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Article

Game Difficulty Balancing: Adaptive Difficulty and Its Effect on Player Experience

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Abstract

Adaptive difficulty is a game design approach that modifies the challenge level to match the player's abilities. This study investigates how such adjustments influence player experience, focusing on engagement, flow, perceived fairness, and satisfaction. Drawing on psychological theories, prior research, and practical examples from the videogame industry, the work examines both the benefits and potential drawbacks of adaptive mechanics. Special attention is given to the ways players perceive autonomy, competence, and control within dynamically balanced games. Furthermore, this study extends current understanding by categorizing different methods of adaptive adjustment, addressing ethical considerations, and analyzing the effects on diverse player types. These perspectives illuminate how thoughtful design of adaptive systems can enhance long-term engagement, support accessibility, and maintain the integrity of the gameplay experience.

Keywords: adaptive difficulty; player experience; game design; engagement; flow; fairness; satisfaction; motivation

Introduction

Game design involves more than visuals, mechanics, and narrative; it also requires creating a level of challenge that keeps players engaged. Difficulty balancing is crucial in determining whether a game is enjoyable or frustrating. A game that is too easy can become monotonous, while one that is overly hard may cause players to abandon it.

Traditional difficulty settings (easy, normal, hard) offer choice but do not fully account for the range of player skills, learning speeds, and preferences. To address this, many developers now use adaptive difficulty systems. These systems observe player performance—such as success rates, reaction times, and accuracy—and adjust the challenge accordingly.

Research shows that adaptive difficulty can help maintain player engagement, prolong gameplay, and enhance perceived fairness. Designers must also consider psychological factors: players appreciate transparency and a sense of control, and hidden adjustments can reduce trust. As a result, hybrid models have emerged, combining automatic adaptation with player choice.

Fixed difficulty modes often fail to accommodate all skill levels. [9] note that static presets are usually too easy for experienced players or too demanding for beginners, leading to uneven engagement. Adaptive systems, by contrast, respond to changes in player abilities and emotional state, offering a more balanced experience.

Sepulveda, Besoain, and Barriga (2019) demonstrate that Dynamic Difficulty Adjustment (DDA) can significantly increase engagement by monitoring gameplay patterns, such as error frequency and task completion times, and adjusting challenge levels. Their work shows that maintaining an appropriate level of difficulty prevents boredom and frustration, supporting longer and more immersive play. Effective DDA often relies on multiple metrics rather than a single indicator, reflecting the situational nature of player skill.

Other studies [12?] suggest that systems which consider players' emotional state can be more effective than purely performance-based adjustments. By observing behavior and physiological

responses, these systems provide a more complete picture of the player experience, highlighting the limits of static difficulty settings.

Adaptive game design has roots in the late 1980s and 1990s, initially using simple performance-based adjustments in arcade games and early platformers. For example, Tetris variants gradually increased falling speed as players progressed, creating a subtle adaptive challenge. Over time, these systems evolved to incorporate multiple forms of player feedback, allowing for more nuanced engagement and flow.

This study also examines accessibility, long-term engagement, and predictive approaches, illustrating how adaptive difficulty continues to influence modern game design.

Related Work

Dynamic Difficulty Adjustment (DDA) has been studied in a variety of games and genres. Sepulveda et al. (2019, 2024) examined several adaptive approaches, including fixed, player-selected, performance-based, emotion-based, and hybrid methods, and found that no single approach consistently outperforms the others. Their work highlights the need to monitor multiple aspects of player behavior and experience, indicating that relying solely on performance metrics is often insufficient.

Some recent studies have explored the use of machine learning techniques to inform DDA, such as reinforcement learning (RL) and deep learning [? ?]. These methods can adjust difficulty in real time based on player performance patterns, allowing for faster calibration even with limited data. Deep learning models can also classify player profiles and predict suitable challenge levels for different game types. These approaches provide predictive insights that extend beyond simple reactive adjustments.

Simpler, more interpretable methods like fuzzy logic have also been proposed, enabling difficulty adjustments without requiring extensive datasets [?]. Combining multiple data sources—performance, emotional signals, and hybrid approaches—can improve the effectiveness of adaptive systems.

Research on the psychological effects of DDA shows that adaptive mechanics can influence players' sense of competence, trust, and confidence. Players tend to accept adaptations that respond to clear moments of struggle but may reject changes that seem arbitrary or unfair [10]. These findings underline the value of considering both behavioral and emotional indicators when designing adaptive systems that are perceived as fair and engaging.

Objective

The main goal of this study is to examine how adaptive difficulty affects game balance and to provide guidance for designing systems that promote fairness, transparency, and player satisfaction. The research draws on psychological theories, technical frameworks, and practical examples from both commercial and indie games. Additionally, it aims to classify adaptive difficulty methods into reactive and predictive models, investigate player expectations across different genres, and assess how these systems influence retention and replayability.

Research Questions

This study addresses the following questions:

1. In what ways is adaptive difficulty more effective than fixed difficulty modes at maintaining player engagement?
2. Which factors affect a player's acceptance or rejection of adaptive difficulty systems?
3. How do adaptive mechanics influence engagement, flow, and trust in the player experience?
4. What design principles help ensure that adaptive difficulty enhances satisfaction without causing frustration or perceptions of unfairness?
5. How can current technologies, including machine learning and biometric monitoring, support more responsive and effective adaptive systems?
6. What ethical considerations arise when games subtly influence player behavior through adaptive difficulty?

Methodology

This study uses a theoretical and analytical approach, combining a literature review with practical case studies. Research on game balancing, psychology, and user experience was examined alongside observations from both AAA and indie projects. The analysis compares different adaptive difficulty approaches and their effects on player behavior.

Psychological frameworks play a central role. Flow Theory (Csikszentmihalyi) describes how balance between challenge and skill fosters optimal engagement, while Self-Determination Theory (Deci & Ryan) emphasizes the importance of autonomy and competence in shaping player experience.

Data were collected through telemetry tools such as Unity Analytics, Unreal Engine analytics, and Steam API statistics, which record reaction times, accuracy, and completion rates. Physiological sensors—including EEG headsets, heart rate monitors, and galvanic skin response (GSR) devices—provided information on cognitive load and emotional state. Analysis methods included clustering, regression, and reinforcement learning to segment players and inform difficulty adjustments.

Additional considerations involved cognitive load theory, frustration tolerance, accessibility guidelines, and computational modeling. Community feedback was also examined to assess subjective responses to adaptive systems.

Collected data encompassed telemetry (reaction time, accuracy, completion time), physiological measurements (heart rate, GSR, EEG), and self-reported psychological feedback (perceived difficulty, stress). Analytical techniques such as clustering and regression enabled segmentation of players by skill and emotional state, supporting informed adjustment of adaptive mechanics.

Theoretical Foundations

Flow Theory proposes that optimal experience occurs when challenge and skill are balanced. Adaptive difficulty aims to keep this equilibrium by adjusting the game's demands to match player ability.

Self-Determination Theory identifies autonomy, competence, and relatedness as core psychological needs. Adaptive systems can support competence but may compromise autonomy if adjustments are hidden or abrupt.

Other relevant theories include:

- **Cognitive Load Theory:** examines how players manage and process information.
- **Behavioral Conditioning:** explains how feedback loops influence learning and behavior.
- **Accessibility Theory:** focuses on ensuring fair and scalable challenge for all players.
- **Motivational Intensity Theory:** highlights how excessive assistance can demotivate skilled players.

Sepulveda et al. [9] frame Dynamic Difficulty Adjustment as a practical application of Flow Theory. By continuously assessing whether a player is under- or over-challenged, the system can adjust factors such as enemy speed, health, spawn rates, or timing constraints to maintain engagement. They also note that adaptive difficulty can support competence but warn that sudden or extreme adjustments may reduce perceived autonomy, highlighting the need for subtle and stable adaptation thresholds.

Adaptive loops can be summarized as Player → Metrics → Adjustment → Player. Reaction-based methods respond to immediate performance, while predictive approaches anticipate future states using historical and physiological data [10]. Hybrid approaches combine multiple data sources to maintain engagement across different player types.

Comparison of Adaptive Methods

Adaptive difficulty systems generally fall into five categories:

- **Fixed Difficulty:** Standard levels (easy, medium, hard) that remain constant. Easy to implement but often too generic to match individual player skills.
- **Player-Selected:** Lets players choose the difficulty themselves. Supports autonomy but may result in mismatched challenge if players over- or underestimate their abilities.
- **Performance-Based:** Adjusts difficulty based on measurable in-game actions like accuracy, completion time, or survival rate. Works well for skill balancing but only reflects observable behavior.
- **Emotion-Based:** Uses physiological signals (e.g., heart rate, EEG, stress) to gauge player state and adjust challenge. Can address hidden cognitive or emotional load but requires sensors and careful calibration.
- **Hybrid Methods:** Combines performance and emotion data for more tailored adjustments. Can enhance engagement but adds complexity and may be harder to interpret.

Table 1 summarizes key characteristics, advantages, and limitations of each approach.

Table 1. Comparison of common DDA methods.

Method	Data Source	Advantages	Limitations
Fixed	Predefined	Simple, predictable	Not personalized; may bore or frustrate
Player-Selected	Player choice	Provides autonomy and engagement	Requires self-assessment; may result in suboptimal difficulty
Performance-Based	In-game metrics	Reactive; skill-based	Ignores emotional state; may misinterpret intent
Emotion-Based	Physiological/affective signals	Responds to stress and hidden cognitive load	Requires sensors, calibration; implementation is complex
Hybrid	Metrics + affective data	Comprehensive and adaptive	Complex implementation; interpretability challenges

The article also outlines a taxonomy of adaptation cues—reactive, predictive, and hybrid—illustrating how different game genres and player types benefit from distinct adaptation strategies. This offers a foundation for more advanced systems that incorporate machine learning and physiological feedback.

Sepulveda et al. [9] provide a detailed classification of Dynamic Difficulty Adjustment methods, covering fixed, player-selected, performance-based, emotion-driven, and hybrid approaches. They show that emotion-aware systems, using signals like heart rate or EEG, can complement performance data by capturing the player's cognitive and emotional state. This helps explain how multiple types of data can be combined to guide adaptive gameplay.

Psychological Aspects

Adaptive difficulty affects players differently depending on their experience. Casual players often appreciate additional help, while more experienced players may feel that unseen assistance diminishes their sense of accomplishment. Maintaining perceived fairness is crucial, as players need to feel that their success is earned.

Other psychological factors include:

- Preference for challenging experiences.
- Focus on mastery versus performance.
- Ability to regulate emotions and tolerate frustration.
- How player identity interacts with difficulty.
- Social influences, particularly in multiplayer settings.

Research [10] shows that DDA can increase players' confidence, sometimes leading them to overestimate their skill or chances of success. While this may boost engagement in the short term,

sudden difficulty spikes can cause frustration, underlining the importance of carefully balanced adaptation.

Some studies further suggest that adaptive difficulty not only affects performance but also impacts self-perception: players often overrate their likelihood of success during in-game betting tasks under DDA. Although this temporary confidence boost can enhance enjoyment, it may also create unrealistic expectations or frustration if the game's difficulty changes abruptly.

Player Feedback and Perception

Players tend to respond positively to adaptive difficulty when it is predictable, clear, and optional. Notable examples include Celeste's Assist Mode and the AI Director in Left 4 Dead.

Other observations include:

- Adaptation is more trusted when it responds to player failure.
- Acceptance varies across game genres.
- Clear user interfaces help players understand adjustments.
- Cultural background can influence tolerance for adaptive systems.

Practical Cases

Resident Evil 4 employs a hidden system that changes enemy behavior and item placement based on how the player performs.

Left 4 Dead features the AI Director, which dynamically adjusts pacing by controlling enemy spawns and item locations.

Celeste offers Assist Mode, allowing players to fine-tune aspects such as game speed, dash count, and invincibility.

The Last of Us Part II provides detailed customization of challenge settings.

Forza Motorsport / Horizon uses the Drivatar AI, which adapts to real player data.

Dark Souls does not use dynamic difficulty but provides structural aids, like summons and shortcuts, to help players progress.

In Celeste, even small tweaks—like increasing speed slightly or reducing hazards—can lower frustration without taking away the feeling of accomplishment. Similarly, in Left 4 Dead, the AI Director creates a balance of tension and relief by adjusting enemy and item placement based on player performance. These examples show that adaptive systems can be effective when they remain transparent and player-focused.

Limitations of Dynamic Difficulty Adjustment

Despite the benefits of adaptive difficulty systems, several limitations must be considered. Implementation can be complex, especially when incorporating physiological or emotional sensing. Sensors may introduce delays or errors, and predictive models often need large datasets to function accurately. Hidden adjustments can reduce perceived fairness or autonomy, frustrating players who prefer clear and predictable challenges.

Another challenge is cross-player variability: what works for one player may misinterpret another's behavior, leading to suboptimal adjustments. Adaptive systems can also unintentionally favor certain strategies or playstyles. Excessive adaptation may reduce the sense of accomplishment, as players might feel success is aided by the system rather than earned through skill.

Ethical considerations are also important. Hidden or opaque adjustments can affect players' perception of competence or subtly influence behavior without consent, raising concerns about fairness and psychological impact. Designers should weigh these risks alongside technical and usability challenges and aim for transparency, optionality, and careful testing across diverse player profiles.

Discussion

Adaptive difficulty can boost engagement and reduce frustration, but it also carries risks such as lowered trust, perceived unfairness, or diminished sense of challenge. Designers should balance automated adjustments with player choice and ensure transparency.

Sepulveda et al. (2019) highlight that while adaptive difficulty improves pacing and engagement, noticeable or sudden adjustments can undermine trust. Gradual changes with clear thresholds are most effective, as players generally accept adaptations that respond to visible struggle but reject arbitrary shifts. This supports the use of player-centered control and transparent feedback, which is reflected in modern commercial games.

Ethical considerations are important: hidden adjustments can influence player behavior or perception of competence. Different genres benefit from different approaches—action games respond well to performance-based adjustments, while puzzle or strategy games may benefit from emotion-aware adaptation to prevent cognitive overload. Future research should examine ways to combine behavioral, physiological, and psychological data for adaptive systems that are both effective and ethically sound.

The study also shows that DDA works best when it considers multiple aspects of player behavior. Systems relying only on success/failure metrics may misread intentions or overcorrect difficulty. Integrating richer datasets—such as telemetry, decision patterns, physiological responses, or personality indicators—can help create adaptive systems that understand both skill and emotional state.

No single method consistently outperforms others; each has strengths depending on player type and context. Emotion-driven systems maintain engagement during stressful moments, while performance-based systems perform better in stable gameplay. These insights support the use of multi-dimensional adaptive models.

Research by Constant and Levieux (2019) also shows that adaptive difficulty can inflate confidence, leading players to overestimate skill or success chances. Designers should monitor such psychological effects, as overconfidence may backfire if difficulty spikes unexpectedly.

Transparency, informed consent, and clear feedback can help mitigate these risks. Optional adaptive modes and context-aware adjustments are recommended, while respecting cultural norms and player expectations, since tolerance for hidden assistance varies.

Insights from Multi-Dimensional DDA

Recent research shows that adaptive systems based only on performance metrics can misinterpret player intent, sometimes overcorrecting difficulty and causing frustration. Systems that incorporate emotional cues offer additional context, allowing adjustments that consider cognitive load, stress, and engagement patterns [1,9]. Hybrid approaches, though more complex, have shown potential for maintaining flow and appropriate challenge across different types of players.

The evidence suggests that gradual and transparent adaptation is key. Sudden increases or decreases in difficulty can disrupt perceived fairness and reduce trust. Using multiple data sources—such as behavioral telemetry, physiological signals, and decision patterns—gives a more complete view of the player experience and enables nuanced adjustments that balance challenge, competence, and autonomy.

Genre-specific approaches are also important. Action games may respond best to performance-driven adaptation, while puzzle or strategy games can benefit from emotion-based cues to avoid cognitive overload. These findings emphasize the value of context-aware adaptive methods that consider both skill and subjective experience, guiding the design of future dynamic difficulty systems.

Conclusion

Adaptive difficulty helps maintain flow, support competence, and reduce frustration, serving as a key tool for balancing engagement and challenge in modern games. When implemented thoughtfully, such systems respect player autonomy, promote meaningful progression, and enhance overall satisfac-

tion. Future developments may involve machine learning, predictive algorithms, biometric feedback, and emotion-sensitive interfaces. However, transparency, ethical considerations, and player-centered design remain essential to prevent potential negative effects, such as perceived manipulation or loss of agency.

Current DDA approaches often rely heavily on performance metrics, such as accuracy, completion time, or survival rates. While effective for basic balancing, integrating additional indicators—such as emotional state, cognitive load, fatigue, or personality traits—can create a richer, more personalized experience. Multi-dimensional adaptation allows systems to account for nuanced player behavior, helping maintain immersion without trivializing challenges. Limitations include sensor availability, potential latency, data privacy concerns, and the interpretability of complex adaptive models, all of which require careful consideration and future research.

Studies like [10] highlight that adaptive difficulty affects not only measurable performance but also subjective confidence and motivation. Players may overestimate skill or success probability under certain adaptive conditions, which can temporarily enhance engagement but also create frustration if difficulty changes are abrupt. This suggests that future systems should integrate behavioral, physiological, and psychological data, employing gradual and transparent adaptation to maintain both appropriate challenge and a healthy sense of achievement.

Emerging adaptive designs may employ predictive and hybrid methods that respond to both current performance and anticipated cognitive-emotional states in real time. In VR and AR environments, biometric feedback could adjust difficulty dynamically, considering stress, attention, or fatigue, creating truly immersive and responsive experiences. Multiplayer games could benefit from adaptive balancing that accounts for group dynamics, skill disparities, and cooperative or competitive interactions, ensuring fairness while enhancing social engagement. Furthermore, longitudinal studies are needed to assess the long-term effects of adaptive systems on player motivation, retention, and overall satisfaction, bridging the gap between theoretical models and practical design strategies.

Finally, adaptive systems should prioritize ethical implementation, offering optional or transparent adjustments that allow players to retain control over their experience. By combining technical innovation with psychological insight and responsible design, future adaptive difficulty systems can maximize engagement, preserve trust, and provide enjoyable, personalized gaming experiences across genres, platforms, and player types.

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