Beyond the One-Size-Fits-All: A Systematic Review of Personalized and Gamified e-Learning for Neurodivergent Learners

Sheejamol P. T., Anu Mary Chacko and S.D. Madhu Kumar
Department of Computer Science and Engineering, National Institute of Technology Calicut, India

sheejamolpt@gmail.com (Corresponding author)
anu.chacko@nitc.ac.in
madhu@nitc.ac.in

https://doi.org/10.34190/ejel.23.3.4051

Abstract: Traditional education, characterized by rigid curricula and inflexible teaching methods, often fails to accommodate the diverse cognitive profiles of neurodivergent learners, including those with Autism Spectrum Disorder (ASD), Attention Deficit Hyperactivity Disorder (ADHD), and dyslexia. Although e-Learning has introduced greater flexibility and interactivity into education, many existing platforms continue to adopt a one-size-fits-all approach, primarily catering to neurotypical learners, often overlooking the diverse cognitive and behavioral needs of neurodivergent students. The neurodivergent students frequently encounter challenges related to attention regulation, sensory processing, and retention of information, and these factors are rarely addressed in the design of conventional digital learning environments. While gamification and intelligent technologies have shown promise in enhancing learner engagement and personalization, their application in neurodiverse contexts remains limited and insufficiently customized. This systematic literature review investigates the potential of gamified e-Learning platforms, enhanced by advanced intelligent technologies, to create personalized and inclusive educational experiences for neurodivergent students. Following the PRISMA protocol, this study analyzed 82 studies published between 2020 and 2024 from Scopus, Web of Science, and Google Scholar databases, focusing on gamification in e-Learning and its effectiveness for neurodivergent learners. The findings suggest that traditional e-Learning platforms lack the adaptability and personalization required to engage neurodivergent students effectively. However, emerging approaches—such as adaptive gamification, multisensory content delivery, personalized feedback, and AI-driven analytics—show promise in improving engagement and learning outcomes. Technologies like reinforcement learning and generative AI offer further potential for dynamic content customization. The study identified the pressing need for future research focusing on developing inclusive, personalized, adaptive e-Learning systems and pedagogical models; conducting longitudinal studies on their efficacy; exploring sensory overload and accessibility barriers; evaluating the effectiveness of generative AI and immersive technologies; addressing the digital divide; and ensuring ethical AI-driven personalization.

Keywords: e-Learning, Gamification, Engagement, Knowledge retention, Learning outcome, Adaptive, Neurodivergent

1. Introduction

Education has always been centered on rigid curricula and inflexible modes of learning without considering the fact that people are different. In a classroom filled with unique cognitive styles, fostering success requires embracing neurodiversity and creating inclusive learning environments (Lynch, Singal, and Francis, 2024). Neurodiversity refers to a wide range of neurological variations, not limited to autism spectrum disorder (ASD), attention deficit hyperactivity disorder (ADHD), dyslexia, and other sensory processing challenges. These individuals often exhibit unique cognitive, sensory, and social-emotional profiles that can pose challenges in traditional educational settings. Recognizing and accommodating these differences is crucial to ensure equal access to quality education and to foster an inclusive learning environment (Sofiadin and Azuddin, 2021).

As the world embraces digital transformation, e-Learning has emerged as a powerful tool to enhance accessibility and personalization in education. E-Learning technologies encompass a broad spectrum of tools and platforms designed to facilitate digital learning experiences (Blezu and Popa, 2008). Most e-Learning platforms are not designed with the needs of neurodivergent learners in mind, limiting their accessibility and adoption. The literature recommends combining e-Learning with gamification as a promising direction to overcome this challenge. Gamification is an approach that uses game elements such as points, badges, leaderboards, awards, etc., in non-game contexts like e-Learning to engage and motivate neurodivergent learners (Deterding et al., 2011). While gamification is known to benefit e-Learning, existing implementations are seldom tailored to the varied learning styles and neurocognitive needs of neurodivergent learners, highlighting the need for more customized and inclusive design strategies. The learner's behavior, learning style (LS), goals, and motivation are to be considered when developing the learning approach. AI-driven personalization and intelligent tutoring systems are growing, but their role in enhancing learning outcomes

Cite this article: P. T.,S., Chacko, A.M. and Kumar, S.D.M. 2025. "Beyond the One-Size-Fits-All: A Systematic Review of Personalized and Gamified e-Learning for Neurodivergent Learners", *Electronic Journal of e-Learning*, 23(3), pp 101-119, https://doi.org/10.34190/ejel.23.3.4051

remains underexplored. To the best of our knowledge, there has not been any systematic work that reviews the current state of literature addressing the extent to which e-Learning systems and pedagogical models support neurodivergent learners, the ways in which gamification can be customized to suit their diverse learning styles, and the role of intelligent technologies in enhancing personalized learning for this population. Therefore, this study aims to address this research gap by attempting to answer the following research questions (RQs).

RQ 1. How do different e-Learning systems and pedagogical models impact engagement, knowledge retention, and learning outcomes among neurodivergent learners?

RQ 2. How can gamification approaches be customized to address the diverse learning styles of neurodivergent students?

RQ 3. What impact does the integration of advanced intelligent technologies have on enhancing student performance in personalized e-Learning platforms?

The selection of the RQs is based on the fundamental goal of e-Learning platforms: to support effective learning, best measured through learner engagement, knowledge retention (KR), and learning outcomes (LOs). Neurodivergent learners, due to their distinct cognitive profiles, often experience e-Learning environments differently from neurotypical learners, particularly in the absence of real-time teacher support. RQ1 examines the effects of various pedagogical models and e-Learning system designs on the efficacy of learning for neurodivergent students. One persistent challenge in e-Learning is sustaining learner engagement and improving LOs and KR. Gamification has emerged as a promising strategy to address this issue. Therefore, RQ2 focuses on how gamification can be tailored to align with the diverse learning styles of neurodivergent individuals. Finally, RQ3 explores how advanced intelligent technologies can be used to personalize learning experiences and improve performance for this diverse learner group.

The remainder of this manuscript is organized as follows: Section 2 provides an overview of the background and comparative study of prior reviews and other empirical and conceptual studies within the gamified e-Learning domain. Section 3 outlines the research methodology and details the approach adopted for the retrieval and analysis of the literature. Section 4 presents the findings of the review, addressing the research questions formulated in this study. Section 5 discusses the findings from the reviewed articles based on the research questions. Section 6 provides the practical and research implications of the findings, future research directions, and conclusions of the study, along with a summary of contributions and limitations.

2. Literature Review

Traditional learning, a teacher-centered mode of instruction based on face-to-face interactions in classrooms, relies on standardized teaching methods, assuming uniform learning styles and pacing, typically a one-size-fits-all approach (OSFA) (Buzzi et al., 2019). Neurodivergent students face barriers in such settings due to limited flexibility, lack of multisensory experiences, and emotional challenges from classroom interactions (Chugh, Vyas and Shukla, 2022). The COVID-19 pandemic accelerated e-Learning adoption, enabling remote access to education but exposing challenges in inclusivity, engagement, and accessibility (Fabriz, Mendzheritskaya and Stehle, 2021). Studies document how educators integrated digital tools into classrooms post-pandemic, but issues remain, especially for marginalized groups (Adedoyin and Soykan, 2023; Maatuk et al., 2022). Research has explored assistive technology in traditional classrooms, with gamified applications to improve motivation and learning for students with disabilities (Al-Dababneh and Al-Zboon, 2022; Sulaimani and Bagadood, 2023; Alkhawaldeh and Saleem, 2024). Gamification, defined as the integration of game design elements in non-game settings, gained prominence in the educational domain as a strategy to enhance learner motivation and engagement in digital learning environments. Early implementations focused on points, badges, and leaderboards to encourage learner involvement and maintain engagement in digital learning (Rincón-Flores, Mena and Montoya, 2020). With the advancement of e-Learning platforms, particularly the widespread adoption of Massive Open Online Courses (MOOCs) and Learning Management Systems (LMS), gamification has progressively shifted toward adaptive and personalized approaches (Raju et al., 2021). It is now recognized not merely as a motivational tool but as a comprehensive framework for delivering inclusive, learner-centered, and effective educational experiences. However, limited studies focus on e-Learning accessibility for neurodivergent learners (Cinquin, Guitton and Sauzéon, 2023). Studies have indicated that gamification has improved motivation, engagement, and learning outcomes attainment in e-Learning (Awad, Salameh and Al Redhaei, 2023), but its impact on neurodivergent learners remains significantly under-researched (Lampropoulos and Sidiropoulos, 2024). Equitable e-Learning requires addressing digital accessibility disparities (Park and Kim, 2021), ensuring assistive technology compatibility, and accommodating diverse learning styles. Hence, there is

a need for research in e-Learning ecosystems to create recommendations to ensure accessibility and adaptability for neurodivergent individuals.

2.1 Related Works

Recent advancements in gamified e-Learning systems have shown promise in enhancing learner engagement and motivation. However, most studies continue to focus on generic personalization strategies, often overlooking the diverse cognitive needs of neurodivergent learners. This section synthesizes the most relevant prior works, highlighting key trends, limitations, and research gaps.

2.1.1 Prior reviews

This section briefly reviews some of the relevant systematic literature reviews on gamification in e-Learning related to the topic of our systematic review. Many existing reviews highlight the importance of gamification in education, from early childhood to higher education, as a tool for next-generation education. Table 1 summarizes the primary focus of the existing systematic review studies and their limitations.

These studies explored gamification in e-Learning across various contexts such as MOOCs (Jarnac de Freitas and Mira da Silva, 2023; Major and Mira da Silva, 2023; Rohan, Pal and Funilkul, 2020; Saputra, Hidayanto and Prabowo, 2021; Karsen, Masrek and Safawi, 2022), LMS platforms (Saleem, Noori and Ozdamli, 2022; Sabri, Fakhri and Moumen, 2022), and higher education (Alalgawi and Sadkhan, 2022; Khaldi, Bouzidi, and Nader et al., 2023), primarily emphasizing its role in enhancing learner engagement, motivation, and short-term LOs (Hebbar, Manohar and Hungund, 2024; Behl et al., 2022; Burlacu, Coman and Bularca, 2023; Halachev, 2024; Jayawardena et al., 2021; Patiño-Toro et al., 2022; Tan, Sunar and Goh, 2021; Walaszczyk, 2023; Yu, Yu and Li, 2024; Zamahsari et al., 2023). However, they revealed significant gaps in the personalization of gamified content, the long-term impact on KR, and support for neurodivergent learners.

Table 1: Research Focus and Gaps Identified from Prior Reviews

Study	Focus/Contribution	Identified Gaps
Rohan, Pal and Funilkul, 2020; Tan, Sunar and Goh, 2021; Saputra, Hidayanto and Prabowo, 2021; Jayawardena et al., 2021; Patiño-Toro et al., 2022; Karsen, Masrek and Safawi, 2022; Saleem, Noori and Ozdamli, 2022; Walaszczyk, 2023; Burlacu, Coman and Bularca, 2023; Major and Mira da Silva, 2023; Jarnac de Freitas and Mira da Silva, 2023; Yu, Yu and Li, 2024	Gamified MOOC, cognitive effects, and the role of game elements for motivation, engagement, and LOs.	Lack of personalized adaptive design frameworks and limited understanding of how specific game elements align with individual cognitive profiles. Lack of empirical validation. Minimal evidence of longitudinal knowledge retention
Behl et al., 2022	Gamification effect on cognitive and social development in young learners	No longitudinal studies on cognitive growth. Lack of longitudinal validation of KR and measurable learning results. Limited implementation of responsive gamification strategies
Bennani, Maalel and Ben Ghezala, 2022a	Adaptive gamification for personalized engagement.	Scalability and implementation challenges. Lack of evaluation of KR and academic performance impacts. Limited inclusion of cognitive diversity in adaptive design.
Alalgawi and Sadkhan, 2022; Khaldi, Bouzidi and Nader, 2023	Gamification in higher education, PBL (points, badges, and leaderboards), cognitive engagement	Limited use in non-technical subjects. Lack of adaptive feedback loops and personalized gamified interventions. Lack rigorous validation of AI-driven personalization models
Sabri, Fakhri and Moumen, 2022; Zamahsari et al., 2023	Intrinsic motivation and long-term impact on KR and engagement, language learning	Need for adaptive strategies and ethical challenges like privacy. Limited experimental evaluation of intelligent adaptive models
Hussein et al., 2023; Honorato et al., 2023	Gamification for skill development in special education and focus on sensory needs.	Lack of empirical validation. Limiting insights into sustained LOs and KR.

Study	Focus/Contribution	Identified Gaps
Suresh Babu and Dhakshina Moorthy, 2024; Hebbar, Manohar and Hungund, 2024; Halachev, 2024	Gamification's effects on engagement and retention, perceived quality of learning	Limited verification of long-term learning gains and outcome consistency. Need of adaptive strategies. Scarcity of evidence-based evaluation of AI-powered adaptive platforms

Only a few studies discussed the potential of personalized and adaptive gamification (Bennani, Maalel, and Ben Ghezala, 2022a; Sabri, Fakhri and Moumen, 2022; Alalgawi and Sadkhan, 2022) and explored the integration of machine learning or generative technologies for personalized content delivery, dynamic feedback, or cognitive modeling, and advanced technologies such as AI for customization (Suresh Babu and Dhakshina Moorthy, 2024; Halachev, 2024). Only two reviews (Hussein et al., 2023; Honorato et al., 2023) were focusing on special needs children, but the impact of gamification on neurodivergent learners was not explored. These limitations indicate a need for future research focused on adaptive, inclusive, and AI-powered gamification frameworks that go beyond static designs to support diverse learning needs.

2.1.2 Other empirical and conceptual studies

The recent empirical studies explored diverse applications of gamification in e-Learning, with a strong focus on enhancing student engagement, motivation, and LOs across MOOCs, LMS platforms, and subject-specific domains (El-Sabagh, 2021; Pitthan, 2024; Xiao, 2024; Rahayu et al., 2022). Several studies highlighted positive effects of gamified elements such as adaptive feedback, visual rewards, and social interactions on learner participation and short-term performance (Ng et al., 2021; Poondej and Lerdpornkulrat, 2020; Handayani, Raharjo, and Putra, 2021). Studies in STEM and MOOC domains (Rincón-Flores, Mena and Montoya, 2020; De-Marcos et al., 2020) showed improved engagement, motivation and completion rates but rarely addressed LOs and KR or reinforcement personalization. A few studies recognized the importance of LOs and KR; longitudinal evidence on sustained cognitive gains and inclusive design remains scarce. Few works addressed the intersection of gamification with cognitive diversity or special education contexts (Zairon et al., 2023; Alshammari, 2020), indicating the need for adaptive systems that support varied learner profiles.

The conceptual studies mainly propose frameworks, models, and adaptation strategies for gamified e-Learning without large-scale validation. Framework-based and model-driven designs (Zubkov, 2023; Kamunya et al., 2020; Xiao, 2024) revealed engagement benefits but lacked user-centered customization. Several studies focused on attention-based and affective adaptations in MOOCs to foster learner motivation (Hocine, 2021; Cheng, 2023; and Rohan et al., 2021), yet they lacked depth in personalization and evaluation across diverse learner profiles. Adaptive gamification aligned with learning styles or learner profiles (El-Sabagh, 2021; Chugh, Vyas and Shukla, 2022; Hassan, 2021; Moussa, Maher and Khalifa, 2020; Maher, Moussa and Khalifa, 2020) addressed performance gains among school and university learners, yet often failed to account for neurodivergent cognition or dynamic learning needs. Dynamic adaptation techniques (Shabadurai, Chua and Lim, 2024; Pratama et al., 2024) underscored performance improvements but revealed integration gaps in feedback loops. Works emphasizing collaboration and analytics (Zairon et al., 2023; Maher, Moussa and Khalifa, 2020; Yamani, 2021) remained limited in blending gamification with real-time data insights. Personalization via motivational and personality traits (Abbasi et al., 2021; Shrestha et al., 2023; Leung et al., 2023) focused on retention gains but lacked cognitive diversity validation. Gamified platforms in computing domains (Malone, Wang and Monrose, 2021; Bernik, 2021) demonstrated effectiveness within specific disciplines, raising concerns about transferability. Various other research studies examined gamification's role in addressing technostress and sustainability (Fajri et al., 2021; Rahayu et al., 2022; Park and Kim, 2021), perceived usefulness (Aguilos and Fuchs, 2022; Handayani, Raharjo, and Putra, 2021), and emotional engagement (Taskın and Kılıç Çakmak, 2023; Puig et al., 2023), though these often lacked real-time adaptive emotional feedback. The comparative analysis of empirical and conceptual studies on gamified e-Learning with the primary focus on the impact of learning and research gaps is given in Table 2.

Table 2: Comparative Study of Related Literature in Gamified e-Learning with Gaps identified

Study(s)	Primary Focus	Target Group	Outcome	Gap Identified
Hocine, 2021; Cheng, 2023; Rohan et al., 2021	Attention-based and affective gamified adaptation	MOOC learners	Engagement, Motivation	Limited evaluation in diverse populations and personalization depth.
Bachiri, Mouncif and Bouikhalene, 2023; Sayed et al., 2023; Ng et al., 2021; Bennani et al., 2022b	AI-enhanced gamification and learner profiling	General learners	Engagement, Learning Outcomes	Lack of longitudinal impact studies and real-world deployment.
El-Sabagh, 2021; Chugh, Vyas and Shukla, 2022; Hassan et al., 2021; Moussa, Maher and Khalifa, 2020	Adaptive gamification based on learning styles	School & university students	Engagement, Learning Outcome	Gaps in supporting neurodivergent learning profiles and dynamic adaptation. Lack of longitudinal validation of retention and measurable learning results
Zubkov, 2023; Kamunya et al., 2020; Xiao and Hew, 2024	Gamification frameworks and models	Higher education students	Engagement, Motivation	Limited verification of long-term learning gains and outcome consistency. Lack of user-centered customization and behavioral validation.
Rincón-Flores, Mena and Montoya, 2020; De-Marcos et al., 2020	Gamification for STEM/MOOC completion	MOOC learners	Motivation, Completion Rate	Inadequate focus on KR and LOs. Absence of real-time adaptive personalization and context-aware gamification
Shabadurai, Chua and Lim, 2024; Pratama et al., 2024	Dynamic and static adaptation models	Online trainees or learners	Engagement, Learning Performance	Need for better integration of feedback loops and real-time adaptation.
Zairon et al., 2023; Maher, Moussa and Khalifa, 2020; Yamani, 2021	Collaborative interaction and analytics visualization	e-Learning users	Engagement, Collaboration	Underexplored integration of analytics with gamification elements.
Abbasi et al., 2021; Shrestha et al., 2023; Leung et al., 2023	Personalized gamification	Higher education learners	Motivation, Retention	Limited empirical testing across cognitive diversity. Limited experimental evaluation of intelligent adaptive models
Malone, Wang and Monrose, 2021; Bernik, 2021	Gamified platforms for CS/cybersecurity/higher education	Computer science students	Engagement, Learning Outcomes	Lack of generalizability beyond computing domains.
Fajri et al., 2021; Rahayu et al., 2022; Park and Kim, 2021	Gamification's role in technostress or sustainability	General learners	Motivation, Cognitive Outcomes	Limited attention to emotional regulation and stress factors.
Aguilos and Fuchs, 2022; Handayani, Raharjo, and Putra, 2021	Perceived usefulness of gamification in e-Learning	Undergraduate & LMS users	Engagement, Usefulness	Missing alignment between perceived value and long-term outcomes. Insufficient support for on-the-fly adaptation and tailored engagement models.
Taskın and Kılıç Çakmak, 2023; Puig et al., 2023	Effects of gamification on behavioral and cognitive engagement of students	Online learners	Emotional Engagement, LOs, and completion rate	Few studies address real-time emotion feedback mechanisms. Limited experimental validation for AI-supported gamification systems.
Abdirahma et al., 2023; Palaniappan and Noor, 2022; Schull and Brocksieper, 2021	Self-directed learning and gamification	Online learners	Behavioral & Cognitive Engagement	Customization and autonomy support are still under-theorized. Limited real-world assessment of AI-driven adaptive learning approaches.

Study(s)	Primary Focus	Target Group	Outcome	Gap Identified
Barua and Bharali, 2023; Kashive and Mohite, 2023; Poondej and Lerdpornkulrat, 2020	Gamification effects in regional e-Learning contexts	Computer science & vocational learners	Performance , Motivation	Underexplored assessment of enduring cognitive and educational outcomes. Lack of customization frameworks.
Alshammari, 2020; Acosta-Medina, Torres-Barreto, and Cárdenas-Parga, 2021	Gamification effect in language/elementary domains	Language learners & school students	Engagement , Learning Outcomes	Limited verification of long-term learning gains. Scarce focus on age-appropriate gamification strategies.

The integration of artificial intelligence (AI) and machine learning (ML) has emerged as a promising avenue for enhancing adaptive gamification through learner profiling, personalized content delivery, and dynamic feedback loops (Bennani et al., 2022b; Sayed et al., 2023; Bachiri, Mouncif and Bouikhalene, 2023; Daghestani, 2020), but the empirical evaluation of such systems remains limited. Finally, research on self-directed learning (Abdirahma et al., 2023; Palaniappan and Noor, 2022; Schull and Brocksieper, 2021), regional applications (Barua and Bharali, 2023; Kashive and Mohite, 2023; Poondej and Lerdpornkulrat, 2020), and age-domain-specific use (Alshammari, 2020; Dikcius, 2021; Acosta-Medina, Torres-Barreto, and Cárdenas-Parga, 2021) highlights improvements in engagement but has revealed persistent gaps in gamification customization and age-appropriate design frameworks and fails to systematically address the needs of neurodivergent learners. Hence, this review intends to address these gaps by formulating RQs that focus on gamification for neurodivergent learners in an e-Learning context.

2.2 Gaps Identified

Despite the proliferation of gamification research across diverse educational domains, several persistent gaps remain:

- Limited Personalization and Inclusivity: Most e-Learning systems optimize for neurotypical users, fail to accommodate neurodivergent learners, and do not dynamically adapt to individual learning styles and cognitive profiles.
- Lack of Longitudinal Evidence: While engagement and motivation are commonly evaluated, there is a lack of longitudinal studies assessing the sustained impact of gamification on learning outcomes and knowledge retention in special education and inclusive contexts.
- Shallow Customization: The depth of customization and integration of real-time feedback in adaptive gamification systems remains insufficiently developed.
- Insufficient Integration of Intelligent Technologies: AI-driven personalization and analytics are rarely deployed in real-world educational settings; the integration of such technologies into gamified e-Learning environments remains limited.

These gaps indicate the importance of more adaptive, inclusive, and empirically validated gamification models that use intelligent technologies to support diverse learners across evolving e-Learning systems.

3. Research Methodology

The review focused on identifying and analyzing scholarly literature published between 2020 and 2024 related to gamification in e-Learning, with a particular emphasis on its relevance and effectiveness for neurodivergent learners. This publication period was selected because the scope of online learning got much attention during the COVID-19 pandemic.

3.1 Search Strategy and Study Selection

The search was done in the Scopus, Web of Science, and Google Scholar databases, and most of the articles were retrieved from the following publishers: IEEE, Springer, ACM, Semantic Scholar, SAGE, and ScienceDirect. Thus, the quality of the review was maintained by selecting high-quality articles from these sources. The search strings used were (gamification OR gamified AND e-Learning OR MOOC OR LMS OR Moodle AND neurodivergent OR neurodivergence OR special needs OR intellectual disability OR cognitive disability OR cognitive impairment OR autism spectrum disorder OR ASD). The initial search retrieved 375 documents from Scopus, 102 from Web of Science, and 1,350 from Google Scholar, totaling 1,827 documents. The document selection process followed

the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocols (Page et al., 2021), as shown in Figure 1.

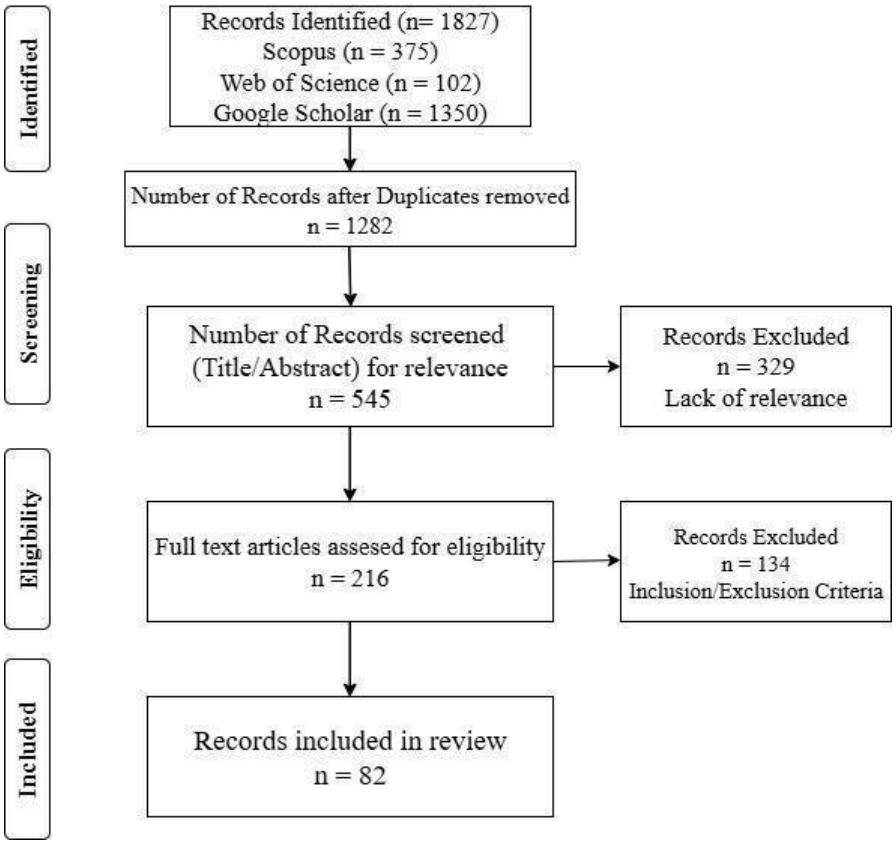

Figure 1: PRISMA Flow Diagram outlining the Document Selection Process

A manual screening was performed to select the relevant studies for this SLR. After removing 1,282 duplicate entries, 545 unique records remained and were screened based on title and abstract. Of these, 329 records were excluded for lack of relevance. A full-text assessment was conducted on 216 articles, from which 134 were excluded based on predefined inclusion and exclusion eligibility criteria. Due to scope limitations, several papers were excluded from the analysis. For instance, some studies focused solely on gamification concepts without any application to e-Learning environments, while others examined e-Learning platforms without incorporating any gamified elements. We finally selected 82 studies on gamification in e-Learning for qualitative analysis, aiming to address the RQs.

3.2 Inclusion and Exclusion Criteria

The SLR was relevantly screened using specific inclusion and exclusion criteria, ensuring that the selected studies aligned with research objectives and provided sufficient data for analysis. Table 3 summarizes the inclusion and exclusion criteria outlined. We included peer-reviewed journal and conference papers published between 2020 and 2024 in English that focused on the application of gamification within e-Learning platforms, specifically targeting neurodivergent learners. As there is a lack of studies on this population, we also included studies on neurotypical learners with a focus on inclusion, personalization, or adaptability. We excluded studies that dealt solely with general game-based learning or serious games, as these typically involve fully immersive gameplay rather than the integration of game elements into existing educational systems.

Table 3: Inclusion-Exclusion Criteria

Criteria	Inclusion	Exclusion
Literature Type	Journal, Conference proceedings	Book chapters, Thesis
Language	English	Non-English
Timeline	Between 2020 and 2024	Before 2020
Context	Education	Other than education context
Learning Approach	Gamification in e-Learning, online learning	Game-based, serious game-based learning, other than e-Learning

3.3 Data Extraction and Analysis

A structured data extraction process was employed to ensure consistency and relevance to the research objectives. A predefined spreadsheet template was used to systematically record key information from the studies included in this review. The extracted data fields included study title, year, author and domain; participant type (with a focus on neurodivergent learners, such as those with ASD, ADHD, or dyslexia or neurotypical learners with a focus on inclusion, personalization, or adaptability); type of intervention (e.g., gamification strategies and adaptive mechanisms); reported outcomes (such as engagement, KR, and LOs); technologies used (including AI, ML, reinforcement learning (RL), augmented reality/virtual reality (AR/VR), and GenAI); and theoretical frameworks applied. While the initial extraction was conducted by the lead author, all entries were independently verified by a second reviewer to ensure accuracy and reduce bias. Any discrepancies were resolved through collaborative discussion among authors and consensus after revisiting the original articles.

4. Findings by Research Question

This section addresses the proposed research questions by synthesizing findings from the selected literature to determine the current state of research on gamification in e-Learning environments, with special focus on neurodivergent students.

RQ 1 : How do different e-Learning systems and pedagogical models impact engagement, knowledge retention, and learning outcomes among neurodivergent learners?

Neurodivergent students need e-Learning with customizable interfaces and easy navigation to avoid overload and improve engagement (attention, interest, interaction, and participation) (El-Sabagh, 2021). Assistive technology integration helps KR remember information and show learning effectiveness (Bernik, 2021). Different accessibility options are needed for various learning styles. Alternative assessment methods are required to measure learning outcomes (LOs) (knowledge, skills, and competencies) (Kamiliya, Syahchari, and Omar, 2024). The rest of the section summarizes the current e-Learning systems and pedagogical models and how they perform in the objective.

Pedagogical models in e-Learning are frameworks derived from learning theories that guide instructional and learning practices, aiming to enhance educational outcomes (Yamani, 2021). Synchronous e-Learning focuses on real-time interaction and immediate feedback, while asynchronous e-Learning offers flexibility but lacks live engagement. Blended learning combines face-to-face and online instruction, and the flipped classroom reverses traditional learning by having students prepare at home and engage in activities during class. Adaptive learning personalizes content and pace using technology, and collaborative learning encourages group problem-solving. Self-paced learning allows learners to progress at their speed, while gamified learning uses game elements like points and badges to boost engagement and comprehension. Differentiated instruction tailors lessons to individual student needs, ensuring equitable and effective learning experiences.

Pedagogical models are integrated into e-Learning systems to enhance learning experiences. Learning Management Systems (LMS) like Moodle provide the foundation for institutional e-Learning, enabling synchronous and asynchronous learning, progress tracking, and customizable assessments for LOs (Handayani, Raharjo, and Putra, 2021). Virtual Learning Environments (VLEs) create online collaborative spaces with tools like forums, video conferencing, and file sharing to boost student engagement (Acosta-Medina, Torres-Barreto, and Cárdenas-Parga, 2021). Massive Open Online Courses (MOOCs) offer global access to diverse education through multimedia content and self-paced modules (Abdirahma et al., 2023; Schull and Brocksieper, 2021). Mobile Learning (M-learning) delivers educational content via smartphones and tablets, and the focus is on

accessibility and flexibility. Digital learning platforms have advanced, but their effectiveness in addressing the unique needs and engagement challenges of neurodivergent learners remains largely unexplored.

The proposal of the Universal Design for Learning (UDL) framework for inclusive education tries to address this gap. UDL principles—multiple means of engagement, representation, and action/expression—directly tackle the shortcomings of existing systems and promote diverse content and customized assessment. Integrating UDL into platforms like MOOCs, LMS, and VLEs can transform them into inclusive spaces, guaranteeing equitable learning for everyone, including neurodivergent students.

The literature reports success in the use of synchronous and asynchronous learning techniques (Antonopoulou et al., 2022) in e-Learning during the Covid-19 pandemic in elementary school children with learning and behavioral problems. Gamified MOOCs have been suggested as a solution to address low engagement and high dropout in MOOCs (Rinc´on Flores et al., 2020; de Marcos et al., 2020) as they report improved engagement (Ortega-Arranz et al., 2022; Wen, Hu, and Fang, 2024), KR (Oliveira et al., 2021), and LOs (Boboc et al., 2023; Palaniappan and Noor, 2022). Adaptive gamification within MOOCs personalizes the learning experience and dynamically adjusts the content to match the learner's progress. This approach holds promise for neurodivergent learners, who often require customized pacing and multimodal content delivery. More research is required to explore the potential of MOOCs in addressing the unique needs of neurodivergent learners.

Gamified LMS has also been reported to improve learning engagement (Bouchrika et al., 2021; Toimah, Maulana, and Fajar, 2021), motivation (Rahayu et al., 2022; Vapiwala and Pandita, 2022; Kuˇcak, Biuk, and Mršić, 2022), and LOs for general learners (Poondej and Lerdpornkulrat, 2020; Alshammari, 2020; Raju et al., 2021). Gamified LMSs promote active learning, self-pacing, and collaboration (Aguilos and Fuchs, 2022; Barua and Bharali, 2023; Gupta, 2024), but these systems may be challenging for neurodivergent learners with difficulties in social interaction. Personalized gamification in LMSs could significantly benefit neurodivergent learners, as it can address their unique sensory and cognitive needs by adapting specific gamification strategies (Kashive and Mohite, 2023).

The literature proposes a theoretical model called the Personalized Adaptive Gamified e-Learning model (PAGE) that combines adaptive learning with gamification, using student data and advanced technologies such as AI and ML to create a personalized and engaging learning experience (Moussa, Maher, and Khalifa, 2020). The PAGE model dynamically adjusts game mechanics, content difficulty, and learner feedback based on individual progress and preferences (Abbasi et al., 2021). This model has shown significant potential to increase engagement, KR, and LO among diverse learners' populations (Leung et al., 2023; Pradana et al., 2023). The adaptive capabilities proposed in PAGE make it particularly promising for neurodivergent learners, as it allows the delivery of customized content and challenges that align with unique learning styles and needs (Daghestani et al., 2020).

The impact of different platforms and the PAGE model on engagement, KR, and LOs, as reported in the literature, is detailed in Figure 2, revealing that KR is the least explored aspect among them. Research on MOOC-based systems mainly focuses on learner engagement (Rohan, Pal and Funilkul, 2020; Saputra et al., 2021; and Cheng, 2023). Some studies (Patino-Toro et al. 2022 and Karsen et al. 2022) investigated engagement and KR in MOOCs. Other studies (Bachiri, Mouncif and Bouikhalene, 2023) stand out for addressing all three impacts—engagement, KR, and LOs—across MOOC, LMS, and PAGE systems. LMS-focused studies (Poondej and Lerdpornkulrat, 2020; Raju et al., 2021; and Handayani, Raharjo, and Putra, 2021) concentrated mainly on enhancing engagement through gamified dashboards and performance tracking tools but often omitted metrics for KR or adaptive support. Yuliana et al. (2023) integrated both MOOC and LMS platforms, measuring all three learning impacts. PAGE-based studies, representing personalized adaptive gamification (Hocine et al., 2021; Moussa and Khalifa; and Pitthan et al., 2024), were largely focused on adaptive engagement and LO improvement, although only a few (Ng et al., 2021, and Bennani et al., 2022) discussed KR. Thus, stronger research on KR may be necessary to properly benefit neurodivergent learners, who frequently need repeated reinforcement, even while engagement and LOs are highly focused. The findings emphasize the need for adaptive gamification and personalized learning strategies (PAGE) to better support neurodivergent learners in e-Learning environments.

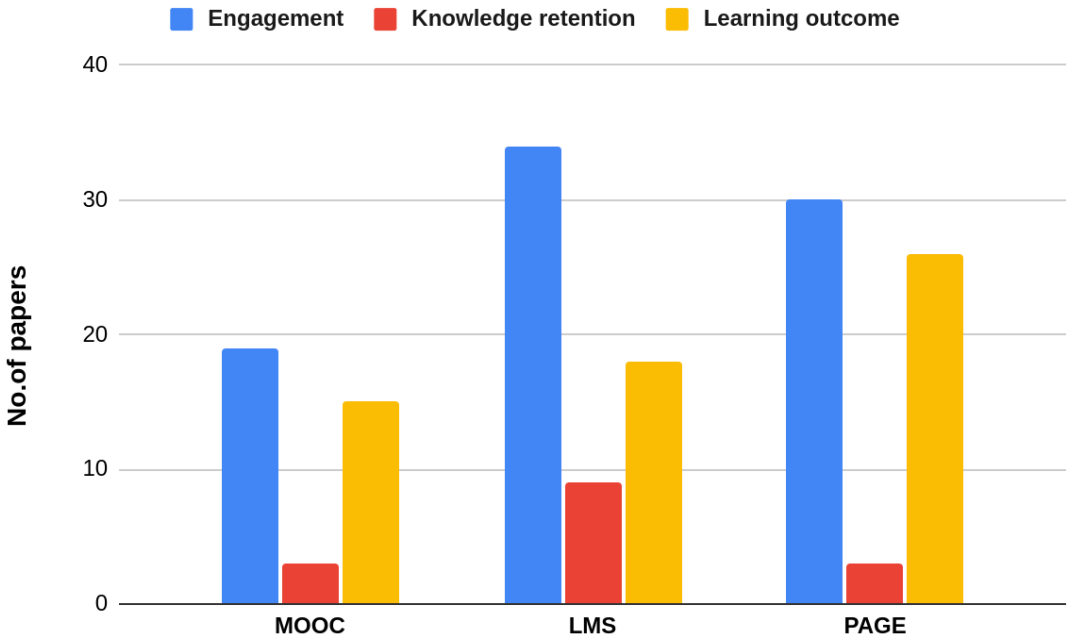

Figure 2: Comparative Analysis of Studies on MOOC, LMS, and PAGE Platforms, Focusing on the Learning Impacts of Engagement, Knowledge Retention, and Learning Outcomes

There are many commercial e-Learning products that incorporate the ideas that have been recommended in literature, like Khan's Academy, Coursera, Udemy, Quizlet, and Kahoot, to name a few. Khan's Academy focuses on self-paced learning and provides the user with adaptive content that is provided as per the progress of the student based on its algorithms. It provides multimodal content and offers support for many accessibility tools. These adaptations improve the engagement of learners. Coursera and Udemy are examples of MOOCs with limited gamification and a lot of multimodal content to engage learners of diverse learning styles (Kurteva et al., 2023). Adaptive personalization of learning paths, which might be helpful to neurodivergent individuals who struggle with planning and execution are missing. The ability to revisit content, frequent quizzes, and assignments help in KR and attainment of LOs. The KR is implemented better in Quizlet and Quizz, which allows users to create flashcards and quizzes to allow spaced repetition of concepts. Kahoot gamifies the learning process, reinforces learning, and improves KR (Sari, Ftriani and Saputra, 2020). Neurodivergent learners usually need differentiated and scaffolded learning through an appropriate multisensory approach. Currently, to the best of the author's knowledge, there is no study evaluating the same.

To provide equitable education to all, it is essential to adopt a more comprehensive strategy to ensure that the e-Learning systems and pedagogical models are effective for neurodivergent learners. The study indicates that learners' sensory, cognitive, and social challenges can be better addressed by incorporating adaptive learning technologies, multimodal content delivery, and inclusive design principles.

RQ 2: How can gamification approaches be customized to address the diverse learning styles of neurodivergent students?

Gamification in e-Learning can improve learner engagement, KR, and LO by integrating game elements and narrative-driven tasks into educational contexts . While its benefits are well documented across general learners' populations, its application to neurodivergent learners requires thoughtful customization. Neurodivergent learners exhibit diverse cognitive, sensory and social-emotional profiles that require customized approaches to meet their unique learning needs. E-Learning platforms can accommodate diverse learning styles by incorporating gamified elements, enhancing motivation, satisfaction, and outcomes, especially for neurodivergent students, by integrating adaptive and inclusive design principles.

There are several learning style models that categorize and describe how people prefer to learn and process information. The literature identifies three primary learning style models: VARK, Kolb's, and Felder-Silverman (FSLSM). VARK categorizes learners by sensory preference (visual, auditory, read/write, or kinesthetic) for practical application in instructional settings. Kolb's experiential learning theory proposes a four-stage cycle

(concrete experience, reflective observation, abstract conceptualization, and active experimentation) and is applied in adult and higher education. FSLSM is applied more in STEM disciplines and explores learning preferences across four dimensions: sensing/intuitive, visual/verbal, active/reflective, and sequential/global. Sensing learners prefer concrete, practical information, and intuitive learners favor abstract, theoretical information. Visual learners prefer pictures, diagrams, and other visual aids, and verbal learners prefer written and spoken explanations. Active learners prefer hands-on activities and group work, and reflective learners prefer to think things through and work independently. Global learners favor broad learning, while sequential learners favor linear learning. Instead of simply categorizing students into a few different types of learning, the FSLSM offers a thorough analysis of different learning styles, distinguishing between preferences in four dimensions (Hassan et al., 2021; Shrestha et al., 2023). To improve engagement and efficacy, e-Learning materials can be designed and delivered with an understanding of various learning styles (Smiderle et al., 2020). Auditory learners might benefit from spoken instructions and sound-based feedback, while visual learners engage better with graphics and diagrams. Kinesthetic learners thrive in hands-on interactive simulations, highlighting the critical role of multimodal content delivery. Gamified e-Learning platforms can use artificial intelligence-based techniques to detect learners' learning styles automatically and customize the delivery of content. Gamification approaches can be customized as given in Table 4 to address the diverse learning styles of neurodivergent students by using the following.

- Adaptive and multimodal gamification
- Incorporating feedback and rewards
- Using AI and analytics for personalization

Adaptive gamification dynamically adjusts challenges and game mechanics based on learners' real-time performance (Zairon et al., 2023). This ensures that the content aligns with individual abilities and pace preferences, preventing cognitive overload or disengagement. Adaptive platforms used personalized learning paths to address individual cognitive strengths and weaknesses (Alsubhi, Ashaari and Wook, 2021).

Table 4: Gamification Customization Approaches to Address the Diverse Learning Styles

Category	Key Features	Method	Study
Adaptive and Multimodal Gamification	Real-time challenge adjustments	Reinforcement Learning	Sezgin and Yüzer, 2022; Shrestha et al., 2023
	Multisensory content (visual, auditory, tactile)	Multimodal Integration Frameworks	Yuliana and Palumian, 2023; Xiao and Hew, 2024
	Dynamic pacing	Adaptive Algorithms	Alsubhi, Sahari and Wook, 2020; Moussa, Maher, Moussa and Khalifa, 2020; Hassan et al., 2021; Hocine, 2021; Malone, Wang and Monrose, 2021; Villegas and Aguero, 2023; Puig et al., 2023; Shabadurai, Chua and Lim, 2024; Pratama et al., 2024
Personalized Feedback and Rewards	Performance based feedback	Gamified Feedback Loops	Maher, Moussa and Khalifa, 2020; Kamunya et al., 2020; Zubkov, 2023; Zairon et al., 2023
	Reward system integration	Reinforcement Learning, Incentive Algorithms	Dikcius et al., 2021; Sayed et al., 2023
AI and Analytics	Personalization, Predictive analytics	AI recommendation engines, ML models	Ng et al., 2021; Cheah, 2021; Bennani et al., 2022b; Sayed et al., 2023
	Behavioral tracking	Data-driven insights	Bennani et al., 2022b; Taskın and Kılıç Çakmak, 2023; Xiao and Hew, 2024

Multimodal designs integrate visual aids, auditory feedback, and tactile simulations to engage learners in all sensory modalities and allow them to interact effectively with content. Gamification platforms incorporate personalized feedback and reward mechanisms to maintain motivation. Studies integrate feedback loops and performance-based adjustments to improve motivation and sustain learning. Dynamic adjustments to rewards, such as badges for achievement-oriented learners or avatars for creative individuals (Pakinee and Puritat, 2021), help in ensuring that neurodivergent students remain engaged. AI-powered systems (Ng et al., 2021) analyze learners' interactions to personalize the game's elements dynamically. Reinforcement learning techniques optimize difficulty levels and reward structures, ensuring alignment with individual learning styles. Learning analytics platforms provide insight into user behavior, enabling the continuous refinement of gamification strategies.

The reviewed studies bring out the potential of gamification to improve engagement and LOs when customized to diverse learning styles, although the explicit focus on neurodivergent learners remains limited.

RQ 3: What impact does the integration of advanced intelligent technologies have on enhancing student performance in personalized e-Learning platforms?

Personalization through AI techniques promises to enhance e-Learning by addressing individual needs. ML models, capable of predictive analytics, can identify areas where students are likely to struggle and recommend targeted interventions. These capabilities result in better KR, higher test scores, and increased motivation. They can also provide real-time modifications to the learning path based on the learner's performance. This adaptive functionality is crucial for neurodivergent learners, who may require individualized pacing and multimodal content delivery. RL optimizes performance through dynamic adaptation in gamified platforms. RL addresses motivational needs by personalizing gamification elements and adjusting learning objectives to help students stay committed to their educational goals. RL-based gamification has been reported to reduce dropout rates and increase task completion by providing customized support and appropriate challenges. Immersive technologies (AR/VR/MR) boost KR and engagement (Yakubov, Nazarov and Rodionov, 2024). Further studies are required to look at how it impacts neurodivergent learners in terms of cognitive overload and sensory sensitivities. Generative AI is reported to promote improved engagement and performance by reducing barriers and providing consistent, personalized guidance to a wide range of learners (Son et al., 2024; Arslan et al., 2024; Pesovski et al., 2024). It acts as a virtual tutor in real time to offer consistent support and scaffolding to address specific cognitive or sensory needs. Although there are limited studies with neurodivergent students, it has the potential to improve inclusivity and accessibility. Inherent challenges in technology, such as biases and hallucinations, and their impact on the generated content need to be further studied. The effect of these advanced technologies on personalized e-Learning is shown in Table 5.

Table 5: Impact of Advanced Technologies on Student Performance in Personalized e-Learning Platforms

Technology	Key Studies	Features	Impact on Student Performance
Machine Learning (ML) / Deep Learning (DL)	Rohan et al., 2021; Hocine, 2021; Bennani et al., 2022b; Bachiri, Mouncif and Bouikhalene, 2023; Sayed et al., 2023; Cheah, 2021; Yakubov, Nazarov and Rodionov, 2024; Shabadurai, Chua and Lim, 2024; Bucchiarone et al., 2024	Personalization, predictive analytics, adaptive gamification, intelligent tutoring systems, LS classification, learner profiling	Improved engagement, perception, boosted retention, cognitive flexibility, and customized learning pathways
Reinforcement Learning (RL)	Chugh, Vyas and Shukla, 2022; Sayed et al., 2023	Gamification optimization, difficulty scaffolding, dynamic adaptation	Higher engagement, reduced dropout rates and performance improvement.
Immersive Technologies (AR/VR/MR)	Yakubov, Nazarov and Rodionov, 2024	Immersive and experiential learning	Improved practical skills, and cognitive retention
Generative AI	Ng et al., 2021	Content creation, adaptive narratives	Enhanced customization of learning materials, higher engagement and improved KR.

Intelligent systems collect and process vast amounts of learner data to optimize personalization, raising issues about consent and security, especially for vulnerable populations (Fajri et al., 2021). Therefore, focused studies

are needed to understand how advanced technologies can achieve transparency and data privacy in learning tools.

5. Discussion of Findings

This section synthesizes the findings of the review in relation to the proposed Research Questions (RQs), with a focus on the applicability of gamified, intelligent e-Learning systems in supporting neurodivergent learners. Each subsection interprets results through the lens of inclusivity and pedagogical adaptability.

RQ 1 : How do different e-Learning systems and pedagogical models impact engagement, knowledge retention, and learning outcomes among neurodivergent learners?

The review indicates that while mainstream platforms such as LMSs, MOOCs, VLEs, and mobile learning apps have evolved in terms of accessibility and interactivity, they often fall short in addressing the heterogeneous cognitive and sensory needs of neurodivergent learners. Most systems implicitly assume neurotypical learning trajectories and fail to implement scaffolds aligned with UDL or the PAGE model. Platforms should integrate multisensory engagement strategies (text, audio, visual, and haptic) and dynamic pacing, which are critical for learners with conditions such as ADHD, ASD, and dyslexia. Pedagogical models based on the user's learning style are a promising direction for improving students' learning experience that can result in better engagement, KR, and LOs.

RQ 2: How can gamification approaches be customized to address the diverse learning styles of neurodivergent students?

The findings reveal the potential of adaptive gamification as a personalization engine for neurodivergent users. Specifically, gamification strategies that adjust in real-time by modulating difficulty levels, pacing, feedback frequency, and content sequencing enhance learner engagement, mitigate overload, and improve LOs.

Key techniques identified include:

- Multimodal feedback loops (e.g., combining audio prompts with visual animations)
- Sensory-aware User Interface/User Experience (UI/UX) design, minimizing cognitive noise while maintaining engagement
- Reward systems personalized through avatars, badges, and creative affordances
- Dynamic challenge scaling based on learner performance or biometric or behavioral cues

AI-driven personalization (e.g., using RL or real-time learning analytics) enables instructional alignment with individual preferences and needs. This includes optimizing flow states, preventing disengagement, and reinforcing motivation through targeted micro-interventions. These findings suggest a gap in current practice, where static gamification schemes often dominate despite growing evidence favoring adaptive models.

RQ 3: What impact does the integration of advanced intelligent technologies have on enhancing student performance in personalized e-Learning platforms?

Advanced intelligent technologies, including ML, RL, generative AI, and immersive XR, exhibit significant utility in developing responsive, learner-centered settings. These technologies facilitate the creation of environments that can compensate for attention or processing challenges. Unlike traditional systems, these platforms facilitate:

- Predictive modeling for early detection of disengagement or learning bottlenecks
- Real-time content adaptation, aligning tasks with learner state
- Emotion-aware interaction, using affective computing to adjust delivery tone or pacing
- Immersive experiences, which compensate for attention deficits through rich sensory input

This aligns with theoretical models of adaptive learning and learner-centered design, reinforcing the value of real-time responsiveness and contextual intelligence in education. However, few empirical studies rigorously validate their use in neurodivergent populations, highlighting an urgent need for domain-specific implementations and longitudinal validation.

6. Implications of the Findings and Conclusion

The findings of this SLR point out the transformative potential of integrating adaptive gamification and intelligent technologies in e-Learning environments to support neurodivergent learners. These insights yield important practical and research implications, as well as a clear direction for future investigations.

6.1 Practical Implications

To build inclusive and personalized e-Learning ecosystems, current platforms must be restructured to address the sensory, cognitive, and behavioral diversity of neurodivergent students. Based on the reviewed literature, the following design recommendations are essential:

- Design for cognitive accessibility: Implement adaptive gamification techniques that include task decomposition, minimalist UI/UX, and personalized difficulty scaling to reduce cognitive overload.
- Adopt multimodal content delivery: Support learning via text, visuals, audio, and haptics to accommodate varying sensory processing preferences.
- Integrate inclusive design frameworks: Apply Universal Design for Learning (UDL) and Personalization for Adaptive Gamified Education (PAGE) principles to ensure accessibility and flexibility.
- Employ AI-driven personalization: Use machine learning models for dynamic adaptation of content pacing, sequencing, and feedback mechanisms.
- Use of emotion-aware technologies: Utilize affective computing to detect user frustration or disengagement in real time and trigger adaptive support.
- Enable learner-driven customization: Incorporate customizable avatars, scaffolded learning structures, and gamified reward systems tailored to learner profiles.

These strategies aim to enhance learner engagement, reduce anxiety, and improve retention and learning outcomes across neurodiverse populations.

6.2 Research Implications

Despite the expanding body of work on adaptive and gamified e-Learning, there remains a critical gap in rigorous empirical studies specifically targeting neurodivergent populations and their unique learning requirements. To advance the field, several key research directions are recommended:

- Focused empirical studies: Address the lack of dedicated investigations on the effect of adaptive gamification on engagement, KR, and LOs among neurodivergent students.
- Profiling for personalization: Develop real-time neurodiversity-aware profiling models using cognitive assessments, behavioral analytics, and learning analytics.
- Framework refinement and validation: Adapt and empirically test theoretical models, such as UDL, PAGE and reinforcement learning within neurodivergent learning contexts.
- Sustained engagement modeling: Explore the role of affective computing, adaptive feedback loops, and motivational design in maintaining long-term engagement.
- Mixed-methods evaluation: Employ integrative approaches that combine quantitative learning analytics with qualitative user feedback to assess usability, effectiveness, and learner satisfaction.
- Ethical considerations in personalization: Examine transparency, algorithmic fairness, bias mitigation, and data privacy in the deployment of AI-driven personalization.

These areas present critical opportunities for expanding evidence-based practices in inclusive e-Learning design.

6.3 Future Research Directions

Building upon the identified gaps and emerging technologies, this review outlines the following strategic research priorities:

- Framework Development: Construct a theoretically grounded and empirically validated framework for inclusive adaptive e-Learning that integrates UDL principles and assistive technologies.
- Longitudinal Impact Studies: Conduct long-term studies to evaluate the sustained effects of adaptive and gamified learning environments on academic and behavioral outcomes among neurodivergent learners.
- Sensory and Cognitive Adaptation: Investigate how digital platforms can mitigate sensory overload and cognitive strain through customizable interfaces and assistive supports.
- Generative AI for Personalization: Evaluate the use of generative AI in creating personalized learning trajectories, with a focus on fairness, transparency, and content bias.
- Immersive Learning Environments: Explore the impact of augmented and virtual reality in providing experiential learning tailored to the sensory and cognitive profiles of neurodivergent users.
- Digital Inclusion Strategies: Examine scalable approaches to reduce the digital divide, ensuring equitable access to adaptive learning technologies in both rural and urban settings.

6.4 Conclusion

This systematic literature review highlights the untapped potential of adaptive gamification, AI-driven personalization, and inclusive design in transforming e-Learning for neurodivergent learners. This paper emphasizes the importance of creating personalized adaptive systems tailored to diverse cognitive profiles that focus on measurable outcomes such as engagement, knowledge retention, and learning performance. However, a notable limitation is the lack of longitudinal studies that assess the sustained impact of these technologies on neurodivergent learners. Despite the limited empirical evidence, the review maps out areas that merit further investigation and provides a foundation for future research. Focused research into personalized adaptive systems, sensory-friendly interfaces, ethically responsible gamification strategies, and effective knowledge retention learning approaches will help bring more neurodivergent individuals into the mainstream and create a more inclusive and equitable society through accessible education.

AI Statement: Large language models were used for sentence restructuring and grammar correction.

Ethics Statement: Ethics approval is not required in this study.

References

Abbasi, M., Montazer, G., Ghrobani, F. and Alipour, Z., 2021. Personalized gamification in e-Learning with a focus on learners' motivation and personality. *Interdisciplinary Journal of Virtual Learning in Medical Sciences*, *12*(3), pp.201-212.

Abdirahma, A.A., Hashi, A.O., Elmi, M.A., Dahir, U.M. and Rodriguez, O.E.R., 2023. Exploring the impact of gamification on self-directed learning: A study in an online learning environment. *International Journal of Engineering Trends and Technology*, *71*(9), pp.129-137.

Acosta-Medina, J.K., Torres-Barreto, M.L. and Cárdenas-Parga, A.F., 2021. Students' preference for the use of gamification in virtual learning environments. *Australasian Journal of Educational Technology*, *37*(4), pp.145-158.

Adedoyin, O.B. and Soykan, E., 2023. Covid-19 pandemic and online learning: the challenges and opportunities. *Interactive learning environments*, *31*(2), pp.863-875.

Aguilos, V. and Fuchs, K., 2022, July. The perceived usefulness of gamified e-Learning: A study of undergraduate students with implications for higher education. In *Frontiers in Education* (Vol. 7, p. 945536). Frontiers Media SA.

Alalgawi, D. and Sadkhan, S.B., 2022, May. Gamification Trends in e-Learning–A Survey. In *2022 5th International Conference on Engineering Technology and its Applications (IICETA)* (pp. 193-198). IEEE.

Al-Dababneh, K.A. and Al-Zboon, E.K., 2022. Using assistive technologies in the curriculum of children with specific learning disabilities served in inclusion settings: teachers' beliefs and professionalism. *Disability and Rehabilitation: Assistive Technology*, *17*(1), pp.23-33.

Alkhawaldeh, M.A. and Saleem Khasawneh, M.A., 2024. Designing gamified assistive apps: A novel approach to motivating and supporting students with learning disabilities. *International Journal of Data & Network Science*, *8*(1).

Alshammari, M.T., 2020. Evaluation of gamification in systems for elementary school students. *TEM journal*, *9*(2), pp.806-813.

Alsubhi, M.A., Ashaari, N.S. and Wook, T.S.M.T., 2021. Design and evaluation of an engagement framework for e-Learning gamification. *International Journal of Advanced Computer Science and Applications*, *12*(9), pp.411-417.

Alsubhi, M.A., Sahari, N. and Wook, T.T., 2020. A conceptual engagement framework for gamified e-Learning platform activities. *International Journal of Emerging Technologies in Learning (iJET)*, *15*(22), pp.4-23.

Antonopoulou, H., Halkiopoulos, C., Gkintoni, E. and Katsimpelis, A., 2022. Application of gamification tools for identification of neurocognitive and social function in distance learning education. *International Journal of Learning, Teaching and Educational Research*, *21*(5), pp.367-400.

Arslan, B., Lehman, B., Tenison, C., Sparks, J.R., López, A.A., Gu, L. and Zapata-Rivera, D., 2024. Opportunities and challenges of using generative AI to personalize educational assessment. *Frontiers in Artificial Intelligence*, *7*, p.1460651.

Awad, M., Salameh, K. and Al Redhaei, A., 2023. Gamification in higher education: assessing its impact in on-line and traditional classes. *Global Journal of Engineering Education*, *24*(3), pp.226-231.

Bachiri, Y.A., Mouncif, H. and Bouikhalene, B., 2023. Artificial intelligence empowers gamification: Optimizing student engagement and learning outcomes in e-Learning and moocs. *International Journal of Engineering Pedagogy*, *13*(8).

Barua, A.M. and Bharali, S.S., 2023. Gamification and its challenges in e-Learning: a case study of computer science learners in KKHSOU. *Asian Association of Open Universities Journal*, *18*(3), pp.233-245.

Behl, A., Jayawardena, N., Pereira, V., Islam, N., Del Giudice, M. and Choudrie, J., 2022. Gamification and e-Learning for young learners: A systematic literature review, bibliometric analysis, and future research agenda. *Technological Forecasting and Social Change*, *176*, p.121445.

Bennani, S., Maalel, A. and Ben Ghezala, H., 2022a. Adaptive gamification in E-learning: A literature review and future challenges. *Computer Applications in Engineering Education*, *30*(2), pp.628-642.

Bennani, S., Maalel, A., Ben Ghezala, H. and Daouahi, A., 2022b, September. Integrating machine learning into learner profiling for adaptive and gamified learning system. In *International Conference on Computational Collective Intelligence* (pp. 65-71). Cham: Springer International Publishing.

Bernik, A., 2021. Gamification framework for e-Learning systems in higher education. *Tehnički glasnik*, *15*(2), pp.184-190.
Blezu, C. and Popa, E.M., 2008, July. E-Learning and its Prospects in Education. In *12th WSEAS International Conference on COMPUTERS, Heraklion, Greece*.
Boboc, C.R., Petrascu, G.M., Ghita, S.I. and Saseanu, A.S., 2023. Does gamification lead to better results in education?. *Transformations In Business & Economics*, *22*(2).
Bouchrika, I., Harrati, N., Wanick, V. and Wills, G., 2021. Exploring the impact of gamification on student engagement and involvement with e-Learning systems. *Interactive Learning Environments*, *29*(8), pp.1244-1257.
Bucchiarone, A., Martorella, T., Frageri, D. and Colombo, D., 2024. PolyGloT: A personalized and gamified eTutoring system for learning modelling and programming skills. *Science of Computer Programming*, *231*, p.103003.
Burlacu, M., Coman, C. and Bularca, M.C., 2023. Blogged into the System: A Systematic Review of the Gamification in e-Learning before and during the COVID-19 Pandemic. *Sustainability*, *15*(8), p.6476.
Buzzi, M.C., Buzzi, M., Perrone, E. and Senette, C., 2019. Personalized technology-enhanced training for people with cognitive impairment. *Universal Access in the Information Society*, *18*(4), pp.891-907.
Cheah, C.W., 2021. Developing a gamified AI-enabled online learning application to improve students' perception of university physics. *Computers and Education: Artificial Intelligence*, *2*, p.100032.
Cheng, Y-M., 2023. How different categories of gamified stimuli affect massive open online courses continuance intention and learning performance? Mediating roles of internal experiences. *Social Science Computer Review*, 41(2), pp.495–527.
Chugh, M., Vyas, S. and Shukla, V.K., 2022, May. Adaptive Gamification in e-Learning Platforms: Enhancing Learners' Experience. In *The International Conference on Recent Innovations in Computing* (pp. 627-634). Singapore: Springer Nature Singapore.
Cinquin, P.A., Guitton, P. and Sauzéon, H., 2023. Toward truly accessible MOOCs for persons with cognitive impairments: a field study. *Human–Computer Interaction*, *38*(5-6), pp.352-373.
Daghestani, L.F., Ibrahim, L.F., Al-Towirgi, R.S. and Salman, H.A., 2020. Adapting gamified learning systems using educational data mining techniques. *Computer Applications in Engineering Education*, *28*(3), pp.568-589.
De Marcos-Ortega, L., Garcia-Cabot, A., Garcia-Lopez, E., Ramirez-Velarde, R., Teixeira, A.M. and Martínez-Herráiz, J.J., 2020. Gamifying massive online courses: Effects on the social networks and course completion rates. *Applied Sciences*, *10*(20), p.7065.
Deterding, S., Sicart, M., Nacke, L., O'hara, K. and Dixon, D., 2011. Gamification. using game-design elements in non-gaming contexts. In *CHI'11 extended abstracts on human factors in computing systems* (pp. 2425-2428).
Dikcius, V., Urbonavicius, S., Adomaviciute, K., Degutis, M. and Zimaitis, I., 2021. Learning marketing online: The role of social interactions and gamification rewards. *Journal of Marketing Education*, *43*(2), pp.159-173.
El-Sabagh, H.A., 2021. Adaptive e-Learning environment based on learning styles and its impact on development students' engagement. *International Journal of Educational Technology in Higher Education*, *18*(1), p.53.
Fabriz, S., Mendzheritskaya, J. and Stehle, S., 2021. Impact of synchronous and asynchronous settings of online teaching and learning in higher education on students' learning experience during COVID-19. *Frontiers in psychology*, *12*, p.733554.
Fajri, F.A., Haribowo P, R.Y., Amalia, N. and Natasari, D., 2021. Gamification in e-Learning: The Mitigation Role in Technostress. *International Journal of Evaluation and Research in Education*, *10*(2), pp.606-614.
Gupta, S., 2024. Gamification and e-Learning adoption: a sequential mediation analysis of flow and engagement. *VINE Journal of Information and Knowledge Management Systems*, *54*(6), pp.1342-1359.
Halachev, P., 2024. Gamification as an e-Learning tool: A literature review. *E-Learning Innovations Journal*, *2* (2), 4–20.
Handayani, P.W., Raharjo, S.R. and Putra, P.H., 2021. Active student learning through gamification in a learning management system. *Electronic Journal of e-Learning*, *19*(6), pp.601-613.
Hassan, M.A., Habiba, U., Majeed, F. and Shoaib, M., 2021. Adaptive gamification in e-Learning based on students' learning styles. *Interactive Learning Environments*, *29*(4), pp.545-565.
Hebbar, S., Manohar, S. and Hungund, S., 2024. Examining gamification's impact on perceived satisfaction through learning parameters: a preliminary perception-based study among prospective users. *Interactive Learning Environments*, pp.1-20.
Hocine, N., 2021, December. Attention-based adaptation in gamified moocs. In *2021 International Conference on Information Systems and Advanced Technologies (ICISAT)* (pp. 1-7). IEEE.
Honorato, N., Oliveira, W., Hamari, J. and Delabrida, S., 2023, July. Gameful approaches for the education of autistic children: A systematic mapping and research agenda. In *2023 IEEE international conference on advanced learning technologies (ICALT)* (pp. 116-120). IEEE.
Hussein, E., Kan'An, A., Rasheed, A., Alrashed, Y., Jdaitawi, M., Abas, A., Mabrouk, S. and Abdelmoneim, M., 2023. Exploring the impact of gamification on skill development in special education: A systematic review. *Contemporary Educational Technology*, *15*(3), p.ep443.
Jarnac de Freitas, M. and Mira da Silva, M., 2023. Systematic literature review about gamification in MOOCs. *Open Learning: The Journal of Open, Distance and e-Learning*, *38*(1), pp.73-95.
Jayawardena, N.S., Ross, M., Quach, S., Behl, A. and Gupta, M., 2021. Effective online engagement strategies through gamification: A systematic literature review and a future research agenda. *Journal of Global Information Management (JGIM)*, *30*(5), pp.1-25.

Kamiliya, N., Syahchari, D.H. and Omar, A., 2024, August. Enhancing e-Learning through Gamification: Increasing User Enjoyment and Learning Outcomes. In *2024 3rd International Conference on Creative Communication and Innovative Technology (ICCIT)* (pp. 1-7). IEEE.

Kamunya, S., Mirirti, E., Oboko, R. and Maina, E., 2020, May. An adaptive gamification model for e-Learning. In *2020 IST-Africa Conference (IST-Africa)* (pp. 1-10). IEEE.

Karsen, M., Masrek, M.N. and Safawi, A.R., 2022. Gamification in MOOC: A systematic literature review. *Environment-Behaviour Proceedings Journal*, *7*(SI10), pp.111-119.

Kashive, N. and Mohite, S., 2023. Use of gamification to enhance e-Learning experience. *Interactive Technology and Smart Education*, *20*(4), pp.554-575.

Khaldi, A., Bouzidi, R. and Nader, F., 2023. Gamification of e-Learning in higher education: a systematic literature review. *Smart Learning Environments*, *10*(1), p.10.

Kučak, D., Biuk, A. and Mršić, L., 2022. Enhancing student learning productivity with gamification-based e-Learning platform: empirical study and best practices. In *Intelligent Computing & Optimization: Proceedings of the 4th International Conference on Intelligent Computing and Optimization 2021 (ICO2021) 3* (pp. 857-866). Springer International Publishing.

Lampropoulos, G. and Sidiropoulos, A., 2024. Impact of gamification on students' learning outcomes and academic performance: A longitudinal study comparing online, traditional, and gamified learning. *Education Sciences*, *14*(4), p.367.

Leung, A.C.M., Santhanam, R., Kwok, R.C.W. and Yue, W.T., 2023. Could gamification designs enhance online learning through personalization? Lessons from a field experiment. *Information Systems Research*, *34*(1), pp.27-49.

Lynch, P., Singal, N. and Francis, G.A., 2024. Educational technology for learners with disabilities in primary school settings in low-and middle-income countries: a systematic literature review. *Educational Review*, *76*(2), pp.405-431.

Maatuk, A.M., Elberkawi, E.K., Aljawarneh, S., Rashaideh, H. and Alharbi, H., 2022. The COVID-19 pandemic and e-Learning: challenges and opportunities from the perspective of students and instructors. *Journal of computing in higher education*, *34*(1), pp.21-38.

Maher, Y., Moussa, S.M. and Khalifa, M.E., 2020. Learners on focus: Visualizing analytics through an integrated model for learning analytics in adaptive gamified e-Learning. *IEEE Access*, *8*, pp.197597-197616.

Major, R.R. and Mira da Silva, M., 2023. Gamification in MOOCs: A systematic literature review. *Cogent Education*, *10*(2), p.2275820.

Malone, M., Wang, Y. and Monrose, F., 2021, October. An online gamified learning platform for teaching cybersecurity and more. In *Proceedings of the 22nd Annual Conference on Information Technology Education* (pp. 29-34).

Moussa, S., Maher, Y. and Khalifa, M.E., 2020. Learning preferences adaptation based on the Personalized Adaptive Gamified e-Learning (PAGE) model. *International Journal of Intelligent Computing and Information Sciences*, *20*(2), pp.32-52.

Ng, A.K., Atmosukarto, I., Cheow, W.S., Avnit, K. and Yong, M.H., 2021, October. Development and implementation of an online adaptive gamification platform for learning computational thinking. In *2021 IEEE Frontiers in Education Conference (FIE)* (pp. 1-6). IEEE.

Oliveira, R.P., Souza, C.G.D., Reis, A.D.C. and Souza, W.M.D., 2021. Gamification in e-Learning and sustainability: A theoretical framework. *Sustainability*, *13*(21), p.11945.

Ortega-Arranz, A., Asensio-Pérez, J.I., Martínez-Monés, A., Bote-Lorenzo, M.L., Ortega-Arranz, H. and Kalz, M., 2022. GamiTool: Supporting instructors in the gamification of MOOCs. *IEEE Access*, *10*, pp.131965-131979.

Page, M.J., McKenzie, J.E., Bossuyt, P.M., Boutron, I., Hoffmann, T.C., Mulrow, C.D., Shamseer, L., Tetzlaff, J.M., Akl, E.A., Brennan, S.E. and Chou, R., 2021. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *bmj*, *372*.

Pakinee, A. and Puritat, K., 2021. Designing a gamified e-Learning environment for teaching undergraduate ERP course based on big five personality traits. *Education and Information Technologies*, *26*(4), pp.4049-4067.

Palaniappan, K. and Noor, N.M., 2022. Gamification strategy to support self-directed learning in an online learning environment. *International Journal of Emerging Technologies in Learning (iJET)*, *17*(3), pp.104-116.

Park, S. and Kim, S., 2021. Is sustainable online learning possible with gamification?—The effect of gamified online learning on student learning. *Sustainability*, *13*(8), p.4267.

Patiño-Toro, O., Rodríguez-Correa, P., Valencia-Arias, A., Fernández-Toro, A., Jiménez-Guzmán, A. and Escorcia-González, J., 2022. Thematic trends around gamification in MOOC: a bibliometric analysis. *Journal of Information Systems Engineering and Management*, *7*(4).

Pesovski, I., Santos, R., Henriques, R. and Trajkovik, V., 2024. Generative AI for customizable learning experiences. *Sustainability*, *16*(7), p.3034.

Poondej, C. and Lerdpornkulrat, T., 2020. Gamification in e-Learning: A Moodle implementation and its effect on student engagement and performance. *Interactive Technology and Smart Education*, *17*(1), pp.56-66.

Pradana, F., Setyosari, P., Ulfa, S. and Hirashima, T., 2023. Development of Gamification-Based e-Learning on Web Design Topic. *International Journal of Interactive Mobile Technologies*, *17*(3).

Pratama, M.F., Puspasari, M.A., Hidayat, T.S. and Iqbal, B.M., 2024, February. The development of gamification 3.0 concepts for learning materials in e-Learning systems using the ADDIE model approach. In *AIP Conference Proceedings* (Vol. 2710, No. 1). AIP Publishing.

Puig, A., Rodríguez, I., Rodríguez, Á. and Gallego, I., 2023. Evaluating learner engagement with gamification in online courses. *Applied Sciences*, *13*(3), p.1535.

Rahayu, F.S., Nugroho, L.E., Ferdiana, R. and Setyohadi, D.B., 2022. Motivation and engagement of final-year students when using e-Learning: A qualitative study of gamification in pandemic situation. *Sustainability*, *14*(14), p.8906.

Raju, R., Bhat, S., Bhat, S., D'Souza, R. and Singh, A.B., 2021. Effective usage of gamification techniques to boost student engagement. *Journal of Engineering Education Transformations*, *34*(0), pp.713-717.

Rincón-Flores, E.G., Mena, J. and Montoya, M.S.R., 2020. Gamification: a new key for enhancing engagement in MOOCs on energy?. *International Journal on Interactive Design and Manufacturing (IJIDeM)*, *14*, pp.1379-1393.

Rohan, R., Pal, D. and Funilkul, S., 2020, July. Gamifying MOOC's a Step in The Right Direction? A Systematic Literature Review. In *Proceedings of the 11th international conference on advances in information technology* (pp. 1-10).

Rohan, R., Pal, D., Funilkul, S., Chutimaskul, W. and Eamsinvattana, W., 2021. How gamification leads to continued usage of MOOCs? A theoretical perspective. *Ieee Access*, *9*, pp.108144-108161.

Sabri, Z., FAKHRI, Y. and MOUMEN, A., 2022. The effects of gamification on e-Learning education: Systematic literature review and conceptual model. *Statistics, Optimization & Information Computing*, *10*(1), pp.75-92.

Saleem, A.N., Noori, N.M. and Ozdamli, F., 2022. Gamification applications in e-Learning: A literature review. *Technology, Knowledge and Learning*, *27*(1), pp.139-159.

Saputra, J.P.B., Hidayanto, A.N. and Prabowo, H., 2021, November. A systematic literature review of gamification in massive online open course. In *2021 IEEE 5th International Conference on Information Technology, Information Systems and Electrical Engineering (ICITISEE)* (pp. 55-60). IEEE.

Sari, D.E., Ftriani, S.A. and Saputra, R.C., 2020, May. Active and interactive learning through Quizlet and Kahoot. In *International Conference on Online and Blended Learning 2019 (ICOBL 2019)* (pp. 118-120). Atlantis Press.

Sayed, W.S., Noeman, A.M., Abdellatif, A., Abdelrazek, M., Badawy, M.G., Hamed, A. and El-Tantawy, S., 2023. AI-based adaptive personalized content presentation and exercises navigation for an effective and engaging e-Learning platform. *Multimedia Tools and Applications*, *82*(3), pp.3303-3333.

Schüll, A. and Brocksieper, L., 2021, July. Gamified self-paced e-Learning: Two iterations of an educational design experiment. In *International Conference on E-Business and Telecommunications* (pp. 84-102). Cham: Springer Nature Switzerland.

Sezgin, S. and Yüzer, T.V., 2022. Analysing adaptive gamification design principles for online courses. *Behaviour & information technology*, *41*(3), pp.485-501.

Shabadurai, Y., Chua, F.F. and Lim, T.Y., 2024. Dynamic adaptive gamification framework to improve user gamification experience for online training. *International Journal of Information and Education Technology*, *14*(1), pp.42-49.

Shrestha, S., Joshi, M., Bashyal, A., Timilsina, A. and Subedi, S., 2023. Integration of Gamified Elements and Learning Style Data in Online Learning System. *Journal of Educational Technology Systems*, *52*(2), pp.227-244.

Smiderle, R., Rigo, S.J., Marques, L.B., Peçanha de Miranda Coelho, J.A. and Jaques, P.A., 2020. The impact of gamification on students' learning, engagement and behavior based on their personality traits. *Smart Learning Environments*, *7*(1), p.3.

Sofiadin, A. and Azuddin, M., 2021. An Initial Sustainable e-Learning and Gamification Framework for Higher Education. *International Association for Development of the Information Society*.

Son, H.X., Nguyen, T.M., Vo, H.K., Dang, K.T., Gia, K.H., Tran, N.B., Khanh, B.L. and Nguyen, N.T., 2024, January. Generative AI-Driven Digital Assistance for e-Learning: A Novel Paradigm for Personalized Recommendations. In *Workshop on Artificial Intelligence with and for Learning Sciences: Past, Present, and Future Horizons* (pp. 89-98). Cham: Springer Nature Switzerland.

Sulaimani, M.F. and Bagadood, N.H., 2023. Assistive technology for students with intellectual disability: examining special education teachers 'perceptions in Saudi Arabia. *Assistive Technology*, *35*(3), pp.235-241.

Suresh Babu, S. and Dhakshina Moorthy, A., 2024. Application of artificial intelligence in adaptation of gamification in education: A literature review. *Computer Applications in Engineering Education*, *32*(1), p.e22683.

Tan, W.K., Sunar, M.S. and Goh, E.S., 2021, December. Review of gamified MOOC's impact toward learner's motivation in learning effectiveness context. In *International Conference on Intelligent Technologies for Interactive Entertainment* (pp. 189-207). Cham: Springer International Publishing.

Taşkın, N. and Kılıç Çakmak, E., 2023. Effects of gamification on behavioral and cognitive engagement of students in the online learning environment. *International Journal of Human–Computer Interaction*, *39*(17), pp.3334-3345.

Toimah, T.F., Maulana, Y.I. and Fajar, I., 2021. Gamification model framework and its use in e-Learning in higher education. *IAIC Transactions on Sustainable Digital Innovation (ITSDI)*, *3*(1), pp.28-35.

Vapiwala, F. and Pandita, D., 2022, May. Strategies for effective use of gamification technology in e-Learning and e-assessment. In *2022 7th International Conference on Business and Industrial Research (ICBIR)* (pp. 596-601). IEEE.

Villegas, C.G. and Aguero, N.A.L., 2023. The gamification of e-Learning environments for learning programming. *JOIV: International Journal on Informatics Visualization*, *7*(2), pp.455-462.

Walaszczyk, L., 2023, October. A Review of Tools for the Design and Development of Online Interactive Gamified Content: A Simulation Study. In *22nd European Conference on e-Learning: ECEL 2023*. Academic Conferences and publishing limited.

Wen, B., Hu, P.J.H. and Fang, Y., 2024. Influences of leaderboard direction on learning performance and satisfaction in gamified e-Learning. *Journal of Global Information Management (JGIM)*, *32*(1), pp.1-33.

Xiao, Y. and Hew, K.F., 2024. Personalized gamification versus one-size-fits-all gamification in fully online learning: Effects on student motivational, behavioral and cognitive outcomes. *Learning and Individual Differences*, *113*, p.102470.

Yakubov, A., Nazarov, Y. and Rodionov, A.A., 2024, June. Advancing e-Learning and M-Learning Environments Incorporating AI and Gamification to Boost Learner Motivation. In *2024 4th International Conference on Technology Enhanced Learning in Higher Education (TELE)* (pp. 29-31). IEEE.

Yamani, H.A., 2021. A conceptual framework for integrating gamification in elearning systems based on instructional design model. *International Journal of Emerging Technologies in Learning (Online)*, *16*(4), p.14.

Yu, Q., Yu, K. and Li, B., 2024. Can gamification enhance online learning? Evidence from a meta-analysis. *Education and Information Technologies*, *29*(4), pp.4055-4083.

Yuliana, O.Y. and Palumian, Y., 2023, October. Gamification of Learning Management System Improves Students' Engagement, Active Learning and Performance. In *2023 14th International Conference on Information & Communication Technology and System (ICTS)* (pp. 62-66). IEEE.

Zairon, I.Y., Wook, T.S.M.T., Salleh, S.M. and Dahlan, H.A., 2023, October. Gamification Adaptive Elements in Virtual Learning to Improve Behaviour and Collaborative Interaction. In *2023 International Conference on Electrical Engineering and Informatics (ICEEI)* (pp. 1-6). IEEE.

Zamahsari, G.K., Romadhon, S., Amalia, M.N., Rifah, L., Prihatini, A. and Saputra, A.W., 2023, December. A Review in e-Learning Context: Gamification Elements for Language Learning. In *2023 International Conference on Technology, Engineering, and Computing Applications (ICTECA)* (pp. 1-5). IEEE.

Zubkov, A., 2023, November. Gamification Techniques in Massive Open Online Courses: Challenges and Opportunities. In *International Conference on Professional Culture of the Specialist of the Future* (pp. 391-401). Cham: Springer Nature Switzerland.