

Reclaiming pedagogical architecture in adaptive gamification: Design-time scenario-level adaptivity beyond algorithmic personalization

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Highlights

- Adaptive gamification research has elaborated adaptation almost entirely at the element level.
- Design-time adaptivity remains underexplored, particularly at the scenario level.
- Scenario-level design-time adaptive gamification is proposed as a pedagogical architecture.
- This approach preserves assessment equivalence while accommodating motivational diversity.
- Adaptivity is repositioned as a pedagogical responsibility rather than a technical capability.

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Keywords: *adaptive gamification, design-time adaptivity, scenario-level personalization, pedagogical architecture, self-determination theory*

Abstract

Adaptive gamification has emerged as a prominent strategy for addressing engagement and motivation challenges in higher education and distance learning. Recent research has increasingly framed adaptivity as a run-time, algorithmic process driven by artificial intelligence and learning analytics. While such systems offer computational efficiency, they frequently reduce adaptivity to parameter optimization within fixed instructional structures, resulting in limited transparency and superficial personalization. This article argues that adaptive gamification should be reconceptualized as a design-time pedagogical architecture rather than a reactive algorithmic feature. Drawing on a conceptual synthesis of adaptive gamification literature, the study distinguishes between the temporal locus of adaptivity (run-time versus design-time) and the scope of adaptation (element-level versus scenario-level), foregrounding a structural imbalance: adaptation has been elaborated almost entirely at the element level, while scenario-level alternatives remain largely untheorized. Grounded in self-determination theory and informed by systemic gamification theory, the article proposes scenario-level design-time adaptive gamification as a coherent alternative that foregrounds learner agency, pedagogical transparency, and instructional integrity. By embedding adaptivity into pre-authored pedagogically equivalent scenarios, this approach accommodates motivational diversity while preserving assessment equivalence. The study concludes by positioning adaptivity as a pedagogical responsibility rather than a purely technical capability.

1. Introduction: Adaptive Gamification at a Pedagogical Crossroads

The integration of gamification into higher education and distance learning has become a widely adopted strategy to address persistent challenges related to student engagement, motivation, and retention (Bozkurt & Durak, 2018; Simsek & Karakus Yilmaz, 2025). Grounded in the premise that game design elements can shape user engagement in non-game contexts (Deterding et al., 2011), gamification is frequently positioned as a mechanism to enhance learner participation and engagement in online environments (Antonaci et al., 2019; Smirani & Yamani, 2024; Simsek & Karakus Yilmaz, 2025). However, the empirical literature consistently reports mixed outcomes, suggesting that identical gamification designs can motivate some learners while disengaging others (Hamari et al., 2014; Khaldi et al., 2023; Sailer & Homner, 2020). While this highlights the necessity for careful, context-specific design as poorly implemented game elements can

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actually hinder learning outcomes rather than support them (Kaya & Ercag, 2023), these inconsistent findings have increasingly been attributed to learner heterogeneity, including differences in motivational orientations, personality traits, cultural background, and learning preferences (Brandl & Schrader, 2024; Zairon et al., 2025). Consequently, moving beyond standardized, one-size-fits-all designs to tailor game elements to distinct player profiles and demographics is now recognized as a critical requirement for deeper student engagement (González-López et al., 2025; Taşkın & Kılıç Çakmak, 2022).

In contemporary research, this adaptivity is predominantly conceptualized as a run-time, system-driven process: leveraging artificial intelligence (AI), learning analytics, and machine learning techniques, such systems dynamically adjust difficulty levels, reward structures, or content sequencing in real time based on learner interaction data, including clickstream logs, time-on-task metrics, or performance indicators (Gligorea et al., 2023; Naseer et al., 2025).

While run-time adaptive gamification offers computational efficiency and responsiveness, its growing dominance has also narrowed the conceptualization of adaptivity itself — privileging computer-driven parameter adjustments over learner-directed progression and alternative adaptive strategies (Chernikova et al., 2025). Adaptivity is increasingly equated with algorithmic optimization, where personalization is reduced to continuous micro-adjustments within a fixed instructional structure (Monterrat, Lavoué, et al., 2015). As a result, many adaptive systems operate with limited transparency, obscuring the pedagogical rationale behind adaptive decisions (Gligorea et al., 2023) and limiting both learner and instructor understanding of how and why specific gamified experiences are delivered (Naseer et al., 2025). In such systems, the learner is often treated as a set of behavioral signals to be optimized rather than as an intentional agent whose motivation is shaped by meaning, context, and choice (Krath et al., 2021).

This technocentric orientation raises critical pedagogical concerns. First, algorithmic adaptivity typically prioritizes engagement metrics such as frequency of interaction or persistence without necessarily aligning these optimizations with deeper learning objectives (Gligorea et al., 2023). Second, run-time adaptation commonly operates at the level of individual game elements, adjusting parameters such as difficulty or reward frequency while leaving the broader instructional narrative and learning activities unchanged (Monterrat, Lavoué, et al., 2015; Hallifax et al., 2019a). Third, the opacity of adaptive logic can undermine learner autonomy and trust, particularly when students are unaware of why certain elements are emphasized or withdrawn from their learning environment (Hanus & Fox, 2015; Naseer et al., 2025). Consequently, personalization remains largely superficial, modifying how learners progress through a single scenario rather than offering qualitatively different learning experiences (Benkhalfallah et al., 2024).

At the same time, an alternative strand of research has emphasized design-time approaches to personalization, often described as tailored gamification. Design-time tailoring involves configuring gamified learning environments prior to instruction based on predefined learner profiles, self-reported preferences, or contextual characteristics (Ertan Şevk & Arkün Kocadere, 2024; Klock et al., 2020). However, empirical implementations of design-time adaptivity have largely remained confined to element-level personalization, such as assigning leaderboards to competitive learners or progress indicators to autonomy-oriented learners (Lavoué et al., 2019). While these approaches acknowledge learner diversity, they rarely extend to the adaptation of the instructional scenario itself; that is, the narrative structure, social organization, or pedagogical logic through which learning activities are experienced (Dumas Reyssier et al., 2024).

This situation has created a conceptual impasse in adaptive gamification literature. On the one hand, run-time algorithmic systems promise dynamic responsiveness but risk pedagogical opacity and fragmentation (Naseer et al., 2025; Gligorea et al., 2023). On the other hand, design-time tailoring offers pedagogical intentionality but is often implemented in a shallow and static manner (Bennani et al., 2022; Ertan Şevk & Arkün Kocadere, 2024; Puig et al., 2023). As a result, adaptivity is frequently framed as a technical enhancement rather than as a core pedagogical design decision (Coelho & Abreu, 2025; Elkady et al., 2025; Khaldi et al., 2023; Klock et al., 2020). What remains underexplored is the possibility of rethinking adaptive gamification as a form of pedagogical architecture, one in which instructional designers intentionally

construct multiple, coherent learning scenarios at the design stage to accommodate diverse motivational needs while preserving transparency, agency, and instructional alignment.

This article argues that adaptive gamification should be reconceptualized beyond algorithmic run-time personalization and repositioned as a design-time pedagogical architecture. Rather than treating adaptivity as a reactive system feature that continuously optimizes learner behavior, adaptivity should be understood as a proactive instructional decision embedded in the structural design of learning environments.

The central contribution of this article is twofold. First, it provides a conceptual synthesis that clarifies how adaptivity is currently operationalized in gamified higher education contexts, distinguishing between the temporal locus of adaptation (run-time versus design-time) and the scope of adaptation (element-level versus scenario-level). Second, it advances a theoretical argument for scenario-level design-time adaptive gamification, positioning instructional designers—not algorithms—as the primary architects of adaptive learning experiences. By foregrounding pedagogical coherence, transparency, and learner agency, this approach seeks to reclaim adaptivity as a fundamentally educational concern rather than a purely computational one. In doing so, the article does not reject the value of AI-driven personalization but challenges the assumption that *more dynamic* necessarily means *more pedagogically effective*. Instead, it suggests that meaningful personalization in formal education often requires stability, narrative coherence, and intentional design choices made before instruction begins.

2. Methodological Positioning: Conceptual Synthesis and Design-Oriented Review

This study employs conceptual synthesis and design-oriented analytical review as its methodological approach to investigate how adaptivity is conceptualized and operationalized within gamified learning environments in higher education. The aim of this approach is not to produce an exhaustive inventory of studies or a statistically aggregated overview of the field; rather, it is to clarify the conceptual patterns, theoretical assumptions, and design logics that shape how adaptive gamification is currently understood and practiced. This positioning is particularly appropriate given that the central contribution of the article is theoretical and architectural rather than empirical. Review methodologies do not constitute a single genre; distinct types serve distinct purposes and follow correspondingly distinct conventions (Snyder, 2019). It is important to distinguish this approach from systematic literature reviews or meta-analyses, which are governed by comprehensive inclusion protocols and quantitative synthesis procedures. A conceptual synthesis, by contrast, foregrounds theoretical meaning-making and analytical interpretation, treating the literature not as a dataset to be exhaustively catalogued but as a discursive space within which assumptions, framings, and design rationales can be critically examined. In the context of adaptive gamification, this interpretive orientation enables the identification of underlying assumptions about learner modeling such as the increasingly recognized need to move from static player typologies toward dynamic, context-sensitive learner profiles (Bennani et al., 2022; Rodríguez et al., 2022) as well as assumptions about pedagogical control and the role of technology in mediating instructional decisions. Given that prior reviews have extensively documented both the rapid growth and the thematic diversity of gamification research (Hamari et al., 2014; Bennani et al., 2022; Zairon et al., 2025), the present study deliberately redirects analytical attention from quantifying how much research exists to examining how adaptivity is conceptually framed and practically enacted across studies.

Accordingly, the sources integrated into this synthesis were selected based on their direct theoretical relevance to the two analytical dimensions outlined below — temporal locus and scope of adaptivity — rather than through predetermined bibliometric inclusion criteria. Priority was given to studies that explicitly addressed adaptive gamification design logic, learner profiling mechanisms, or the relationship between personalization strategies and pedagogical coherence in higher education contexts.

Reviews of the field provide a consistent picture of where adaptation has been located. Hallifax et al. (2019a) classify existing systems according to the information used for adaptation, its effect, and whether adaptation is initial or ongoing, and summarize their findings by observing that most systems use this information to select which game elements would be most appropriate for learners, with only five adapting by modifying how those elements function. Bennani et al. (2022) similarly characterize prevailing

approaches as reliant on self-reported instruments administered at discrete intervals rather than on continuous interaction data, and argue for a shift toward dynamic learner modelling. Read together, these accounts indicate that adaptation in gamified learning — whether specified in advance or enacted during instruction — has been directed almost exclusively at discrete game components. What the field has not developed is a vocabulary for adaptation at the level of the instructional scenario itself. The reading advanced in this article is that this concentration is structural rather than incidental: the taxonomies through which the field describes itself do not extend beyond the element layer, and design-time scenario-level adaptivity has consequently remained untheorized as a coherent pedagogical architecture. It is this conceptual space, represented as Quadrant IV in Figure 1, that the present study addresses.

Although this article does not constitute a systematic review, the basis of the reading advanced above is stated here for transparency. The literature informing the study was assembled in February 2026 through semantic search of the Semantic Scholar corpus. Rather than Boolean keyword strings, retrieval proceeded through natural-language queries formulated at the level of the research problem, the principal query being: *“In adaptive gamification within distance education, at what level and stage is adaptivity embedded: real-time system response, content variation, learner-path differentiation, or pre-designed structural personalization?”* A second, proposition-level query concerning whether the growing emphasis on run-time adaptivity has narrowed the conceptualization of adaptivity itself was used to locate work bearing directly on the argument developed in Sections 3 and 4. Retrieval was supplemented by citation chaining through the reference lists of the reviews and design frameworks thus identified and was not restricted by publication date.

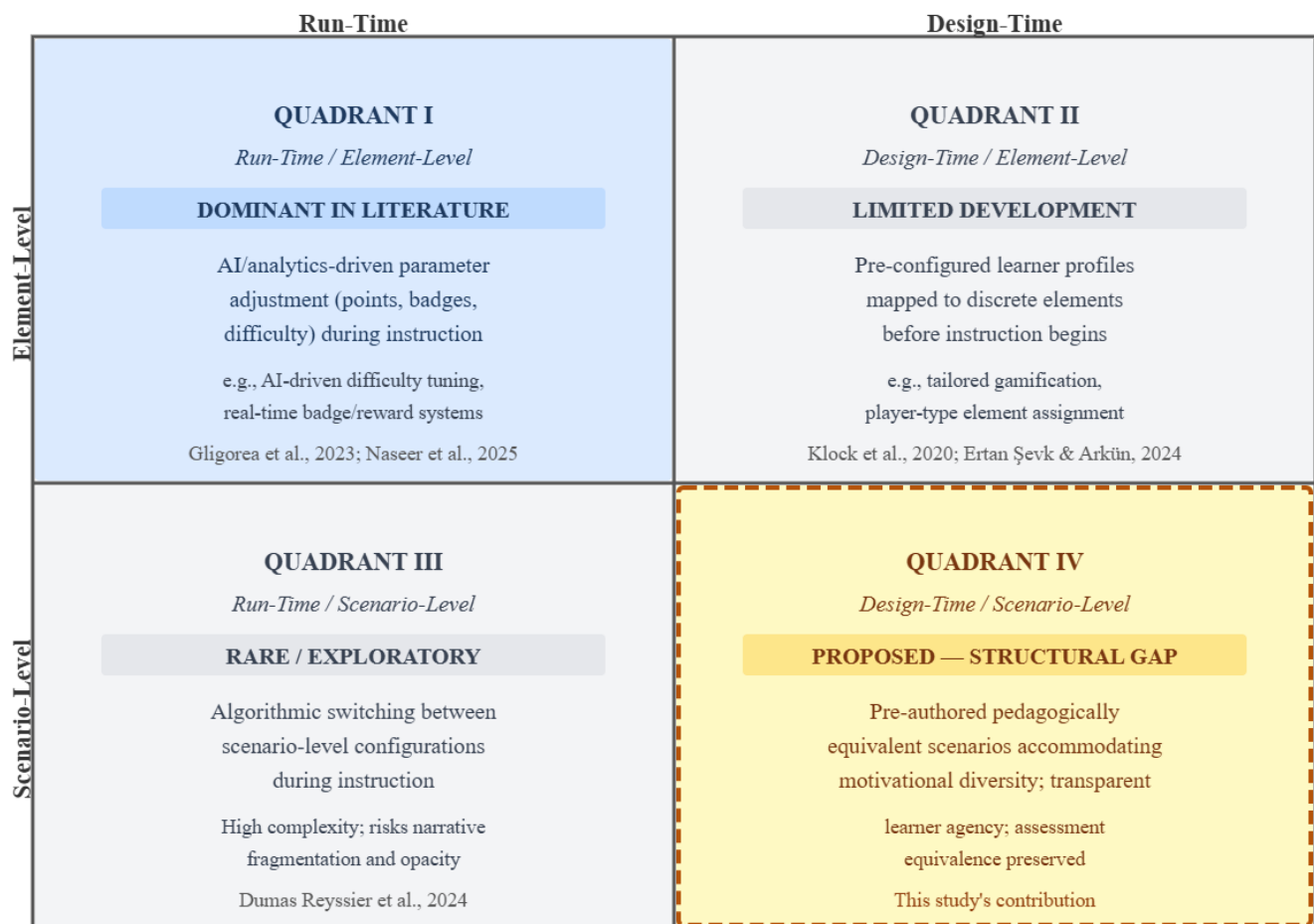
This yielded a working corpus of 47 sources. Sources were retained where the design logic of adaptation could be assessed from the account given — whether as framework, implementation, or review — and set aside where gamification was addressed without reference to adaptation, or too briefly to permit such assessment. Both journal articles and conference proceedings were retained, reflecting the presence of design-framework contributions in the latter venue. A distinction should be drawn between this corpus and the reference list of the present article: not all 47 sources are individually cited, and the article additionally draws on motivational and instructional theory — self-determination theory, flow theory, player typologies, and foundational definitions of gamification — consulted as conceptual grounding rather than retrieved through the queries above. Bartle’s (1996) player typology, for instance, informs the critique of static learner modelling in Section 5 without itself constituting an instance of adaptive gamification design.

Sources addressing adaptation design were read against the two dimensions set out below. Temporal locus was assigned according to whether adaptation is specified by the designer before instruction or enacted by the system during it; where both were present, classification followed the primary mechanism. Scope was assigned according to whether adaptation modifies discrete game components while holding the instructional scenario constant, or restructures the narrative framing, social organization, or task logic of the learning experience itself. Systems describing themselves as adaptive while varying only presentation or difficulty parameters were read as element-level irrespective of that self-description. This reading was carried out by the author; as it is an interpretive mapping rather than a measurement procedure, no reliability statistic is reported, and the resulting classification is offered as an analytical lens open to reassessment rather than as a definitive taxonomy.

The analytical framework that guides this synthesis is organized around two intersecting dimensions. The first dimension addresses the temporal locus of adaptivity, drawing a distinction between run-time and design-time approaches. Run-time adaptivity encompasses system-driven modifications that unfold dynamically during the learning process, typically mediated by AI, machine learning algorithms, or learning analytics engines (Gligorea et al., 2023; Naseer et al., 2025). Design-time adaptivity, by contrast, involves pre-configured differentiation strategies that are established prior to the commencement of instruction, generally informed by learner profiling instruments, self-report measures, or contextual assumptions about the learning population (Klock et al., 2020; Ertan Şevk & Arkün Kocadere, 2024).

The second dimension concerns the scope of adaptivity, distinguishing between element-level and scenario-level personalization. Element-level adaptivity refers to the selective modification or activation of

individual game components — such as points, badges, leaderboards, or feedback frequency — while preserving a uniform instructional scenario across all learners. Scenario-level adaptivity, by contrast, involves the deliberate construction of structurally distinct learning experiences that vary in their narrative framing, social organization, or task logic, while maintaining equivalent learning objectives and assessment criteria. This distinction carries particular analytical significance, as a considerable number of studies that characterize themselves as “adaptive” in the literature operate exclusively at the element level, despite advancing claims of deep or meaningful personalization (Dumas Reyssier et al., 2024). Figure 1 illustrates this analytical framework by mapping the two dimensions that structure the synthesis.



Note. The matrix maps the two analytical dimensions guiding this conceptual synthesis: temporal locus (run-time vs. design-time) and scope (element-level vs. scenario-level). Quadrant I corresponds to the orientation toward which the field has increasingly moved (Gligorea et al., 2023; Naseer et al., 2025). Quadrant IV — design-time, scenario-level adaptivity — denotes the conceptual space this article develops.

Fig. 1. Temporal locus and scope of adaptivity in gamified learning environments. The matrix maps the two analytical dimensions guiding this conceptual synthesis: temporal locus (run-time vs. design-time) and scope (element-level vs. scenario-level). Quadrant I corresponds to the orientation toward which the field has increasingly moved (Gligorea et al., 2023; Naseer et al., 2025). Quadrant IV — design-time, scenario-level adaptivity — denotes the conceptual space this article develops.

These two dimensions are proposed as an analytical lens rather than a classification exercise. Read through them, the design rationales reported in the literature cluster at the element layer, and the scenario layer emerges as the dimension along which adaptivity has not been pedagogically articulated. This classification does not imply a hierarchical valuation of methods; rather, it provides a conceptual lens through which different forms of adaptivity can be evaluated in relation to pedagogical coherence, transparency, and instructional intent. Notably, this study does not seek to evaluate the empirical effectiveness of individual adaptive systems or to compare learning outcomes across experimental conditions. Such evaluative goals

are beyond the scope of a conceptual synthesis and would require controlled empirical designs. Instead, the focus is on the *design rationales* embedded within adaptive gamification systems and the theoretical implications of locating adaptivity primarily within algorithmic versus pedagogical domains. As such, the review treats adaptive systems as artifacts of design decisions rather than neutral technological solutions.

This methodological positioning also aligns with calls for greater reflexivity in educational technology research, particularly regarding the increasing reliance on AI-driven personalization (Ertan Şevk & Arkün Kocadere, 2024; Naseer et al., 2025). By foregrounding the locus and scope of adaptivity, the present study makes explicit the often-implicit assumptions about who—or what—should control adaptation in learning environments. This transparency is essential for evaluating not only the technical sophistication of adaptive systems but also their pedagogical integrity and ethical implications. In summary, the conceptual synthesis and design-oriented review approach adopted in this study provides a structured yet flexible framework for interrogating adaptive gamification research. By systematically distinguishing between temporal and structural forms of adaptivity, the methodology establishes a foundation for the subsequent sections, which critically examine prevailing design logics in the literature and advance a design-time architectural perspective on adaptive gamification in higher education.

3. Adaptive Gamification in Current Literature: Prevailing Design Logics and Structural Gaps

Adaptive gamification research in higher education has expanded rapidly over the past decade, largely driven by advances in learning analytics, AI, and data-driven personalization technologies (Bennani et al., 2022; Gligorea et al., 2023). However, recent multidisciplinary perspectives emphasize that relying solely on AI is insufficient; intelligent technologies must be deeply integrated with foundational pedagogical theories—such as constructivism and Bloom’s taxonomy—to create truly effective personalized learning systems (Elkady et al., 2025). Within this growing body of literature, adaptivity is commonly framed as a mechanism for aligning game elements with individual learner characteristics or behaviors in order to enhance motivation, engagement, and persistence (Alalgawi & Sadkhan, 2022). However, closer examination reveals that adaptive gamification is far from conceptually unified. Instead, the field divides along two lines: an established body of work that assigns game elements to learner profiles established in advance, and a growing turn toward data-driven adjustment during instruction (Hallifax et al., 2019a; Bennani et al., 2022). What the two share is that adaptation is enacted upon game elements rather than upon the instructional scenario. To address this underdeveloped area, researchers have begun calling for rigorous, pre-established adaptive gamification design principles that map out the learning journey and adaptation rules before the course begins (Sezgin & Yüzer, 2022).

3.1. Run-Time, System-Driven Adaptive Gamification

Run-time adaptivity conceptualizes adaptation as a dynamic process executed by the learning system during instruction, and it is toward this conception that recent work has increasingly moved. While existing design frameworks have provided structured methods for mapping user characteristics to specific game elements (Böckle et al., 2018), these models primarily facilitate system-driven adjustments. In these models, adaptive logic is embedded within algorithms that continuously monitor learner behavior and adjust game-related parameters accordingly. Common data sources include quiz performance, time-on-task, interaction frequency, navigation patterns, and clickstream logs (Gligorea et al., 2023; Naseer et al., 2025). Based on these inputs, the system may dynamically alter difficulty levels, unlock rewards, modify feedback frequency, or adjust pacing in an attempt to maintain engagement and support learning progression.

Run-time adaptivity is frequently justified through theories such as flow theory, which emphasizes the importance of maintaining an optimal balance between challenge and skill to prevent boredom or anxiety (Zairon et al., 2025). From this perspective, algorithmic personalization is positioned as a means of continuously fine-tuning the learning experience to keep learners within a desirable experiential zone. Empirical studies have demonstrated that such systems can be effective in managing cognitive load, supporting short-term engagement, and improving task completion rates, particularly in skill-based or practice-oriented learning contexts (Benkhalfallah et al., 2024; Zhang & Huang, 2024). Despite these advantages, run-time adaptive gamification typically operates within a relatively fixed pedagogical

architecture, with adaptation occurring primarily in the gamification layer rather than the underlying pedagogical structure (Monterrat, Lavoué, et al., 2015). While parameters are adjusted dynamically, the underlying instructional scenario—defined by the learning objectives, task structure, narrative framing, and social organization—remains largely unchanged for all learners. Adaptation thus occurs at the level of system behavior rather than instructional design. Gamification elements are treated as modular components that can be tuned or swapped without altering the broader learning experience, resulting in what several authors have described as element-level personalization (Monterrat, Desmarais, et al., 2015; Dumas Reyssier et al., 2024).

This structural constraint has important implications. First, the reliance on algorithmic decision-making often renders the adaptation logic opaque to both learners and instructors, reinforcing concerns about opaque algorithmic decision-making (Naseer et al., 2025). Learners may be unaware of why certain elements are emphasized or suppressed, while instructors have limited insight into how pedagogical intentions are translated into system behavior. Second, run-time systems tend to prioritize behavioral optimization—such as increasing interaction frequency or persistence—without necessarily ensuring alignment with deeper pedagogical goals or learning outcomes (Gligorea et al., 2023). As a result, adaptivity risks becoming an efficiency-driven process rather than a pedagogically grounded one.

3.2. Design-Time Tailoring and Element-Level Personalization

In contrast to run-time approaches, design-time adaptive gamification involves configuring gamified learning environments prior to instruction based on predefined learner profiles, self-reported preferences, or contextual characteristics. This approach is often described in the literature as tailored gamification (Klock et al., 2020; Ertan Şevk & Arkün Kocadere, 2024). Rather than continuously modifying the system during use, design-time tailoring assigns learners to specific configurations or pathways at the outset, with the goal of providing a stable and coherent learning experience.

Design-time adaptivity is frequently operationalized through the use of player typologies, learning style models, or motivational frameworks. For example, learners identified as competitive or achievement-oriented may be presented with leaderboards and performance rankings, while those characterized as autonomy-oriented may receive progress indicators or self-paced challenges (Dumas Reyssier et al., 2024; Puig et al., 2023). Compared to run-time systems, this approach offers greater pedagogical transparency, as the logic of personalization is typically explicit and interpretable by designers and learners alike. However, the review of existing studies reveals that most design-time implementations remain confined to element-level personalization. While game components are selectively activated or deactivated, the instructional scenario itself remains uniform across learners. Tasks, narratives, collaboration structures, and assessment strategies are rarely differentiated in a systematic manner. This element-level orientation is visible in higher education implementations, where gamification is typically operationalised as points, badges, and leaderboards layered onto an otherwise unchanged course structure (Şengel & Fidan, 2022; Kalay & Arıkan, 2023). Consequently, design-time adaptivity often reproduces the same structural limitations observed in run-time systems, albeit without the complexity of algorithmic control.

Several authors have noted this limitation implicitly, observing that many adaptive gamification systems modify surface features without engaging with the deeper pedagogical design of learning activities (Khaldi et al., 2023; Coelho & Abreu, 2025). From a systemic perspective, this approach risks fragmenting the learning experience, as individual game elements may be tailored without ensuring coherence between motivational design and instructional intent. Gamification becomes an overlay rather than an integrated pedagogical structure. Reported outcomes are correspondingly uneven; Kalay and Arıkan (2023), for instance, found no significant difference in motivation or achievement between undergraduates using gamified materials and a control group, even though learner attitudes towards the materials remained positive.

3.3. The Neglected Space of Scenario-Level Design-Time Adaptivity

The synthesis of the literature highlights a significant gap at the intersection of design-time and scenario-level adaptivity. Scenario-level adaptivity refers to the intentional design of multiple, structurally distinct

learning experiences that differ in narrative framing, social organization, or task logic, while maintaining equivalent learning objectives and assessment criteria. Unlike element-level personalization, scenario-level adaptation treats the learning experience as a coherent whole rather than a collection of adjustable components. By treating the experience holistically, this architectural approach actively counters the limitations of purely algorithmic opaque algorithmic decision-making, which frequently lacks systematic pedagogical intent and relies on algorithms without embedding holistic motivational strategies (Naseer et al., 2025; Gligorea et al., 2023).

Although systemic gamification theory (SGT) emphasizes the importance of integration, synergy, and emergent outcomes in gamified systems (Coelho & Abreu, 2025), empirical examples of scenario-level design-time adaptive gamification remain scarce (Bennani et al., 2022; Hallifax et al., 2019a). Most studies that invoke systemic or holistic perspectives stop short of operationalizing these principles through differentiated instructional scenarios (Khaldi et al., 2023). Work that does address the design side tends to stop at the artefact level — for example, Güzel (2023) engaged pre-service teachers in developing gamified lesson plans — rather than treating scenario architecture as the unit of design. As a result, the potential of design-time adaptivity to support narrative coherence, inclusivity, and pedagogical intentionality remains largely underexplored. This absence is particularly notable given the increasing recognition that learner motivation is contextual, situational, and dynamic rather than static or trait-based (Brandl & Schrader, 2024; Dumas Reyssier et al., 2024). When adaptivity is limited to element-level adjustments within a single scenario, systems struggle to accommodate shifts in learner motivation across different tasks or social contexts. In contrast, scenario-level design-time adaptivity offers a mechanism for aligning motivational design with instructional context by allowing learners to engage with learning activities through pathways that resonate with their current motivational orientation.

Taken together, the literature suggests that adaptive gamification research has converged on the element level as the site of adaptation, whether specified in advance or enacted during instruction, at the expense of deeper pedagogical differentiation. While these approaches offer valuable insights into system responsiveness and behavioral optimization, they leave unresolved questions about pedagogical coherence, transparency, and designer agency. Addressing these questions requires moving beyond the prevailing focus on algorithmic adjustment toward a design-time architectural perspective that foregrounds instructional intent and learner experience.

4. Theoretical Foundations: Why Algorithmic Adaptivity Is Pedagogically Insufficient

The way adaptive gamification is designed and implemented is inseparable from the motivational theories that underpin it. Although adaptive systems are often presented as neutral technological solutions, they implicitly encode assumptions about how learners are motivated, how learning occurs, and what constitutes effective engagement. Consequently, understanding the limitations of predominantly run-time, algorithmic adaptivity requires examining the theoretical paradigms that have historically shaped gamification research. Three motivational frameworks—behaviorism, flow theory, and self-determination theory—are particularly influential in this regard, each leading to distinct interpretations of adaptivity and its pedagogical role (Krath et al., 2021).

4.1. Behaviorist Foundations and Reinforcement-Oriented Adaptivity

Early gamification systems were strongly influenced by behaviorist principles, particularly reinforcement theory. Within this paradigm, motivation is understood as a function of external stimuli, where desired behaviors are encouraged through rewards and discouraged through the absence of reinforcement (Krath et al., 2021). In educational gamification, this logic is most visibly expressed through points, badges, leaderboards, and achievement systems that reward task completion, speed, or accuracy.

From a design perspective, behaviorist gamification aligns naturally with run-time adaptivity. Algorithms can efficiently monitor learner behavior and adjust reinforcement schedules in real time, for example by increasing rewards when engagement drops or by escalating challenges when performance improves. Such systems are well suited to optimizing observable behaviors, particularly in repetitive or procedural learning

tasks. However, extensive research has highlighted the limitations of this approach. Overreliance on extrinsic rewards can lead to short-term engagement gains while undermining intrinsic motivation, learner autonomy, and long-term persistence (Hanus & Fox, 2015).

When behaviorist logic dominates adaptive gamification, adaptivity is reduced to reward optimization. The system focuses on manipulating surface behaviors rather than supporting meaningful learning experiences. In this context, personalization becomes synonymous with fine-tuning incentives, leaving the underlying instructional structure unchanged. As a result, adaptivity operates at the level of stimulus–response calibration rather than pedagogical design, reinforcing a narrow and instrumental view of learner motivation.

4.2. Flow Theory and Computational Optimization

Flow theory represents a second major paradigm shaping adaptive gamification research. According to this framework, optimal learning and engagement occur when learners experience a balance between perceived challenge and skill level, resulting in deep concentration and enjoyment (Chalco Challco et al., 2023; Kiili et al., 2012). In adaptive learning systems, flow theory has been widely used to justify dynamic difficulty adjustment, pacing mechanisms, and adaptive feedback loops designed to keep learners within an optimal experiential zone (Pastushenko et al., 2020; Zairon et al., 2025).

Flow-based adaptivity lends itself particularly well to algorithmic implementation through continuous performance monitoring, enabling systems to dynamically adjust task difficulty, unlock challenges, or provide scaffolding (Puig et al., 2023; Idika & Saihi, 2025). However, empirical evidence for effectiveness is mixed. While some studies demonstrate engagement improvements in specific contexts (Chalco Challco et al., 2023), others reveal only “modest impact” on performance metrics and emotional responses compared to static difficulty settings (Fisher & Kulshreshth, 2024, p. 230). More critically, Chapman et al. (2025) found no significant differences on flow theory measures despite gamification improving academic outcomes, suggesting flow theory provides “insufficient explanations for gamification’s effectiveness” (p. 417).

These limitations reflect deeper conceptual constraints. Flow theory primarily addresses individual task experiences rather than broader pedagogical contexts, leading adaptive systems to focus on optimizing moment-to-moment engagement without addressing meaning, social interaction, or learner agency (Guo et al., 2024). Effectiveness varies significantly across cultural contexts, disciplines, and age groups, with insufficient attention to pedagogical alignment (Kode, 2025). Consequently, Flow-based adaptivity often becomes computational tuning rather than meaningful pedagogical differentiation.

4.3. Self-Determination Theory and Contextualized Motivation

Self-determination theory (SDT) provides a more comprehensive foundation for understanding motivation in adaptive gamification. SDT posits that sustained engagement and meaningful learning depend on the satisfaction of three basic psychological needs: autonomy, competence, and relatedness (Ryan & Deci, 2000). As a comprehensive theory that “covers a spectrum of motivations from extrinsic to intrinsic” (Gao, 2024, p. 662), SDT stands out among motivational frameworks for its theoretical breadth and empirical grounding. Unlike behaviorist or flow-based models, SDT emphasizes that motivation is inherently contextual and meaning-driven, with the functional significance of an event; how individuals interpret events in relation to their autonomy and competence- being crucial for motivational outcomes (Gao, 2024). Learners are not merely responding to stimuli or challenges but actively interpreting their learning environment in relation to their goals, identities, and social relationships.

From an SDT perspective, adaptivity cannot be reduced to run-time parameter adjustment. Supporting autonomy requires providing learners with “meaningful choices and in-depth narratives” that construct task significance rather than superficial options (Zhao, 2025, p. 206). Supporting competence requires coherent challenges that are aligned with learning goals rather than isolated performance optimizations (Ryan & Deci, 2000). Promoting relatedness requires prioritizing shared objectives and collaborative roles that enable functional interdependence through social structures and narrative framing, rather than relying solely

on task difficulty or reward frequency (Zhao, 2025). Rather than treating basic psychological needs as independent variables, this approach addresses their mutually supportive qualities (Gao, 2024).

Research grounded in SDT has consistently shown that gamification designs emphasizing narrative coherence, voluntary participation, and social connection are more likely to foster intrinsic motivation than those relying solely on extrinsic rewards or algorithmic optimization (Bennani et al., 2022; Zairon et al., 2025). However, much gamification research has applied SDT superficially, limiting its potential to significantly impact design and implementation (Tyack & Mekler, 2024). Ultimately, successful pedagogical architecture does not impose content mechanically onto the learner; rather, it leverages learners' inherent tendency to explore and learn by systematically satisfying their fundamental needs for autonomy and competence (Rowicka & Postek, 2023). However, translating these principles into adaptive systems presents significant challenges. While algorithms can dynamically adjust difficulty levels or feedback frequency, they struggle to construct authentic narrative coherence, cultivate meaningful social contexts, or ensure transparent decision-making processes. As Tyack and Mekler (2024) observe, theoretical frameworks tend to underspecify design practice, requiring additional translation work to bridge theoretical concepts and practical implementation. Consequently, SDT-oriented adaptivity cannot rely solely on simplistic algorithmic parameter adjustment; research indicates that adaptive gamification must dynamically tailor game mechanics to support autonomy and competence in ways consistent with self-determination theory, rather than only tweaking superficial system parameters (Naseer et al., 2025).

4.4. *The Pedagogical Limits of Algorithmic Adaptivity*

Taken together, these theoretical perspectives reveal a fundamental tension in adaptive gamification research. While behaviorist and flow-based paradigms align well with run-time, algorithmic personalization, they support a limited conception of adaptivity focused on efficiency and optimization. Such system-driven adaptations frequently rely on superficial inputs—like the frequency of failure and success events—while largely ignoring the deeper psychological profiles and diverse backgrounds of the learners (Dalponte Ayastuy et al., 2021). In contrast, SDT foregrounds learner agency, contextual meaning, and social embeddedness—dimensions that are difficult to accommodate through purely reactive, data-driven systems.

This tension helps explain why many adaptive gamification systems achieve technical sophistication without corresponding pedagogical depth. When adaptivity is primarily defined as algorithmic responsiveness, instructional designers relinquish control over the structure and meaning of the learning experience to computational processes. The result is often a fragmented form of personalization that optimizes isolated variables while neglecting coherence, transparency, and inclusivity.

From this perspective, the limitations of algorithmic adaptivity are not merely technical but conceptual. Algorithms can respond to behavior, but they cannot determine pedagogical intent. They can optimize parameters, but they cannot design learning experiences. Recognizing these limits does not entail rejecting AI-driven personalization; rather, it calls for a rebalancing of roles in which algorithms support, rather than replace, pedagogical design decisions.

This theoretical analysis underscores the need to reconceptualize adaptive gamification as a design-time pedagogical architecture. By embedding motivational theory into the structural design of learning environments, instructional designers can create adaptive systems that support autonomy, competence, and relatedness in a transparent and coherent manner. The following section builds on this theoretical foundation by examining how prevailing notions of learner profiling and player typologies further constrain adaptive gamification, and how these limitations can be addressed through a pedagogical reframing of learner identity.

5. **Redefining “Dynamic”: From Static Player Typologies to Pedagogical Fluidity**

A central assumption underpinning many adaptive gamification systems is that learner motivation can be captured through stable player typologies. Frameworks such as Bartle's player types or the Hexad model categorize learners into predefined identities—such as *Achievers*, *Socializers* or *Philanthropists*—based on

questionnaire responses or inferred behavioral patterns (Bartle, 1996; Marczewski, 2015). These models have been widely adopted in both run-time and design-time adaptive gamification research, serving as the primary mechanism through which personalization decisions are justified (Klock et al., 2020; Brandl & Schrader, 2024; Lavoué et al., 2019).

While player typologies have contributed valuable insights into motivational diversity, their application in adaptive systems is often grounded in a problematic assumption: that learner motivation constitutes a relatively stable trait that can be measured once and targeted consistently throughout the learning process. In practice, this assumption simplifies the complexity of human motivation and risks reifying learner identity into fixed categories. As a result, adaptivity becomes a matter of aligning game elements with a presumed profile rather than responding to the evolving relationship between the learner, the task, and the learning context.

Recent empirical research increasingly challenges this static view of learner motivation. Kirchner-Krath et al. (2024) conducted a comprehensive analysis of popular player typologies and found considerable overlap between different models, with some relationships being “consistent whereas others contradicted theoretically assumed relationships” (p. 1). Their findings reveal that these typologies “overall factor into five underlying and fundamental dimensions” (p. 1) rather than discrete categories, leading them to conclude that researchers should favor continuous representations of users’ motivations in specific situations instead of a dichotomous operationalization of user types as static manifestations of their preferences.

Clustering analyses and longitudinal studies suggest that learners frequently exhibit mixed motivational profiles and that these profiles shift depending on task type, social setting, and instructional demands (Brandl & Schrader, 2024; Dumas Reyssier et al., 2024). Hallifax et al. (2019b) demonstrated through a study of 300 participants that “the dominant user type is not sufficient to differentiate users according to their preferences for game elements” (p. 560), finding that users sharing the same dominant type showed low agreement coefficients. Van Houdt et al. (2020) provided compelling evidence that “the preference for gamification strategies as well as their motivational impact, may vary in different contexts and situations” (p. 241), showing that contextual motivation predicted preferences more effectively than stable user types. A learner may, for example, display competitive tendencies during individual quizzes while preferring collaboration during project-based activities. Such findings indicate that motivational orientation is situational and dynamic, rather than a fixed attribute that can be permanently assigned.

Despite this evidence, most adaptive gamification systems attempt to address motivational fluidity through computational means rather than pedagogical design. In run-time adaptive systems, learner behavior is continuously monitored and translated into dynamic player profiles, often represented as weighted vectors that shift over time based on interaction data (Rodríguez et al., 2022; Puig et al., 2023). When a learner interacts frequently with competitive elements such as leaderboards, the system may infer an “Achiever” orientation and adjust subsequent content accordingly. In this model, “dynamic” identity is defined as a variable to be predicted and updated algorithmically.

Although computational profiling offers technical flexibility, it introduces several pedagogical limitations. First, it treats learner motivation as a hidden state to be inferred by the system rather than as an experiential condition that learners can recognize and articulate themselves. Second, it reinforces opacity: learners are rarely informed when or why their inferred profile changes, which can undermine autonomy and trust. Third, it conflates behavioral signals with motivational intent, assuming that observable actions reliably reflect underlying preferences. As a result, adaptive systems risk misinterpreting exploratory behavior, compliance, or situational constraints as stable motivational traits.

To address these limitations, this article proposes a pedagogical reframing of what it means for learner identity to be “dynamic.” Rather than defining dynamism as the system’s ability to continuously recalculate user profiles, dynamic identity should be understood as the learner’s fluid relationship with the learning context. From this perspective, motivation is not something the system detects and manages covertly, but something that emerges through interaction with tasks, narratives, and social structures. Adaptivity,

therefore, should create conditions that allow learners to express and negotiate their motivational orientation rather than having it algorithmically imposed.

This reframing aligns closely with self-determination theory, which emphasizes that autonomy and meaning are central to sustained engagement (Ryan & Deci, 2000). Supporting autonomy requires more than adjusting parameters in the background; it requires making motivational pathways visible and selectable. When learners are given transparent choices—such as opting into a collaborative pathway or a competitive challenge—they are able to align their learning experience with their current motivational state. In this sense, dynamism is enacted pedagogically through design, not inferred computationally through surveillance.

Importantly, this argument does not reject player typologies outright. Player models can still function as design heuristics that inform the creation of alternative learning scenarios. However, their role shifts from classification tools used to assign learners to fixed categories toward design lenses that help instructional designers anticipate diverse motivational needs. In a design-time architecture, typologies inform scenario construction rather than dictate system behavior in real time.

By redefining dynamic as pedagogical fluidity rather than computational volatility, adaptive gamification can move beyond the limitations of static profiling and opaque algorithmic switching. This shift foregrounds learner agency, supports transparency, and acknowledges that motivation is context-dependent and evolving. The implication is clear: truly adaptive gamification requires not faster algorithms, but more intentional design of alternative learning experiences that learners can navigate meaningfully. This reconceptualization sets the stage for the central contribution of this article: the articulation of design-time adaptive gamification as a pedagogical architecture. The following section builds on this reframing by outlining how instructional designers can operationalize pedagogical fluidity through scenario-level differentiation embedded at the design stage of gamified learning environments.

6. Design-Time Adaptive Gamification as Pedagogical Architecture

The previous sections have demonstrated that prevailing approaches to adaptive gamification; whether run-time or design-time, remain largely constrained by element-level personalization and algorithmic control. While such approaches offer technical flexibility, they fall short of addressing the pedagogical requirements articulated by motivational theory, particularly with respect to autonomy, coherence, and learner agency (Ryan & Deci, 2000; Dumas Reyssier et al., 2024; Tyack & Mekler, 2024). To move beyond these limitations, adaptive gamification must be reconceptualized not as a system feature but as a form of pedagogical architecture designed intentionally at the instructional level. This architectural shift is necessary because current literature highlights a severe lack of comprehensive models capable of aligning specific game elements with dynamic learner profiles to provide sustained, long-term motivation (Kamunya et al., 2020). Design-time adaptive gamification, as proposed in this article, refers to the deliberate construction of multiple, pedagogically coherent learning scenarios prior to instruction. In contrast to run-time systems that dynamically modify parameters within a single instructional structure, a design-time architecture embeds adaptivity into the foundational design of the learning experience. Here, adaptivity is not something that happens to the learner during instruction, but something that is offered to the learner through alternative, pre-authored pathways that reflect different motivational orientations and learning needs.

This architectural perspective foregrounds the role of the instructional designer as the primary agent of adaptivity. Rather than delegating pedagogical decision-making to opaque algorithmic processes, designers explicitly author the relationship between learning objectives, game mechanics, narrative framing, and social organization, thereby restoring pedagogical intentionality to gamified learning environments and ensuring that motivational design aligns with instructional goals rather than merely optimizing engagement metrics. A key distinction between design-time and run-time adaptivity lies in the locus of control: in run-time systems, control is largely ceded to the algorithm, which reacts to learner behavior by adjusting system parameters autonomously once instruction begins; in contrast, design-time adaptivity reclaims control for the educator by embedding adaptive logic directly into the instructional design. Learners are not silently

repositioned by the system; instead, they engage with clearly differentiated learning scenarios whose structure and intent are transparent. This shift has significant implications for transparency and trust. Run-time adaptive systems often lack transparency, leaving learners uncertain about why specific elements are emphasized or withheld. Design-time architectures, by contrast, make adaptivity legible. When learners are presented with distinct scenarios—each with a clear narrative, set of mechanics, and social logic—the rationale for personalization becomes visible. This transparency supports learner autonomy by allowing individuals to make informed choices about how they engage with the learning experience.

The proposed design-time architecture aligns closely with systemic gamification theory, which emphasizes integration, synergy, and emergence as defining characteristics of effective gamified systems (Coelho & Abreu, 2025). From an SGT perspective, gamification cannot be reduced to the additive deployment of isolated elements; rather, it must function as a coherent system in which mechanics, narratives, and social structures interact to produce emergent motivational outcomes. Scenario-level design-time adaptivity provides a practical mechanism for operationalizing these principles by enabling designers to craft integrated learning experiences tailored to different motivational contexts. Within this architectural framework, adaptivity is realized through scenario-level differentiation rather than parameter-level adjustment. Each scenario represents a distinct pedagogical configuration that integrates game mechanics, instructional activities, and motivational framing into a unified experience. Importantly, these scenarios are designed to maintain equivalence at the level of learning objectives and assessment criteria. While the experiential pathway may differ, the educational outcomes remain consistent, preserving fairness and accreditation requirements in formal education contexts.

Design-time adaptive gamification also addresses a core limitation of player typology-based personalization. Rather than assigning learners permanently to predefined categories, the architecture treats motivational profiles as design considerations rather than deterministic labels. Scenarios are informed by typologies but are not dictated by them. Learners may enter, exit, or switch between scenarios at designated points, allowing motivation to be expressed dynamically through choice rather than inferred through behavioral surveillance. In this way, pedagogical fluidity is achieved without sacrificing coherence. Crucially, this approach does not reject the use of technology or analytics. Instead, it repositions their role. Analytics may inform the design process by revealing patterns of engagement or preference, and AI tools may support instructors in managing complex learning environments. However, these technologies function as decision-support tools rather than autonomous pedagogical agents. The architectural logic of the learning experience remains human-authored, ensuring that adaptivity serves educational intent rather than replacing it. By framing adaptive gamification as pedagogical architecture, this article offers a conceptual shift that integrates theoretical insight with practical design implications. Adaptivity becomes a matter of instructional planning rather than algorithmic reaction, enabling educators to design learning environments that are coherent, transparent, and responsive to motivational diversity. The following section builds on this architectural perspective by illustrating how scenario-level design-time adaptivity can be operationalized through conceptual exemplars, demonstrating the practical implications of the proposed framework.

7. Scenario-Level Design-Time Adaptivity: Conceptual Exemplars

To illustrate the practical implications of design-time adaptive gamification as a pedagogical architecture, this section presents conceptual exemplars of scenario-level differentiation. These exemplars are not intended as empirical case studies, but as theoretically grounded design models that demonstrate how motivational diversity can be addressed through pre-authored instructional scenarios. Their purpose is to clarify how scenario-level adaptivity differs fundamentally from element-level personalization and to show how pedagogical coherence can be preserved across adaptive pathways. A defining characteristic of scenario-level design-time adaptivity is the maintenance of assessment equivalence. Regardless of the scenario through which learners engage with the course, learning objectives, content coverage, and evaluation criteria remain constant. What differs is the experiential framing of learning activities—the narrative context, social organization, and motivational logic through which learners encounter the same instructional material. This principle is essential in formal higher education contexts, where accreditation, fairness, and comparability of outcomes must be preserved (Benkhalfallah et al., 2024).

In a socially oriented scenario, the learning experience is structured around collaboration, collective progress, and shared goals, with learners engaging in team-based quests, group problem-solving activities, and peer feedback cycles. Progress is framed as collective achievement rather than individual competition, and rewards emphasize contribution, support, and mutual success. From a gamification perspective, mechanics such as shared milestones, cooperative challenges, and community-based achievements are not added as superficial overlays but embedded within the learning activities themselves — for example, completion of a programming module may require coordinated contributions from multiple learners, reinforcing interdependence and relatedness. This scenario aligns closely with self-determination theory's emphasis on relatedness and has particular relevance for learners who find competitive environments demotivating or anxiety-inducing (Zairon et al., 2025). Unlike run-time systems that simply hide competitive elements for certain users, the collaborative scenario reconfigures the pedagogical logic of the course entirely, providing a coherent experience in which collaboration functions as a central motivational driver rather than an incidental feature.

In contrast, a competitive scenario frames learning as a structured challenge in which individual mastery, progression, and performance are emphasized. Learners advance by completing time-bound tasks, earning rankings, or unlocking increasingly difficult challenges, with leaderboards, performance indicators, and progression ladders integrated as core design elements rather than optional add-ons. Motivation is driven by competence and achievement: challenges are clearly defined, feedback is immediate and performance-focused, and progression is visibly linked to demonstrated mastery. Importantly, while the narrative framing differs from the collaborative scenario, the instructional content and assessment standards remain identical — learners engage with the same concepts, complete equivalent assignments, and are evaluated according to the same criteria. This design is particularly suited to learners who thrive in goal-oriented, performance-driven environments and who experience competition as motivating rather than discouraging, allowing educators to support achievement-oriented motivation without imposing competitive pressure on those who may find it counterproductive.

The contrast between these scenarios highlights the limitations of element-level personalization. In a run-time adaptive system, a learner who struggles in a competitive environment might simply see a leaderboard removed or receive additional rewards. However, the underlying competitive narrative remains intact. The learner is still participating in a tournament-like structure, albeit with certain features muted. In scenario-level design-time adaptivity, by contrast, the learner enters a fundamentally different pedagogical architecture, one in which collaboration rather than competition defines the learning experience.

This distinction has important implications for motivational coherence. When game elements are swapped dynamically within a single scenario, the learning experience can become fragmented or internally inconsistent. Scenario-level design-time adaptivity avoids this problem by ensuring that all elements within a pathway align with a unified motivational logic. As a result, learners encounter experiences that feel intentional and meaningful rather than algorithmically manipulated. Furthermore, scenario-level adaptivity supports pedagogical transparency. Learners are aware of the pathway they are engaging with and can understand how the design of the environment reflects particular motivational assumptions. This visibility fosters trust and allows learners to reflect on their own preferences and learning strategies. Adaptivity thus becomes an explicit pedagogical feature rather than a hidden system behavior.

An important concern regarding design-time adaptivity is the potential rigidity of pre-authored scenarios. To address this, scenario-level architectures can incorporate structured points of choice, allowing learners to switch pathways at predefined moments; transitions that are intentional and pedagogically meaningful rather than reactive and opaque. This approach contrasts sharply with run-time systems that continuously adjust parameters in response to short-term behavioral fluctuations; while such systems offer responsiveness, they can also produce volatility, leading to inconsistent experiences and unclear motivational framing. By prioritizing stability and coherence while still accommodating motivational change through deliberate design, scenario-level adaptivity demonstrates how design-time gamification can move beyond surface-level personalization to support meaningful pedagogical differentiation without sacrificing fairness or transparency.

Table 1 sets out these exemplars against the design dimensions along which scenario-level differentiation operates, and is offered as a template through which instructional designers may specify pedagogically equivalent pathways for their own courses.

Table 1.

Scenario-mapping template for design-time, scenario-level adaptivity, with two worked exemplars.

	Learning objective	Narrative framing	Social organization	Task logic	Assessment equivalence	LMS implementation
Scenario A — Collaborative	Held constant across pathways (e.g., <i>implement and document a working module</i>)	Shared enterprise; progress framed as collective achievement	Small teams with interdependent roles; peer feedback cycles	Tasks decomposed so completion requires coordinated contributions; milestones released on group progress	Identical objectives, content coverage, submission requirements, and grading criteria	Cohort-based routing; group-attributed submission with individual grading; structured peer review; completion tracked at group level.
Scenario B — Competitive	<i>As above — unchanged</i>	Structured challenge; progress framed as individual mastery	Individual progression; visible performance standing	Time-bound tasks; sequential unlocking of increasingly demanding challenges	<i>As above — unchanged</i>	Individual submission; time-constrained assessment; conditional release on attainment thresholds; visible progress indicators
Scenario C — [template]	<i>Specify once; hold constant</i>	<i>Motivational logic organizing the pathway</i>	<i>Individual, dyadic, team, or community</i>	<i>How activities are sequenced and released</i>	<i>Confirm objectives, coverage, and criteria are unchanged</i>	<i>Routing mechanism, activity types, release conditions</i>

Note. LMS = learning management system. Scenarios A and B are worked exemplars; Scenario C is a blank template in which italicized text indicates the design decision to be specified for a given course.

The template makes explicit what scenario-level adaptivity holds constant and what it varies: the first and fifth columns are fixed across all pathways, while the intervening columns constitute the design space within which motivational diversity is accommodated. Element-level personalization, by contrast, operates only within a single row. The final column indicates the functional capabilities a pathway requires rather than prescribing platform-specific procedures; the extent to which these are natively supported varies across learning management systems, and scenario-level routing in particular typically requires deliberate configuration rather than a dedicated feature.

8. Boundary Conditions and Design Implications for Adaptive Gamification

While the preceding sections have articulated the theoretical and pedagogical advantages of design-time adaptive gamification, it is essential to acknowledge that this approach is not universally applicable. Adaptivity, regardless of its form, is always context-dependent. Treating design-time architecture as a blanket solution would risk reproducing the same conceptual overreach observed in overly technocentric models of run-time personalization. Instead, the value of design-time adaptive gamification lies in its strategic application under specific boundary conditions where pedagogical coherence and motivational stability are particularly critical.

One key condition under which design-time adaptivity is especially appropriate is stable learner heterogeneity. When differences among learners are relatively enduring; such as motivational orientation,

collaboration preference, or anxiety toward competition, pre-authored scenarios can provide more coherent and supportive learning experiences than continuously recalibrated algorithmic adjustments (Dumas Reyssier et al., 2024). In such contexts, repeated run-time switching risks fragmenting the learner experience, whereas design-time scenarios offer sustained motivational alignment.

A second condition concerns formal educational settings with fixed learning outcomes. In accredited higher education environments, all learners are typically required to achieve identical competencies and are evaluated against standardized criteria. Design-time scenario-level adaptivity aligns well with this requirement by preserving assessment equivalence while allowing experiential differentiation. Because the instructional objectives remain constant across scenarios, design-time architectures can accommodate motivational diversity without compromising fairness or academic rigor (Benkhalfallah et al., 2024).

Third, technological and institutional constraints often limit the feasibility of sophisticated run-time adaptive systems. Many learning management systems (LMS) lack advanced AI engines or real-time analytics capabilities. In such environments, design-time adaptivity can be implemented using existing LMS functionalities such as grouping, conditional access, or differentiated activity pathways (Jayalath & Esichaikul, 2022). This makes design-time architecture a pragmatic alternative for institutions seeking personalization without significant technical overhead.

Finally, long-duration courses represent another context in which design-time adaptivity is particularly effective. In semester-long or year-long courses, maintaining a coherent narrative arc and stable motivational framing is often more important than moment-to-moment responsiveness. Frequent algorithmic adjustments may disrupt continuity and reduce learners' sense of progression. Design-time scenarios, by contrast, provide a consistent experiential structure that supports sustained engagement over extended periods.

Recognizing the strengths of design-time architecture does not entail dismissing the value of run-time adaptivity. Run-time systems remain highly effective in contexts that require rapid responsiveness and fine-grained adjustment. For example, skill acquisition domains that involve procedural practice, such as mathematics drills or programming exercises, often benefit from dynamic difficulty adjustment and immediate feedback. In such cases, algorithmic tuning can efficiently support learners' moment-to-moment needs. Similarly, short-term learning interventions; including microlearning modules or adaptive assessments, may not justify the design investment required for multiple scenario-level pathways. Here, run-time adaptivity offers a cost-effective means of personalization without extensive instructional redesign. These observations underscore the importance of viewing design-time and run-time adaptivity as complementary rather than mutually exclusive.

From a design perspective, distinguishing between design-time and run-time adaptivity carries significant implications for how instructional decisions are structured and enacted. The principles outlined below offer a practical framework to guide instructional designers in the implementation of scenario-level design-time adaptive gamification: First, the purpose of adaptivity should be explicitly defined before any technical solution is selected. When the instructional goal centers on supporting autonomy, fostering relatedness, or maintaining narrative coherence, a design-time architecture is likely to be more appropriate. Conversely, when the primary objective is to manage cognitive load or deliver immediate remediation, run-time mechanisms may prove sufficient. Second, a design-time orientation necessitates a fundamental shift in design practice — moving from the selection of individual game elements toward the construction of integrated learning scenarios. Rather than deliberating over which game components to include or omit, designers are called upon to consider how distinct configurations of activities, narratives, and social structures give rise to qualitatively different learning experiences. Although this shift entails greater investment at the design stage, it produces adaptive systems that are more coherent and more transparent in their pedagogical logic. Third, transparency should be positioned as an intentional design principle rather than an incidental byproduct. Scenario-level adaptivity renders the logic of personalization visible and interpretable, thereby enabling learners to understand, evaluate, and reflect on their own learning pathways. This characteristic stands in marked contrast to opaque algorithmic systems, in which the adaptive logic typically remains concealed from both learners and instructors. Finally, design-time adaptive gamification

invites a reconceptualization of the role played by analytics and AI in educational contexts. Rather than functioning as autonomous pedagogical decision-makers, these technologies can serve as design-support tools; informing scenario development, surfacing patterns of learner engagement, or signaling moments when design revisions may be warranted. Within this configuration, technology augments and extends pedagogical expertise rather than supplanting it.

In summary, design-time adaptive gamification achieves its greatest impact when deployed deliberately and within clearly defined contextual boundaries. By attending carefully to where and when this approach adds pedagogical value, educators can move beyond false dichotomies between human-authored design and algorithmic personalization. The final section synthesizes these insights by examining the broader ethical and pedagogical implications of reclaiming adaptivity as a design-centered practice in higher education.

9. Discussion: Inclusivity, Ethics, and Pedagogical Integrity

Reconceptualizing adaptive gamification as a design-time pedagogical architecture has implications that extend beyond instructional efficiency or motivational optimization. At stake are broader questions of inclusivity, ethics, and pedagogical integrity—issues that have become increasingly salient as AI-driven personalization gains prominence in higher education. This discussion situates the proposed design-time approach within these concerns, arguing that architectural decisions about adaptivity are inherently value-laden and must therefore be evaluated not only in terms of effectiveness but also in terms of educational responsibility.

One of the most persistent critiques of gamification in education concerns its uneven effects across learner populations. Competitive mechanics such as leaderboards and time pressure have been shown to motivate some learners while alienating others, particularly those with high anxiety, low prior confidence, or neurodivergent profiles (Hanus & Fox, 2015; Zairon et al., 2025). When gamification designs assume a universal motivational response, they risk reproducing exclusionary learning environments under the guise of engagement. Design-time scenario-level adaptivity offers a structurally inclusive alternative. By providing distinct pedagogical pathways—rather than selectively muting elements within a single competitive framework—design-time architectures acknowledge that motivational diversity is not a deviation to be corrected but a condition to be accommodated. Inclusivity, in this sense, is not achieved through personalization as compensation, but through intentional differentiation of learning experiences that are equally legitimate and pedagogically sound. Importantly, this approach aligns with emerging calls to consider neurodiversity and affective diversity in educational technology design. Learners who are sensitive to social comparison, sensory overload, or rapid feedback cycles may benefit from narrative-driven or collaborative scenarios that reduce extraneous pressure. Design-time adaptivity enables such accommodations without stigmatizing learners or positioning them as exceptions within a dominant design logic.

Adaptive systems necessarily involve decisions about what learners see, experience, and are encouraged to value. In run-time, algorithm-driven systems, these decisions are often automated and opaque, raising ethical concerns related to transparency, consent, and agency (Naseer et al., 2025). Learners may be unaware that their behavior is being monitored, interpreted, and used to shape their learning environment, nor are they typically informed about the criteria guiding these adaptations. From an ethical standpoint, design-time adaptive gamification mitigates several of these concerns by making adaptivity explicit. When learners are presented with clearly differentiated scenarios and informed about their underlying logic, personalization becomes a matter of choice rather than surveillance. This transparency supports informed participation and respects learners as intentional agents rather than passive recipients of algorithmic judgment. Moreover, design-time architectures reduce the risk of misinterpretation inherent in data-driven profiling. Behavioral data alone cannot reliably capture motivation, intent, or contextual constraints. By shifting the locus of adaptivity from covert inference to overt design, educators can avoid ethical pitfalls associated with over-reliance on predictive models that may encode bias or misread learner behavior.

A central implication of the proposed framework concerns the role of the educator in adaptive learning environments. In many AI-driven systems, pedagogical authority is partially displaced by algorithmic logic that prioritizes efficiency, engagement metrics, or predictive accuracy. While such systems may optimize short-term interaction patterns, they risk decoupling gamification from instructional intent. Design-time adaptive gamification reasserts pedagogical integrity by positioning instructional designers and educators as the architects of adaptive experiences. Decisions about how motivation is supported, how challenges are framed, and how social interaction is structured are treated as pedagogical judgments rather than technical optimizations. This reorientation ensures that gamification serves curricular goals and educational values rather than functioning as an independent engagement layer. Furthermore, pedagogical integrity requires coherence between learning objectives, assessment practices, and motivational design. Scenario-level design-time adaptivity facilitates such coherence by embedding game mechanics within unified instructional narratives. Unlike run-time element swapping, which can produce disjointed experiences, design-time architectures preserve internal consistency across the learning experience, reinforcing the legitimacy of gamification as an educational strategy rather than a motivational gimmick.

Finally, the discussion must address the persistent conflation of engagement with learning in adaptive gamification research. Engagement metrics—such as time on task, interaction frequency, or system usage—are often treated as proxies for learning outcomes. However, high engagement does not necessarily translate into deep understanding or transferable knowledge. By foregrounding pedagogical architecture, design-time adaptivity reframes engagement as a means rather than an end. The question shifts from “How can the system keep learners interacting?” to “How can different learners meaningfully engage with the same learning objectives?” This distinction is critical for maintaining educational credibility in gamified systems, particularly in higher education contexts where learning outcomes carry formal and societal significance. In this sense, the proposed framework does not reject engagement as a goal but situates it within a broader pedagogical logic. Engagement is valuable insofar as it supports learning, autonomy, and inclusion—not merely because it can be measured and optimized.

Taken together, these considerations suggest that adaptive gamification cannot be evaluated solely on technical or motivational grounds. Decisions about adaptivity shape who feels included, who retains agency, and how educational values are enacted in digital environments. By reclaiming adaptivity as a design-centered practice, educators can align gamification with principles of inclusivity, ethical transparency, and pedagogical integrity. The final section synthesizes these arguments and articulates the broader contribution of this study to adaptive gamification research.

10. Conclusion

This article argued that adaptive gamification in higher education has reached a conceptual crossroads. While advances in AI and learning analytics have enabled increasingly sophisticated forms of run-time personalization, the prevailing equation of adaptivity with algorithmic optimization has narrowed the pedagogical imagination of the field. Adaptivity has largely been treated as a reactive system behavior—one that fine-tunes parameters within a fixed instructional structure—rather than as a deliberate pedagogical design decision.

Through a conceptual synthesis of adaptive gamification literature, this study distinguished between the temporal locus of adaptivity (run-time versus design-time) and the scope of adaptivity (element-level versus scenario-level). Read through these dimensions, the field exhibits a structural imbalance: adaptation has been elaborated extensively at the element level, across both temporal loci, while the scenario level has remained largely unaddressed as a site of pedagogical design. Although design-time tailoring is frequently invoked in theory, its implementation has remained shallow, rarely extending beyond the selective activation of individual game elements.

To address this gap, the article advanced a reconceptualization of adaptive gamification as a design-time pedagogical architecture. Grounded in motivational theory and informed by systemic perspectives on gamification, this approach positions instructional designers as the architects of adaptivity. Rather than relying on opaque algorithmic inference, design-time architecture embeds adaptivity into the structural

design of learning experiences through coherent, pre-authored scenarios that accommodate motivational diversity while preserving assessment equivalence and instructional integrity. Importantly, this perspective does not reject the value of AI-driven personalization. Instead, it reframes the role of algorithms as supportive tools that inform and enhance pedagogical design rather than replace it. By foregrounding transparency, learner agency, and narrative coherence, scenario-level design-time adaptivity offers a pathway toward more inclusive, ethical, and pedagogically defensible gamified learning environments.

The contribution of this study is therefore primarily conceptual. It challenges the assumption that greater dynamism necessarily yields better pedagogy and argues that meaningful personalization in formal education often requires stability, intentionality, and human authorship. Future research should empirically examine the learning and motivational effects of scenario-level design-time adaptive gamification across disciplines and contexts, as well as explore hybrid models that integrate design-time architecture with selective run-time support. For instance, a hybrid approach might employ design-time scenario-level architecture as the primary pedagogical structure while incorporating limited run-time adjustments — such as adaptive feedback timing or scaffolding intensity — within each scenario, thereby combining structural coherence with contextual responsiveness.

Ultimately, adaptivity is not merely a technical capability but a pedagogical responsibility. Reclaiming adaptive gamification as a design-centered practice ensures that personalization serves educational purposes rather than subordinating them to algorithmic efficiency. In doing so, this work seeks to re-anchor adaptive gamification within the core values of higher education: coherence, fairness, and respect for the learner as an intentional agent.

Declaration of generative AI and AI-assisted technologies in the writing process

Generative AI tools, including ChatGPT (OpenAI), Claude (Anthropic), Gemini (Google), and DeepL, were used to support language polishing, sentence-level revision for clarity and readability, and translation assistance. These tools were not used to generate original scientific content, research ideas, hypotheses, data, analyses, or conclusions. All intellectual contributions, arguments, and scholarly decisions remain solely the author's own.

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