

## Gamified Hybrid Learning for Neurodiverse Students: Designing Universally Accessible Instructional Models

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### Article Info

Received: March 15, 2025

Revised: March 17, 2025

Accepted: April 30, 2025

Online Version: April 30, 2025

### Abstract

The increasing presence of neurodiverse learners in mainstream educational environments has necessitated a rethinking of instructional models to ensure equitable access and participation. Traditional pedagogical approaches often fail to accommodate the diverse cognitive profiles and sensory needs of students with conditions such as autism spectrum disorder (ASD), ADHD, and dyslexia. This study explores the design and implementation of gamified hybrid learning environments aimed at enhancing engagement, inclusivity, and learning outcomes for neurodiverse students. The primary objective is to develop universally accessible instructional models that integrate gamification principles with hybrid learning modalities. Using a design-based research methodology, the study was conducted across three inclusive secondary schools with 72 neurodiverse students over two academic terms. Data were collected through classroom observations, semi-structured interviews, and learning analytics. Results indicate that gamified hybrid learning models significantly improved students' focus, motivation, and task completion rates, particularly when game elements were personalized to align with students' sensory preferences and learning styles. Teachers reported increased flexibility in instructional delivery and greater student participation. The study concludes that gamified hybrid instruction represents a promising pathway toward universal design for learning (UDL), supporting both academic achievement and psychological safety for neurodiverse learners.

**Keywords:** neurodiversity, gamification, hybrid learning, universal design for learning, inclusive education



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Journal Homepage

<https://journal.ypidathu.or.id/index.php/jnhl> ISSN: (P: 2987-2316) - (E: 2986-979X)

How to cite:

Belhaj, R., Ali, A, N., & Boulahrouf, I. (2025). Gamified Hybrid Learning for Neurodiverse Students: Designing Universally Accessible Instructional Models. *Journal Neosantara Hybrid Learning*, 3(1), 38-46. <https://doi.org/10.70177/jnhl.v3i1.2229>

Published by:

Yayasan Pendidikan Islam Daarut Thufulah

## INTRODUCTION

The rise of inclusive education has brought attention to the diverse cognitive and sensory needs of neurodiverse students, including those with autism, ADHD, and dyslexia. Despite policy-level inclusion, many hybrid learning environments remain inaccessible due to rigid instructional models that overlook neurodiverse learning profiles.

The growing adoption of hybrid learning—where instruction is delivered through a combination of face-to-face and digital modalities—offers both challenges and opportunities for meeting the needs of neurodiverse students. Hybrid formats can introduce flexibility and multimodal engagement but can also exacerbate sensory overload, cognitive fatigue, and social disengagement if not carefully designed. Educators require frameworks that move beyond traditional differentiation toward more holistic and universally accessible learning environments.

Gamification, or the integration of game design elements into non-game contexts, has emerged as a promising strategy for enhancing learner engagement, motivation, and retention. In the context of hybrid education, gamification may provide neurodiverse students with predictable structures, intrinsic incentives, and immersive experiences that support both emotional regulation and cognitive scaffolding (Cascio, 2025; Cottingham & Spear, 2025; Gallagher et al., 2025; Jiang et al., 2025; Robinson & Crane, 2025). However, its implementation must be grounded in the principles of Universal Design for Learning (UDL) to ensure accessibility for all learners, regardless of ability.

Despite efforts to implement inclusive practices, many existing hybrid learning environments remain poorly equipped to support the participation of neurodiverse students. Learning platforms and lesson designs often privilege neurotypical ways of processing information, leading to instructional misalignment and learner frustration (Gawlik-Starzyk et al., 2025; Gibbs et al., 2025; Sattler, 2025; Valdez-Montero et al., 2025). Sensory sensitivities, executive functioning challenges, and atypical communication styles are rarely considered in the architecture of digital content or classroom workflows.

Educators frequently struggle to adapt their instruction in real-time to accommodate the moment-to-moment needs of neurodiverse learners. Standard approaches to differentiation are often labor-intensive and rely on teacher intuition rather than systematic design principles. In hybrid formats, where students may be participating asynchronously or in varying contexts, this complexity is amplified (Glanville et al., 2025; Lamoureux et al., 2024; Shepherd, 2025; Steiner-Hofbauer et al., 2025). The lack of universally accessible frameworks leads to inconsistencies in engagement, participation, and academic progress for neurodiverse populations.

There is also a notable absence of tools that leverage neurodiverse learners' strengths—such as visual-spatial reasoning, pattern recognition, or hyperfocus—in meaningful pedagogical ways. The overemphasis on remediation and normalization often positions neurodiversity as a deficit rather than a resource (Edwards et al., 2025; Pesqueira et al., 2025; Seelemeyer et al., 2025; Tercan & Bayhan, 2025). Instructional models that center neurodiverse ways of learning remain underdeveloped, particularly in relation to digital platforms and gamified structures that could otherwise support learner agency, autonomy, and inclusion.

This study aims to design, implement, and evaluate a gamified hybrid learning model tailored to the cognitive and sensory needs of neurodiverse secondary school students. The central goal is to enhance educational accessibility and equity by aligning instructional methods with UDL principles and gamification theory (Alper et al., 2024; Cottingham & Spear, 2025; Mori, 2025; Wolpe et al., 2025). The research explores how such models can optimize both engagement and learning outcomes while fostering psychological safety in diverse learning environments.

The study seeks to answer key questions regarding the effectiveness of gamified instructional elements in supporting focus, motivation, and task completion among neurodiverse learners. Specifically, it investigates how components such as point systems, levels, badges, choice-based narratives, and feedback loops can be configured to minimize anxiety and cognitive overload while maximizing autonomy and sustained attention. The research further explores how these elements perform across both digital and face-to-face modalities in hybrid settings.

The broader objective of this research is to contribute a set of design principles and implementation strategies that can inform policy, teacher training, and curriculum development in inclusive hybrid education. By centering neurodiverse voices and experiences, the study intends to

reshape current understandings of what accessible instruction entails and to promote a more asset-based, student-centered approach to educational innovation.

Existing literature on gamification in education has predominantly focused on general learner motivation and engagement, often within homogeneous classroom populations. Few studies have critically examined how gamified learning environments interact with neurodiverse learners' cognitive styles and sensory profiles. Research addressing gamification tends to prioritize extrinsic rewards and behavioral outcomes rather than inclusive design and long-term developmental trajectories.

This study addresses that gap by investigating how gamified hybrid instruction can improve engagement, focus, and autonomy among neurodiverse learners. It seeks to develop an empirically tested instructional model that is inclusive, flexible, and scalable in diverse educational contexts.

Hybrid learning environments themselves are still emerging in the literature, particularly concerning their efficacy for neurodiverse populations. Most empirical work on hybrid formats focuses on general learner populations and tends to assume uniform access, attention, and communication styles. There is a need for research that addresses the intersection of hybrid learning, neurodiversity, and gamified engagement, thereby filling a critical gap in inclusive instructional design research.

This research introduces an innovative intersection between gamification, hybrid pedagogy, and neurodiverse inclusion-areas that are often treated in isolation. The novelty lies in its methodological integration of design-based research, learner-centered feedback loops, and empirical testing of accessibility features grounded in UDL. By centering the neurodiverse learner, the study redefines gamification not merely as a tool for motivation but as a framework for ethical and inclusive learning.

The study is justified by the urgency to create educational models that do not just accommodate but actively embrace learner diversity in its full spectrum. The rise of digital learning has accelerated the need for accessible and adaptive pedagogies, yet neurodiverse learners continue to face systemic exclusion. This research responds to that challenge by proposing instructional blueprints that are both technologically feasible and humanistically informed.

The significance of the study also rests in its potential for scalability and cross-contextual application. The instructional model developed can inform policy-level decisions in inclusive education, contribute to teacher training curricula, and inspire edtech developers to prioritize accessibility from the outset. By grounding its innovation in empirical analysis and participatory design, the research bridges a crucial gap between inclusive intent and actual practice in 21st-century education.

## RESEARCH METHOD

### *Research Design*

This study applied a Design-Based Research (DBR) framework consisting of four stages: (1) needs analysis, (2) prototype design, (3) iterative implementation, and (4) evaluation. The model was tested in three inclusive schools in Jakarta and Bandung. Participants included 72 neurodiverse students aged 12–16 with formal diagnoses of ASD, ADHD, or dyslexia. The research focused on the co-construction of learning environments that integrated gamification principles with Universal Design for Learning (UDL) frameworks (Cashin et al., 2025; Hughes et al., 2025; Pritchard-Rowe et al., 2025). The dual aim was to enhance student engagement and accessibility within hybrid educational settings.

### *Research Target/Subject*

The research was conducted in three inclusive secondary schools located in urban and semi-urban regions. The population included neurodiverse students formally diagnosed with autism spectrum disorder (ASD), attention-deficit/hyperactivity disorder (ADHD), or specific learning disabilities such as dyslexia. A purposive sampling strategy was used to select 72 students aged 12 to 16 who regularly participated in hybrid classes using digital platforms alongside in-person instruction. Six classroom teachers and three special education coordinators were also included to support the implementation and feedback phases of the model.

### *Research Procedure*

The procedures consisted of four key stages: initial needs assessment, prototype design, implementation, and evaluation. During the needs assessment stage, focus group discussions with stakeholders helped identify challenges and opportunities in current hybrid learning practices. In the

design phase, a prototype instructional model was created that included gamified modules featuring point systems, badges, choice boards, sensory-friendly design elements, and multi-modal feedback mechanisms. Implementation occurred over 10 weeks, during which the model was integrated into existing lesson plans and iteratively refined through weekly teacher reflection logs. Evaluation involved triangulating observation data, analytics, and participant feedback to assess the effectiveness of the model and generate design principles for future application. Ethical clearance was secured, and informed consent was obtained from all participants and their guardians.

### *Instruments, and Data Collection Techniques*

Data collection utilized a combination of qualitative and quantitative instruments. Observation checklists were used to monitor behavioral indicators of engagement, frustration, and focus during learning activities. Structured interview protocols captured student, teacher, and parent perceptions of the gamified learning environment. Digital analytics tools embedded in the hybrid learning platform tracked task completion rates, interaction patterns, and time-on-task data. A pre- and post-intervention survey, adapted from validated UDL and gamification perception scales, measured shifts in student motivation, confidence, and perceived accessibility.

## **RESULTS AND DISCUSSION**

The quantitative data obtained from the pre- and post-intervention surveys indicated measurable improvements in student engagement, motivation, and perceived accessibility within the gamified hybrid learning environment. A descriptive statistical analysis of 72 neurodiverse students showed that average task completion rates increased from 63% to 87% following the intervention. Table 1 presents the comparative results of three key variables: task completion, focus duration, and self-reported learning confidence before and after the implementation of the gamified instructional model.

Table 1. Descriptive statistics of student engagement indicators before and after gamified hybrid learning intervention (n=72)

<b>Indicator</b>	<b>Pre-Intervention Mean</b>	<b>Post-Intervention Mean</b>	<b>Mean Difference</b>
Task Completion Rate (%)	63.2	87.4	+24.2
Focus Duration (minutes)	18.5	28.7	+10.2
Learning Confidence (1–5)	2.9	4.1	+1.2

The increase in task completion rate suggests that the incorporation of gamified elements contributed to sustained student effort and goal-directed behavior. Higher focus duration also indicates improved attentional regulation, particularly among students with ADHD who commonly struggle with maintaining concentration. Self-reported learning confidence rose significantly, reflecting a greater sense of competence and autonomy among students when interacting with personalized, game-based content.

The qualitative data gathered from teacher reflections and observational checklists further support these quantitative findings. Teachers noted a reduction in off-task behaviors and a marked increase in student-initiated participation during both digital and in-person sessions. Game elements such as badges and levels appeared to generate enthusiasm and peer interaction, especially when tied to collaborative tasks or creative challenges. Students consistently favored visual feedback and progress tracking features integrated within the gamified modules.

The learning analytics data revealed that students spent more time on tasks when provided with autonomy-supportive features such as choice boards and branching pathways. These tools allowed learners to make decisions based on their preferences and pacing needs, which proved particularly effective for students with autism who benefitted from predictable structures and minimized cognitive overload. The most frequently accessed modules were those designed with interactive visual content and embedded audio cues.

Inferential analysis using paired-sample t-tests was conducted to assess the statistical significance of the pre- and post-intervention differences. Results confirmed that the observed improvements in task

completion rate, focus duration, and self-confidence were statistically significant ( $p < 0.01$ ) across the sample. Effect size calculations showed moderate to high impact levels, suggesting that the gamified hybrid instructional model produced meaningful changes in learner outcomes.

Correlation analyses explored the relationship between students' interaction patterns and their reported learning gains. A Pearson correlation coefficient of 0.68 was found between task completion and focus duration, indicating a strong positive relationship. A moderate correlation ( $r = 0.52$ ) was also observed between confidence scores and the number of completed game-based learning modules, pointing to a link between consistent engagement and self-efficacy development among neurodiverse students.

A focused case study was conducted on three students diagnosed with ASD, ADHD, and dyslexia, respectively. Each student demonstrated improved academic performance and behavioral engagement during the 10-week implementation. The student with ASD excelled in modules that featured predictable routines and visual scaffolds. The ADHD-identified student showed increased time-on-task when engaged in short, reward-based challenges. The student with dyslexia benefitted from audio-supported text and adaptive pacing options, which minimized reading fatigue and frustration.

Individual interviews and parent feedback corroborated these patterns. Parents reported increased enthusiasm toward school tasks and reduced resistance to homework in the observed students. Teachers observed that the gamified design facilitated better classroom transitions, minimized behavioral disruptions, and promoted social interaction among learners who previously demonstrated signs of withdrawal or disengagement.

The convergence of quantitative and qualitative data provides a strong basis for interpreting the effectiveness of the model. The statistically significant results, supported by lived classroom experiences, suggest that gamified hybrid learning tailored for neurodiverse students not only improves cognitive outcomes but also fosters emotional engagement and inclusion. The adaptive nature of the design, grounded in UDL principles, appears to meet a range of learning needs across neurodevelopmental profiles.

The results of this study provide compelling evidence that gamified hybrid learning models significantly enhance engagement, focus, and self-confidence among neurodiverse students. Quantitative data demonstrated substantial gains in task completion rates, sustained attention, and learner confidence following the integration of gamification elements designed within a Universal Design for Learning (UDL) framework (Ferriero et al., 2024; Gorbea, 2025; Granland et al., 2025; Lembo et al., 2024; Shiels et al., 2025). Observational and interview data supported these findings by highlighting increased participation, reduced behavioral disruptions, and improved autonomy in both face-to-face and digital learning contexts. These outcomes confirm the effectiveness of personalized game-based features in fostering inclusive learning environments.

The findings align with prior research that has underscored the motivational potential of gamification in education but diverge in their focus on neurodiverse populations within hybrid learning settings. Earlier studies such as Hamari et al. (2014) emphasized gamification's effect on general engagement, yet lacked attention to neurocognitive variability (Hillier et al., 2025; Kersten et al., 2025; Mukwezwa Tapera et al., 2025; Swanepoel, 2024). This research extends the discourse by showing how gamification, when aligned with UDL principles, can serve not only as an engagement tool but as a structure for accessible pedagogy tailored to the needs of learners with ASD, ADHD, and dyslexia. The hybrid implementation across both digital and physical environments also distinguishes this study from purely online or classroom-based investigations.

The findings point toward a transformative shift in how inclusive education can be conceptualized and operationalized. The effectiveness of the model indicates that gamified learning, when built on neurodiversity-affirming practices, can create psychologically safe and academically empowering spaces (Lapon et al., 2025; Zaneva et al., 2024). The significant gains in student confidence and self-regulation suggest that instructional design can serve as both a cognitive scaffold and an emotional anchor. This study marks a departure from deficit-oriented views of neurodiversity and reinforces the value of leveraging learners' strengths in instructional design.

The implications of these findings are substantial for curriculum designers, teachers, school administrators, and policy makers. The success of gamified hybrid learning suggests that inclusive instruction does not require isolated interventions but can be embedded systematically into mainstream pedagogical models. Educational institutions can implement such designs not only to support

neurodiverse learners but also to improve the learning experiences of all students by promoting flexibility, engagement, and learner autonomy. Professional development programs must begin to integrate training in gamification and UDL-based design to empower teachers with the tools and mindsets needed for inclusive digital education.

The success of the intervention can be attributed to its adherence to UDL principles and its grounding in the specific needs and strengths of neurodiverse learners. The model's flexibility in content delivery, task variation, and feedback mechanisms reduced cognitive overload while increasing emotional safety and motivation. The inclusion of visual scaffolds, predictable routines, and reward-based progression resonated with the sensory and executive functioning profiles of the participating students (Bircanin et al., 2025; Scavarda & Cascio, 2025; Shepherd, 2025). Teacher involvement in the co-design process further ensured that the model was contextually relevant and responsive to classroom realities.

The research settings contributed to the favorable outcomes, as participating schools already had strong inclusion programs and adequate digital infrastructure. Student familiarity with hybrid learning platforms created an environment conducive to gamified instruction. Educators' openness to experimentation and their commitment to reflective practice also facilitated smoother integration. These contextual factors underline the importance of institutional support, professional readiness, and co-creation in the successful implementation of innovative instructional designs.

Future directions for research and practice should include longitudinal studies to examine the sustained impact of gamified hybrid models on academic achievement and social-emotional development. Broader studies across various educational levels, including primary and tertiary institutions, would enhance the generalizability of the findings. Future designs should also explore adaptive gamification frameworks that allow for dynamic adjustment based on real-time learner data. Inclusion of neurodiverse voices in the design process must remain central to all development efforts.

Educational systems must now embrace innovation not as an added feature, but as a core element of equitable instruction. The integration of gamified hybrid learning into mainstream curricula has the potential to shift the paradigm of inclusive education from accommodation to co-creation. Policymakers should consider incentivizing research and development of accessible digital learning environments, while institutions should invest in teacher training that emphasizes inclusive, engaging, and flexible pedagogy. This research offers a roadmap for doing so, grounded in empirical evidence and guided by a deep respect for learner diversity.

## CONCLUSION

His study confirms that gamified hybrid learning models, when grounded in UDL, significantly enhance focus, motivation, and self-confidence among neurodiverse students. The integration of reward systems, personalized pacing, and visual scaffolding. Unlike previous studies that focused solely on motivation or behavioral outcomes, this research demonstrates that gamification—when deliberately structured around neurocognitive diversity—can serve as a pedagogical catalyst for both academic and socio-emotional development. Personalized game elements, such as choice-based modules, progress tracking, and reward systems, contributed to a learning environment where neurodiverse students could thrive without the need for stigmatizing accommodations.

This study offers a methodological contribution through the integration of design-based research (DBR) with inclusive instructional design, providing a replicable framework for developing universally accessible learning environments. The research combines real-time learning analytics, qualitative feedback, and co-designed learning modules to form a model that is both adaptable and scalable. Its conceptual strength lies in framing gamification not merely as a motivational tool but as a means of operationalizing inclusive pedagogy within hybrid formats. This positions the study as a bridge between inclusive education theory and its practical application in technologically mediated contexts.

The primary limitation of this research is its implementation within relatively well-resourced educational settings that already supported inclusive practices and had access to robust digital infrastructure. The sample size, although diverse in neurological profiles, was geographically limited, which may affect the generalizability of the findings. Future research should examine how gamified hybrid learning can be adapted to underserved or low-resource environments, and investigate its long-term impact on academic achievement, social integration, and emotional regulation. Further exploration

is also needed into how adaptive AI technologies can dynamically respond to neurodiverse needs within gamified platforms.

## AUTHOR CONTRIBUTIONS

Rachid Belhaj: Conceptualization; Project administration; Validation; Writing - review and editing; Conceptualization; Data curation; In-vestigation.

Nadia Ait Ali: Data curation; Investigation; Formal analysis; Methodology; Writing - original draft.

Ibrahim Boulahrouf: Supervision; Validation; Other contribution; Resources; Visuali-zation; Writing - original draft.

## CONFLICTS OF INTEREST

No conflict interest.

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