CHAPTER NINE

Fostering Intellectual Autonomy in AI-Mediated Postgraduate Supervision: A Gamified Approach

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Abstract: This chapter examines how gamification strategies facilitate self-directed learning, intellectual autonomy, and academic growth within AI-mediated postgraduate supervision. Employing a systematic literature review methodology in accordance with PRISMA 2020 standards, the chapter synthesises research that investigates the integration of gamification and artificial intelligence in postgraduate education. Key strategies, including milestone-based progression, collaborative problem-solving, and interactive feedback, are analysed as mechanisms for fostering autonomy and intrinsic motivation among postgraduate students. The review indicates that structured challenges and rewards enhance engagement, reduce over-reliance on AI tools, and support the development of complex research skills. Furthermore, gamification serves as a catalyst for professional growth, with collaborative and reflective practices enhancing critical thinking and resilience. Ethical considerations, such as algorithmic bias, fairness, and the necessity of maintaining human-centred mentorship, are also examined. The chapter concludes that the integration of gamification into AI-mediated supervision frameworks promotes creativity, independence, and intellectual rigour, providing valuable insights for educators and institutions seeking to align technological innovation with the enduring values of postgraduate mentorship.

Keywords: AI in education, gamification, intellectual autonomy, postgraduate supervision, self-directed learning.

1. Introduction

The integration of artificial intelligence (AI) into postgraduate supervision is fundamentally reshaping academic mentorship by introducing more personalised and efficient support systems (Dai et al., 2023; Makokotlela, 2024; Sim et al., 2023). Tools such as ChatGPT and EndNote streamline research tasks, support academic writing and referencing, and enhance overall productivity (Luckin, 2024; Zawacki-Richter et al., 2019; Chauke et al., 2024; Cui, 2024; Kızıltaş, 2025). Nevertheless, these advancements also raise concerns regarding the erosion of intellectual autonomy, which remains a core pillar of academic and professional development (Veletsianos & Kimmons, 2012; Zawacki-Richter et al., 2019; Deci & Ryan, 1985; Deci & Ryan, 2000). Scholars (Marengo & Pange, 2024; Ferris, 2011; Bond et al., 2020) caution that excessive reliance on AI may diminish students' opportunities to cultivate critical thinking, independent learning, and reflective skills. Furthermore, the evolving relationship between supervisors and students necessitates that supervisors strike a balance between the rapid advancement of technology and the provision of human guidance that fosters deep learning (Luckin, 2024; Laurillard, 2013;

Albertyn & Bennett, 2021; Emilsson & Johnsson, 2007; Oparinde, 2021). Some studies (Dai et al., 2023; Cowling et al., 2023; Chauke et al., 2024; Kızıltaş, 2025) suggest that while students value AI support, a significant risk exists that they may begin to rely on such technologies even for tasks that necessitate original thought and clear understanding.

As AI becomes increasingly commonplace in postgraduate education, there is a pressing need to reconsider how students learn, receive feedback, and engage with their supervisors (Qudsi, 2024; Rivera, 2021; Cui, 2024; Dai et al., 2023; Sim et al., 2023). Most AI systems are designed to prioritise clarity and efficiency, which may enhance superficial academic performance but can impede deeper cognitive engagement (Selwyn, 2019; Chauke et al., 2024; Kızıltaş, 2025). In the context of postgraduate research, where sustained reflection and conceptual development are critical, this limitation is particularly concerning (Luckin, 2024; Bell, 2016; Jones, 2017; Willcoxson, 1998). Selwyn (2019) and Zawacki-Richter et al. (2019) warn that AI-generated feedback may undermine the dialogic and relational aspects of supervision (Albertyn & Bennett, 2021; Daramola, 2021; Maistry, 2015). Research conducted by Dai et al. (2023) and Selwyn (2019) indicates that students tend to produce more reflective and meaningful work when AI support is augmented with feedback from their supervisors, rather than relying exclusively on AI (Cowling et al., 2023; Sim et al., 2023).

Hamari, Koivisto, and Sarsa (2014), Deterding, Dixon, Khaled, and Nacke (2011), Subhash and Cudney (2018), and Muchuweni, Jojo, and Kariyana (2025) demonstrate that gamification can enhance motivation and support self-directed learning. In postgraduate contexts, where learners manage complex, multi-phase research tasks, gamified structures can provide essential scaffolding and maintain momentum (Rivera, 2021; Dicheva et al., 2015; Indriasari et al., 2020; Landers, 2014; Ortiz-Rojas et al., 2025; Zainuddin et al., 2024). Features such as progress tracking, achievement systems, and leaderboards assist students in monitoring their development, encouraging accountability, and recognising milestones (Müller & Mildenberger, 2021; Looyestyn et al., 2017; Landers, 2014; Li et al., 2024; Ortiz-Rojas et al., 2025; Venter & de Wet, 2024). Integrated feedback mechanisms within gamification facilitate iterative improvement and continuous reflection (Qudsi, 2024; Black & Wiliam, 2009; Olsher et al., 2016; Ramadhan et al., 2024). Findings from a recent systematic literature review further substantiate these patterns, with evidence demonstrating that Quizizz enhances student engagement, strengthens motivation, improves academic performance, and supports formative assessment (Muchuweni et al., 2025, p. 119). Several studies (Hamari et al., 2014; Dicheva et al., 2015; Subhash & Cudney, 2018; Omodan & Marongwe, 2024) indicate that students respond positively when gamification is employed to scaffold meaningful checkpoints, such as proposal submissions or reflective journaling.

Poorly designed gamified systems may lead students to focus on rewards rather than meaningful learning (Nicholson, 2015; Li et al., 2024; Seaborn & Fels, 2015). When these strategies lack intrinsic alignment, they can promote shallow engagement and discourage deeper inquiry (Deci

& Ryan, 1985; Leon et al., 2015; Ng et al., 2012; Reeve, 2012; Standage, 2023). However, the convergence of artificial intelligence (AI) and gamification in postgraduate supervision also introduces complex ethical considerations (Floridi & Cowls, 2022; Buckley, Doyle, & Doyle, 2017; Cui, 2024; Dai et al., 2023; Xu, 2025). AI systems may perpetuate algorithmic bias by favouring dominant academic norms or linguistic styles, which can disadvantage students from non-traditional backgrounds (Winkler & Söllner, 2018; Floridi & Cowls, 2022; Bond et al., 2020; Zawacki-Richter et al., 2019). Furthermore, unequal access to digital tools and platform variability across institutions may exacerbate existing educational inequities (Zawacki-Richter et al., 2019; Cullen et al., 2020; Hidayat & Firmanti, 2024; Viberg et al., 2020). Gamification structures that overemphasise competition or fixed metrics can diminish inclusivity and weaken intrinsic motivation (Buckley et al., 2017; Li et al., 2024; Sailer & Homner, 2020; Yığ & Sezgin, 2021). Ethically grounded supervision should remain adaptive, inclusive, and attentive to the unintended consequences of digital tools (Albertyn & Bennett, 2021; Maistry, 2015; Oparinde, 2021).

Despite the increasing body of research on artificial intelligence (AI) and gamification as discrete domains, there remains a dearth of studies that explore their combined impact on postgraduate supervision (Bond et al., 2020; Dichev & Dicheva, 2017; Majuri et al., 2018; Rahmi et al., 2025; Triantafyllou et al., 2025). The majority of gamification research concentrates on undergraduate settings, primarily with short-term engagement objectives (Subhash & Cudney, 2018; Dicheva et al., 2015; Indriasari et al., 2020; Lathwesen & Belova, 2021; Ortiz-Rojas et al., 2025; Sánchez-Arévalo et al., 2025; Yllana-Prieto et al., 2025), while studies addressing AI in education frequently prioritise administrative or technical functionalities over pedagogical depth (Dai et al., 2023; Selwyn, 2019; Chauke et al., 2024; Cowling et al., 2023; Cui, 2024; Kızıltaş, 2025; Sim et al., 2023). This separation has contributed to a fragmented understanding of the interactions between these tools and their potential to support or impede postgraduate development (Bond et al., 2020; Li et al., 2024; Rahmi et al., 2025; Triantafyllou et al., 2025). Furthermore, many ethical and pedagogical implications of these technologies remain under-theorised (Marengo & Pange, 2024; Floridi & Cowls, 2022; Looyestyn et al., 2017; Seaborn & Fels, 2015; Xu, 2025).

While concerns such as algorithmic bias, cognitive overload, and gamification fatigue are acknowledged, they are seldom examined in relation to sustained academic growth (Buckley et al., 2017; Rivera, 2021; Dichev & Dicheva, 2017; Hamari et al., 2014; Li et al., 2024; Sailer & Homner, 2020; Triantafyllou et al., 2025). Much of the literature continues to emphasise task performance rather than the long-term development of critical thinking, resilience, and research identity (Veletsianos & Kimmons, 2012; Bond et al., 2020; Landers, 2014; Leon et al., 2015; Ng et al., 2012; Ortiz-Rojas et al., 2025; Rahmi et al., 2025; Sánchez-Arévalo et al., 2025). This gap between the utilisation of technology and pedagogical objectives highlights the necessity for more integrative research that considers student development, equity, and sustained learning (Bond et al., 2020; Li et al., 2024; Triantafyllou et al., 2025). Institutions may adopt AI and

gamification primarily for operational efficiency, often overlooking their deeper academic ramifications (Dockendorff & Gómez Zaccarelli, 2025; Oulaich, 2019; Shumba, 2024; Viberg et al., 2020). In the absence of careful planning, these technologies risk valuing convenience over mentorship, reflection, and intellectual profundity (Dichev & Dicheva, 2017; Hamari et al., 2014; Landers, 2014). Consequently, this chapter employs the PRISMA 2020 framework (Page et al., 2021) to synthesise contemporary literature and provide guidance for the design of learner-centred, ethical, and autonomy-supportive models of AI-mediated postgraduate supervision.

1.1 Problem statement

While AI-supported postgraduate supervision enables more personalised feedback and efficient administration (Aoun, 2017), it also raises concerns about students' independence and decision-making in research (Selwyn, 2019; Melisa et al., 2025). Gamification has been proposed as a complementary strategy to address these risks by enhancing motivation, structuring progression, and promoting self-directed learning in AI-mediated environments (Dicheva et al., 2015; Hamari et al., 2014). Its role in supporting intellectual independence at the postgraduate level is still not well studied (Subhash & Cudney, 2018). This study addresses a critical gap in evidence on how gamification can be strategically applied to counterbalance the cognitive and ethical risks associated with over-reliance on AI in postgraduate supervision. If this gap remains unaddressed, students may become more dependent on AI, their intellectual autonomy may weaken, and institutions may overlook important ethical risks in supervision.

1.1.1 Research question

This study investigates the role of gamification in fostering intellectual autonomy within AI-mediated postgraduate supervision and is structured around the following guiding question:

- How does the integration of gamification into AI-mediated postgraduate supervision influence students' intellectual autonomy, including their critical thinking and independent research skills?

1.2 Theoretical framework: Self-Determination theory

Self-Determination Theory (SDT), developed by Deci and Ryan (1985), is utilised in this chapter to explain how AI tools and gamified structures influence postgraduate supervision. SDT posits that learning improves when three basic needs are supported: autonomy, competence, and relatedness (Deci & Ryan, 1985; Ryan & Deci, 2017). Autonomy involves making one's own decisions in learning (Deci & Ryan, 1985; Ryan & Deci, 2017). While AI tools can assist with routine tasks, students may lose autonomy if they rely too heavily on automated suggestions or overly rigid digital systems (Dai et al., 2023; Selwyn, 2019; Chauke et al., 2024; Albertyn & Bennett, 2021; Oparinde, 2021). Competence refers to the feeling of being capable and witnessing improvement (Deci & Ryan, 1985; Ryan & Deci, 2017). Gamified elements, such as progress tracking and milestone badges, can enhance competence by providing clear steps and visible progress (Subhash & Cudney, 2018; Dicheva et al., 2015). Research also indicates that

meaningful feedback helps students recognise their growth and build confidence (Reeve, 2023; Standage, 2023). Relatedness pertains to feeling supported by others (Deci & Ryan, 1985; Ryan & Deci, 2017). Human feedback encourages deeper thinking and reflection, something that AI cannot fully replicate (Laurillard, 2013; Selwyn, 2019; Emilsson & Johnsson, 2007; Maistry, 2015). Studies demonstrate that students develop more effectively when AI support is combined with supervisor feedback (Dai et al., 2023; Laurillard, 2013). Overall, SDT helps explain how AI and gamification can either support or undermine autonomy, competence, and relatedness in postgraduate learning. Figure 1 illustrates how these three needs relate to AI tools and gamified supervision.

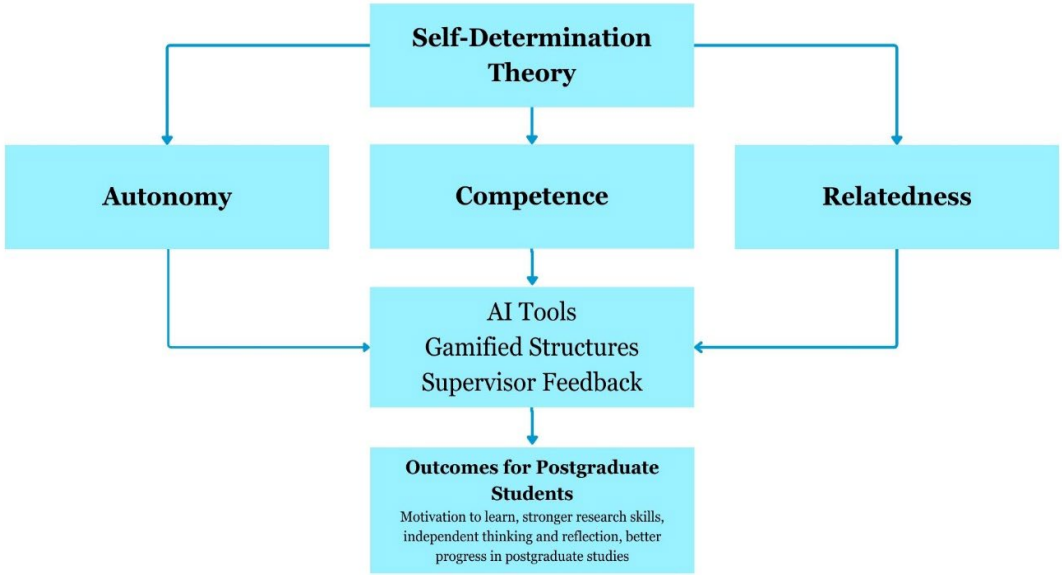

Figure 1: *SDT components and their connection to AI and gamified postgraduate supervision*

2. Materials and Methods

This chapter draws on a structured review of academic literature, employing the PRISMA 2020 approach (Page et al., 2021), to examine how gamified strategies can encourage independent thinking within AI-supported postgraduate supervision. The review synthesised empirical and theoretical research published between 2014 and 2025 on the integration of gamification and AI technologies in higher education, with a focus on postgraduate contexts. A structured search was conducted across three academic databases (ERIC, ScienceDirect, and SpringerLink). Search terms were created to capture studies linking gamification, AI-mediated supervision, and intellectual autonomy. Examples included "gamification AND higher education," "gamification AND AI-mediated supervision," "intellectual autonomy AND postgraduate education," and "artificial intelligence AND postgraduate supervision." Only peer-reviewed studies written in English and situated in higher education were included. Both empirical and theoretical studies were eligible. The reference lists of key papers were manually checked to identify additional

sources, and duplicate studies were removed during the screening process. Figure 2 presents the main search topics and keywords used in this review.

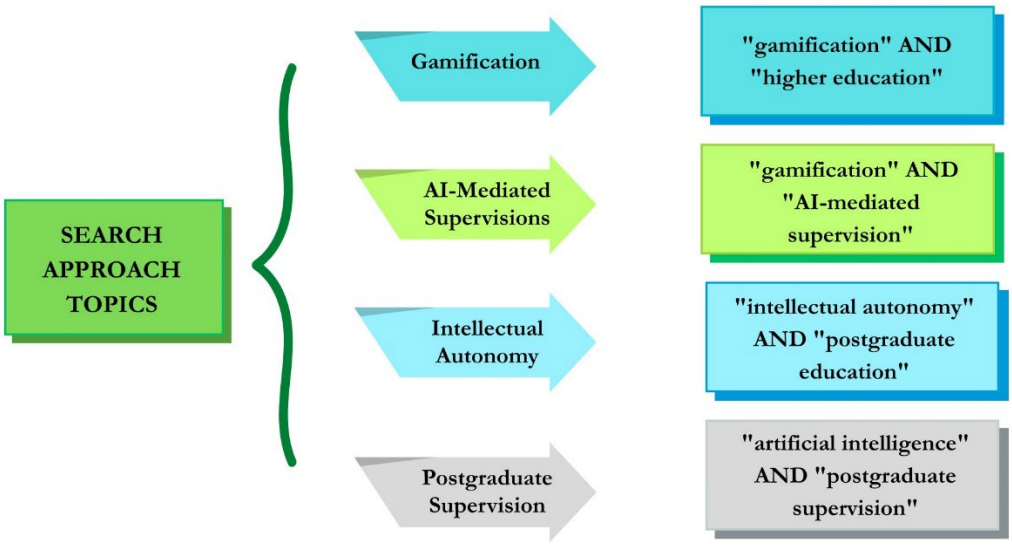

Figure 2: *Search topics and keyword combinations for the review*

Clear inclusion and exclusion criteria guided the selection of studies. Eligible studies examined gamification in higher education, AI-supported supervision, or concepts related to motivation, engagement, or intellectual autonomy. Studies were excluded if they focused solely on undergraduate populations without relevant insights for postgraduate contexts, were not written in English, or did not pertain to higher education. These criteria are summarised in Figure 3.

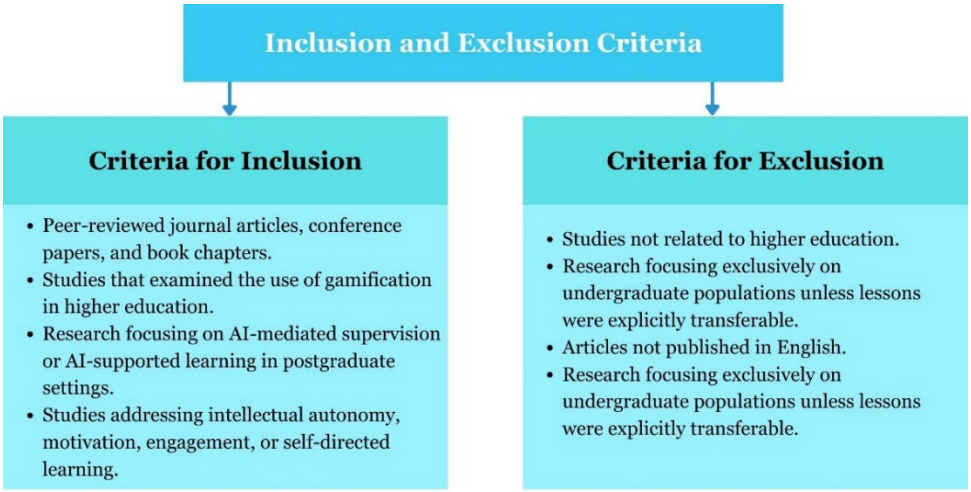

Figure 3: *Summary of inclusion and exclusion criteria used in this review*

The selection process followed the PRISMA 2020 protocol to ensure rigour and transparency. After duplicates were removed, titles and abstracts were screened for relevance based on the predefined criteria, and full-text articles were reviewed to confirm eligibility. A total of 41 studies met the inclusion criteria and were included in the qualitative synthesis. Data extraction was then

carried out for all included studies using a structured extraction form. Information recorded for each study included the author and year of publication, country of study, research question, study design and methodology, gamification strategies used, details of AI integration, and findings related to engagement, motivation, intellectual autonomy, and postgraduate supervision. The extracted data were analysed using a narrative synthesis approach to identify common themes and patterns. Figure 4 presents the PRISMA flow diagram that summarises the identification, screening, eligibility, and inclusion stages.

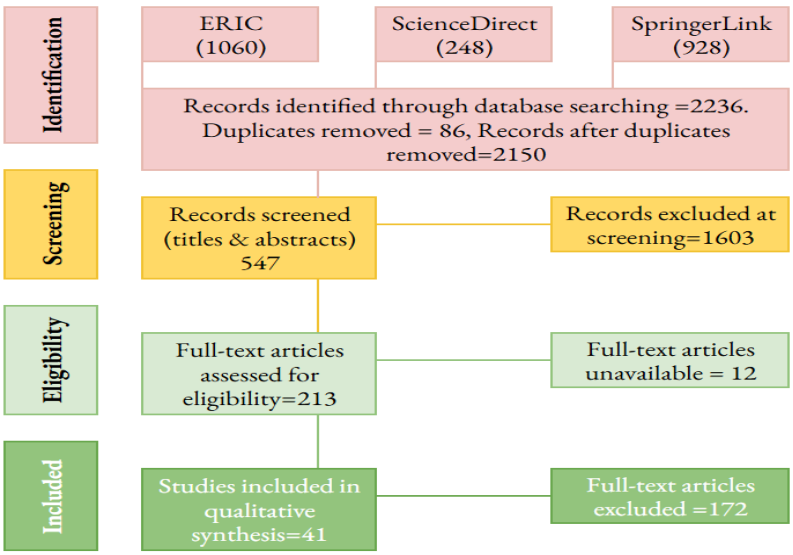

Figure 4: *PRISMA 2020 diagram*

3. Presentation of Results

Across the 41 included studies, a few common patterns emerged. Many of the studies indicated that gamification increased student engagement, particularly when combined with AI tools that support feedback or supervision. Elements such as progress tracking, badges, leaderboards, and real-time feedback enhanced motivation and improved interaction with supervision platforms (Hamari et al., 2014; Dicheva et al., 2015). These features helped students stay actively involved, complete research tasks on time, and monitor their progress. Milestone tracking facilitated long-term project management by breaking research into smaller, achievable goals. Leaderboards encouraged peer accountability and friendly competition, while instant feedback helped maintain momentum and reinforce progress. Collectively, these gamification elements contributed to higher levels of task engagement and platform participation. Gamified feedback loops enhance students' engagement with formative feedback in AI-mediated supervision environments (Shute, 2008; Luckin, 2024). Immediate feedback, paired with revision incentives, encourages students to view research as an evolving process rather than a series of isolated tasks.

Well-designed gamified systems motivate students to revise, reflect, and improve their work through iterative learning cycles. These systems align with self-regulated learning principles by

reinforcing progress and encouraging repeated engagement with challenging content (Subhash & Cudney, 2018). Evidence from recent gamification research also indicates that students benefit when progress is divided into clear steps and when improvements are recognised over time (Muchuweni et al., 2025). The structure of these feedback loops is illustrated in Figure 5, which outlines the typical cycle of feedback, reflection, and revision in AI-mediated gamified supervision models. However, the effectiveness of feedback depends on its quality and cognitive load. Studies have noted that when feedback is excessive or poorly structured, students may experience cognitive overload or confusion (Carless, 2006), which can result in surface-level revisions or disengagement. To support sustainable learning, gamified supervision should employ tiered feedback. AI systems can provide quick insights early on, while human supervisors offer deeper feedback at key milestones. This layered approach maintains student motivation, manages workload, and promotes meaningful revision.

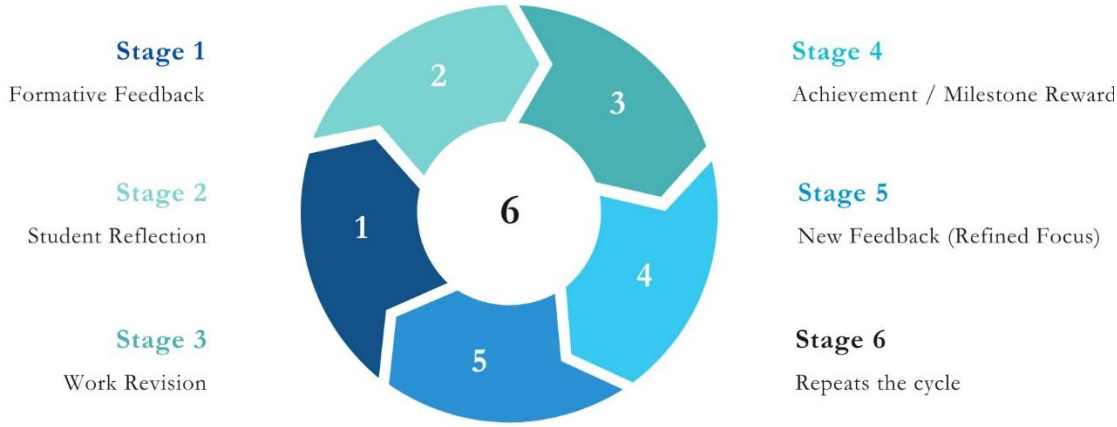

Figure 5: *Gamified Feedback and Learning Iterations in AI-Mediated Postgraduate Supervision*

The reviewed literature consistently emphasised that thoughtfully designed gamified progression systems contribute to improved research milestone completion rates in postgraduate supervision settings. Structured elements such as goal-setting mechanisms, visual progress tracking, and achievement recognition were strongly associated with enhanced student accountability and timely submission of key research components, including literature reviews, data analyses, and thesis drafts (Nicholson, 2015; Omodan & Marongwe, 2024). By breaking complex research projects into smaller, achievable goals, gamified systems promote a sense of continuous advancement. This incremental structure supports better time management, reduces procrastination, and helps sustain motivation over extended research timelines. Progress visualisation tools, such as completion charts and milestone badges, provide immediate reinforcement, encouraging consistent student engagement. However, some studies cautioned that an overemphasis on external rewards could lead students to prioritise task speed over deep academic engagement (Nicholson, 2015; Deci & Ryan, 1985; Buckley et al., 2017). To address this risk, researchers recommended integrating reflective components alongside milestone achievements to maintain academic rigour and critical inquiry. Table 1 summarises the key

gamification features identified in the reviewed studies that support research milestone completion.

Ethical and institutional challenges were prominent across the reviewed studies, with recurring concerns related to algorithmic bias, over-reliance on AI feedback, gamification fatigue, cognitive overload, and inequitable access to digital tools (Floridi & Cowls, 2022; Zawacki-Richter et al., 2019). Algorithmic bias was identified as a significant risk, with AI systems sometimes privileging certain research approaches or student profiles based on narrow training datasets. Over-reliance on AI-generated feedback raised concerns about weakening students' critical thinking and independent research skills.

Table 1: *Gamification features supporting research milestone completion*

Gamification Element	**Contribution to Research Milestone Completion**
Structured Goal-Setting	Organises complex research projects into manageable phases
Visual Progress Tracking	Provides immediate reinforcement through visible advancement
Achievement Badges	Recognises intermediate accomplishments to sustain persistence
Reflective Milestone Reviews	Ensures depth of engagement and prevents superficial task focus

Gamification fatigue, arising from static leaderboards and repetitive rewards, has been linked to reduced motivation, while poorly structured feedback systems risk contributing to cognitive overload. Furthermore, unequal access to AI technologies could exacerbate existing educational inequalities. To address these risks, studies recommend using hybrid supervision models that combine AI support with human mentorship (Luckin, 2024; Laurillard, 2013), improving the diversity of AI training datasets to reduce bias (Floridi & Cowls, 2022), prioritising clear and manageable feedback (Carless, 2006), designing adaptive gamification systems that support autonomy rather than relying solely on rewards (Nicholson, 2015), and ensuring equitable access to digital tools and platforms across institutions (Zawacki-Richter et al., 2019).

In postgraduate supervision, gamification functions very differently from its use in classroom settings. Instead of short quizzes or competitive games, studies such as those by Rivera (2021), Müller and Mildenberger (2021), and Omodan and Marongwe (2024) showed that gamification is employed to structure long-term research tasks, support independent decision-making, and guide students through extended milestones such as proposal development, data collection, and thesis drafting. Nicholson (2015) also emphasised that meaningful gamification supports autonomy by helping students manage progress without relying solely on rewards. These studies demonstrated that gamified elements act as organisational tools rather than classroom activities, as they assist students in monitoring progress, managing timelines, and sustaining motivation over prolonged periods of supervision. This distinction is important because postgraduate learning requires sustained autonomy and deep reflection, rather than rapid classroom

engagement. A concise summary of these key ethical challenges and proposed mitigation strategies is provided in Table 2.

Table 2: *Key ethical challenges and recommended mitigations in AI-mediated gamified supervision*

Ethical Challenge	Description	Recommended Mitigation
Algorithmic Bias	AI systems may favour certain research approaches or student profiles if trained on narrow datasets.	Regular audits of AI feedback systems; diversify training datasets; include human oversight.
Over-Reliance on AI	Excessive dependence on automated feedback may weaken students' critical thinking and research independence.	Maintain hybrid supervision models combining AI feedback with human mentorship.
Gamification Fatigue	Prolonged exposure to static leaderboards or reward systems may cause anxiety, disengagement, and reduced motivation.	Implement adaptive gamification strategies that evolve with student progression and offer personalised pathways.
Cognitive Overload	Overwhelming students with frequent or poorly prioritised feedback can impair learning efficiency.	Prioritise feedback relevance; stagger notifications; embed structured reflection opportunities.
Inequitable Access	Disparities in access to AI tools or digital infrastructure may exacerbate educational inequalities.	Ensure institutional support for equitable access to AI resources and digital tools.

4. Discussion of Findings

The findings show that gamification can support engagement, motivation, and intellectual autonomy in AI-mediated postgraduate supervision, and these patterns can be better understood through Self-Determination Theory (Deci & Ryan, 1985). Across the reviewed studies, gamification is shown to increase student engagement in AI-supported supervision by employing elements such as milestone tracking, leaderboards, badges, and real-time feedback (Hamari et al., 2014; Dicheva et al., 2015). These features encourage more consistent interaction with supervision platforms and help students stay on track with long-term research tasks (Hamari et al., 2014; Dicheva et al., 2015; Muchuweni et al., 2025). Hamari et al. (2014) find that milestone-based tracking fosters a sense of ownership, while Dicheva et al. (2015) emphasise that competitive elements, such as leaderboards, encourage peer interaction and accountability.

Students also demonstrate stronger engagement when they can visualise progress and receive immediate feedback. These findings align with SDT's competence principle, which states that motivation increases when learners can see evidence of their progress. However, several studies caution that motivation may decline over time if gamified systems remain static. This supports the need for adaptive designs that evolve as students advance through their research. The review also indicates that gamification contributes to intellectual autonomy when systems support self-regulation, independent planning, and critical reflection. Structured milestones, personalised pacing, and iterative feedback encourage students to take ownership of their work, reflecting the

autonomy component of SDT (Subhash & Cudney, 2018; Shute, 2008). These elements are especially important in postgraduate supervision, where learners must plan months of research, track their progress, and make independent decisions. However, studies warn that designs focused too heavily on points or badges can shift attention away from deep learning. Nicholson (2015) and Deci and Ryan (1985) argue that such designs may lead students to prioritise task completion rather than meaningful academic engagement. In AI-supported postgraduate supervision, gamification therefore works best when it encourages reflection and decision-making rather than simply rewarding speed or task completion. Table 3 summarises the specific gamification elements identified in the reviewed studies that support intellectual autonomy in AI-mediated supervision contexts.

Table 3: *Gamification elements supporting intellectual autonomy among postgraduate students*

Gamification Strategy	How it Supports Autonomy	Supporting Authors
Milestone Tracking	Encourages self-paced goal setting and monitoring	Subhash & Cudney (2018)
Achievement Badges	Reinforces mastery experiences and self-confidence	Ryan & Deci (2017)
Interactive Feedback Loops	Promotes iterative reflection and independent improvement	Shute (2008)
Self-Assessment Challenges	Supports critical self-evaluation and autonomy	Vygotsky (1978); Wingate (2006)

Gamified feedback systems significantly enhance iterative learning processes by promoting active student engagement with formative feedback. A range of studies indicates that immediate and structured feedback increases revision cycles and facilitates deeper critical thinking (Shute, 2008; Luckin, 2024; Muchuweni et al., 2025). Such patterns are consistent with the competence principle of Self-Determination Theory (SDT), as they assist students in developing confidence in revising and improving their work. Incentives such as badges for multiple revision cycles or rewards for enhanced drafts serve to maintain engagement over extended periods of supervision. However, an excess of or poorly organised feedback may introduce cognitive overload, thereby diminishing learning efficiency (Carless, 2006). To mitigate this risk, tiered feedback models are recommended. These systems gradually transition students from frequent AI-generated suggestions to more in-depth feedback from supervisors at critical points, thereby supporting both cognitive manageability and sustained development.

The literature also demonstrates that gamification influences the timely completion of research milestones within postgraduate supervision. Tools such as milestone maps, completion trackers, and achievement systems enhance accountability and assist students in adhering to structured timelines (Nicholson, 2015; Omodan and Marongwe, 2024). By deconstructing large research tasks into manageable steps, these tools facilitate improved time management and reduce procrastination. This approach is aligned with the autonomy principle of SDT, as students are afforded the opportunity to select how they navigate tasks while still perceiving clear progress.

However, an over-reliance on external rewards can distract from meaningful engagement (Deci and Ryan, 1985). Institutions may counter this by integrating reflective components such as research journals or self-assessments, which aid students in connecting milestone completion to deeper academic growth. Ethical considerations also emerge within the literature, as scholars caution that algorithmic bias may manifest in AI feedback systems when training data fails to adequately represent diverse academic backgrounds, potentially disadvantaging certain students (Floridi and Cowls, 2022). Excessive dependence on automated tools may impair critical thinking skills if students rely too heavily on AI-generated suggestions (Zawacki-Richter et al., 2019). Furthermore, gamification fatigue is reported when systems employ repetitive reward structures, resulting in diminished intrinsic motivation over time (Buckley et al., 2017). To address these challenges, researchers advocate for regular audits of AI systems, dynamic reward designs that adapt to students' needs, and sustained human oversight to maintain the relational aspects of supervision.

The findings demonstrate that gamification can significantly enhance student engagement, motivation, and intellectual autonomy when applied judiciously within AI-mediated postgraduate supervision. Interactive feedback systems and structured progression pathways align effectively with Self-Determination Theory (SDT) by fostering autonomy, competence, and relatedness. However, institutions must meticulously manage ethical risks such as bias, over-reliance on automation, and diminished motivation resulting from inadequately designed gamification systems. Supervision models that integrate adaptive gamification, reflective learning tools, ethical oversight, and human mentorship can ensure that AI-driven supervision reinforces postgraduate learning rather than undermining it. The design of such balanced systems is critical for safeguarding the long-term integrity and sustainability of postgraduate research training.

While the findings offer valuable insights, several limitations should be acknowledged. Firstly, publication bias may exist, as studies yielding positive results are more likely to be disseminated. Secondly, the review encompassed only English-language sources, potentially excluding pertinent works from other regions. Thirdly, variations in the definitions and applications of gamification and AI across studies complicated direct comparisons. Notwithstanding these limitations, the review provides significant insights into the influence of gamification and AI on postgraduate supervision and identifies areas meriting further research.

5. Conclusions and Recommendations

This chapter consolidates key insights derived from the systematic review and provides recommendations for the integration of gamification into AI-mediated postgraduate supervision. The studies reviewed indicate that gamification has the potential to enhance student engagement, motivation, and intellectual autonomy by offering structured, interactive, and rewarding supervision environments. Features such as milestone tracking, progress visualisation, badges, and timely feedback assist postgraduate students in remaining organised, maintaining

motivation, and completing research tasks more consistently. These advantages are particularly pertinent in long-term postgraduate work, where sustained engagement and self-regulation are crucial for academic success. Concurrently, the literature highlights several risks that necessitate careful consideration. An over-reliance on AI-generated feedback may lead to superficial learning, diminished critical thinking, or excessive dependence on automated tools. Algorithmic bias may create inequitable learning environments, especially when AI systems are predicated on narrow or non-representative datasets. Furthermore, gamification fatigue may occur when systems employ repetitive rewards or static design features, consequently undermining intrinsic motivation over time. These concerns underscore the necessity for robust human oversight, ethical safeguards, and ongoing evaluations of AI technologies to uphold academic integrity and foster equitable supervision experiences. Notwithstanding these challenges, the overarching evidence suggests that gamification possesses significant potential to enhance postgraduate research training when integrated within a thoughtfully designed, human-centred supervision model. Effective designs should support intellectual autonomy, encourage iterative learning, and provide opportunities for reflection and self-assessment. Institutions must strike a balance between innovation and responsibility, ensuring that AI tools complement rather than supplant meaningful academic mentorship.

Several recommendations emerge from this review. Institutions are encouraged to implement adaptive gamification designs that enable students to personalise milestones, badges, and progress tracking as they advance through their research. The combination of AI-generated feedback with human mentorship remains essential for preserving depth, reflection, and contextualised guidance. Regular audits of AI systems are necessary to identify and mitigate bias, while clear ethical guidelines should reinforce the irreplaceable role of human judgment in supervision. Embedding reflective practices, such as research journals and self-assessment tools, can further enhance students' intellectual autonomy and self-regulated learning. Future research should investigate the long-term effects of gamified supervision, particularly how dynamic AI-driven gamification systems can adapt to learner progression. Studies are also required to examine how cultural and institutional contexts influence the efficacy of gamified supervision and to explore emerging ethical issues, such as academic integrity and the impact of automated feedback on student decision-making. Assessing faculty readiness and institutional capacity will also be critical for facilitating responsible and sustainable implementation.

6. Declarations

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References

Albertyn, R., & Bennett, K. (2021). Containing and harnessing uncertainty during postgraduate research supervision. *Higher Education Research & Development, 40*(6), 1122–1135. https://doi.org/10.1080/07294360.2020.1775559

Aoun, J. E. (2017). *Robot-proof: Higher education in the age of artificial intelligence*. MIT Press. https://doi.org/10.7551/mitpress/11456.001.0001

Bell, A. (2016). Intercultural postgraduate supervision: Reimagining time, place and knowledge. *Higher Education Research & Development, 35*(2), 227–240. https://doi.org/10.1080/07294360.2016.1106931

Black, P., & Wiliam, D. (2009). Developing the theory of formative assessment. *Educational Assessment, Evaluation and Accountability, 21*(1), 5–31. https://doi.org/10.1007/s11092-008-9068-5

Bond, M., Buntins, K., Bedenlier, S., Zawacki-Richter, O., & Kerres, M. (2020). Mapping research in student engagement and educational technology in higher education: A systematic evidence map. *International Journal of Educational Technology in Higher Education, 17*(1), 1–30. https://doi.org/10.1186/s41239-019-0176-8

Buckley, P., Doyle, E., & Doyle, S. (2017). Game on! Students' perceptions of gamified learning. *Educational Technology & Society, 20*(3), 1–10.

Carless, D. (2006). Differing perceptions in the feedback process. *Studies in Higher Education, 31*(2), 219–233. https://doi.org/10.1080/03075070600572132

Chauke, T. A., Mkhize, T. R., Methi, L., & Dlamini, N. (2024). Postgraduate students' perceptions on the benefits associated with artificial intelligence tools on academic success: A case of ChatGPT AI tool. *Journal of Curriculum Studies Research, 6*(1), 46–64. https://doi.org/10.46303/jcsr.2024.4

Cowling, M., Crawford, J., Allen, K. A., & Wehmeyer, M. (2023). Using leadership to leverage ChatGPT and artificial intelligence for undergraduate and postgraduate research supervision. *Australasian Journal of Educational Technology, 39*(6), 17–32. https://doi.org/10.14742/ajet.8598

Cui, J. (2024). The impact of general artificial intelligence on university students' research and technological innovation: A case study of DeepSeek AI and ChatGPT [Preprint]. *SSRN*. https://doi.org/10.2139/ssrn.5179907

Cullen, C. J., Hertel, J. T., & Nickels, M. (2020). The roles of technology in mathematics education. *The Educational Forum, 84*(2), 166–178. https://doi.org/10.1080/00131725.2020.1698683

Dai, Y., Lai, S., Lim, C. P., & Liu, A. (2023). ChatGPT and its impact on research supervision: Insights from Australian postgraduate research students. *Australasian Journal of Educational Technology, 39*(6), 143–159. https://doi.org/10.14742/ajet.8843

Daramola, O. (2021). Lessons from postgraduate supervision in two African universities: An autoethnographic account. *Education Sciences, 11*(7), Article 345. https://doi.org/10.3390/educsci11070345

Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior*. Springer. https://doi.org/10.1007/978-1-4899-2271-7

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From game design elements to gamefulness: Defining "gamification." In *Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments* (pp. 9–15). ACM. https://doi.org/10.1145/2181037.2181040

Dicheva, D., Dichev, C., Agre, G., & Angelova, G. (2015). Gamification in education: A systematic mapping study. *Journal of Educational Technology & Society*, 18(3), 75-88.

Dichev, C., & Dicheva, D. (2017). Gamifying education: What is known, what is believed and what remains uncertain: A critical review. *International Journal of Educational Technology in Higher Education*, 14(1), 1–36. https://doi.org/10.1186/s41239-017-0042-5

Dockendorff, M., & Gómez Zaccarelli, F. (2025). Successfully preparing future mathematics teachers for digital technology integration: A literature review. *International Journal of Mathematical Education in Science and Technology*, 56(5), 948–979. https://doi.org/10.1080/0020739x.2024.2309273

Emilsson, U. M., & Johnsson, E. (2007). Supervision of supervisors: On developing supervision in postgraduate education. *Higher Education Research & Development*, 26(2), 163–179. https://doi.org/10.1080/07294360701310797

Ferris, D. (2011). *Treatment of error in second language student writing* (2nd ed.). University of Michigan Press. https://doi.org/10.3998/mpub.2173290

Floridi, L., & Cowls, J. (2022). A unified framework of five principles for AI in society. In *Machine learning and the city* (Chapter 45). Wiley. https://doi.org/10.1002/9781119815075.ch45

Hamari, J., Koivisto, J., & Sarsa, H. (2014). Does gamification work? A literature review of empirical studies on gamification. *Proceedings of the 47th Hawaii International Conference on System Sciences*, 3025–3034. https://doi.org/10.1109/HICSS.2014.377

Hidayat, A., & Firmanti, P. (2024). Navigating the tech frontier: A systematic review of technology integration in mathematics education. *Cogent Education*, 11(1), Article 2373559. https://doi.org/10.1080/2331186x.2024.2373559

Indriasari, T. D., Luxton-Reilly, A., & Denny, P. (2020). Gamification of student peer review in education: A systematic literature review. *Education and Information Technologies*, 25(6), 5481–5503. https://doi.org/10.1007/s10639-020-10228-x

Jones, B. (2017). Factors in postgraduate supervision that impact on the quality of research at a selected department at a university of technology (Master's dissertation, Durban University of Technology). DUT Institutional Repository. https://doi.org/10.51415/10321/1429

Kızıltaş, Y. (2025). Integration of artificial intelligence (AI) into primary school students' writing skills: The impact of ChatGPT on creative writing and writing self-efficacy. *Journal of Educational Computing Research. Advance online publication.*https://doi.org/10.1177/07356331251365187

Landers, R. N. (2014). Developing a theory of gamified learning: Linking serious games and gamification of learning. *Simulation & Gaming*, 45(6), 752–768. https://doi.org/10.1177/1046878114563660

Laurillard, D. (2013). *Rethinking university teaching: A conversational framework for the effective use of learning technologies* (2nd ed.). Routledge.

Lathwesen, C., & Belova, N. (2021). Escape rooms in STEM teaching and learning—Prospective field or declining trend? A literature review. *Education Sciences*, 11(12), 788. https://doi.org/10.3390/educsci11060308

Leon, J., Núñez, J. L., & Liew, J. (2015). Self-determination and STEM education: Effects of autonomy, motivation, and self-regulated learning on academic achievement. *Educational Psychology*, 35(3), 328–336. https://doi.org/10.1016/j.lindif.2015.08.017

Li, L., Hew, K. F., & Du, J. (2024). Gamification enhances student intrinsic motivation, perceptions of autonomy and relatedness, but minimal impact on competency: A meta-analysis and systematic review. *Educational Technology Research and Development*, 72(2), 1561–1590. https://doi.org/10.1007/s11423-023-10337-7

Looyestyn, J., Kernot, J., Boshoff, K., Ryan, J., Edney, S., & Maher, C. (2017). Does gamification increase engagement with online programs? A systematic review. *PLOS ONE, 12(3), e0173403. https://doi.org/10.1371/journal.pone.0173403*

Luckin, R. (2024). Nurturing human intelligence in the age of AI: Rethinking education for the future. *Development and Learning in Organizations:An International Journal, 1*(4), 1–4. https://doi.org/10.1108/DLO-04-2024-0108

Majuri, J., Koivisto, J., & Hamari, J. (2018). Gamification of education and learning: A review of empirical literature. In *Proceedings of the 2nd International GamiFIN Conference* (pp. 11–19).

Makokotlela, M. V. (2024). Digitising the supervision of postgraduate students in higher education. In D. Guralnick, M. E. Auer, & A. Poce (Eds.), *Advances in higher education and professional development* (Chapter 7). IGI Global. https://doi.org/10.4018/979-8-3693-1289-6.ch007

Maistry, S. (2015). Towards a humanising pedagogy: An autoethnographic reflection of my emerging postgraduate research supervision practice. *Journal of Education*, 61, 35–52. https://doi.org/10.17159/i62a05

Marengo, A., & Pange, P. J. (2024). Envisioning general AI in higher education: Transforming learning paradigms and pedagogies. In D. Guralnick, M. E. Auer, & A. Poce (Eds.), *Creative approaches to technology-enhanced learning for the workplace and higher education* (Vol. 1150, pp. 28–41). Springer. https://doi.org/10.1007/978-3-031-72430-5_28

Melisa, R., Ashadi, A., Triastuti, A., Hidayati, S., Salido, A., Luansi Ero, P. E., Marlini, C., Zefrin, Z., & Al Fuad, Z. (2025). Critical thinking in the age of AI: A systematic review of AI's effects on higher education. *Education and Information Technologies*, 14(1), Article e2025031. https://doi.org/10.22521/edupij.2025.14.31

Muchuweni, T., Jojo, Z., & Kariyana, I. (2025). Enhancing mathematics instruction through Quizizz: A systematic literature review. *International Journal of Learning, Teaching and Educational Research*, 24(10), 106–124. https://doi.org/10.26803/ijlter.24.10.5

Müller, C., & Mildenberger, T. (2021). Facilitating flexible learning by replacing classroom time with an online learning environment: A systematic review of blended learning in higher education. *Educational Research Review*, 34, 100394. https://doi.org/10.1016/j.edurev.2021.100394

Ng, B. B., Liu, W. C., & Wang, J. C. K. (2012). Self-determination and classroom engagement of adolescents in Singapore. *Learning and Individual Differences*, 22(6), 561–566. https://doi.org/10.1016/j.lindif.2012.07.004

Nicholson, S. (2015). A recipe for meaningful gamification. In *Gamification in education and business* (pp. 1–20). Springer. https://doi.org/10.1007/978-3-319-10208-5_1

Olsher, S., Yerushalmy, M., & Chazan, D. (2016). How might the use of technology in formative assessment support changes in mathematics teaching? *For the Learning of Mathematics, 36*(3), 11–18. https://www.jstor.org/stable/44382716

Omodan, B. I., & Marongwe, N. (2024). The role of artificial intelligence in decolonising academic writing for inclusive knowledge production. *Interdisciplinary Journal of Education Research, 6*(S1), 1–14. https://doi.org/10.38140/ijer-2024.vol6.s1.06

Oparinde, K. (2021). Postgraduate supervision: A heuristic approach to learning, unlearning, and relearning. *Asian Journal of University Education, 17*(4), 243–250. https://doi.org/10.24191/ajue.v17i4.16202

Ortiz-Rojas, M., Chiluiza, K., Valcke, M., & Bolanos-Mendoza, C. (2025). How gamification boosts learning in STEM higher education: A mixed methods study. *International Journal of STEM Education, 12*(1), Article 73. https://doi.org/10.1186/s40594-024-00521-3

Oulaich, S. (2019). Pedagogy in the digital age. In *Proceedings of the 4th International Conference on E-Learning and Games (ICELG '19)* (pp. 1–6). ACM Digital Library. https://doi.org/10.1145/3368756.3369058

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., ... & Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, **372**, n71. https://doi.org/10.1136/bmj.n71

Qudsi, H. (2024). Gamification in education: Boosting student engagement and learning outcomes. *ShodhKosh: Journal of Visual and Performing Arts, 5*(4), 686–693. https://doi.org/10.29121/shodhkosh.v5.i4.2024.2542

Rahmi, I., Rimenda, T., & Ariyanti, T. D. (2025). Gamification as an alternative to increase students' motivation: A scoping review. *Journal of Education and Learning (EduLearn), 19*(2), 233–241. https://doi.org/10.11591/edulearn.v19i2.21771

Ramadhan, A., Warnars, H. L. H. S., & Abdul Razak, F. H. (2024). Combining intelligent tutoring systems and gamification: A systematic literature review. *Education and Information Technologies, 29*(1), 77–98. https://doi.org/10.1007/s10639-023-12092-x

Reeve, J. (2012). A self-determination theory perspective on student engagement. In S. Christenson, A. Reschly, & C. Wylie (Eds.), *Handbook of research on student engagement* (pp. 149–172). Springer. https://doi.org/10.1007/978-1-4614-2018-7_7

Reeve, J. (2023). Cognitive evaluation theory. In *The Oxford handbook of self-determination theory* (Chapter 3). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780197600047.013.3

Rivera, E. S. (2021). Gamification for student engagement: A framework. *Journal of Further and Higher Education*, 45(7), 999–1012. https://doi.org/10.1080/0309877X.2021.1875201

Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behaviour. *Psychological Inquiry*, 11(4), 227–268. https://doi.org/10.1207/s15327965pli1104_01

Ryan, R. M., & Deci, E. L. (Eds.). (2017). *Self-determination theory: Basic psychological needs in motivation, development, and wellness*. Guilford Press. https://doi.org/10.1521/978.14625/28806

Sailer, M., & Homner, L. (2020). The gamification of learning: A meta-analysis. *Educational Psychology Review*, 32(1), 77–112. https://doi.org/10.1007/s10648-019-09498-w

Sánchez-Arévalo, B. M., Valenciano-Valcárcel, J., & Fernández-Cézar, R. (2025). Analysis on the use of gamification in mathematics in primary education: A literature review. *Mathematics Education Research Journal*, 37(1), 30–55. https://doi.org/10.17583/redimat.16133

Seaborn, K., & Fels, D. I. (2015). Gamification in theory and action: A survey. *International Journal of Human-Computer Studies*, 74, 14–31. https://doi.org/10.1016/j.ijhcs.2014.09.006

Selwyn, N. (2019). Should robots replace teachers? AI and the future of education. John Wiley & Sons.

Shumba, T. (2024). Exploring lecturers' readiness and perceptions of gamification in higher education institutions of South Africa. *Journal of Public Administration and Development Alternatives*, 9(3), 115–127. https://doi.org/10.55190/jpada.2024.346

Shute, V. J. (2008). Focus on formative feedback. *Review of Educational Research*, 78(1), 153–189. https://doi.org/10.3102/0034654307313795

Sim, K. N., Northcote, M., & Lim, C. P. (2023). Technology-enabled undergraduate and postgraduate research supervision. *Australasian Journal of Educational Technology*, 39(6), 33–48. https://doi.org/10.14742/ajet.9149

Standage, M. (2023). Self-determination theory applied to sport. In *The Oxford handbook of self-determination theory* (Chapter 35). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780197600047.013.35

Subhash, S., & Cudney, E. A. (2018). Gamified learning in higher education: A systematic review of the literature. *Computers in Human Behavior*, 87, 192–206. https://doi.org/10.1016/j.chb.2018.05.028

Triantafyllou, S. A., Georgiadis, C., & Sapounidis, T. (2025). Gamification in education and training: A literature review. *International Review of Education*. https://doi.org/10.1007/s11159-025-10034-z

Veletsianos, G., & Kimmons, R. (2012). Networked participatory scholarship: Emergent techno-cultural pressures toward open and digital scholarship in online networks. *Computers & Education*, 58(2), 766–774. https://doi.org/10.1016/j.compedu.2011.10.001

Venter, M., & de Wet, L. (2024). The influence of player type on the motivation of students in a gamified programming learning environment. *ICT in Education Journal*, 19(2), 88–102. https://doi.org/10.1007/978-3-031-82478-4_1

Viberg, O., Grönlund, Å., & Andersson, A. (2020). Integrating digital technology in mathematics education: A Swedish case study. *Interactive Learning Environments*, 31(1), 232–243. https://doi.org/10.1080/10494820.2020.1770801

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.

Wingate, U. (2006). Doing away with "study skills." *Teaching in Higher Education*, 11(4), 457–469. https://doi.org/10.1080/13562510600874268

Willcoxson, L. (1998). The impact of academics' learning and teaching preferences on their teaching practices: A pilot study. *Studies in Higher Education*, 23(1), 59–70. https://doi.org/10.1080/03075079812331380492

Winkler, R., & Söllner, M. (2018). Unleashing the potential of chatbots in education: A state-of-the-art analysis. *Academy of Management Proceedings*, 2018(1), Article 15903. https://doi.org/10.5465/ambpp.2018.15903

Xu, C. (2025). Research on security risks and supervision of generative AI large models. In *Proceedings of the 2025 International Conference on Artificial Intelligence and Educational Systems* (pp. 120–128). ACM. https://doi.org/10.1145/3744367.3744395

Yığ, K. G., & Sezgin, S. (2021). An exploratory holistic analysis of digital gamification in mathematics education. *Journal of Educational Technology and Online Learning, 4*(2), 115–136. https://doi.org/10.31681/jetol.888096

Yllana-Prieto, F., González-Gómez, D., & Jeong, J. S. (2025). The escape room and breakout as an aid to learning STEM contents in primary schools: An examination of the development of pre-service teachers in Spain. *Education* 3-13, 53(1), 43–57. https://doi.org/10.1080/03004279.2022.2163183

Zainuddin, Z., Chu, S. K. W., & Perera, C. J. (2024). Gamification platforms for flipped learning implementation. In Z. Zainuddin, S. K. W. Chu, & C. J. Perera (Eds.), *Gamification in a flipped classroom* (pp. 45–62). Springer. https://doi.org/10.1007/978-981-97-2219-8_5

Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education: Recommendations for future research. *International Journal of Educational Technology in Higher Education, 16*(1), 1–27. https://doi.org/10.1186/s41239-019-0171-0