113], [117]
IE2	Gift/Sharing	4	Players giving or sharing resources. Promotes generosity and mutual support among players.	[81], [89], [90], [110]
IE3	Avatar/Character Generation	3	Creating and customizing player avatars. Enhances personal expression and social interaction.	[83], [99], [117]
IE4	Emotion	3	Expression of emotions within the game. Facilitates emotional connection and empathy among players.	[86], [98], [106]
IE5	Point	2	Points awarded to players for achievements. Motivates individual and collective team performance, strengthening collaboration.	[89], [100]
IE6	Social Media Integration	1	Integration with social media platforms. Extends social interaction and community building beyond the game.	[80]
IE7	Virtual food	1	Use of virtual food items within the game. Enhances social interaction through shared experiences.	[110]
IE8	Virtual pets	1	Use of virtual pets within the game. Promotes social bonding through shared pet activities.	[110]
IE9	XP/Level	1	Experience points or levels for individual players. Encourages personal growth that can benefit team collaboration.	[117]

a solid foundation for further research in this field. It is important for researchers and practitioners to integrate the understanding from this review with findings from other sources and practical experiences to gain a more comprehensive understanding of the use and impact of multiplayer gamification in various contexts. In addition, interdisciplinary collaboration and the development of more inclusive methodologies can help address some of the limitations identified in this review. With a more holistic and inclusive approach, the understanding of multiplayer gamification can continue to evolve and enrich, enabling more effective implementation and positive impact in various domains.

VII. CONCLUSION

A systematic literature review was conducted on 44 selected articles to improve the understanding of gamification in multiplayer environments that support collaborative aspects. The review protocol and methods were developed to evaluate the texts, integrating the approaches used in previous research. This method was used to organize and summarize textual data in a systematic and coherent way. The research provides significant contributions in the following areas:

- This study identifies and analyzes existing research on gamification within multiplayer contexts, with a specific focus on collaborative aspects. The findings reveal that gamification not only enhances player engagement, but also fosters improved social interaction, which is crucial in multiplayer settings. Thus, this research provides a clear perspective on how gamification can be applied to enhance collaboration across various sectors.
- This review poses several research questions that could expand the knowledge in the field of multiplayer gamification. These questions include a further exploration of the most effective gamification elements to support collaboration, as well as how psychological factors influence player interactions. Addressing these questions in future research could provide deeper insight into collaborative dynamics within gamification.
- The study also presents a representation of current topics related to collaborative aspects in multiplayer gamification. By identifying existing trends and challenges, this research paves the way for further studies exploring new technologies and the impact on collaboration within gamification.

This review of the literature enhances the understanding of multiplayer gamification and underscores collaboration's critical role in improving user experience. Provides a foundation for future research and the development of more effective gamification systems to increase collaboration and social interaction between players.

APPENDIX
COMPLETE LIST OF INCLUDED PAPERS

See Table 18.

REFERENCES

[1] J. Landsell and E. Hägglund. (2016). *Towards a Gamification Framework: Limitations and Opportunities When Gamifying Business Processes*. [Online]. Available: http://umu.diva-portal.org/smash/get/diva2:929548/FULLTEXT01

[2] M. Raftopoulos. (2015). *Gamification Project Success and Failures—Marigo Raftopoulos (Strategic Games Lab) GWC15*. [Online]. Available: https://www.youtube.com/watch?v=GztWDpQxBDA

[3] S. Deterding, D. Dixon, R. Khaled, and L. E. Nacke, "From game design elements to gamefulness: Defining gamification," in *Proc. ACM*, 2011, pp. 9–15, doi: 10.1145/2181037.2181040.

[4] A. Christopoulos and S. Mystakidis, "Gamification in education," *Encyclopedia*, vol. 3, no. 4, pp. 1223–1243, Oct. 2023, doi: 10.3390/encyclopedia3040089.

[5] S. Deterding, "Gamification: Designing for motivation," *Interactions*, vol. 19, no. 4, pp. 14–17, Jul. 2012, doi: 10.1145/2212877.2212883.

[6] M. Ma, A. Oikonomou, and L. C. Jain, *Serious Games and Edutainment Applications*. London, U.K.: Springer, 2011, doi: 10.1007/978-1-4471-2161-9.

[7] K. M. Kapp. (2012). *The Gamification of Learning and Instruction: Game-Based Methods and Strategies for Training and Education*. [Online]. Available: https://dl.acm.org/citation.cfm?id=2378737

[8] Y. Rosmansyah, B. L. Putro, A. Putri, N. B. Utomo, and Suhardi, "A simple model of smart learning environment," *Interact. Learn. Environments*, vol. 31, no. 9, pp. 5831–5852, Jan. 2022, doi: 10.1080/10494820.2021.2020295.

[9] Z. N. Khlaif and S. Farid, "Transforming learning for the smart learning paradigm: Lessons learned from the palestinian initiative," *Smart Learn. Environments*, vol. 5, no. 1, p. 1, Aug. 2018, doi: 10.1186/s40561-018-0059-9.

[10] M. B. Armstrong and R. N. Landers, "Gamification of employee training and development," *Int. J. Training Develop.*, vol. 22, no. 2, pp. 162–169, Apr. 2018, doi: 10.1111/ijtd.12124.

[11] K. Seaborn and D. I. Fels, "Gamification in theory and action: A survey," *Int. J. Hum.-Comput. Stud.*, vol. 74, pp. 14–31, Feb. 2015, doi: 10.1016/j.ijhcs.2014.09.006.

[12] M. Vesa and J. T. Harviainen, "Gamification: Concepts, consequences, and critiques," *J. Manage. Inquiry*, vol. 28, no. 2, pp. 128–130, Aug. 2018, doi: 10.1177/1056492618790911.

[13] R. L. S. Díaz, G. R. Ruiz, M. Bouzouita, and K. Coninx, "Building blocks for creating enjoyable games—A systematic literature review," *Int. J. Hum.-Comput. Stud.*, vol. 159, Mar. 2022, Art. no. 102758, doi: 10.1016/j.ijhcs.2021.102758.

[14] G. Lampropoulos, E. Keramopoulos, K. Diamantaras, and G. Evangelidis, "Augmented reality and gamification in education: A systematic literature review of research, applications, and empirical studies," *Appl. Sci.*, vol. 12, no. 13, p. 6809, Jul. 2022, doi: 10.3390/app12136809.

[15] G. Lampropoulos, E. Keramopoulos, K. Diamantaras, and G. Evangelidis, "Integrating augmented reality, gamification, and serious games in computer science education," *Educ. Sci.*, vol. 13, no. 6, p. 618, Jun. 2023, doi: 10.3390/educsci13060618.

[16] S. M. C. Loureiro, R. G. Bilro, and F. J. D. A. Angelino, "Virtual reality and gamification in marketing higher education: A review and research agenda," *Spanish J. Marketing ESIC*, vol. 25, no. 2, pp. 179–216, Sep. 2020, doi: 10.1108/sjme-01-2020-0013.

[17] A. Bucchiarone, "Gamification and virtual reality for digital twin learning and training: Architecture and challenges," *Virtual Reality Intell. Hardw.*, vol. 4, no. 6, pp. 471–486, Dec. 2022, doi: 10.1016/j.vrih.2022.08.001.

[18] B. Sakulkueakulsuk, S. Witoon, P. Ngarmkajornwiwat, P. Pataranutaporn, W. Surareungchai, P. Pataranutaporn, and P. Subsoontorn, "Kids making AI: Integrating machine learning, gamification, and social context in STEM education," in *Proc. IEEE Int. Conf. Teaching, Assessment, Learn. Eng. (TALE)*, Wollongong, NSW, Australia, Dec. 2018, pp. 1005–1010, doi: 10.1109/TALE.2018.8615249.

[19] K. G. Binmore, *Game Theory and the Social Contract*. Cambridge, MA, USA: MIT Press, 1994.

[20] M. D. Hanus and J. Fox, "Assessing the effects of gamification in the classroom: A longitudinal study on intrinsic motivation, social comparison, satisfaction, effort, and academic performance," *Comput. Educ.*, vol. 80, pp. 152–161, Jan. 2015, doi: 10.1016/j.compedu.2014.08.019.

[21] J. Looyestyn, J. Kernot, K. Boshoff, J. Ryan, S. Edney, and C. Maher, "Does gamification increase engagement with online programs? A systematic review," *PLoS ONE*, vol. 12, no. 3, Mar. 2017, Art. no. e0173403, doi: 10.1371/journal.pone.0173403.

[22] J. C.-S. Ho, Y.-S. Hung, and L. Y.-Y. Kwan, "The impact of peer competition and collaboration on gamified learning performance in educational settings: A meta-analytical study," *Educ. Inf. Technol.*, vol. 27, no. 3, pp. 3833–3866, Oct. 2021, doi: 10.1007/s10639-021-10770-2.

[23] M. Dindar, L. Ren, and H. Järvenoja, "An experimental study on the effects of gamified cooperation and competition on English vocabulary learning," *Brit. J. Educ. Technol.*, vol. 52, no. 1, pp. 142–159, Jun. 2020, doi: 10.1111/bjet.12977.

[24] E. D. Mekler, F. Brühlmann, A. N. Tuch, and K. Opwis, "Towards understanding the effects of individual gamification elements on intrinsic motivation and performance," *Comput. Hum. Behav.*, vol. 71, pp. 525–534, Jun. 2017, doi: 10.1016/j.chb.2015.08.048.

[25] M. Riar, B. Morschheuser, R. Zarnekow, and J. Hamari, "Gamification of cooperation: A framework, literature review and future research agenda," *Int. J. Inf. Manage.*, vol. 67, Dec. 2022, Art. no. 102549, doi: 10.1016/j.ijinfomgt.2022.102549.

[26] O. Goethe, "Gamified thinking," in *Human-Computer Interaction Series*. Cham, Switzerland: Springer, 2019, pp. 13–24, doi: 10.1007/978-3-030-11078-9_2.

[27] A. Martens and W. Müller, "Gamification," in *Handbook of Digital Games and Entertainment Technologies*. Singapore: Springer, 2015, pp. 1–23, doi: 10.1007/978-981-4560-52-8_66-1.

[28] R. Caillois. (1958). *Les Jeux Et Les Hommes: Le Masque Et Le Vertige*. France: Gallimard. [Online]. Available: http://monoskop.org/images/4/41/Caillois_Roger_Les_jeux_et_les_hommes_1958.pdf

[29] J. Hamari, "Gamification," in *The Blackwell Encyclopedia of Sociology*, G. Ritzer, Ed., Hoboken, NJ, USA: Wiley, 2019, pp. 1–3, doi: 10.1002/9781405165518.wbeos1321.

[30] M. Trinidad, A. Calderón, and M. Ruiz, "GoRace: A multi-context and narrative-based gamification suite to overcome gamification technological challenges," *IEEE Access*, vol. 9, pp. 65882–65905, 2021, doi: 10.1109/ACCESS.2021.3076291.

[31] P. Anunpattana, M. N. A. Khalid, H. Iida, and W. Inchamnan, "Capturing potential impact of challenge-based gamification on gamified quizzing in the classroom," *Heliyon*, vol. 7, no. 12, Dec. 2021, Art. no. e08637, doi: 10.1016/j.heliyon.2021.e08637.

[32] M. A. Harris, "Maintenance of behaviour change following a community-wide gamification based physical activity intervention," *Preventive Med. Rep.*, vol. 13, pp. 37–40, Mar. 2019, doi: 10.1016/j.pmedr.2018.11.009.

[33] J. Navarro-Alamán, R. Lacuesta, I. Garcia-Magariño, and J. Gallardo, "A methodology for the design and development of gamified mobile apps for monitoring cancer survivors," *J. Biomed. Informat.*, vol. 106, Jun. 2020, Art. no. 103439, doi: 10.1016/j.jbi.2020.103439.

[34] N. V. Wünderlich, A. Gustafsson, J. Hamari, P. Parvinen, and A. Haff, "The great game of business: Advancing knowledge on gamification in business contexts," *J. Bus. Res.*, vol. 106, pp. 273–276, Jan. 2020, doi: 10.1016/j.jbusres.2019.10.062.

[35] H. Korhonen and E. M. I. Koivisto, "Playability heuristics for mobile multi-player games," in *Proc. 2nd Int. Conf. Digit. Interact. Media Entertainment Arts*. Perth, Australia: ACM, Sep. 2007, pp. 28–35, doi: 10.1145/1306813.1306828.

[36] P. Baltzar, L. Hassan, and M. Turunen, "Social accessibility in multiplayer games: Theory and praxis," *Entertainment Comput.*, vol. 47, Aug. 2023, Art. no. 100592, doi: 10.1016/j.entcom.2023.100592.

[37] J. P. Zagal, M. Nussbaum, and R. Rosas, "A model to support the design of multiplayer games," *Presence*, vol. 9, no. 5, pp. 448–462, Oct. 2000, doi: 10.1162/105474600566943.

[38] J.-Y. Wang, W. Lin, and H.-P. Yueh, "Collaborate or compete? How will multiplayers' interaction affect their learning performance in serious games," in *Cross-Cultural Design. Culture and Society*, P.-L. P. Rau, Ed., vol. 11577. New York, NY, USA: Springer, Jan. 2019, pp. 482–491, doi: 10.1007/978-3-030-22580-3_36.

[39] R. P. Griffiths, M. S. Eastin, and V. Cicchirillo, "Competitive video game play: An investigation of identification and competition," *Commun. Res.*, vol. 43, no. 4, pp. 468–486, Feb. 2015, doi: 10.1177/0093650214565895.

[40] J. Pierre and J. de Fine Licht, "Collaborative gaming: When principals and agents agree to game the system," *Public Admin.*, vol. 99, no. 4, pp. 711–722, Feb. 2021, doi: 10.1111/padm.12720.

[41] V. A. Badrinarayanan, J. J. Sierra, and H. A. Taute, "Determinants and outcomes of online brand tribalism: Exploring communities of massively multiplayer online role playing games (MMORPGs)," *Psychol. Marketing*, vol. 31, no. 10, pp. 853–870, Sep. 2014, doi: 10.1002/mar.20739.

[42] N. Cavdar Aksoy, A. Kocak Alan, and E. Tumer Kabadayi, "How to create positive word of mouth (WOM) in the world of gaming? The social side of multiplayer games," *Entertainment Comput.*, vol. 45, Mar. 2023, Art. no. 100541, doi: 10.1016/j.entcom.2022.100541.

[43] B. Choi and H. S. Kim, "Online customer-to-customer interactions, customer–firm affection, firm-loyalty and participation intention," *Asia Pacific J. Marketing Logistics*, vol. 32, no. 8, pp. 1717–1735, May 2020, doi: 10.1108/apjml-07-2019-0450.

[44] R. Wehrle, M. Wiens, and F. Schultmann, "Application of collaborative serious gaming for the elicitation of expert knowledge and towards creating situation awareness in the field of infrastructure resilience," *Int. J. Disaster Risk Reduction*, vol. 67, Jan. 2022, Art. no. 102665, doi: 10.1016/j.ijdrr.2021.102665.

[45] D. Buchinger and M. da Silva Hounsell, "Guidelines for designing and using collaborative-competitive serious games," *Comput. Educ.*, vol. 118, pp. 133–149, Mar. 2018, doi: 10.1016/j.compedu.2017.11.007.

[46] J. P. Zagal, J. Rick, and I. Hsi, "Collaborative games: Lessons learned from board games," *Simul. Gaming*, vol. 37, no. 1, pp. 24–40, Mar. 2006, doi: 10.1177/1046878105282279.

[47] E. Milliet, C. Plancherel, A. Roulin, and F. Butera, "The effect of collaboration on farmers' pro-environmental behaviors—A systematic review," *J. Environ. Psychol.*, vol. 93, Feb. 2024, Art. no. 102223, doi: 10.1016/j.jenvp.2023.102223.

[48] A. A. Gokhale, "Collaborative learning and critical thinking," in *Encyclopedia of the Sciences of Learning*, N. M. Seel, Ed., Boston, MA, USA: Springer, 2012, pp. 634–636, doi: 10.1007/978-1-4419-1428-6_910.

[49] C.-M. Chen, M.-C. Li, and T.-C. Chen, "A web-based collaborative reading annotation system with gamification mechanisms to improve reading performance," *Comput. Educ.*, vol. 144, Jan. 2020, Art. no. 103697, doi: 10.1016/j.compedu.2019.103697.

[50] R. M. Ryan and E. L. Deci, "Intrinsic and extrinsic motivations: Classic definitions and new directions," *Contemp. Educ. Psychol.*, vol. 25, no. 1, pp. 54–67, Jan. 2000, doi: 10.1006/ceps.1999.1020.

[51] K. Ofosu-Ampong, "The shift to gamification in education: A review on dominant issues," *J. Educ. Technol. Syst.*, vol. 49, no. 1, pp. 113–137, Apr. 2020, doi: 10.1177/0047239520917629.

[52] F. Gallego-Durán and C. J. V. Arnedo, "Enchanted talk: Multiplayer gamification using Google spreadsheets," in *Proc. 6th Int. Conf. Technological Ecosystems for Enhancing Multiculturality (TEEM)*, Salamanca, Spain. New York, NY, USA: ACM, Oct. 2018, p. 6, doi: 10.1145/3284179.3284284.

[53] A. Bandura, "On the functional properties of perceived self-efficacy revisited," *J. Manage.*, vol. 38, no. 1, pp. 9–44, Sep. 2011, doi: 10.1177/0149206311410606.

[54] M. F. Ali, N. Nadeem, F. Khalid, N. M. Anwar, G. Nabie, and C. Docherty, "SonoGames: Sounds of the right kind introducing gamification into radiology training," *BMC Res. Notes*, vol. 14, no. 1, Aug. 2021, Art. no. 341, doi: 10.1186/s13104-021-05761-y.

[55] E. Savolainen, S. Rutberg, Y. Backman, and A.-K. Lindqvist, "Long-term perspectives of a school-based intervention to promote active school transportation," *Int. J. Environ. Res. Public Health*, vol. 17, no. 14, p. 5006, Jul. 2020, doi: 10.3390/ijerph17145006.

[56] L. Vygotsky, "Interaction between learning and development," in *Mind and Society*. Cambridge, MA, USA: Harvard Univ. Press, 1978, pp. 79–91.

[57] A. Kozulin, "Vygotsky's theory of cognitive development," in *International Encyclopedia of the Social & Behavioral Sciences*. Amsterdam, The Netherlands: Elsevier, 2015, pp. 322–328, doi: 10.1016/b978-0-08-097086-8.23094-8.

[58] N. Gajdamaschko, "Vygotsky's sociocultural theory," in *International Encyclopedia of the Social & Behavioral Sciences*. Amsterdam, The Netherlands: Elsevier, 2015, pp. 329–334, doi: 10.1016/b978-0-08-097086-8.23203-0.

[59] E. L. Deci and R. M. Ryan, *Intrinsic Motivation and Self-Determination in Human Behavior*. Boston, MA, USA: Springer, 1985, doi: 10.1007/978-1-4899-2271-7.

[60] K. F. Hew, B. Huang, K. W. S. Chu, and D. K. W. Chiu, "Engaging Asian students through game mechanics: Findings from two experiment studies," *Comput. Educ.*, vols. 92–93, pp. 221–236, Jan. 2016, doi: 10.1016/j.compedu.2015.10.010.

[61] M. Thongmak, "A model for enhancing employees' lifelong learning intention online," *Learn. Motivat.*, vol. 75, Aug. 2021, Art. no. 101733, doi: 10.1016/j.lmot.2021.101733.

[62] S. Abuhamdeh, "Investigating the 'flow' experience: Key conceptual and operational issues," *Frontiers Psychol.*, vol. 11, p. 158, Feb. 2020, doi: 10.3389/fpsyg.2020.00158.

[63] O. S. Kaya and E. Ercag, "The impact of applying challenge-based gamification program on students' learning outcomes: Academic achievement, motivation and flow," *Educ. Inf. Technol.*, vol. 28, no. 8, pp. 10053–10078, Jan. 2023, doi: 10.1007/s10639-023-11585-z.

[64] Y.-K. Chou, *Actionable Gamification: Beyond Points, Badges, and Leaderboards*. Fremont, CA, USA: Octalysis Media, 2016. [Online]. Available: http://ci.nii.ac.jp/ncid/BB18977357

[65] R. Hunicke, M. LeBlanc, and R. Zubek. (2004). *MDA: A Formal Approach To Game Design and Game Research*. [Online]. Available: https://api.semanticscholar.org/CorpusID:6056852

[66] T. Ouariachi, C.-Y. Li, and W. J. L. Elving, "Gamification approaches for education and engagement on pro-environmental behaviors: Searching for best practices," *Sustainability*, vol. 12, no. 11, p. 4565, Jun. 2020, doi: 10.3390/su12114565.

[67] I. Araújo and A. A. Carvalho, "Enablers and difficulties in the implementation of gamification: A case study with teachers," *Educ. Sci.*, vol. 12, no. 3, p. 191, Mar. 2022, doi: 10.3390/educsci12030191.

[68] H. Golrang and E. Safari, "Applying gamification design to a donation-based crowdfunding platform for improving user engagement," *Entertainment Comput.*, vol. 38, May 2021, Art. no. 100425, doi: 10.1016/j.entcom.2021.100425.

[69] G. Lampropoulos and Kinshuk, "Virtual reality and gamification in education: A systematic review," *Educ. Technol. Res. Develop.*, vol. 72, no. 3, pp. 1691–1785, Mar. 2024, doi: 10.1007/s11423-024-10351-3.

[70] M. M. Tenório, F. A. F. Reinaldo, L. A. Góis, R. P. Lopes, and G. D. S. Junior, "Elements of gamification in virtual learning environments," in *Advances in Intelligent Systems and Computing*. Cham, Switzerland: Springer, 2018, pp. 86–96, doi: 10.1007/978-3-319-73204-6_12.

[71] F. Erdős, R. Németh, and B. Firuza, "Virtual teamwork in gamified 3D environment," *Infocommunications J.*, vol. 15, pp. 15–20, Jan. 2023, doi: 10.36244/icj.2023.si-iodcr.3.

[72] S. Kushnarev, K. Kang, and S. Goyal, "Assessing the efficacy of personalized online homework in a first-year engineering multivariate calculus course," in *Proc. IEEE Int. Conf. Teaching, Assessment, Learn. Eng. (TALE)*, Dec. 2020, pp. 770–773, doi: 10.1109/TALE48869.2020.9368417.

[73] D. Y. Tan and C. W. Cheah, "Developing a gamified AI-enabled online learning application to improve students' perception of university physics," *Comput. Educ., Artif. Intell.*, vol. 2, Jan. 2021, Art. no. 100032, doi: 10.1016/j.caeai.2021.100032.

[74] O. Zawacki-Richter, V. I. Marín, M. Bond, and F. Gouverneur, "Systematic review of research on artificial intelligence applications in higher education–where are the educators?" *Int. J. Educ. Technol. Higher Educ.*, vol. 16, no. 1, Oct. 2019, Art. no. 39, doi: 10.1186/s41239-019-0171-0.

[75] Q.-F. Yang, L.-W. Lian, and J.-H. Zhao, "Developing a gamified artificial intelligence educational robot to promote learning effectiveness and behavior in laboratory safety courses for undergraduate students," *Int. J. Educ. Technol. Higher Edu.*, vol. 20, no. 1, Apr. 2023, Art. no. 18, doi: 10.1186/s41239-023-00391-9.

[76] B. Kitchenham and S. M. Charters. (2007). *Guidelines for Performing Systematic Literature Reviews in Software Engineering*. [Online]. Available: https://www.researchgate.net/publication/302924724_Guidelines_for_performing_Systematic_Literature_Reviews_in_Software_Engineering

[77] C. Wohlin, P. Runeson, M. Höst, M. C. Ohlsson, B. Regnell, and A. Wesslén, *Experimentation in Software Engineering*. Berlin, Germany: Springer, 2012, doi: 10.1007/978-3-642-29044-2.

[78] N. R. Haddaway, M. J. Page, C. C. Pritchard, and L. A. McGuinness, "PRISMA2020: An R package and shiny app for producing PRISMA 2020-compliant flow diagrams, with interactivity for optimised digital transparency and open synthesis," *Campbell Systematic Rev.*, vol. 18, no. 2, p. e1230, Jun. 2022, doi: 10.1002/cl2.1230.

[79] I. Kavouras, E. Sardis, E. Protopapadakis, I. Rallis, A. Doulamis, and N. Doulamis, "A low-cost gamified urban planning methodology enhanced with co-creation and participatory approaches," *Sustainability*, vol. 15, no. 3, p. 2297, Jan. 2023, doi: 10.3390/su15032297.

[80] T. H. Laine, N. Duong, H. Lindvall, S. S. Oyelere, S. Rutberg, and A.-K. Lindqvist, "A reusable multiplayer game for promoting active school transport: Development study," *JMIR Serious Games*, vol. 10, no. 1, Mar. 2022, Art. no. e31638, doi: 10.2196/31638.

[81] M. Riar, B. Morschheuser, R. Zarnekow, and J. Hamari, "Altruism or egoism–how do game features motivate cooperation? An investigation into user we-intention and I-intention," *Behaviour Inf. Technol.*, vol. 43, no. 6, pp. 1017–1041, Apr. 2023, doi: 10.1080/0144929x.2023.2196581.

[82] C. Weng, K. N. P. Tran, C.-C. Yang, H.-I. Huang, and H. Chen, "Can an augmented reality-integrated gamification approach enhance vocational high school students' learning outcomes and motivation in an electronics course?" *Educ. Inf. Technol.*, vol. 29, no. 4, pp. 4025–4053, Jul. 2023, doi: 10.1007/s10639-023-11966-4.

[83] J. D. Fijnheer, H. van Oostendorp, G.-J. Giezeman, and R. C. Veltkamp, "Competition in a household energy conservation game," *Sustainability*, vol. 13, no. 21, p. 11991, Oct. 2021, doi: 10.3390/su132111991.

[84] B. Morschheuser, J. Hamari, and A. Maedche, "Cooperation or competition–when do people contribute more? A field experiment on gamification of crowdsourcing," *Int. J. Hum.-Comput. Stud.*, vol. 127, pp. 7–24, Jul. 2019, doi: 10.1016/j.ijhcs.2018.10.001.

[85] A. Manzano-León, P. Camacho-Lazarraga, M. A. Guerrero-Puerta, L. Guerrero-Puerta, A. Alias, J. M. Aguilar-Parra, and R. Trigueros, "Development and validation of a questionnaire on motivation for cooperative playful learning strategies," *Int. J. Environ. Res. Public Health*, vol. 18, no. 3, p. 960, Jan. 2021, doi: 10.3390/ijerph18030960.

[86] F. Garcia-Sanjuan, S. Jurdi, J. Jaen, and V. Nacher, "Evaluating a tactile and a tangible multi-tablet gamified quiz system for collaborative learning in primary education," *Comput. Educ.*, vol. 123, pp. 65–84, Aug. 2018, doi: 10.1016/j.compedu.2018.04.011.

[87] L. R. Murillo-Zamorano, J. Á. López-Sánchez, M. J. López-Rey, and C. Bueno-Muñoz, "Gamification in higher education: The ECOn+ star battles," *Comput. Educ.*, vol. 194, Mar. 2023, Art. no. 104699, doi: 10.1016/j.compedu.2022.104699.

[88] G. Eryigit, A. Sentas, and J. Monti, "Gamified crowdsourcing for idiom corpora construction," *Natural Lang. Eng.*, vol. 29, no. 4, pp. 909–941, Jan. 2022, doi: 10.1017/s1351324921000401.

[89] H. S. Du, Y. Lin, F. Zhang, and D. Zhang, "Gamified incentive sharing mechanism of edge computing among edge service providers," *J. Cleaner Prod.*, vol. 376, Nov. 2022, Art. no. 134168, doi: 10.1016/j.jclepro.2022.134168.

[90] A. Spanellis, V. Dörfler, and J. MacBryde, "Investigating the potential for using gamification to empower knowledge workers," *Expert Syst. Appl.*, vol. 160, Dec. 2020, Art. no. 113694, doi: 10.1016/j.eswa.2020.113694.

[91] T. Kolar and B. Čater, "Managing group flow experiences in escape rooms," *Int. J. Contemp. Hospitality Manage.*, vol. 30, no. 7, pp. 2637–2661, Aug. 2018, doi: 10.1108/ijchm-03-2017-0152.

[92] S. C. de las Heras, C. L. Gargalo, C. L. Weitze, S. S. Mansouri, K. V. Gernaey, and U. Krühne, "A framework for the development of pedagogical process simulators (P2Si) using explanatory models and gamification," *Comput. Chem. Eng.*, vol. 151, Aug. 2021, Art. no. 107350, doi: 10.1016/j.compchemeng.2021.107350.

[93] A. Rapp, "An exploration of world of warcraft for the gamification of virtual organizations," *Electron. Commerce Res. Appl.*, vol. 42, Jul. 2020, Art. no. 100985, doi: 10.1016/j.elerap.2020.100985.

[94] T. Jagust, I. Boticki, and H. J. So, "Examining competitive, collaborative and adaptive gamification in young learners' math learning," *Comput. Educ.*, vol. 125, pp. 444–457, Oct. 2018, doi: 10.1016/j.compedu.2018.06.022.

[95] Y. Cao, F. Kou, H. Hu, and G. Wan, "How gamified cooperation and competition motivate low-carbon actions: An investigation of gamification in a popular online payment platform in China," *J. Environ. Manage.*, vol. 324, Dec. 2022, Art. no. 116259, doi: 10.1016/j.jenvman.2022.116259.

[96] P. Weretecki, G. Greve, K. Bates, and J. Henseler, "Information management can't be all fun and games, can it? How gamified experiences foster information exchange in multi-actor service ecosystems," *Int. J. Inf. Manage.*, vol. 61, Dec. 2021, Art. no. 102391, doi: 10.1016/j.ijinfomgt.2021.102391.

[97] G. Zhang, J. Wu, K. Zhao, X. Zhou, Y. Chen, Y. Wang, and M. Tan, "Sustainable society based on social gamification using Nova empire ecology mining," *Sustain. Cities Soc.*, vol. 66, Mar. 2021, Art. no. 102666, doi: 10.1016/j.scs.2020.102666.

[98] J. Montaner, A. Carrión, F. García-Sanjuán, and J. Jaén, "Tangibot: A collaborative multiplayer game for pediatric patients," *Int. J. Med. Informat.*, vol. 132, Dec. 2019, Art. no. 103982, doi: 10.1016/j.ijmedinf.2019.103982.

[99] M. Featherstone and J. Habgood, "UniCraft: Exploring the impact of asynchronous multiplayer game elements in gamification," *Int. J. Hum.-Comput. Stud.*, vol. 127, pp. 150–168, Jul. 2019, doi: 10.1016/j.ijhcs.2018.05.006.

[100] R. van Roy and B. Zaman, "Unravelling the ambivalent motivational power of gamification: A basic psychological needs perspective," *Int. J. Hum.-Comput. Stud.*, vol. 127, pp. 38–50, Jul. 2019, doi: 10.1016/j.ijhcs.2018.04.009.

[101] H. F. Hasan, M. Nat, and V. Z. Vanduhe, "Gamified collaborative environment in moodle," *IEEE Access*, vol. 7, pp. 89833–89844, 2019, doi: 10.1109/ACCESS.2019.2926622.

[102] T. W. Kian, M. S. Sunar, and G. E. Su, "The analysis of intrinsic game elements for undergraduates gamified platform based on learner type," *IEEE Access*, vol. 10, pp. 120659–120679, 2022, doi: 10.1109/ACCESS.2022.3218625.

[103] E. Musi, L. Federico, and G. Riotta, "Human–computer interaction tools with gameful design for critical thinking the media ecosystem: A classification framework," *AI Soc.*, vol. 39, no. 3, pp. 1317–1329, Nov. 2022, doi: 10.1007/s00146-022-01583-z.

[104] N. Ratnawati, S. Sukamto, I. N. Ruja, and N. Wahyuningtyas, "'Defense of the ancients' gamification in learning: Improvement of student's social skills," *Int. J. Emerg. Technol. Learn.*, vol. 15, no. 7, p. 132, Apr. 2020, doi: 10.3991/ijet.v15i07.13221.

[105] E. Zheng and Q. Wang, "Effectiveness of online collaborative learning in gamified environments," *Int. J. Emerg. Technol. Learn. (iJET)*, vol. 18, no. 17, pp. 33–44, Sep. 2023, doi: 10.3991/ijet.v18i17.42851.

[106] R. Patricio, A. C. Moreira, and F. Zurlo, "Gamification in innovation teams," *Int. J. Innov. Stud.*, vol. 6, no. 3, pp. 156–168, Sep. 2022, doi: 10.1016/j.ijis.2022.05.003.

[107] B. Haworth, M. Usman, D. Schaumann, N. Chakraborty, G. Berseth, P. Faloutsos, and M. Kapadia, "Gamification of crowd-driven environment design," *IEEE Comput. Graph. Appl.*, vol. 41, no. 4, pp. 107–117, Jul. 2021, doi: 10.1109/MCG.2020.2965069.

[108] C. Redondo-Rodríguez, J. A. Becerra-Mejías, G. Gil-Fernández, and F. J. Rodríguez-Velasco, "Influence of gamification and cooperative work in peer, mixed and interdisciplinary teams on emotional intelligence, learning strategies and life goals that motivate university students to study," *Int. J. Environ. Res. Public Health*, vol. 20, no. 1, p. 547, Dec. 2022, doi: 10.3390/ijerph20010547.

[109] S. S. Oyelere, S. M. Berghem, R. Brännström, S. Rutberg, T. H. Laine, and A.-K. Lindqvist, "Initial design and testing of multiplayer cooperative game to support physical activity in schools," *Educ. Sci.*, vol. 12, no. 2, p. 100, Jan. 2022, doi: 10.3390/educsci12020100.

[110] B. Liu and J. Tanaka, "Integrating gamification and social interaction into an AR-based gamified point system," *Multimodal Technol. Interact.*, vol. 4, no. 3, p. 51, Aug. 2020, doi: 10.3390/mti4030051.

[111] S. Laato and T. Tregel, "Into the unown: Improving location-based gamified crowdsourcing solutions for geo data gathering," *Entertainment Comput.*, vol. 46, May 2023, Art. no. 100575, doi: 10.1016/j.entcom.2023.100575.

[112] G. Gorjup, L. Gerez, and M. Liarokapis, "Leveraging human perception in robot grasping and manipulation through crowdsourcing and gamification," *Frontiers Robot. AI*, vol. 8, Apr. 2021, Art. no. 652760, doi: 10.3389/frobt.2021.652760.

[113] I. Doney, "Research into effective gamification features to inform e-learning design," *Res. Learn. Technol.*, vol. 27, p. 2093, Jan. 2019, doi: 10.25304/rlt.v27.2093.

[114] A. Rapp, "Social game elements in world of warcraft: Interpersonal relations, groups, and organizations for gamification design," *Int. J. Human–Computer Interact.*, vol. 34, no. 8, pp. 759–773, Apr. 2018, doi: 10.1080/10447318.2018.1461760.

[115] A. Harilal, F. Toffalini, I. Homoliak, J. H. Castellanos, J. Guarnizo, S. Mondal, and M. Ochoa, "The wolf of SUTD (TWOS): A dataset of malicious insider threat behavior based on a gamified competition," *J. Wireless Mobile Netw., Ubiquitous Comput., Dependable Appl. (JoWUA)*, vol. 9, no. 1, pp. 54–85, Mar. 2018, doi: 10.22667/jowua.2018.03.31.054.

[116] D. Zou, "Gamified flipped EFL classroom for primary education: Student and teacher perceptions," *J. Comput. Educ.*, vol. 7, no. 2, pp. 213–228, Jan. 2020, doi: 10.1007/s40692-020-00153-w.

[117] I. Danka, "Motivation by gamification: Adapting motivational tools of massively multiplayer online role-playing games (MMORPGs) for peer-to-peer assessment in connectivist massive open online courses (cMOOCs)," *Int. Rev. Edu.*, vol. 66, no. 1, pp. 75–92, Feb. 2020, doi: 10.1007/s11159-020-09821-6.

[118] T. H. Laine, J. Normark, H. Lindvall, A.-K. Lindqvist, and S. Rutberg, "A distributed multiplayer game to promote active transport at workplaces: User-centered design, implementation, and lessons learned," *IEEE Trans. Games*, vol. 12, no. 4, pp. 386–397, Dec. 2020, doi: 10.1109/TG.2020.3021728.

[119] M. A. Teruel, N. Condori-Fernandez, E. Navarro, P. González, and P. Lago, "Assessing the impact of the awareness level on a co-operative game," *Inf. Softw. Technol.*, vol. 98, pp. 89–116, Jun. 2018, doi: 10.1016/j.infsof.2018.02.008.

[120] A. D. Samala, L. Bojic, D. Vergara-Rodríguez, B. Klimova, and F. Ranuharja, "Exploring the impact of gamification on 21st-century skills: Insights from DOTA 2," *Int. J. Interact. Mobile Technol. (iJIM)*, vol. 17, no. 18, pp. 33–54, Sep. 2023, doi: 10.3991/ijim.v17i18.42161.

[121] O. Feyisetan and E. Simperl, "Beyond monetary incentives: Experiments in paid microtask contests," *ACM Trans. Social Comput.*, vol. 2, no. 2, pp. 1–31, Jun. 2019, doi: 10.1145/3321700.

[122] M. Mohamad, F. K. M. Arif, B. S. Alias, and M. M. Yunus, "Online game-based formative assessment: Distant learners post graduate students' challenges towards quizizz," *Int. J. Sci. Technol. Res.*, vol. 9, no. 4, pp. 994–1000, Apr. 2020. [Online]. Available: https://www.ijstr.org/final-print/apr2020/Online-Game-based-Formative-Assessment-Distant-Learners-Post-Graduate-Students-Challenges-Towards-Quizizz.pdf

[123] E. L. Deci and R. M. Ryan, "Self-determination theory," in *International Encyclopedia of the Social & Behavioral Sciences*. Amsterdam, The Netherlands: Elsevier, 2015, doi: 10.1016/b978-0-08-097086-8.26036-4.

[124] J. G. S. Goldie, "Connectivism: A knowledge learning theory for the digital age?" *Med. Teacher*, vol. 38, no. 10, pp. 1064–1069, Apr. 2016, doi: 10.3109/0142159x.2016.1173661.

[125] G. Siemens, "Connectivism: A learning theory for the digital age," *Int. J. Instructional Technol. Distance Learn.*, vol. 2, no. 1, Jan. 2005. [Online]. Available: http://www.itdl.org/Journal/Jan_05/article01.htm

[126] S. Lindenberg and L. Steg, "Normative, gain and hedonic goal frames guiding environmental behavior," *J. Social Issues*, vol. 63, no. 1, pp. 117–137, Feb. 2007, doi: 10.1111/j.1540-4560.2007.00499.x.

[127] D. W. Johnson and R. T. Johnson, "New developments in social interdependence theory," *Genetic, Social, Gen. Psychol. Monographs*, vol. 131, no. 4, pp. 285–358, Nov. 2005, doi: 10.3200/mono.131.4.285-358.

[128] D. W. Johnson and R. T. Johnson, "An educational psychology success story: Social interdependence theory and cooperative learning," *Educ. Researcher*, vol. 38, no. 5, pp. 365–379, Jun. 2009, doi: 10.3102/0013189x09339057.

[129] B. Morschheuser, J. Hamari, and J. Koivisto, "Gamification in crowdsourcing: A review," in *Proc. 49th Hawaii Int. Conf. Syst. Sci. (HICSS)*, Koloa, HI, USA, 2016, pp. 4375–4384.

[130] C.-M. Chen, L. Ming-Chaun, and C.-P. Kuo, "A game-based learning system based on octalysis gamification framework to promote employees' Japanese learning," *Comput. Educ.*, vol. 205, Nov. 2023, Art. no. 104899, doi: 10.1016/j.compedu.2023.104899.

[131] B. Morschheuser, J. Hamari, J. Koivisto, and A. Maedche, "Gamified crowdsourcing: Conceptualization, literature review, and future agenda," *Int. J. Hum.-Comput. Stud.*, vol. 106, pp. 26–43, Oct. 2017, doi: 10.1016/j.ijhcs.2017.04.005.

[132] K. Werbach and D. Hunter. (May 2015). *The Gamification Toolkit: Dynamics, Mechanics, and Components for the Win*. [Online]. Available: http://hdl.handle.net/1959.3/401604

[133] C. L. Weitze, "Designing for learning and play–the smiley model as a framework," *Interact. Des. Archit.*, no. 29, pp. 52–75, Jun. 2016, doi: 10.55612/s-5002-029-003.

[134] J. Simões, R. D. Redondo, and A. F. Vilas, "A social gamification framework for a K-6 learning platform," *Comput. Hum. Behav.*, vol. 29, no. 2, pp. 345–353, Mar. 2013, doi: 10.1016/j.chb.2012.06.007.

[135] C. Balakrishna, "The impact of in-classroom non-digital game-based learning activities on students transitioning to higher education," *Educ. Sci.*, vol. 13, no. 4, p. 328, Mar. 2023, doi: 10.3390/educsci13040328.

[136] Z. Cömert and Y. Samur, "A comprehensive player types model: Player head," *Interact. Learn. Environments*, vol. 31, no. 5, pp. 2930–2946, May 2021, doi: 10.1080/10494820.2021.1914113.

[137] S. Farmasari, "Peer-learning in young learners English speaking tasks: An ecological analysis," *IJoLE Int. J. Lang. Educ.*, vol. 6, no. 3, p. 254, Nov. 2022, doi: 10.26858/ijole.v6i3.32000.

[138] C. Qiu, B. Long, D. Yu, and K. H. Cheong, "Evolving the classroom: A mathematical and didactic exploration of teacher-guided peer learning," *Chaos, Solitons Fractals*, vol. 174, Sep. 2023, Art. no. 113853, doi: 10.1016/j.chaos.2023.113853.

[139] H. Donelan and K. Kear, "Online group projects in higher education: Persistent challenges and implications for practice," *J. Comput. Higher Educ.*, vol. 36, no. 2, pp. 435–468, Mar. 2023, doi: 10.1007/s12528-023-09360-7.

[140] P. A. Ertmer, "Addressing first- and second-order barriers to change: Strategies for technology integration," *Educ. Technol. Res. Develop.*, vol. 47, no. 4, pp. 47–61, Dec. 1999, doi: 10.1007/bf02299597.

[141] J. Garzón, J. Pavón, and S. Baldiris, "Systematic review and meta-analysis of augmented reality in educational settings," *Virtual Reality*, vol. 23, no. 4, pp. 447–459, Feb. 2019, doi: 10.1007/s10055-019-00379-9.

[142] Y.-H. Wang, "Using augmented reality to support a software editing course for college students," *J. Comput. Assist. Learn.*, vol. 33, no. 5, pp. 532–546, Jun. 2017, doi: 10.1111/jcal.12199.

HERYANTO received the bachelor's degree in informatics engineering from Kuningan University, Indonesia, in 2017. He is currently pursuing the master's degree in electrical engineering with Bandung Institute of Technology, Indonesia. His current research interest includes educational technology.

FERI HIDAYATULLAH FIRMANSYAH received the bachelor's degree in informatics engineering from the State University of Malang, in 2014, and the master's degree in information technology management from the Sepuluh Nopember Institute of Technology, in 2018. He is currently pursuing the Ph.D. degree with the School of Electrical Engineering and Informatics, Bandung Institute of Technology. He is a Researcher. He is also a Lecturer with the Department of Multimedia Education, Indonesia University of Education (UPI), Indonesia. His area of research interests include educational technology, interactive learning media, and information technology.

YUSEP ROSMANSYAH received the bachelor's degree in electrical engineering from Bandung Institute of Technology, Indonesia, in 1993, and the M.Sc. and Ph.D. degrees from the University of Surrey, U.K., in 1996 and 2003, respectively. He has been a Researcher and a Professor of smart multimedia processing with the School of Electrical Engineering and Informatics, Bandung Institute of Technology. His areas of research interests include multimedia, educational technology, and cyber security.