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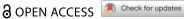
Wilk Oliveira & Juho Hamari

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Flow Experience in Gameful Approaches: A Systematic Literature Review, Scientometric Analysis, and Research Agenda

Wilk Oliveira (1) and Juho Hamari (1)



Gamification Group, Faculty of Information Technology and Communication Sciences, Tampere University, Tampere, Finland

ABSTRACT

The flow experience is a central focus in the design of game-like environments. However, the current state of research in this area remains unclear. We conducted a systematic literature review to answer the following questions: How has the flow experience been analyzed in gameful environments? In what types of gameful environments has the flow experience been analyzed? and What types of technology have been utilized to present gameful environments? In addition, we performed a scientometric analysis. We identified 601 authors who contributed to the field, primarily through quantitative studies published as journal articles in education. Self-report scales are the predominant method for assessing the user flow experience. Games and gamified environments are the most commonly used approaches, with websites as the primary technology for delivering gameful experiences. Based on these findings, we propose an agenda for future research to guide further studies in this domain.

KEYWORDS

Flow experience; gameful experience; gamification; user interaction: literature

1. Introduction

The concept of flow experience (i.e., composed by challenge-skill balance, action-awareness merging, clear goals, unambiguous feedback, concentration, sense of control, loss of self-consciousness, transformation of time, and autotelic experience) (Csikszentmihalyi & Csikszentmihalyi, 1975, 1992, 2014) is a state of heightened engagement and optimal cognitive functioning, manifested when an individual perceives an intricate harmony between their skill set and the challenges presented by a particular task (Csikszentmihalyi, 2000; Csikszentmihalyi & Csikszentmihalyi, 1992, 2014). The "flow" has garnered substantial attention due to its multifaceted nature (Abuhamdeh, 2020; Rheinberg, 2020; Van Der Linden et al., 2021). This phenomenon has particularly attracted significant scholarly interest within gameful environments, encompassing a spectrum of applications such as digital games, gamified systems, and simulators (Oliveira et al., 2018, 2021; Perttula et al., 2017). Especially, this experience has been widely investigated because it is directly related to users' positive behavior/experience when using this type of system (D. Kim & Ko, 2019; Lina & Ahluwalia, 2021; Semerci & Goularas, 2021).

Despite the progressive evolution of gameful paradigms (Högberg et al., 2019; Landers et al., 2019; Lucero et al., 2014), the intricate framework of elements underlying the flow experience remains partially obscured in the existing literature (Hassan et al., 2020; Thomas et al., 2023; Whittaker et al., 2021). Although scholarly interest in this area continues to grow, a comprehensive synthesis that encapsulates the current state of research constitutes a significant gap in the field. It remains challenging to discern how the flow experience has been studied (i.e., such as its design, implementation, and analysis) in these environments and to identify the technologies employed to guide users toward a flow experience (Oliveira, Pastushenko et al., 2021).

In response to this gap, we conducted a systematic literature review to address the lack of comprehensive insights. Our study was guided by three research questions (RQs), each exploring a distinct dimension of the flow experience within gameful environments: (i) How has the flow experience been analyzed in gameful environments? (ii) In what types of gameful environments has the flow experience been analyzed? and (iii) What types of technology have been utilized to present gameful environments? First, we sought to clarify the diverse methodological approaches used to analyze the flow experience in these immersive settings. Second, we aimed to map the various gameful environments utilized to investigate this phenomenon. Finally, we explored the technological frameworks employed to design and evaluate gameful environments fostering the flow experience.

Our comprehensive exploration of the scholarly landscape revealed a predominant reliance on self-report scales as the primary methodological approach for examining the nuanced aspects of the flow experience within gameful

CONTACT Wilk Oliveira wilk.oliveira@tuni.fi 🗗 Gamification Group, Faculty of Information Technology and Communication Sciences, Tampere University, Tampere, Finland

environments. The flow experience has been largely studied in the context of digital games, with relatively fewer investigations focusing on gamified environments. Websites have emerged as the most commonly used technology for implementing gameful approaches. Additionally, our systematic investigation uncovered temporal evolutionary patterns, a taxonomic classification encompassing various fields and subfields, and a quantitative analysis through scientometric techniques, collectively providing a holistic view of the scholarly trajectory in this domain.

Aligned with the outcomes of our systematic literature review, our contribution is manifold. By synthesizing and distilling the corpus of knowledge, we contribute to the overarching domain of HCI, underscoring the significance of the design, implementation, and analysis of flow experience within the gameful approaches. Furthermore, our elucidation of insights and perspectives serves as a guiding beacon for the sub-domains of gameful approaches and Flow Theory, proffering a contemporary encapsulation of state-of-the-art knowledge, and simultaneously serving as a compass to navigate the trajectories of forthcoming explorations within these dynamic domains.

2. Background

In this section, we present the background of our study (i.e., Flow Theory (and its practical grounding on flow experience), and gameful approaches).

2.1. Flow theory

Flow theory, originally introduced by Mihaly Csikszentmihalyi in the 1970s (Csikszentmihalyi & Csikszentmihalyi, 1975), constitutes a cornerstone within the landscape of psychological investigation (i.e., based on Positive Psychology) (Csikszentmihalyi, 2000). Rooted in the pursuit of understanding optimal human experiences (Csikszentmihalyi & Csikszentmihalyi, 1992), Flow Theory delves into the intricate interplay between challenge and skill (Nakamura & Csikszentmihalyi, 2009), aiming to unravel the conditions that facilitate the attainment of a state marked by intrinsic motivation, heightened and focus, holistic (Csikszentmihalhi, 2020; Csikszentmihalyi & Csikszentmihalyi, 1992, 2014). This theory emerged as a response to the exploration of the fundamental question of what constitutes a fulfilling engagement, transcending mere satisfaction embracing a holistic sense of fulfillment (Csikszentmihalyi, 2000). Throughout its evolution, Flow Theory has traversed disciplinary boundaries, influencing fields as diverse as psychology, education, sports, and creativity, consequently imprinting its indelible mark on the scholarly landscape (Chapman et al., 2023; Gómez-Rico et al., 2023; Yu et al., 2023).

Central to the theoretical framework of Flow Theory is the concept of the flow experience (also called flow state) (Csikszentmihalyi & Csikszentmihalyi, 1992). Flow experience, often colloquially referred to as being "in the zone" (Connolly, 2024), embodies a state of heightened engagement and optimal cognitive functioning (Csikszentmihalyi, 2000; Csikszentmihalyi & Csikszentmihalyi, 1992, 2014). This state manifests when an individual perceives an intricate harmony between their skill set and the challenges presented by a particular task (Csikszentmihalhi, 2020). A merger of action and awareness transpires, rendering the individual deeply engrossed in the present moment, accompanied by a transcendence of self-consciousness and an altered perception of time (Csikszentmihalhi, 2020). Furthermore, the autotelic nature of the flow experience underscores its intrinsically rewarding quality, where engagement becomes its reward, and motivations align seamlessly with the task at hand (Csikszentmihalhi, 2020).

Beyond theoretical realms, the concept of flow experience has permeated various facets of real-life applications (Chapman et al., 2023; Gómez-Rico et al., 2023; Yu et al., 2023). Athletes, artists, musicians, and professionals across diverse fields have reported instances of being enveloped by the flow experience during their peak performances. In these scenarios, the symbiosis of heightened focus, intrinsic motivation, and seamless execution have been attributed to the manifestation of the flow state. Moreover, educational settings have witnessed the incorporation of flow principles to enhance student engagement and learning outcomes, emphasizing the potential of the flow experience as a pedagogical tool.

The convergence between the flow experience and gameful approaches has engendered a particularly synergistic relationship (Oliveira et al., 2022, 2023). Gameful environments, characterized by elements of challenge, progression, and reward, are aimed to provide an inherently fertile ground for the cultivation of flow experiences. The inherent mechanics of digital games, gamified applications, and simulators often mirror the conditions conducive to the onset of flow, effectively harnessing the principles of Flow Theory to captivate and sustain user engagement. The dynamic interplay between the flow experience and gameful design principles has inspired various studies, prompting the exploration of how the systematic application of gameful elements can amplify the incidence and depth of the flow experience within these immersive contexts.

2.2. Gameful approaches

The evolution of gameful approaches has traversed a dynamic trajectory, carving a niche within the landscape of HCI (Högberg et al., 2019). The inception of gamification marked a pivotal juncture where principles from game design and psychology were harmoniously amalgamated to engender novel ways of engaging users (Eppmann et al., 2018; Högberg et al., 2019). This synthesis is rooted in the principles of motivational psychology and behavioral as a novel paradigm that sought to harness the inherent allure of games to drive user engagement, behavior change, and experiential enhancement across diverse domains (Eppmann et al., 2018; Högberg et al., 2019).

At its core, gameful approaches encompass a spectrum of strategies and design principles derived from games (Landers et al., 2019), with the intent of transforming



mundane activities into engaging experiences (Eppmann et al., 2018; Högberg et al., 2019; Landers et al., 2019). The pivotal tenets of gameful design are imbued with elements that echo the constructs of games, encompassing challenges, rewards, competition, progression, and a sense of achievement (Eppmann et al., 2018; Högberg et al., 2019). This transformational paradigm converges seamlessly with the broader concept of gameful experiences, wherein users are propelled by intrinsic motivation, immersion, and a sense of agency, thereby forging a profound connection between the digital realm and human engagement (Hassan et al., 2020).

The realm of gameful applications is diverse and expansive (Koivisto & Hamari, 2019), encompassing digital games, applications, and simulation environments (Hajarian et al., 2019, 2023; Högberg et al., 2019). Digital games, for instance, are characterized by structured rules, narrative frameworks, and interactive challenges, and represent a quintessential example of gameful experiences (Juul, 2010; Triantafyllou & Sapounidis, 2023). Gamified applications, on the other hand, permeate various sectors, ranging from health and fitness to education and employee training (Koivisto & Hamari, 2019). These applications leverage gameful design to imbue activities with a sense of playfulness and motivation, thereby augmenting user engagement and outcomes (Högberg et al., 2019).

The potential synergies between gameful approaches and the induction of flow experience have been investigated in the last few years (Oliveira et al., 2023). The inherent dynamics of gameful design, characterized by challenge, progression, and reward, inherently dovetail with the tenets of Flow Theory (Johnson & Wiles, 2003). Gameful approaches have the potential to catalyze the emergence of flow states, facilitating a seamless blend of challenge and skill, fostering deep concentration, and engendering a heightened sense of control and autonomy (Johnson & Wiles, 2003). By orchestrating gameful elements that are calibrated to an individual's skill level, user motivations, and preferences, designers can strategically engineer contexts that are primed for the onset of flow experiences.

3. Method

We conducted the study based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol (Page et al., 2021). The protocol for this study was registered on the Open Science Framework (OSF) under reference number 3845Q. Next, we present the steps followed in the study (following the PRISMA protocol).¹

3.1. Objectives and eligibility criteria

The main objectives of this study were to identify (i) the main fields addressed in the studies in the intersection between Flow Theory and gameful environments, (ii) the most frequent type of studies, (iii) the most active researchers conducting studies on the topic, (iv) how the flow experience has been analyzed in gameful environments, (v) in what types of gameful environments the flow experience has been analyzed, and (vi) what types of technology have been utilized to present gameful environments. To achieve the objectives, the following eligibility criteria were defined:

- Inclusion criteria: (i) Primary/empirical studies about Flow Theory and gameful environments; (ii) studies published between 2018 and 2022.
- Exclusion criteria: (i) Secondary or tertiary studies, (ii) gray literature (non-peer-reviewed studies), (iii) non-English written studies.

The decision to focus on primary empirical studies published between 2018 and 2022 was driven by the substantial volume of research in this domain, with these 5 years providing a comprehensive overview of recent publications sufficient to ensure reliable responses to the RQs. Secondary or tertiary studies were excluded to maintain the focus on empirical research, a common practice in systematic reviews, to ensure the quality and reliability of results and identify the most robust evidence. Gray literature was excluded to avoid incorporating studies that lack peer review or represent individual researchers' opinions. The inclusion of only studies in English was based on its status as the predominant language in scientific literature and its frequent use as the sole language in secondary studies.

3.2. Information sources and search strategy

In this study, following the example of recent secondary studies in this field (Cosio, Buruk, Fernández Galeote, Bosman, & Hamari, 2023; Mattinen, Macey, & Hamari, 2023; Oliveira, Pastushenko, et al., 2021), we are using the Scopus² database, which includes all the main databases in the field of gameful studies and Flow Theory (e.g., ACM Digital Library, IEEE Xplorer, Science Direct, and Springer Link).

Next, we defined the search strategy (i.e., search string). We used the method PICOC (Population, Intervention, Comparison, Outcomes, and Context) (Richardson et al., 1995) to define our search string. Thus, the following PICOC was defined:

- Population: studies that describe, apply, or evaluate gameful environments to provide users' flow experience;
- **Intervention**: methods used to provide or evaluate users' flow experience in gameful environments;
- Comparison: not applicable, since the purpose of this study is to provide a scoping review and scientometric analysis;
- Outcomes: general aspects related to research on the intersection between Flow Theory and gameful environments;
- **Context**: studies in the intersection between Flow Theory and gameful environments.

After applying the PICOC method, the following search string (see Table 1) was defined (the generated search string was validated by comparison with topics presented in recent studies in this field). In the search string, we limited the publication time (2018-2022), and removed secondary/

tertiary studies, gray literature, and non-English written studies automatically in the string itself.

3.3. Data selection and data collection process

Initially, immediately after applying the search string and downloading the metadata of the identified studies, an automation tool (i.e., Parsifal³) was used to identify duplicate studies. Next, title and abstract reading were used to define whether a study met the review's inclusion criteria. Finally, full article reading was used to collect data. No automation tool was used in the process.

For this study, the following information was extracted from the studies: (i) field, (ii) sub-field, (iii) type of study, (iv) type of intervention, (v) number of participants, (vi) authors name, (vii) authors institution, and (viii) authors country (both for the scientometric analysis). We also collected how the flow experience was analyzed within the gameful environments (to answer the first RQ), gameful environments used to provide users' flow experience (to answer the second RQ), and technology used to present gameful environments (to answer the third RQ). The data collection process was conducted in April (2023).

All subjective definitions of the process (e.g., definition of the search string and data to be collected) were made by two researchers with about 10 years of experience in gameful studies and Flow Theory. They also have experience in conducting secondary studies. In cases of disagreement in decision-making, a meeting was held to make the final decision. A single researcher (the article's first author) carried out the data collection process.

4. Results

In this section, we present the results of our study, first presenting the evolution in the number of publications per year and scientometric analysis results. Finally, we also present the answers to our RQs.

4.1. Selected studies

From a total of 668 studies identified in the initial analysis, in the end, 207 studies were identified as eligible and included in the review (full reader for data extraction). Figure 1 shows an overview of the analysis performed (step by step) following the PRISMA protocol diagram (Page et al., 2021). The list of studies is presented in Appendix A, presenting the study Id, title, and reference (i.e., citation). The full dataset⁴ is available to identify the details of all studies included in the review.

4.2. Scientometric analysis

In our scientometric analysis, we identified the evolution in the number of publications per year, the fields and subfields, and the types of publications. We also mapped the authors and countries.

4.2.1. Evolution per year

The results show an evolution in the number of publications over the last few years, with special growth in 2021. These results demonstrate a growing community interest in the topic. The drop in 2022 is possibly because the indexing process is slow in some cases and that part of the studies published in 2022 will only be indexed in the second half of 2023. Figure 2 presents the evolution in the number of publications over the years.

4.2.2. Fields and Sub-fields

Studies have been published in different domains, in total, studies published in eight different domains were identified (i.e., Education, Gaming, Health, Business, Marketing, Tourism, Entertainment, Artificial Intelligence, Environment). Following the same line of results found in other secondary studies in the field of gamification (Koivisto & Hamari, 2019; Oliveira, Pastushenko et al., 2021), most of the studies (131 studies (63%)) were published in the field of education. Table 2 presents a complete analysis of the published studies according to the field.

4.2.3. Types of publications

Most of the studies published in the last 5 years were published in journals (149 studies (72%)). Only 58 (less than half of the publications) were published at conferences. Thus, most studies tend to present more robust results, with greater details in relation to the study conducted (e.g., type of analysis performed). Table 3 present which studies were published in journals and which were published at conferences.

4.2.4. Authors and countries

In total, 601 different authors contributed to the field in the last 5 years. This number demonstrates interest from a broad community, with diverse characteristics. Five authors stand out with the highest number of publications (more than five publications each). One author, in particular, is responsible for the vast majority of publications. In the Table 4, we present the 15 most productive authors.

Finally, it is also possible to notice that authors from a vast majority of countries have contributed to the evolution of the area. In total, authors from 40 countries have published studies in the last 5 years. In particular, Taiwan, the United States,

Identification of studies via databases and registers

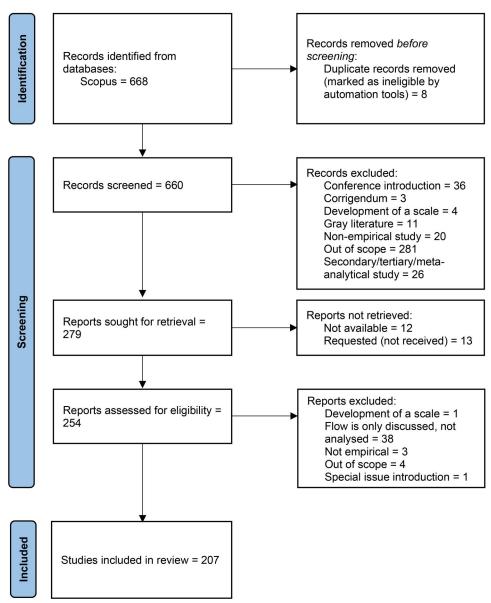


Figure 1. PRISMA diagram (adapted from Page et al. (2021)).

Germany, France, and Switzerland are the countries with the most productive authors in the field. Figure 3 presents a heat map of the countries while Table 5 presents a concrete list of countries with at least 10 publications.

4.3. RQ 1: How has the flow experience been analyzed in gameful environments?

Consistent with findings from other studies in similar domains, scales were identified as the primary resource for measuring users' flow experience within gameful approaches, utilized in 182 studies. While alternative methods, such as facial tracking and inventories, were also employed, their usage was significantly less frequent. Overall, this result indicates that there has been little evolution in recent years regarding how to measure the flow experience in gameful

approaches. Table 6 present the measurement types used in each study.

4.4. RQ 2: In what types of gameful environments has the flow experience been analyzed?

Educational games predominate as the main type of gameful environment used in studies, with a total of 44 occurrences. Next, gamified systems appear and are used in 28 studies. Serious games are used in 24 studies. The results indicate a predominance of classic approaches, such as educational games and gamified systems, which have been widely used in recent years. Approaches such as virtual reality-based games, exergames, and simulators have also been used, albeit

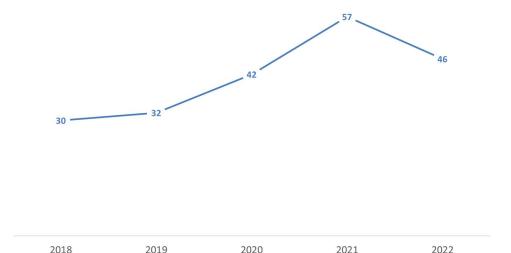


Figure 2. Evolution per year.

Field	Ν	Studies
Education	131	\$1, \$8, \$10, \$15, \$16, \$17, \$18, \$21, \$27, \$28, \$30, \$31, \$32, \$35, \$37, \$38, \$39, \$42, \$43, \$44, \$45, \$47, \$48, \$52, \$53, \$54, \$56, \$57, \$58, \$61, \$62, \$63, \$64, \$65, \$66, \$67, \$72, \$73, \$74, \$75, \$76, \$77, \$79, \$80, \$81, \$82, \$83, \$84, \$85, \$89, \$94, \$95, \$96, \$97, \$98, \$99, \$100, \$101, \$105, \$107,
		\$108, \$110, \$111, \$112, \$113, \$114, \$118, \$119, \$122, \$126, \$127, \$128, \$129, \$130, \$131, \$132, \$133, \$135, \$139, \$140, \$144, \$145, \$146, \$147, \$148, \$149, \$150, \$152, \$153, \$154, \$155, \$156, \$157, \$158, \$162, \$163, \$164, \$167, \$168, \$169, \$171, \$172, \$173, \$174, \$176, \$177, \$178, \$179, \$181, \$182, \$183, \$186, \$187, \$188, \$189, \$190, \$191, \$192, \$193, \$196, \$197, \$198, \$199, \$200,
Gaming	31	S201, S202, S203, S204, S205, S206, S207
		S90, S91, S93, S102, S106, S115, S123, S134, S136, S137, S166
Health	24	S2, S5, S9, S12, S13, S19, S20, S25, S29, S40, S46, S92, S103, S104, S116, S117, S124, S159, S160, S161, S170, S175, S184, S194
Business	10	S3, S23, S51, S109, S120, S121, S125, S141, S142, S143
Marketing	4	S6, S7, S138, S151
Tourism	3	S26, S41, S195
Entertainment		S165, S180
Artificial Intelligence	1	S185
Environment	1	S55

Key: N = number of studies in the field.

in fewer studies. Table 7 present the types of gameful environments where the flow experience has been analyzed.

4.5. RQ 3: What types of technology have been utilized to present gameful environments?

In recent years, different technologies have been used to implement gameful approaches to bring users to a flow experience. Websites predominate with 65 studies, followed by personal computer software with 33 studies and mobile applications with 25 studies. In general, they were making clear a predominance of more traditional technologies. Other types of technology, such as virtual reality glass, augmented reality apps, and tablets are also identified, but less

Туре	Ν	Studies
Conference Paper	58	\$3, \$4, \$5, \$7, \$8, \$9, \$10, \$12, \$14, \$27, \$29, \$30, \$31, \$33, \$34, \$35, \$36, \$38, \$39, \$40, \$46, \$47, \$55, \$56, \$59, \$62, \$63, \$67, \$76, \$77, \$78, \$80, \$82, \$84, \$86, \$91, \$93, \$94, \$95, \$98, \$101, \$102, \$103, \$110, \$113, \$114, \$125, \$126, \$130, \$131, \$136, \$137, \$147, \$154, \$155, \$191, \$202, \$203.
Journal Article	149	\$1, \$2, \$6, \$11, \$13, \$15, \$16, \$17, \$18, \$19, \$20, \$21, \$22, \$23, \$24, \$25, \$26, \$28, \$32, \$37, \$41, \$42, \$43, \$44, \$45, \$48, \$49, \$50, \$51, \$52, \$53, \$54, \$57, \$58, \$60, \$61, \$64, \$65, \$66, \$68, \$69, \$70, \$71, \$72, \$73, \$74, \$75, \$79, \$81, \$83, \$85, \$87, \$88, \$89, \$90, \$92, \$96, \$97, \$99, \$100, \$104, \$105, \$106, \$107, \$108, \$109, \$111, \$112, \$115, \$116, \$117, \$118, \$119, \$120, \$121, \$122, \$123, \$124, \$127, \$128, \$129, \$132, \$133, \$134, \$135, \$138, \$139, \$140, \$141, \$142, \$143, \$144, \$145, \$146, \$147, \$149, \$150, \$151, \$152, \$153, \$156, \$157, \$158, \$159, \$160, \$161, \$162, \$163, \$164, \$165, \$166, \$167, \$168, \$169, \$170, \$171, \$172, \$173, \$174, \$175, \$176, \$177, \$178, \$179, \$180, \$181, \$182, \$183, \$184, \$185, \$186, \$187, \$188, \$189, \$190, \$192, \$193, \$194, \$195, \$196, \$197, \$198, \$199, \$200, \$201, \$204, \$205, \$206, \$207

Key: N = Number of published paper by type.

frequently. Table 8 present the types of technology used to provide gameful environments.

5. Discussion

Promoting user engagement is fundamental in any gameful setting, encompassing gamified systems, simulators, board games, and others. Among the various experiences sought after and extensively examined, the flow experience stands out. However, understanding the current state of employing Flow Theory in gameful environments poses a considerable challenge. Addressing this gap, we conducted a systematic literature review and scientometric analysis focusing on investigations that explore the intersection of Flow Theory and gameful environments. By providing an encompassing overview of the studies involving Flow Theory in gameful environments, our research offers valuable insights into the fields of HCI, gameful approaches, and Flow Theory.

Table 4. Most productive authors.

Authors' names	N
Hou HT	17
Isotani S; Li CT	7
Kiili K; Oliveira W	6
Kuo CC; Martin-Niedecken AL	5
Fang YS; Hamari J; Kannegieser E; Kojic T; Ninaus M; Schättin A; Voigt-Antons JN; and Wang SM	4

Key: N = Number of published paper by each individual author.

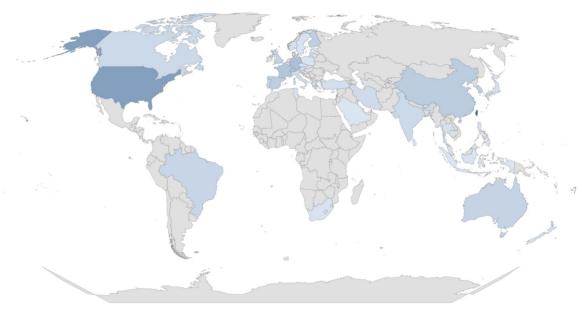


Figure 3. Map.

Table 5. Number of individual authors per country.

Country	N
Taiwan	98
United States	53
Germany	28
France	24
Switzerland	20
China	19
Spain	18
Finland	17
South Korea	16
Australia and United Kingdom	14
Brazil and Hong Kong	13
Portugal	12
Canada and India	10

Key: N = Number of individual author per country.

5.1. An overview of publications

The findings of this review and scientometric analysis revealed an increase in the number of published studies in the last few years, following the same line as other recent secondary studies involving these domains (Oliveira, Pastushenko, et al., 2021; Oliveira et al., 2018; Perttula et al., 2017). This result indicates a growing interest and recognition of the significance of the flow experience in gameful contexts (see Figure 2). This trend suggests that researchers and practitioners are increasingly acknowledging the potential benefits of integrating Flow Theory into the design and evaluation of gameful interventions. Thus, it is also encouraging to witness this upward trajectory, as it signifies the importance of studying and harnessing the power of the

flow experience to enhance engagement and user experiences in gameful environments.

The concentration of studies in the field of education (following the trend of specific areas related to gameful environments (Koivisto & Hamari, 2019; Oliveira, Pastushenko et al., 2021)) highlights the significance of incorporating flow principles in educational settings. On one side, the educational context provides a fertile ground for applying gameful approaches to enhance student motivation, learning outcomes, and overall educational experiences (Oliveira et al., 2022). However, on the other side, it is crucial to expand the scope of research beyond the education domain to explore the applicability of Flow Theory in different contexts such as healthcare, workplace environments, and personal development. Examining flow experiences in diverse settings can provide a more comprehensive understanding of its potential impact across various domains.

The field of Gaming emerges as a prominent area with a substantial number of publications, totaling 31 studies (see Table 2). This finding is indicative of the growing interest in exploring the intersection of gaming and Flow Theory (i.e., games for flow). The popularity of gaming as a research topic can be attributed to several factors. Firstly, the widespread availability and accessibility of gaming platforms and technologies have opened new avenues for investigation and innovation. Researchers demonstrate to recognize the potential of games as immersive and engaging environments that can facilitate learning, behavior change, and psychological experiences such as flow (Juul, 2010; Stenros, 2017).

Table 6. Measurement type.

ID	Measurement type	N
S1, S2, S3, S4, S5, S6, S7, S8, S10, S11, S12, S13,	Scale	182
S14, S15, S16, S17, S18, S19, S20, S21, S23, S24,		
S25, S27, S28, S29, S30, S31, S33, S34, S38, S39,		
S40, S41, S42, S43, S44, S45, S46, S47, S48, S49,		
S50, S51, S52, S53, S54, S58, S59, S60, S61, S62,		
S63, S64, S65, S67, S69, S70, S71, S72, S74, S75,		
S76, S77, S78, S79, S80, S81, S82, S83, S84, S85,		
S86, S87, S89, S90, S91, S92, S93, S94, S95, S96,		
S97, S98, S99, S100, S101, S102, S103, S104,		
S105, S106, S107, S108, S110, S111, S112, S113,		
S114, S115, S116, S117, S118, S120, S122, S123,		
S124, S125, S126, S127, S128, S129, S130, S131,		
S132, S133, S134, S135, S138, S140, S141, S142,		
S143, S145, S146, S147, S148, S149, S150, S151,		
S153, S154, S155, S156, S157, S158, S159, S160,		
S161, S162, S163, S165, S166, S167, S168, S169,		
S170, S171, S172, S173, S174, S175, S176, S177,		
S178, S180, S181, S182, S183, S184, S185, S186,		
S187, S188, S189, S190, S191, S192, S193, S194,		
S195, S196, S197, S198, S199, S200, S202, S203,		
S204, S205, S206, S207		
S37, S57, S139	Interview	3
S68, S136, S137	Scale and EEG	3
S9, S179	Facial tracking	2
S32, S66	Inventory	2
S201	Data logs	1
S119	EEG	1
S152	Open-ended question	1
S36	Physiological measurements and scale	1
S109	Questionnaire	1
S22	Scale and behavior data	1
S35	Scale and Physiological Data	1
\$144 \$100	Scale/Data logs	1
\$88 636	Self-emote	1
\$26	Text analysis	1
S55, S56, S73, S121, S164	Not specified	5

Key: N: Number of studies per measurement type.

Secondly, the integration of game elements into non-game contexts, such as educational systems and health interventions, has gained significant attention (Koivisto & Hamari, 2019). The application of gameful design approaches has shown promise in enhancing motivation, engagement, and flow experience. As a result, scholars from diverse disciplines are increasingly drawn to the field of gaming, contributing to the proliferation of publications in this area.

Another noteworthy result of this literature review is the observation that the field of Health ranks third in terms of the number of publications, with 24 studies identified. The presence of health-related studies in the context of gameful environments underscores the growing recognition of the potential of games and game-like interventions in promoting health behaviors, patient engagement, and therapeutic outcomes. This trend can be attributed to the increasing use of technology and digital solutions in healthcare settings (Senbekov et al., 2020). At the same time, the recognition of the impact of motivation, engagement, and immersive experiences on health-related behaviors and outcomes (Rudolf et al., 2020). The integration of gaming elements, such as rewards, challenges, and social interactions, into health interventions holds promise for improving adherence to treatment regimens, promoting physical activity, managing chronic conditions, and addressing mental health concerns (G. Chan et al., 2024). Also, the substantial number of publications in the field of Health indicates the dedication of

researchers to explore the potential benefits and applications of gameful approaches in different healthcare contexts, relating it to the flow experience.

The predominance of quantitative studies among the identified publications indicates a preference for empirical investigations and objective measurements of flow in gameful environments (which may have to do with the very nature of the study). While quantitative studies offer valuable insights into the prevalence and patterns of flow experiences, it is crucial to complement these approaches with qualitative methodologies (mixed method approaches). Qualitative research can delve into the subjective experiences, perceptions, and interpretations of individuals engaging in gameful activities, providing a deeper understanding of the nuances and complexities of the flow phenomenon. By combining quantitative and qualitative approaches, researchers can gain a more holistic view of flow experiences and uncover rich insights that go beyond mere numerical data.

Most of the studies included in this review were published in journals rather than conference proceedings (see Table 3). This preference for journal publications may stem from several factors inherent to the nature of the research conducted in this domain. Firstly, the complex and multidisciplinary nature of gameful environments and Flow Theory often requires in-depth exploration, rigorous methodology, and comprehensive reporting, which are better suited for

Table 7. Used gameful environments.

ID	Gameful environment	N
\$1, \$21, \$24, \$28, \$32, \$42, \$43, \$52, \$53, \$58, \$61, \$72, \$76, \$81, \$82, \$83, \$84, \$94, \$95, \$102, \$107, \$108, \$110, \$111, \$112, \$113, \$118, \$119, \$121, \$130, \$132, \$133, \$140, \$144, \$145, \$148, \$153, \$156, \$158, \$168, \$174, \$177, \$178, \$197, \$201, \$206	Educational game	44
S6, S10, S16, S18, S19, S31, S37, S41, S47, S51, S67, S85, S90, S101, S106, S109, S120, S126, S146, S147, S157, S167, S169, S171, S180, S191, S196, S198	Gamified system	28
S2, S8, S9, S11, S12, S15, S29, S36, S56, S69, S78, S79, S88, S93, S96, S122, S129, S134, S136, S160, S164, S166, S172, S179, S188	Serious game	24
S33, S34, S40, S46, S57, S59, S65, S68, S86, S89, S91, S103, S115, S116, S117, S127, S149, S184	Virtual reality-based game	18
S4, S13, S14, S20, S22, S75, S92, S104, S123, S124, S161, S176, S194	Exergame	13
S3, S23, S30, S66, S135, S186, S190, S193, S199, S207	Simulator	10
S39, S62, S63, S99, S100, S105, S114, S155, S203 S55, S128, S151, S152, S159, S189, S192, S195, S200	Board game Gamifed app	9
S44, S64, S97, S154, S131, S205	Augmented reality-based game	6
S26, S38, S74, S98, S162, S170, S182, S202	Escape room	8
S05, S50, S60, S141, S165, S185, S187	Entertainment game	5
S54, S71	Business game	2
S27, S163	Gamified environment (non-digital)	2
S175	Active game	1
S181	Adventure game	1
\$204	Capture the flag-based game	1
\$73 	Different games	1
\$77 \$170	Game quest	1
\$173	Platform about games	1
S45	Mini-games	1
\$70	Role-playing game	1
\$7, \$17, \$25, \$35, \$48, \$49, \$80, \$87, \$125, \$137, \$138, \$139, \$142, \$143, \$150, \$183	Not specified	16

N: Number of studies per type of gameful environment.

the format of journal articles. Journals provide researchers with the space and opportunity to present their work in a more detailed and comprehensive manner, allowing for the inclusion of theoretical frameworks, methodological considerations, data analysis, and discussion of implications. By publishing in journals, researchers are more likely to reach a targeted audience of experts and scholars who share a common interest and expertise in gameful environments.

The presence of 601 authors from 40 different countries in recent publications within the field of gameful environments and flow highlights the global reach and collaborative nature of research in this area. This diverse representation signifies the recognition and interest in gameful approaches across various cultural contexts, fostering a comprehensive understanding and advancing the field's knowledge. The involvement of scholars from different countries facilitates cross-cultural exchange, enabling the exploration of the applications and implications of gameful environments worldwide, and promoting the continuous development of innovative strategies to address educational, social, and psychological challenges.

However, the observation that a significant proportion of studies are concentrated in only a few countries raises questions about flow research's generalizability and cross-cultural applicability in gameful environments. Cultural factors, societal norms, and contextual variations can influence the

manifestation and facilitation of flow experiences. Therefore, fostering cross-cultural collaborations and encouraging research from diverse geographical locations is crucial. Investigating flow experiences in different cultural contexts will enable us to discern the universality of Flow Theory while also acknowledging and appreciating cultural nuances that may shape the flow experience differently.

5.2. The flow experience analyzes in gameful approaches

The findings of our systematic literature review provide valuable insights into the methodologies employed to analyze the flow experience within gameful environments. Our investigation reveals a predominant reliance on scales as the primary instrument for identifying and measuring the flow experience in users engaging with gameful approaches (see Table 6). This established trend is consistent with prior research in related domains (Oliveira, Pastushenko et al., 2021; Perttula et al., 2017) and underscores the enduring significance of scale-based assessments in evaluating subjective psychological states.

The prevalence of scales, utilized in 182 studies, highlights their widespread adoption as a standard tool for assessing the flow experience in gameful interactions. Scales offer a structured and quantifiable approach to capturing

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ID	Technology	Ν
S6, S10, S16, S18, S19, S21, S23, S24, S41, S43,	Online (website)	65
S45, S47, S50, S51, S54, S55, S56, S66, S67, S70,		
S71, S72, S76, S79, S85, S90, S94, S95, S101,		
S107, S111, S113, S120, S121, S122, S123, S126,		
S129, S130, S132, S136, S140, S141, S144, S145,		
\$146, \$147, \$148, \$150, \$152, \$153, \$159, \$168,		
\$169, \$173, \$178, \$183, \$191, \$194, \$202, \$170,		
S182, S188, S199, S198		
\$1, \$8, \$11, \$15, \$28, \$31, \$33, \$46, \$48, \$53, \$60,	Personal computer	33
\$78, \$82, \$84, \$98, \$106, \$109, \$134, \$135,		
S162, S167, S171, S174, S179, S181, S184, S186,		
S190, S193, S196, S201, S206, S108		
S2, S42, S64, S69, S83, S88, S97, S110, S112, S117,	Mobile app	25
S118, S119, S128, S131, S151, S154, S156, S157,		
\$158, \$164, \$172, \$189, \$200, \$203, \$207	No. 1 10 10	
\$165, \$176, \$4, \$30, \$40, \$57, \$59, \$68, \$89, \$91,	Virtual reality glass	14
\$115, \$116, \$127, \$149	Could ware	-
\$27, \$39, \$99, \$100, \$114, \$155, \$197	Card game	7
\$13, \$75, \$104	Open room	3
\$38, \$58, \$73, \$160	Tablet	4
\$205 \$62	Augmented reality app Arduin	1 1
S37	Books	1
\$163	Digital (online)/non digital	1
\$124	Dividat senso plate	1
\$9	Kinect	1
S29	Multi-platform	1
\$74	Robot	1
\$44	Table	1
\$103	Virtual reality glass and bike	1
\$187	Virtual reality glass and augmented reality app	1
\$166	Virtual reality glass and personal computer	1
S3, S5, S7, S12, S14, S17, S20, S22, S25, S26, S32,	Not specified	44
S34, S35, S36, S49, S52, S61, S63, S65, S77, S80,	not specifica	
S81, S86, S87, S92, S93, S96, S102, S105, S125,		
S133, S137, S138, S139, S142, S143, S161, S175,		
S177, S180, S185, S192, S195, S204		

N: Number of studies per technology.

subjective experiences, allowing researchers to systematically measure key dimensions of flow, such as challenge-skill balance, clear goals, and immediate feedback. Moreover, established flow scales such as the Flow State Scale (FSS) (Jackson et al., 2011) and the Flow Short Scale (FSS-2) (Hamari & Koivisto, 2014) provide reliable and validated measures for evaluating flow across diverse contexts, facilitating comparability and generalizability across studies.

While scales remain the dominant methodological approach, our review also identifies alternative means of analyzing the flow experience, albeit in smaller numbers. Facial tracking and inventories represent emerging methodologies that offer potential insights into users' affective states and cognitive processes during gameplay. Facial tracking, for instance, enables real-time monitoring of facial expressions and physiological responses, providing nuanced indicators of emotional engagement and immersion (Bailenson et al., 2008; Diwan et al., 2025). Similarly, inventories offer structured frameworks for assessing specific aspects of flow, such as the intensity of flow experiences or the presence of flowinducing factors.

However, despite the emergence of these alternative methodologies, their relatively limited adoption suggests a continued reliance on traditional approaches to analyzing the flow experience in gameful environments. This

observation raises questions about the evolution of measurement techniques and the need for innovation in assessing subjective experiences in interactive contexts. While scales offer a reliable and validated means of quantifying flow, they may overlook subtle nuances and context-specific factors that contribute to the richness of the user experience.

The limited evolution in measurement techniques over recent years suggests an opportunity for future research to explore novel methodologies and technologies for assessing the flow experience in gameful approaches. Advancements in biometric sensing, machine learning, and affective computing present promising avenues for capturing and analyzing user experiences with greater granularity and accuracy. Integrating these innovative approaches with traditional scale-based assessments can enhance our understanding of flow dynamics and inform the design of more engaging and immersive gameful interactions.

5.3. The gameful approaches explored in the studies

Our findings provide insights into the types of gameful environments where the flow experience has been studied. Our investigation reveals a predominant focus on educational games, followed by gamified systems and serious games, as primary contexts for exploring flow dynamics (see Table 7),

posing a trend towards the utilization of classic approaches, such as educational games and gamified systems, which have garnered considerable attention in recent years within HCI research.

Educational games emerge as the most prevalent type of gameful environment in our review, with 44 occurrences in the literature. This prominence underscores the enduring appeal of leveraging gameplay mechanics and interactive elements to enhance learning outcomes and engagement among users. Educational games offer a compelling platform for integrating educational content with engaging gameplay (Juul, 2010; Stenros, 2017), tending to foster an immersive and motivating learning experience. The inclusion of flow experience studies within educational games reflects a concerted effort to understand the cognitive and affective processes underlying effective learning environments, with flow serving as a key construct in this regard.

Following educational games, gamified systems emerge as another prominent context for studying the flow experience, with 28 occurrences identified in our review. Gamification has gained traction as a strategy for promoting engagement, motivation, and behavior change across various domains (Y. Hong et al., 2024; Koivisto & Hamari, 2019; Zeybek & Saygı, 2024). Gamified systems leverage principles of game design to incentivize desired behaviors, enhance user experiences, and foster a sense of achievement and progress (Y.-J. Lee, 2023). The exploration of flow within gamified systems sheds light on the interplay between gameful design elements and psychological states of immersion and absorption, offering valuable insights for designers and practitioners alike.

Serious games represent another notable category of gameful environments, with 24 occurrences identified in our review. Serious games encompass a diverse range of applications, including training, healthcare interventions, and social impact initiatives, among others, striving to engage users in meaningful experiences that transcend mere entertainment value (Larson, 2020). The examination of flow within serious games elucidates the mechanisms by which immersive and challenging gameplay can facilitate skill development, knowledge acquisition, and behavior change, contributing to the growing body of research on the efficacy of serious games as a medium for learning and behavior modification.

While educational games, gamified systems, and serious games dominate the landscape of gameful environments in our review, we also observe the inclusion of alternative approaches, albeit to a lesser extent. Virtual reality-based games, exergames, and simulators represent emerging paradigms that offer unique opportunities for immersive and interactive experiences. While these approaches may have garnered less attention in the literature, their inclusion highlights the evolving nature of gameful design and the exploration of novel contexts for studying flow dynamics within HCI research.

The findings underscore the diverse array of gameful environments where the flow experience has been studied. By examining flow dynamics across various contexts, from educational games to serious simulations, researchers can

deepen our understanding of how interactive technologies shape user experiences and foster optimal states of engagement and immersion. Moving forward, continued exploration of flow within diverse gameful environments promises to inform the design of more engaging, meaningful, and impactful interactive systems in both educational and noneducational domains.

5.4. The technologies used to present gameful approaches

The findings of this systematic literature review shed light on the diverse array of technologies utilized in presenting gameful environments, aimed at fostering a state of flow experience among users. Our investigation revealed a notable prevalence of conventional technologies, particularly websites, personal computer software, and mobile applications, in the implementation of gameful approaches (see Table 8). This prevalence suggests a reliance on established platforms and frameworks within the HCI domain for the delivery of gamified experiences.

The predominance of websites as a medium for presenting gameful environments, as indicated by 65 studies in our review, underscores the enduring significance of web-based applications (especially in HCI research). Websites offer a familiar and accessible platform for deploying gamified interventions (Krath & von Korflesch, 2021; Osipov et al., 2015; Tobon et al., 2020), catering to a broad user base with varying levels of technological proficiency. Furthermore, the versatility of web technologies can enable researchers to experiment with diverse game mechanics and design elements, facilitating the exploration of novel approaches to engagement and immersion.

Similarly, the substantial representation of personal computer software, encompassing 33 studies, underscores the enduring relevance of desktop computing environments in HCI research. Despite the proliferation of mobile devices (Drolia et al., 2022) and emerging technologies, personal computers remain a cornerstone of interactive computing, providing researchers with a robust platform for developing and evaluating gameful interventions. The richness of personal computer software can enable the integration of sophisticated gameplay mechanics and immersive experiences, offering researchers ample opportunities for innovation and exploration.

At the same time, mobile applications emerged as another prominent technology for presenting gameful environments, with 25 studies highlighting the growing interest in leveraging smartphones and tablets to deliver gamified experiences. The ubiquity of mobile devices has transformed the landscape of HCI, empowering researchers to reach users in diverse contexts and environments. Mobile applications offer unique affordances such as location-based services, sensor integration, and real-time feedback, enriching the potential for engaging and personalized game experiences. The inclusion of mobile technologies in our review reflects a concerted effort to adapt gamification strategies to the evolving needs and lifestyles of modern users.

While websites, personal computer software, and mobile applications constitute the primary vehicles for delivering gameful environments, our review also identifies a spectrum of emerging technologies with varying degrees of adoption. VR glasses, AR apps, and tablets represent promising avenues for immersive and interactive experiences, albeit with comparatively fewer instances in the literature. The nascent nature of these technologies presents both opportunities and challenges for HCI researchers, requiring careful consideration of usability, accessibility, and user experience factors.

The findings underscore the diverse landscape of technologies employed in presenting gameful environments within HCI research. While traditional platforms such as websites and personal computer software continue to dominate, the emergence of mobile applications and the exploration of novel technologies signal a dynamic and evolving field. Future research endeavors should continue to embrace technological innovation while prioritizing user-centric design principles to maximize the effectiveness and accessibility of gameful interventions. By harnessing the potential of diverse technologies, HCI researchers can unlock new possibilities for engaging, immersive, and transformative user experiences in gameful environments.

5.5. Threats to validity and limitations

In conducting the systematic literature review on flow experience in gameful approaches, it is crucial to acknowledge certain threats to validity and limitations. Initially, while efforts were made to establish clear inclusion criteria, such as focusing on primary empirical studies published within a specified time frame and written in English, there remains the possibility of overlooking relevant studies that might not meet these criteria. The exclusion of non-English studies and gray literature, while ensuring quality by restricting our search to empirical studies, may introduce bias by excluding potentially valuable insights or studies conducted in other languages.

Limiting the search to the Scopus database, despite its inclusion of studies from commonly used sources in this research area, may have led to the omission of relevant studies indexed in other databases or published in non-indexed sources. Likewise, restricting the search to studies published between 2018 and 2022 may have excluded important research from earlier or later years that could impact the final results of the systematic literature review. This limitation is particularly critical for scientometric analyses, as it may have excluded key scientometric data that could significantly alter the study's conclusions.

The adequacy of the search strategy, including the string of terms used to identify relevant studies, may influence the comprehensiveness of the review. Variations in terminology or keywords related to flow experience and gameful approaches might lead to missed studies. Additionally, the reliability of the data collection process, particularly in screening and selecting studies based on inclusion and exclusion criteria, could be affected considering that only one researcher was involved in this part.

While the PRISMA protocol guided the review process, variations in the interpretation and synthesis of findings among reviewers could introduce subjectivity and bias into the analysis. Finally, the generalizability of the findings may be limited by the specific focus on studies related to flow experience in gameful approaches. Extrapolating conclusions beyond this scope should be done cautiously, considering the diversity of gameful environments and contexts.

6. Agenda for future studies

Our results have enabled us to identify several new findings that make a direct contribution to the community. Additionally, our findings have led to the identification of challenges that the community may encounter in the future. Therefore, in this section, we present a set of recommendations for future research. These recommendations are organized into four areas: HCI, AI, games, and gamification.

Initially, given the predominance of self-report scales in analyzing the flow experience in gameful environments, there is a need to explore alternative interaction modalities to deepen our understanding of user flow experience. Incorporating physiological sensors, eye-tracking technology, and data logs-based approaches can provide objective measures of cognitive and affective states during user interactions, offering insights beyond self-reported data. This recommendation can contribute to the HCI community by enhancing methodological diversity and enriching our understanding of flow dynamics during user interactions within gameful approaches, ultimately leading to the development of more effective user-centered design practices.

The high prevalence of websites as the predominant technology for implementing gameful approaches highlights the importance of prioritizing user-centric design principles. Conducting user-centered design studies and usability evaluations can identify design factors that influence flow induction and user engagement, ensuring that gameful interfaces meet the diverse needs and preferences of users. Additionally, incorporating feedback mechanisms and adaptive interfaces can tailor the game experience to individual users, enhancing overall user satisfaction and enjoyment. This recommendation contributes to the HCI community by promoting the development of more accessible, intuitive, and engaging gameful interfaces, ultimately enhancing user experiences across diverse contexts.

With most studies focusing on digital games and gamified environments, there is an opportunity to leverage AI-based techniques to personalize and adapt gameful experiences. By integrating machine learning algorithms and player modeling techniques, for instance, game systems can dynamically adjust game content and challenges based on individual user characteristics and preferences. This personalized approach can optimize flow induction and maintain user engagement over time, contributing to more immersive and rewarding gaming experiences. This recommendation contributes to the AI and game communities by advancing the state-of-the-art in personalized gaming systems, fostering

Table 9. Agenda for future studies.

Motivation	Recommendation	Type of Study	Beneficiaries
Lack of methodological diversity in flow experience analyses	Explore novel analyses modalities	Experimental	HCI research community
Need for user-centric design	Prioritize user-centric design	User-centered	HCI practitioners
Personalization of game experiences	Integrate AI for personalization and adaptation	Computational	Al researchers
Optimization of challenge balance	Implement novelty dynamic difficulty adjustment	Experimental	Game developers
Exploration of diverse game genres	Diversify game genres	Observational	Game designers
Understanding long-term effects	Conduct longitudinal studies	Longitudinal	Game researchers
Integration in new real-world contexts	Contextual integration of gamification techniques	Field experiments	Gamification practitioners
Interdisciplinary collaboration	Foster cross-disciplinary collaboration	Mixed-methods	Interdisciplinary researchers

innovation in adaptive gameplay mechanisms, and ultimately enhancing player satisfaction and retention.

AI-driven dynamic difficulty adjustment mechanisms have the potential to optimize the balance between challenge and skill in gameful environments, promoting a flow state and preventing user frustration or boredom. By continuously monitoring player performance and behavior, AI systems can dynamically adjust game parameters to maintain an optimal level of challenge and immersion for each player. This recommendation contributes to the AI and game communities by advancing research in adaptive game design, providing insights into the computational modeling of player experience, and enhancing our understanding of player engagement dynamics. Ultimately, this research can lead to the development of more engaging and enjoyable game experiences for players of all skill levels.

The predominance of digital games and gamified environments in flow experience studies underscores the need to explore a wider range of game genres and gamification mechanics/designs. By incorporating elements from diverse genres such as puzzle games, role-playing games, and interactive narratives, researchers can offer more varied and engaging gameplay experiences. This diversification will cater to different user preferences and play styles, ultimately enhancing the inclusivity and accessibility of gameful interventions. This recommendation can contribute to the game and gamification communities by fostering innovation in game design, promoting experimentation with new gameplay mechanics, and expanding our understanding of flow dynamics across diverse gaming contexts.

Longitudinal studies are essential for understanding the sustained impact of flow-inducing game experiences on user engagement and learning outcomes. Also, is a traditional challenge in correlated fields. By tracking user experiences and behaviors over extended periods, researchers can identify factors that contribute to long-term engagement and retention. This recommendation can contribute to the games and gamification communities by providing empirical evidence on the long-term effectiveness of gameful interventions, informing the design of more sustainable and impactful gaming experiences. Additionally, longitudinal studies will contribute to the development of evidence-based guidelines for the design and implementation of gameful interventions in various domains, ultimately benefiting both researchers and practitioners in the field.

With the prevalence of gamification in domains such as education and healthcare, there is a need to explore its contextual integration within other real-world settings. Investigating how gamified interventions influence user behavior and motivation in specific contexts will provide valuable insights into the effectiveness and feasibility of gamification as a behavior change strategy. This recommendation will contribute to the gamification community by advancing research on contextually relevant and impactful gamified solutions, ultimately informing the design of more effective interventions for addressing real-world challenges.

Collaboration across disciplines such as psychology, sociology, and behavioral science can enrich our understanding of the psychological mechanisms underlying gamification and flow experience. By integrating insights from diverse fields, researchers can develop comprehensive theoretical frameworks for understanding and optimizing user engagement in gameful environments. This recommendation can contribute to the gamification community by fostering interdisciplinary collaborations, promoting knowledge exchange, and advancing the theoretical foundations of gamification. Ultimately, cross-disciplinary collaboration will lead to the development of more effective and ethically sound gamified interventions, benefiting both researchers and practitioners in the field. Table 9 summarize the research agenda.

7. Concluding remarks

Through a scientometric analysis and systematic literature review, we identified key trends and patterns in studies on the flow experience within gameful approaches. Our findings reveal a notable increase in publications in recent years, reflecting the growing interest in this field. Education stands out as the domain with the highest number of studies, emphasizing the potential of gameful approaches to improve learning outcomes and engagement. Quantitative studies published in journals dominate the field, showcasing the empirical rigor of research on this topic.

The literature review revealed the prevalent use of selfreport scales to analyze the flow experience, and underscored the need for alternative methodologies and technologies to gain deeper insights into user engagement. Furthermore, the focus on digital games and gamified environments highlights the opportunity to explore flow dynamics across varied contexts and platforms. The frequent use of websites as the primary technology for implementing gameful approaches suggests the need to investigate innovative interaction modalities and design principles to enhance user experiences.

Based on the results, we were able to identify a series of points that can be studied in the coming years by the community to advance the literature. In particular, future research should aim to advance the field of HCI, particularly within gameful approaches through the development of new approaches to promote and analyze the flow experience in gameful environments, as well as deepening the types of analysis and seeking to understand the long-term effects. In future studies, we plan to conduct a meta-analysis to evaluate the effects of gameful environments on users' flow experience.

Notes

- 1. This article is an extension of the conference paper of Oliveira and Hamari (2024).
- 2. https://www.scopus.com/
- 3. https://parsif.al/
- 4. http://doi.org/10.17605/OSF.IO/3845Q

Authors contributions

Oliveira: Conceptualization, Methodology, Validation. Investigation, Writing - Original Draft, Writing - Review & Editing, Visualization, Project administration. Juho Hamari: Conceptualization, Methodology, Writing - Review and Editing, Supervision, Funding acquisition. All authors approved this current version.

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ORCID

Wilk Oliveira http://orcid.org/0000-0003-3928-6520 Juho Hamari (i) http://orcid.org/0000-0002-6573-588X

Data availability statement

The data that support the findings of this study are openly available in Open Science Framework (OSF) at http://doi.org/10.17605/OSF.IO/ 3845Q, reference number 3845Q.

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About the authors

Wilk Oliveira is a Researcher at the Gamification Group, Faculty of Information Technology and Communications, Tampere University, Finland. His main areas of activity are Educational Technologies, Gamification, Game-Based Learning, User Experience, and Computing Education.

Juho Hamari is a Professor at the Gamification Group, Faculty of Information Technology and Communications, Tampere University, Finland. His group focuses on multidisciplinary and multi-methodological gamification research and extended realities in domains striving for ecological, economic, and social sustainability.

Appendix A.

Table A1. List of studies.

ID	Title	Reference
1	How competition in a game-based science learning environment influences students' learning achievement, flow experience, and learning behavioral patterns	(CH. Chen et al., 2018)
2	Mobile Game Induces Active Engagement on Neuromuscular Electrical Stimulation Training in Patients with Stroke	(Ku et al., 2018)
3	Flow in business simulation games: Comparison between online and face-to-face MBA	(J. B. Kim & Watson, 2018)
1	Influence of Virtual Environments and Conversations on User Engagement during Multiplayer Exergames	(Kojić et al., 2018)
i	Flow adaptation in serious games for health	(Alves et al., 2018)
	Gamified interactions: whether, when, and how games facilitate self–brand connections Points for posts and badges to brand advocates: The role of gamification in consumer brand	(Berger et al., 2018) (Vitkauskaitė & Gatautis, 2018)
	engagement Exploring characteristics of students' emotions, flow and motivation in a math game competition	(K. Kiili et al., 2018)
	Real-time stealth intervention for motor learning using player flow-state	(Tadayon et al., 2018)
0	Users' experience in gamified online educational environment	(Bourdas et al., 2018)
1	Multimodal student engagement recognition in prosocial games	(Psaltis et al., 2018)
2	Do you think this is a game? Contrasting a serious game with a gamified application for health	(Pfau et al., 2018)
3	The ExerCube: Participatory design of an immersive fitness game environment	(Martin-Niedecken & Mekler, 2018)
4	Impact of Virtual Environments on Motivation and Engagement during Exergames	(Schmidt et al., 2018)
5	Engaged in learning neurorehabilitation: Development and validation of a serious game with user- centered design	(Savazzi et al., 2018)
5	Individual differences in an English learning achievement system: gaming flow experience, gender differences and learning motivation	(J. C. Yang & Quadir, 2018)
7	Game-based entrepreneurship education: Impact on attitudes, behaviours and intentions	(Fellnhofer, 2018)
8	Effects of digital game-based learning on achievement, flow and overall cognitive load	(CC. Chang et al., 2018)
9	Investigating the direct impact of a gamified versus nongamified well-being intervention: An exploratory experiment	(Kelders et al., 2018)
)	An Exploratory Study on the Köhler Effect and Flow in Long-term Exergaming	(S. Lee et al., 2018)
1	Evaluating Cognitive and Affective Outcomes of a Digital Game-Based Math Test	(K. Kiili & Ketamo, 2018)
2	Exergame experience of young and old individuals under different difficulty adjustment methods	(Kaplan et al., 2018)
}	Exploring students' flow experiences in business simulation games	(Buil et al., 2018)
ŀ	Understanding the role of competition in video gameplay satisfaction	(Sepehr & Head, 2018)
;	Managing group flow experiences in escape rooms	(Kolar & Čater, 2018)
5	Real-life escape rooms as a new recreational attraction: the case of Turkey	(Dilek & Kulakoglu Dilek, 2018)
7	The Design and Evaluation of a Gamification Teaching Activity Using Board Game and QR Code for Organic Chemical Structure and Functional Groups Learning	(CH. Wu et al., 2018)
8	Application-driven educational game to assist young children in learning English vocabulary	(ZH. Chen & Lee, 2018)
9	Design, development and usability test of serious games related to genetics	(Mainetti et al., 2018)
0	Eyestrain impacts on learning job interview with a serious game in virtual reality a randomized double-blinded study	(Souchet et al., 2018)
1	Evaluation of a serious game promoting nutrition and food literacy: Experiment design and preliminary results	(Mitsis et al., 2019)
2	Mindful learning experience facilitates mastery experience through heightened flow and self-efficacy in game-based creativity learning	(Yeh et al., 2019)
3	Impact of Constant Visual Biofeedback on User Experience in Virtual Reality Exergames	(Kojić, Nugyen, et al., 2019)
4	Influence of network delay in virtual reality multiplayer exergames: Who is actually delayed?	(Kojić, Schmidt, et al., 2019)
5	Conducting an experiment for validating the combined model of immersion and flow	(E. Kannegieser et al., 2019)
7	A study to further understand the link between immersion and flow Effects of a gamified learning platform on elementary school students' flow experiences in leisure	(E. Kannegieser & Atorf, 2020) (Mak et al., 2019)
3	reading A Real Escape Gamification Teaching Activity Integrated with Situated Learning and Multi- dimensional Scaffolding for Elementary School Social Studies Course	(CT. Li et al., 2019)
9	Designing a Gamified Activity with Visual Representaion-Based Scenario and Technology-Based Scaffoldings for Learning Electric Potential	(CY. Huang, Lin, et al., 2019)
0	Investigating cyclical stereoscopy effects over visual discomfort and fatigue in virtual reality while learning	(Souchet et al., 2019)
1	The effect of gamification on psychological and behavioral outcomes: Implications for cruise tourism destinations	(B. C. Lee, 2019)
2	Engaging middle school students in scientific practice with a collaborative mobile game	(Bressler et al., 2019)
3	The role of flow in learning distributed computing and mapreduce concepts using hands-on analogy	(Conrad et al., 2019)
1	Effects of gender and different augmented reality learning systems on English vocabulary learning of elementary school students	(TC. Hsu, 2019)
5	Serious games going beyond the call of duty: Impact of an advertising literacy mini-game platform on adolescents' motivational outcomes through user experiences and learning outcomes	(De Jans et al., 2019)
6	Game design principles influencing stroke survivor engagement for vr-based upper limb rehabilitation: A user experience case study	(Herne et al., 2019)
7	Gamification of an asynchronous HTML5-related competency-based guided learning system	(C. H. Li, 2019)
8	Improving instructions in educational computer games: Exploring the relations between goal specificity, flow experience and learning outcomes	(Erhel & Jamet, 2019)
9	A randomized controlled trial on the role of enthusiasm about exergames: Players' perceptions of exercise	(HC. Huang, Nguyen, et al., 2019)



Table A1. Continued.

ID	Title	Reference
550	Collaborate or Compete? How Will Multiplayers' Interaction Affect Their Learning Performance in Serious Games	(JY. Wang et al., 2019)
51	Evaluating the role of gamification and flow in e-consumers: millennials versus generation X	(García-Jurado et al., 2019)
52	Play it again: how game-based learning improves flow in Accounting and Marketing education	(Silva et al., 2019)
53	The roles of engagement and competition on learner's performance and motivation in game-based science learning	(CH. Chen, Law, et al., 2019)
54	Understanding online business simulation games: The role of flow experience, perceived enjoyment and personal innovativeness	(Matute-Vallejo & Melero-Polo, 2019)
55	Adoption of gamified persuasive systems to encourage sustainable behaviors: Interplay between perceived persuasiveness and cognitive absorption	(Shevchuk et al., 2019)
56	Towards Affect Recognition through Interactions with Learning Materials	(Ghaleb et al., 2018)
57	Pupils' opinions on an educational Virtual Reality game in terms of flow experience	(Akman & Çakır, 2019)
58	Playing a Chinese remote-associated game: The correlation among flow, self-efficacy, collective self-esteem and competitive anxiety	(JC. Hong et al., 2019)
59	Virtual performance augmentation in an immersive jump & Run exergame	(loannou et al., 2019)
50	The Effects of Human Factors on the Use of Avatars in Game-Based Learning: Customization vs. Non- Customization	(Z. H. Chen, Lu, et al., 2019)
51	Usability testing of two mini-games and one serious game to educate people bout genetics	(Mainetti et al., 2019)
62	A study on flow experience and learning effectiveness of RFID educational board game system	(YT. Lin & Wang, 2022b)
53	Exploring the effects of card game-based gamification instructional activity on learners' flow experience, learning anxiety, and performance-A preliminary study	(SM. Wang et al., 2020)
54	Impacts of augmented reality and a digital game on students' science learning with reflection prompts in multimedia learning	(CH. Chen, 2020)
65	Self-regulated mobile game-based English learning in a virtual reality environment	(Y. L. Chen & Hsu, 2020)
56 57	Flow and business simulation games: A typology of students Gamifying classroom presentations: Evaluating the effects on engagement across demographic	(Bitrián et al., 2020) (Sillaots et al., 2020)
58	factors Studying the Effect of Display Type and Viewing Perspective on User Experience in Virtual Reality Exergames	(Xu et al., 2019)
59	To Add or Not to Add Game Elements? Exploring the Effects of Different Cognitive Task Designs Using Eye Tracking	(Ninaus et al., 2020)
70	Guidance is good or avoid too much hand-holding? proposing a controlled experiment on the impact of clear proximal goals on digital game enjoyment	(Schaffer, 2020)
71	A mixed method approach to evaluate web 2.0 applications in business games	(Zeiner-Fink et al., 2020)
72	Flow Experience and Situational Interest in an Adaptive Math Game	(Lindstedt et al., 2020)
73	A study of Taiwanese children's learning and preferences in game-based learning scenarios	(Tang, 2020)
74	Exploring Escape Games as a Teaching Tool in Educational Robotics	(Giang et al., 2020)
75	Psychological effects of gamified didactics with exergames in Physical Education at primary schools: Results from a natural experiment	(Quintas et al., 2020)
76	Experimental study on gamification teaching of mathematics classroom practice based on flow experience	(J. Zhao & Li, 2020)
77	Because it is fun: Investigating motives of fake news sharing with exploratory game quests	(Jost, 2020)
78	A novel approach to interactive dialogue generation based on natural language creation with context-free grammars and sentiment analysis	(Palmas et al., 2020)
79	Learning Interdisciplinarity and systems approaches in agroecology: Experience with the serious game SEGAE	(Jouan et al., 2020)
80 81	The Game as a Classroom: Understanding Players' Goals and Attributions from a Learning Perspective Differentiating between the "Need" for and the "Experience" of Self-determination Regarding Their Influence on Pupils' Learning of Croativity through Story based Digital Composition	(Martin & Magerko, 2020) (Yeh et al., 2020)
82	Influence on Pupils' Learning of Creativity through Story-based Digital Games Understanding Enjoyment in ARTé: Mecenas with EGameFlow	(Weng et al., 2020)
83	Applying kahoot in Thai language and culture curriculum: Analysis of the relationship among online cognitive failure, flow experience, gameplay anxiety and learning performance	(Ye et al., 2020)
84	A preliminary study of correlations explaining student interest in digital games-based learning	(YD. Liu et al., 2020)
85	The Effects of Flow, Emotional Engagement, and Motivation on Success in a Gamified Online Learning Environment	(Özhan & Kocadere, 2020)
36	An Immersive Virtual Reality Game Designed to Promote Learning Engagement and Flow	(Bodzin et al., 2020)
87	The impact of fulfilling a desire for idealism on task engagement and enjoyment in digital games	(Schaffer & Fang, 2020)
88	Predicting Real-Time Affective States by Modeling Facial Emotions Captured During Educational Video Game Play	(Verma et al., 2020)
89	The effect of the degree of anxiety of learners during the use of VR on the flow and learning effect	(Kwon, 2020)
90	Effective gamification of the stop-signal task: Two controlled laboratory experiments	(Friehs et al., 2020)
91	Facial Electromyography-based Adaptive Virtual Reality Gaming for Cognitive Training	(Reidy et al., 2020)
92	Gearing Up for the Future of Exercise	(McGloin et al., 2020)
93	Understanding Flow, Identification with Game Characters and Players' Attitudes	(V. H. H. Chen & Koek, 2020)
94 95	A PLS-SEM approach to technology-enhanced EFL writing A methodology for multimodal learning analytics and flow experience identification within gamified	(CC. Lin, 2020) (Pastushenko et al., 2020)
06	assignments Narrative and aesthetics as antocodents of perceived learning in serious games	(Alexiou et al. 2022)
96 97	Narrative and aesthetics as antecedents of perceived learning in serious games Effects of incorporating ar into a board game on learning outcomes and emotions in health	(Alexiou et al., 2022) (HC. Lin et al., 2020)
98	education Designing an Escape Room Educational Game for Cardiopulmonary Resuscitation Training: The Evaluation of Learning Achievement and Flow State	(CT. Li et al., 2020)
99	Educational board game and flashcard: Which one is better for learners at beginner level of Chinese	(Wen et al., 2020)
	language?	(

Table A1. Continued.

ID	Title	Reference		
100	Students' conception of set theory through a board game and an active-learning unit	(Pawa et al., 2020)		
5101	Does tailoring gamified educational systems matter? The impact on students' flow experience	(Oliveira et al., 2020)		
102	A preliminary study of a business-management/Strategic-planning board game with situated learning mechanisms	(Kuo et al., 2020)		
5103	Race Yourselves: A Longitudinal Exploration of Self-Competition between Past, Present, and Future Performances in a VR Exergame	(Michael & Lutteroth, 2020)citep		
5104	"HIIT" the ExerCube: Comparing the Effectiveness of Functional High-Intensity Interval Training in Conventional vs. Exergame-Based Training	(Martin-Niedecken et al., 2020)		
105	Designing an alternate reality board game with augmented reality and multi-dimensional scaffolding for promoting spatial and logical ability	(Hou et al., 2023)		
106	Gamification and social comparison processes in electronic brainstorming	(Guegan et al., 2021)		
107	Effects of a concept mapping-based two-tier test strategy on students' digital game-based learning performances and behavioral patterns	(FY. Li, Hwang, et al., 2021)		
108	Digital game-based learning of information literacy: Effects of gameplay modes on university	(Zou et al., 2021)		
5109	students' learning performance, motivation, self-efficacy and flow experiences Goldilocks conditions for workplace gamification: how narrative persuasion helps manufacturing	(Seo et al., 2021)		
5110	workers create self-directed behaviors The Effect of Visual Reward and Punishment in Mobile Game on Game Experience	(Vuniacri et al. 2021)		
5110	Modeling Secondary Students' Genetics Learning in a Game-Based Environment: Integrating the	(Yuniasri et al., 2021) (Rachmatullah et al., 2021)		
5112	Expectancy-Value Theory of Achievement Motivation and Flow Theory Performance Over Enjoyment? Effect of Game-Based Learning on Learning Outcome and Flow	(K. Chan et al., 2021)		
112	Experience Politicary Chect: Effects of Language Immersion and Interactivity in a Language Learning Game	(Cho at al. 2021)		
5113 5114	Delivery Ghost: Effects of Language Immersion and Interactivity in a Language Learning Game Development and evaluation of an educational board game- "118 job bank" for human resource	(Cho et al., 2021) (Zuo et al., 2021)		
5115	training courses The slippery path to total presence: how omnidirectional virtual reality treadmills influence the	(Wehden et al., 2021)		
116	gaming experience Wayfinding in virtual reality serious game: An exploratory study in the context of user perceived	(Irshad et al., 2021)		
5117	experiences Brain training with the body in mind: Towards gamified approach-avoidance training using virtual	(Kakoschke et al., 2021)		
5118	reality Promoting student flow and interest in a science learning game: a design-based research study of	(Bressler et al., 2021)		
110	School Scene Investigators	(C. F. Mir. et al., 2024)		
119 120	Measuring Effects of Technological Interactivity Levels on Flow with Electroencephalogram Moving beyond the content: The role of contextual cues in the effectiveness of gamification of	(SF. Wu et al., 2021) (Sreejesh et al., 2021)		
	advertising	(6. III.		
5121	Millennials' Leadership Skills for Promoting Flow and Profit in a Business Simulation	(Badibanga & Ohlson, 2021)		
122 123	Mini-games for entrepreneurship in construction: instructional design and effects of the TYCON game User experience with dynamic difficulty adjustment methods for an affective exergame: Comparative	(Hummel et al., 2021) (Darzi et al., 2021)		
5124	laboratory-based study Design and evaluation of user-centered exergames for patients with multiple sclerosis: Multilevel usability and feasibility studies	(Schättin et al., 2021)		
5125	Gamified Reviewer Based on the EFM Model for An Effective Learning Environment	(Gayao et al., 2021)		
5126	The impact of technology-assisted task-based language teaching on self-regulated learning	(CC. Lin, 2021b)		
127	Investigating Engagement and Flow with a Placed-Based Immersive Virtual Reality Game	(Bodzin et al., 2021)		
128	Investigating Engagement and Flow With a Placed-Based immersive virtual Reality Game (Bodzin et al., 2021) Integrating Smartphone-Controlled Paper Airplane Into Gamified Science Inquiry for Junior High (M. Cheng et al., 2021) School Students			
129	Serious statems Serious game in introductory psychology for professional awareness: Optimal learner control and authenticity	(Hummel et al., 2021)		
130	The Development and Evaluation of an Online Educational Game Integrated with Real Person-NPC	(SW. Liu et al., n.d.)		
5131	mechanism for History Learning Escape the Fake: Development and evaluation of an augmented reality escape room game for	(Paraschivoiu et al., 2021)		
3127	fighting fake news	(Silva et al. 2021)		
5132 5133	Games based learning in accounting education—which dimensions are the most relevant? Modelling Chinese EFL learners' flow experiences in digital game-based vocabulary learning: the roles	(Silva et al., 2021) (R. Li, Meng, et al., 2021)		
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134 135	Empirically comparing flow, narrative engagement, and enjoyment as responses to a computer game The Learning Process in Live-Action Simulation Games: The Impact of Personality, Motivation,	(Sherrick, 2021) (Preuß, 2021)		
5136	Immersion, and Flow on Learning Outcome in a Simulation Game Measuring game immersion and flow with electroencephalography	(E. R. Kannegieser & Ratz, 2021)		
137	Exploring data analysis methods to find correlations between physiological data and flow	(E. Kannegieser & Hensler, 2021)		
138	How does a brand's psychological distance in an advergame influence brand memory of the	(Sreejesh et al., 2021)		
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142 143	Does gamified interaction build a strong consumer-brand connection? A study of mobile applications Consumers' psychological reactance and ownership in in-game advertising	(Sangroya et al., 2021) (Malhotra et al., 2021)		
144	Predicting students' flow experience through behavior data in gamified educational systems	(Oliveira, Pastushenko et al., 2021)		
145	Examining flow antecedents in game-based learning to promote self-regulated learning and	(Wan et al., 2021)		
	acceptance			

	Continued

ID	Title	Reference
S147	Modeling students' flow experience through data logs in gamified educational systems	(Oliveira, Pastushenko et al., 2021)
S148	EFL Learners' Perceptions of a Game-based and Technology-assisted Writing Course The Impact of Precents on Learning Transfer Intention in Virtual Peality Simulation Comp	(CC. Lin, 2021a)
S149 S150	The Impact of Presence on Learning Transfer Intention in Virtual Reality Simulation Game Gamification effects on users' motivation to contribute knowledge in a Portuguese Q & A community	(Choi & Noh, 2021) (Oliveira Jordao do Amaral & Kang, 2021)
S150	'Go with the flow' for gamification and sustainability marketing	(Whittaker et al., 2021)
S151	Capturing potential impact of challenge-based gamification on gamified guizzing in the classroom	(Anunpattana et al., 2021)
S153	Flow experience and situational interest in game-based learning: Cousins or identical twins	(K. J. M. Kiili et al., 2021)
S154	Designing an Augmented Reality-based Educational Board Game Integrated with Dual-Scaffolding	(CT. Li et al., 2021)
	Framework for High school History Course: The Evaluation of Learning Performance and Flow State	
S155	The development and preliminary evaluation of a Chinese painting and calligraphy board game with	(Kuo et al., 2021)
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S156	Designing cognitive-based game mechanisms for mobile educational games to promote cognitive	(Chou et al., 2023)
C1 5 7	thinking: an analysis of flow state and game-based learning behavioral patterns	(C. Kim. 2021)
S157	How a company's gamification strategy influences corporate learning: A study based on gamified MSLP (Mobile social learning platform)	(S. Kim, 2021)
S158	Incorporation of a game-based approach into the EFL online classrooms: students' perceptions	(Almusharraf, 2023)
S150	Evaluating a strengths-based mealth tool (mystrengths): Explorative feasibility trial	(Jessen et al., 2021)
S160	The use of game modes to promote engagement and social involvement in multi-user serious	(Pereira et al., 2021)
5.00	games: a within-person randomized trial with stroke survivors	(i e.e.i.a et a.i, 2021)
S161	Comparing the Impact of Heart Rate-Based In-Game Adaptations in an Exergame-Based Functional	(Martin-Niedecken et al., 2021)
	High-Intensity Interval Training on Training Intensity and Experience in Healthy Young Adults	
S162	Comparison of Mini-Game-Based Flipped Classroom and Video-Based Flipped Classroom: An Analysis	(CT. Li et al., 2022)
	of Learning Performance, Flow and Concentration on Discussion	
S163	Comparing the effects of digital and non-digital gamification on EFL learners' collocation knowledge,	(Foroutan Far & Taghizadeh, 2024)
	perceptions, and sense of flow	(7)
S164	Cross-cultural mobile game evaluation shows improvement in environmental learning, but not	(Thomas-Walters & Veríssimo, 2022)
C165	behavior	(do lime et al. 2022)
S165 S166	Adaptive virtual reality horror games based on Machine learning and player modeling Virtual Reality versus Desktop Experience in a Dangerous Goods Simulator	(de Lima et al., 2022)
S166	The effects of personalized gamification on students' flow experience, motivation, and enjoyment	(Chover et al., 2022) (Oliveira et al., 2022)
S168	Comparing flow experience of medical students in cognitive, behavioral, and social educational	(Alizadeh et al., 2022)
3100	games: A quasi-experimental study	(Mizaden et al., 2022)
S169	The effects of gender stereotype-based interfaces on users' flow experience and performance	(Oliveira et al., 2022)
S170	A Web-Based Escape Room to Raise Awareness About Severe Mental Illness Among University	(Rodriguez-Ferrer et al., 2022)
	Students: Randomized Controlled Trial	
S171	Gamifying an assessment method: what signals are organizations sending to applicants?	(Georgiou & Lievens, 2022)
S172	Motivation and Emotions in a Health Literacy Game: Insights from Co-occurrence Network Analysis	(K. Kiili et al., 2022)
S173	Flow in a Game-Based Learning Platform Design for K-12	(Alvarez et al., 2022)
S174	Coding peekaboom: a gaming mechanism for harvesting programming concepts	(YL. Lin et al., 2023)
S175	Design recommendations for active games	(Martinez, 2022)
S176 S177	Development of a Novel Home-Based Exergame With On-Body Feedback: Usability Study Promoting Adaptive Number Knowledge Through Deliberate Practice in the Number Navigation	(Schättin et al., 2022)
31//	Game	(Bui et al., 2022)
S178	An Exploratory Digital Board Game Approach to the Review and Reinforcement of Complex Medical	(Tan et al., 2022)
5.70	Subjects Like Anatomical Education: Cross-sectional and Mixed Methods Study	(Tail Ct any 2022)
S179	Domain Knowledge and Adaptive Serious Games: Exploring the Relationship of Learner Ability and	(Verma et al., 2022)
	Affect Adaptability	
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S182	Digital Escape Rooms as Game-Based Learning Environments: A Study in Sex Education	(von Kotzebue et al., 2022)
S183	Gamification and e-learning adoption: a sequential mediation analysis of flow and engagement	(Gupta & Priyanka, 2024)
S184	Improving Engagement of Stroke Survivors Using Desktop Virtual Reality-Based Serious Games for	(Herne et al., 2022)
S185	Upper Limb Rehabilitation: A Multiple Case Study Measuring Control to Dynamically Induce Flow in Tetris	(Lora-Ariza et al., 2022)
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C103	Intention and Learning Performance? Mediating Roles of Internal Experiences	(Vers. 0.15s, 2022)
S193	Investigating the effect of flow experience on learning performance and entrepreneurial self-efficacy	(Yen & Lin, 2022)
\$104	in a business simulation systems context Factors Associated with Intention of Sustainable Use in Players of the Wii Fit or Smartphone-Based	(I W Loo et al. 2022)
S194	Fitness Applications	(J. W. Lee et al., 2023)
S195	Gamification and the festival experience: the case of Taiwan	(YJ. Lee, 2023)
S196	Investigating how gamified syllabic literacy impacts learning, flow and inappropriate behaviors: A	(Jogo et al., 2022)
	single-subject study design	v-g,,
S197	Chemistry education board game based on cognitive mechanism: multi-dimensional evaluation of	Li, CT., Hou, HT., & Lin, WS. (2024)
	learners' knowledge acquisition, flow and playing experience of board game materials	



Table A1. Continued.

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S199	How Flow Experience and Self-Efficacy Define Students' Online Learning Intentions: View From Task Technology Fit (Framework)	(H. Huang & Wang, 2022)
S200	Design and evaluation of a multi-sensory scaffolding gamification science course with mobile technology for learners with total blindness	(CH. Chang et al., 2022)
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5204	StarsCTF: A Capture the Flag Experiment to Hack Player Types and Flow Experience	(Vitorino et al., 2021)
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S207	The effect of mobile business simulation games in entrepreneurship education: a quasi-experiment	(J. Chen et al., 2023)