

KEMI Journal of Educational Leadership and Management

KJELM

[ISSN 3079-4048]

Volume: 2 Issue: 2 | Aug-2026

Gamification in education: A review of competency-based education (CBE), motivation & engagement through game-based learning in the 21st century

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Cite this article in APA

https://doi.org/10.68147/c1ca2868

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Abstract

As educational institutions transition from traditional time-based models to competency-driven frameworks, there is limited understanding of how to best integrate game elements to support Competency-Based Education (CBE) and sustain motivation and engagement in a self-paced, proficiency-oriented learning environment. A systematic review of 54 peer reviewed articles/scholarly sources was completed identifying patterns in gamification implementation, theoretical frameworks, learning outcomes and critical success factors in order to review insights for CBE contexts. Grounded in Self-Determination Theory and Achievement Goal Theory, this review synthesized research evidence on game elements (badges, leaderboards, adaptive challenges and feedback) addressing motivation needs and supporting competency mastery. The review concluded that gamification supports CBE through competency visualization, progress indicators and sustained engagement, and identified key success factors and design principles for implementation. This research aims to contribute evidence-based gamification insights for CBE for educators and instructional designers developing innovative competency-based learning systems.

Key terms: gamification, competency-based education, motivation, Self-Determination Theory, systematic review

1. INTRODUCTION

1.1 Background and context

The 21st century educational landscape is undergoing a fundamental transformation as educational institutions re-evaluate traditional time-based learning models in favour of competency-based learning

(Nodine, 2016). Competency-Based Education (CBE) represents an approach which focuses learners on competency mastery rather than seat time, allowing learners to progress upon demonstrating proficiency regardless of the time required (Johnstone & Soares, 2014). This student-centered approach meets the demand for verified competencies and transferable skills for the modern workforce, addressing the disconnect between educational credentials and actual capability (Klein-Collins, 2012).

While the benefits of CBE are evident, the implementation faces challenges, notably in sustaining motivation and engagement within a self-paced learning environment (Ordonez, 2014). Traditional educational structures contain extrinsic motivators in the form of fixed schedules, peer comparison and time-bound assessments. Without these structures in favor of individualized progression pathways, learners face challenges with self-regulation, persistence and sustained engagement (Zimmerman & Schunk, 2011). The absence of cohort-based progression leads to isolation while the emphasis on repeated assessment until mastery may result in anxiety or frustration (Gervais, 2016).

1.2 Gamification as a pedagogical strategy

Gamification (application of game design elements and game principles in non-game contexts) has been proposed as a pedagogical strategy to address motivational challenges in CBE contexts (Deterding et al., 2011). Research suggests that well-designed gamification can increase student engagement by up to 60% and knowledge retention by 40% compared to traditional instructional methods (Hamari et al., 2014). The combination of gamification with CBE frameworks is underexplored, resulting in a lack of understanding of how game mechanics support competency mastery, self-paced learning and sustained motivation in proficiency-oriented systems (Papp, 2017).

1.3 Research problem

The study aims to address the problem of limited understanding of how game design elements can effectively enhance mastery-based learning environments which are characteristic of CBE. While extensive research on gamification in traditional educational settings and separately on CBE implementation exist, the intersection of these domains is lacking in investigation (Nicholson, 2013). Educational institutions implementing CBE need to know what gamification strategies effectively support competency visualization, provide meaningful feedback, facilitate autonomous learning and maintain long-term motivation without undermining intrinsic learning goals (Ryan & Deci, 2000).

1.4 Research objectives and questions

The study aims to examine gamification as a pedagogical strategy supporting Competency-Based Education, focusing on addressing motivation and engagement challenges in self-paced, proficiency-oriented learning systems. The research questions are:

1. How do specific game design elements (badges, leaderboards, adaptive challenges and feedback loops) support competency mastery in Competency Based Education?
2. What theoretical frameworks effectively explain the relationship between gamification mechanics and learner motivation in competency-based contexts?
3. What are the critical success factors for implementing gamification in Competency Based Education systems?
4. What design principles should guide the development of gamified competency-based learning environments?

2. LITERATURE REVIEW

2.1 Competency-Based Education: Foundations and Challenges

Competency-Based Education represents a learner-centered approach where progression is based on demonstrated mastery of clearly defined competencies rather than accumulated credit hours (Porter & Reilly, 2014). The CBE framework typically includes five key elements: learning outcomes defined by demonstrated competencies, flexible time-based progression, student support systems, transparent competency documentation and valid and reliable assessment of learning (Johnstone & Soares, 2014).

The theoretical foundations of the Competency Based Education draw from constructivism, mastery learning theory and adult learning principles (Knowles et al., 2014). Bloom's (1968) mastery learning approach, suggesting that all students can learn given adequate time and appropriate instruction, provides the instructional foundation. CBE operationalizes this through clearly articulated learning outcomes, formative assessments, targeted interventions and summative demonstrations of competency (Guskey, 2010).

Research on CBE implementation highlights several challenges. First, the transition from time-based to competency-based systems requires a fundamental transformation of curriculum, assessment, credentialing and student support services (Nodine, 2016). Students used to traditional structures struggle with the increased responsibility for self-paced learning and the ambiguity of variable progression timelines (Book, 2014). Maintaining motivation without the extrinsic pressures of fixed deadlines and competitive grading proves difficult for many learners (Ordonez, 2014). Finally, the iterative assessment model, while pedagogically thorough, can result in assessment exhaustion and anxiety when learners require multiple attempts to demonstrate mastery (Gervais, 2016).

2.2 Gamification in educational contexts

Gamification emerged from the game design industry in the early 2000s and was defined by Deterding et al. (2011): "the use of game design elements in non-game contexts" (p. 10). Educational gamification refers to the application of game mechanics to learning contexts to increase engagement, motivation and desired learning behaviors (Kapp, 2012). Common gamification elements include:

- Points and scoring systems: quantification of progress and achievement
- Badges and achievements: visual representation of accomplishments and milestones
- Leaderboards: comparative displays of performance fostering healthy competition
- Levels and progression systems: structured advancement pathways
- Challenges and quests: goal-oriented tasks with clear objectives
- Feedback loops: immediate responses to learner actions
- Narrative and storytelling: contextual frameworks providing meaning to activities
- Avatars and personalization: customizable representations enhancing ownership (Dicheva et al., 2015).

Hamari et al.'s (2014) systematic review of empirical studies revealed that gamification largely produces positive effects on engagement and learning outcomes, but these effects are contextual. A meta-analysis by Sailer and Homner (2020) examining 38 studies found moderate positive effects on cognitive ($d = 0.49$), motivational ($d = 0.36$), and behavioral learning outcomes ($d = 0.25$).

2.3 Theoretical Frameworks

2.3.1 Self-Determination Theory

Self-Determination Theory (SDT), developed by Deci and Ryan (2000), offers the foundation for understanding motivation in gamified learning environments. SDT postulates that human motivation exists on a continuum from amotivation through extrinsic motivation to intrinsic motivation, with psychological well-being and optimal functioning associated with more autonomous motivation (Ryan & Deci, 2000). Crucial to SDT are three inherent psychological needs which when satisfied promote intrinsic motivation and psychological health:

1. Autonomy: the need to feel volitional and self-directed

2. Competence: the need to feel effective and capable

3. Relatedness: the need to feel connected to others (Deci & Ryan, 2000)

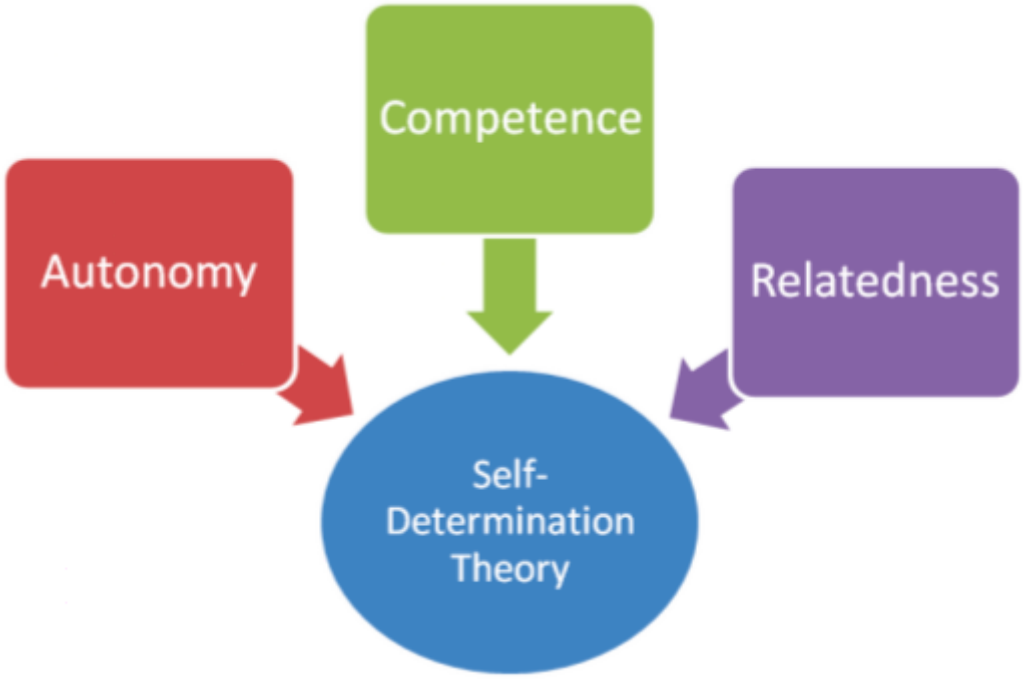


Figure 1: Psychological needs supported by Self-Determination Theory.

(Adapted from Deci and Ryan (2000) and Ryan and Deci (2020))

SDT suggests that learning environments supporting these needs will enhance intrinsic motivation, engagement, persistence and learning outcomes (Ryan & Deci, 2020). Gamification elements can theoretically support these needs: badges and levels provide competence feedback, choices and customization support autonomy, and social features support relatedness (Sailer et al., 2017). SDT also warns of risks in gamification implementation. External rewards like points and badges represent extrinsic motivators which according to cognitive evaluation theory (a sub-theory of SDT), undermine intrinsic motivation when perceived as controlling rather than informational (Deci et al., 1999). This suggests that gamification design must balance extrinsic game elements with support for intrinsic motivation through autonomy, competence, and relatedness satisfaction (Rigby & Ryan, 2011).

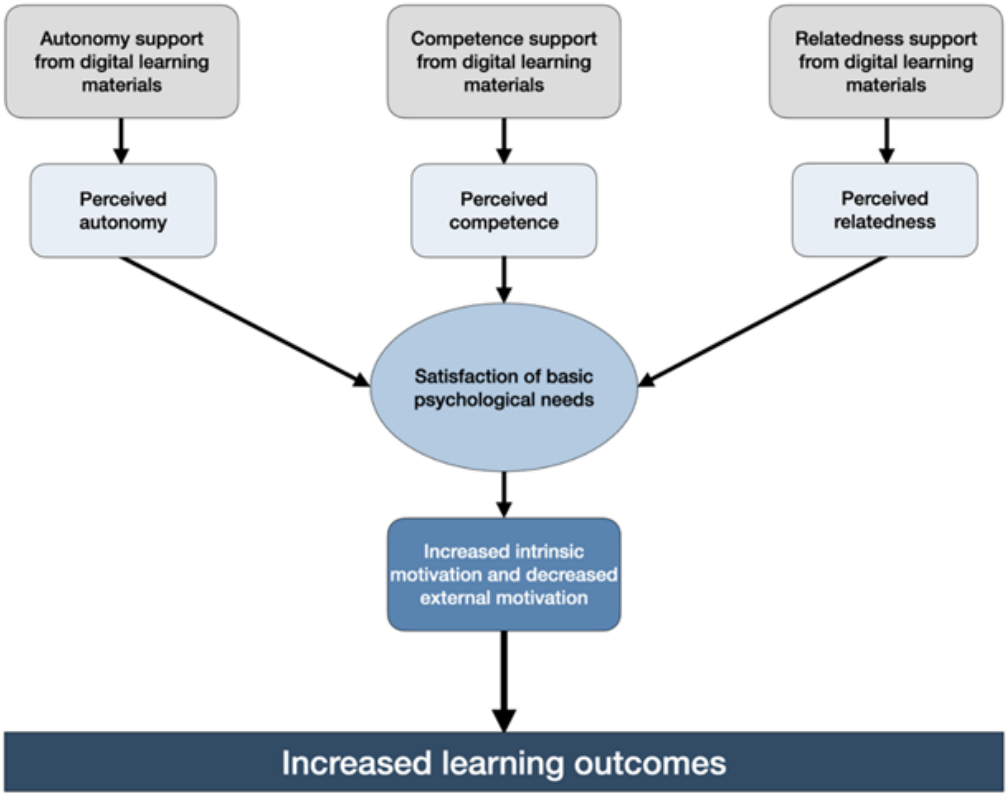


Figure 2: Self-Determination Theory and enhanced learning outcomes in gamified environments. Source: Adapted from Sailer et al. (2017) and Ryan and Deci (2020).

2.3.2 Achievement Goal Theory

Achievement Goal Theory (AGT) provides additional insight into how gamification influences motivation in learning contexts. AGT distinguishes between mastery goals (focused on developing competence and understanding) and performance goals (focused on demonstrating ability relative to others) (Dweck, 1986; Nicholls, 1984).

Research consistently shows that mastery goals correlate with adaptive learning patterns including persistence, deeper cognitive processing, help-seeking and attribution of success to effort (Ames, 1992). Performance goals, particularly performance-avoidance goals, associate with maladaptive patterns including anxiety, surface learning and connection of failure to lack of ability (Elliot & McGregor, 2001). This structure has implications for gamification in CBE. Elements like leaderboards may promote performance goals by emphasizing social comparison, potentially undermining the mastery orientation of competency-based approaches (Landers et al., 2017). Conversely, elements like progressive challenges, mastery badges and personalized feedback can reinforce mastery goals by emphasizing individual improvement (Buckley & Doyle, 2016).

2.4 Gamification and CBE: The Link

Ahn et al. (2014) explored gamification in competency-based teacher training, finding that game mechanics helped visualize complex competency progressions and sustain engagement through self-

paced modules. Papp (2017) proposed a theoretical framework for gamified CBE in higher education, arguing that game elements naturally align with CBE's emphasis on transparency, mastery and personalized pathways. Several characteristics make CBE particularly open to gamification:

1. Clear objectives: CBE's explicit competency statements align with game quests and achievements
2. Immediate feedback: Both CBE and games emphasize rapid performance feedback
3. Mastery orientation: Both frameworks prioritize skill development over time-based progression
4. Personalization: Both support individualized pathways based on current capability
5. Progressive challenge: Both employ scaffolded difficulty increases (Gibson et al., 2015)

3. METHODOLOGY

3.1 Research Design

This study employed a content analysis methodology to examine existing literature on gamification in competency-based educational contexts. Content analysis provides a rigorous, replicable method for making valid inferences from textual data by systematic coding and thematic identification (Krippendorff, 2018). This approach is appropriate for synthesizing diverse evidence on emerging educational innovations where empirical studies are limited but theoretical and applied literature is expanding (Bowen, 2009).

3.2 Data Collection

This review followed a systematic approach consistent with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure transparency and replicability (Moher et al., 2009). A comprehensive literature search was completed across multiple academic databases including ERIC (Education Resources Information Center), Web of Science, Scopus, Google Scholar and ProQuest Education Journals searching for publications from 2000 to 2023. Search strings combined controlled vocabulary and free-text terms using Boolean operators: ("gamification" and "game-based learning" or "game design elements") and ("competency-based education" or "CBE" OR "mastery learning" or "proficiency-based education") and ("motivation" or "engagement" or "self-determination" or "achievement goal"). Inclusion criteria comprised: peer-reviewed empirical studies or scholarly theoretical articles; direct focus on gamification or game mechanics in educational contexts; relevance to motivation, engagement or competency-based outcomes; and publication in English between 2000 and 2023. Exclusion criteria included: grey literature without peer review, studies focused solely on game-based learning without gamification elements, articles inaccessible in full text and studies examining non-educational gamification contexts without transferable pedagogical implications. The initial search yielded 218 records. After removing duplicates (n = 41), title and abstract screening excluded 89 irrelevant records. Full-text review of 88 remaining articles excluded 34 for not meeting inclusion criteria resulting in a final sample of 54 sources included in the content analysis.

3.3 Data Analysis

Thematic coding was applied using both deductive and inductive approaches (Fereday & Muir-Cochrane, 2006). Deductive codes originated from the theoretical frameworks (Self-Determination Theory and Achievement Goal Theory) and established gamification taxonomies. Inductive codes arose through iterative reading and analysis of the literature. The coding process followed three phases:

1. Initial coding: Open coding of all documents to identify key concepts, patterns, and themes

2. Focused coding: Consolidation of initial codes into broader thematic categories
3. Theoretical coding: Integration of themes into coherent analytical framework addressing research questions (Charmaz, 2006)

NVivo 12 qualitative analysis software was utilized for coding, theme management, and pattern identification. Inter-coder reliability was established through independent coding of 15% of documents by two researchers, yielding Cohen's kappa of 0.82 indicating substantial agreement (Landis & Koch, 1977).

4. FINDINGS

4.1 Game Elements supporting competency mastery

Analysis revealed that specific game design elements serve different functions in supporting competency-based learning. The most frequently implemented and researched elements include badges, leaderboards, points, levels, challenges, feedback mechanisms and progress visualization tools.

4.1.1 Badges and Digital Credentials

Badges emerged as particularly compatible with CBE frameworks, serving as visual representations of competency attainment (Gibson et al., 2015). Unlike traditional grades which aggregate performance across multiple dimensions, badges can represent specific, granular competencies, providing transparent documentation of discrete skills (Carey & Stefaniak, 2018). Research by Abramovich et al. (2013) found that meaningfully designed badges increased student goal-setting behaviors and persistence, particularly when badge criteria clearly articulated competency expectations. Effectiveness depends critically on badge design. Badges must represent authentic accomplishments rather than insignificant tasks to maintain credibility and motivation (Hickey et al., 2014). Ahn et al. (2014) established that badges aligned with professional competencies increased motivation in teacher education programs while generic badges for participation had minimal impact. The Open Badges framework, providing portable, verifiable digital qualifications, holds promise for representing stackable micro-competencies across educational contexts (Muilenburg & Berge, 2016).

4.1.2 Adaptive challenges and adaptive difficulty

Adaptive challenge systems (adjusting difficulty based on demonstrated competency) align naturally with CBE's mastery orientation (Landers & Landers, 2015). Studies indicate that appropriately calibrated challenges maintain optimal cognitive load and flow state, preventing both boredom from insufficient challenge and anxiety from overwhelming difficulty (Kiili et al., 2012). Lomas et al. (2017) established that adaptive gamified learning systems increased time-on-task by 32% and performance by 14% compared to static difficulty systems. The key mechanism appears to be maintaining learners in Vygotsky's (1978) "zone of proximal development" where challenges slightly surpass current capability, necessitating growth while remaining achievable (Shute & Ventura, 2013).

4.1.3 Feedback Loops and Progress visualization

Immediate feedback signifies a core element of both effective gamification and CBE (Papp, 2017). Game-inspired feedback systems offer multiple advantages over traditional grading: immediacy, specificity, actionability and repetition (Shute, 2008). Visual progress indicators such as skill trees, competency maps and completion percentages help learners understand their current status and remaining pathway to mastery (Iosup & Epema, 2014). These visualizations address a common CBE challenge helping students navigate self-paced learning without the structure of fixed syllabi and deadlines (Nodine, 2016).

4.1.4 Leaderboards and Social comparison

Leaderboards remain contentious in educational gamification research (Landers et al., 2017). While competitive elements can increase effort and engagement for some learners, they risk promoting performance goals over mastery goals and discouraging lower-performing students (Hanus & Fox, 2015). In CBE, where individualized progression means students work toward different competencies at different paces, traditional leaderboards based on simple point accumulation may be particularly inappropriate (Toda et al., 2019).

However, research recommends alternatives which maintain social elements while supporting mastery orientation. Collaborative leaderboards emphasizing collective achievement, personalized leaderboards comparing current performance to past performance and segmented leaderboards matching similar-ability peers show more positive effects on motivation and learning (Landers et al., 2019). Buckley and Doyle (2016) established that mastery-based leaderboards tracking competency attainment rather than speed or points increased inherent motivation compared to traditional competitive formats.

4.2 Theoretical Mechanisms: How Gamification Supports Motivation

4.2.1 Supporting Psychological Needs (SDT Framework)

Analysis via the Self-Determination Theory revealed how specific game elements satisfy the three psychological needs of autonomy, competence and relatedness (Sailer et al., 2017).

Competence Support: Game elements providing clear goals, immediate feedback and progressive challenges directly support competence satisfaction (Rigby & Ryan, 2011).

Autonomy Support: Personalization features, choice in challenge selection and flexible development pathways support autonomy needs (Nicholson, 2015). Effective gamification in CBE must provide structure without coercion, guiding without commanding (Reeve, 2009). Studies indicate that optional engagement with game elements, where core learning can proceed without gamification participation, better supports autonomy (Hanus & Fox, 2015).

Relatedness Support: Social game elements including collaborative challenges, peer feedback systems, and community features support relatedness needs (Mekler et al., 2017). In self-paced CBE environments, where students may feel isolated, social gamification features can recreate the peer connection of traditional cohort-based learning.

4.2.2 Promoting Mastery Goal Orientation

Achievement Goal Theory analysis revealed that gamification design choices significantly influence whether learners adopt mastery or performance goals (Buckley & Doyle, 2016). Game elements underscoring individual progress, skill development and iterative improvement promote mastery goals whereas elements emphasizing relative performance and social status promote performance goals (Landers & Landers, 2015).

4.3 Critical Success Factors

Synthesis of implementation studies identified six critical success factors for effective gamification in CBE contexts:

1. Alignment between game mechanics and learning competencies: The most consistent predictor of success was tight coupling between game elements and specific competencies (Dicheva et al., 2015).

2. Robust Assessment Integration: Effective systems integrated game progression with authentic competency assessment rather than treating them as separate activities (Papp, 2017).

3. Learner Autonomy and Choice: Systems providing learner choice in how to engage with game elements showed higher intrinsic motivation and persistence (Sailer et al., 2017).

4. Meaningful Feedback Quality: The educational value derives not from game elements themselves but from the quality of feedback they deliver (Shute, 2008).

5. Adaptivity and Personalization: Systems adjusting challenge and progression to individual learner capabilities showed stronger engagement and learning outcomes (Landers & Landers, 2015).

6. Balanced Extrinsic and Intrinsic Motivation: Successful implementations used extrinsic game elements (points, badges) as scaffolding to support intrinsic motivation rather than replacing it (Rigby & Ryan, 2011).

4.4 Learning Outcomes and Effectiveness Evidence

Empirical evidence on gamification effectiveness in CBE reveals primarily positive but contextually dependent outcomes.

Engagement and Persistence: Multiple studies demonstrate that gamification increases student engagement and retention in learning contexts. Specific gamification elements such as badges and leaderboards have been shown to enhance self-regulated learning (Landers et al., 2019).

Knowledge Retention: Gamification has been associated with improved knowledge retention compared to traditional instructional methods (Hamari et al., 2014). Personalized feedback in gamified environments appears to facilitate deeper cognitive processing than static assessments (Shute, 2008).

Learning Motivation: Gamification has positively impacted students' intrinsic motivation for learning (Landers & Landers, 2015). Mastery goal orientation resulting from gamification supports adaptive learning behaviors such as persistence (Buckley & Doyle, 2016).

5. DISCUSSION

The study reviewed insights on gamification to support Competency-Based Education, highlighting gamified elements enhancing competency mastery in CBE. The review revealed that gamification supports CBE through competency visualization, progress indicators and sustained engagement and identified critical success factors for implementation. Findings were discussed in terms of implications for Competency-Based Education, limitations in the literature and recommendations for future research.

Implications for Competency-Based Education

This study contributes to Competency-Based Education by reviewing current evidence on gamification for motivation and engagement in self-paced learning contexts. Understanding gamification's role in supporting CBE can inform institutional decision-making regarding the adoption of gamification strategies and the design of competency-based learning environments. The review highlights that gamification supports competency mastery in CBE through competency visualization, meaningful feedback and sustained engagement and suggests that effective gamification of CBE learning should focus on these areas.

Limitations

The study's limitations primarily relate to the scope of the literature review and the focus on gamification

strategies as a tool to support Competency-Based Education. Firstly, gamification as a pedagogical strategy is primarily conceptual, and while there is substantial research on its theoretical foundations and implications for motivation, there is limited evidence on its practical implementation in competency-based educational settings. Secondly, a systematic content analysis was conducted on a relatively limited volume of literature (54 sources) to explore the complex educational innovation, that is gamification. This approach may not capture the depth and nuance of gamification's impact in CBE contexts. Thirdly, while the focus was on gamification strategies in Competency-Based Education, the review did not examine the differences in effectiveness of gamification strategies among various student populations or educational contexts.

Recommendations for Future Research

Future research directions could explore the effectiveness of gamification strategies to support Competency-Based Education in different educational contexts, including higher education and professional development. Research could also investigate the long-term effects of gamification on the motivation and engagement of learners in self-paced learning environments. Another avenue for exploration is the development of personalized gamification strategies which consider students' differing motivation and learning needs. Finally, future research could utilize mixed-methods approaches to understand the impact of gamification on learning outcomes in CBE contexts.

6. RECOMMENDATIONS

Based on the research undertaken, this study presents several recommendations for stakeholders involved in the process of implementing gamified based Competency Based Education (CBE).

For instructional designers and educators

- Emphasize competencies over superficial rewards;
- Ensure the possibility for individualization of instruction in accordance with one’s own level of mastery;
- Make progression visibly clear;
- Provide learners with choice.

For educational technology developers

- Design flexible systems with regard to customization;
- Develop necessary analytical tools;
- Make products accessible for the target populations.

For institutional leaders

- Provide support for faculty members;
- Design evaluation systems that go beyond measuring engagement;
- Encourage redesigns of instruction.

For researchers

- Conduct further studies of longitudinal nature;

- Consider individual differences and personalize gamification;
- Study the possibility of transfer and application of competencies.

7. CONCLUSION

The present study's contribution to the field relates to the synthesis of the ways in which gamified elements may be utilized in CBE contexts. This research fills a significant gap in the scholarly literature by providing an extensive review of the literature on the topic. It was found that the application of theoretical frameworks related to Self-Determination Theory (SDT) and Achievement Goal Theory is an instrumental basis for examining the specific nature of motivational impact and the particular characteristics of engagement in gamified CBE contexts. Thus, the current review offers an in-depth understanding of how goal-setting and psychological needs fulfillment in gamified settings may be used to address the shortcomings of CBE-related education. Specifically, the motivational benefits of gamification in terms of autonomy support, enhanced sense of competence and progression through feedback were discussed. Additionally, the present study highlights the factors that should be taken into account in order to optimize the benefits of implementing gamification in CBE, namely, the need for the balance between extrinsic and intrinsic motivational drivers and individualization of the gamified intervention. For educational stakeholders, the findings of this study serve as an essential basis for implementing gamified CBE in a psychologically beneficial and educationally optimal manner.

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