International Advance Journal of Engineering, Science and Management (IAJESM)
Multidisciplinary, Indexed, Double Blind, Open Access, Peer-Reviewed, Refereed-International Journal.
SJIF Impact Factor =7.938, January-June 2024, Submitted in June 2024, ISSN -2393-8048

The Evolution of Teacher Trainee Engagement: Assessing Changes in Response to Game-Based Learning at Different Problem-Solving Stages

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Abstract

This research paper explores the evolution of teacher trainee engagement in response to game-based learning (GBL) at different problem-solving stages, utilizing the framework of Critical Theory. The study investigates how teacher trainees interact with GBL environments, how their engagement evolves through various stages of problem-solving and how systemic power structures and pedagogical assumptions impact their learning experiences. By employing a mixed-methods approach, this study assesses the implications of GBL for transformative learning in teacher education.

Keywords: Game-Based Learning, Teacher Trainee Engagement, Problem-Solving, Critical Theory, Pedagogical Transformation

1. Introduction

Game-Based Learning (GBL) in teacher education has emerged as a transformative pedagogical tool, fostering engagement, critical thinking, and skill development among trainees. The effectiveness of GBL, however, is not uniform and is significantly shaped by the problem-solving stages that teacher trainees undergo during the learning process. These stages involve identifying a challenge, exploring potential solutions, implementing strategies, and reflecting on the outcomes. Each phase contributes to a deeper understanding of teaching methodologies, cognitive flexibility, and adaptability. However, the impact of GBL extends beyond cognitive skill development and is deeply entrenched in the socio-political structures governing education systems. Educational policies, institutional frameworks, and hierarchical relationships within teacher training institutions play a crucial role in shaping how game-based strategies are perceived and implemented.

From the perspective of Critical Theory, particularly within the Frankfurt School tradition, GBL is not merely an instructional tool but a site of contestation where power dynamics and knowledge production intersect. Critical Theory critiques the structural inequalities embedded in educational institutions, highlighting how traditional pedagogies often reinforce existing hierarchies and limit transformative learning. The application of game-based learning in teacher education, therefore, must be examined through the lens of power relations—who designs the games, whose perspectives are represented, and how assessment mechanisms reinforce or challenge traditional academic authority. Furthermore, socio-political influences such as curriculum regulations, standardization policies, and funding priorities can either enable or constrain the integration of GBL. In many educational contexts, rigid assessment structures and bureaucratic constraints hinder the full realization of GBL's potential, reducing it to a supplementary tool rather than an integral part of teacher training. Moreover, Critical Theory underscores the importance of empowering teacher trainees to recognize and challenge ideological constructs embedded within game-based learning environments. If designed critically, GBL can serve as a medium for fostering agency, promoting social justice-oriented pedagogies, and encouraging teachers to question the educational status quo. The inclusion of problem-solving tasks that simulate real-world educational challenges allows teacher trainees to navigate complex classroom scenarios, experiment with inclusive teaching practices, and critically engage with issues of diversity, equity, and student-centered learning. However, without a conscious effort to integrate critical pedagogy into game-based approaches, there is a risk that GBL will merely replicate traditional educational models rather than disrupt them.

Learning new ideas and abilities through playing games, both digital and non-digital, is known as game-based learning (Grace, 2019). The use of games in the classroom has the

potential to greatly enhance educational results (Kula, 2021; Syafii, 2021). The two-stage process by which the game-based learning approach facilitates learning is outlined by Boctor (2013): On the one hand, students can see firsthand how their judgments and choices affect the game's consequences; on the other, games can encourage students to draw from a variety of fields and apply that knowledge when making decisions. The opportunity for kids to interact with one another and plan strategies for the game boosts their coordination, which in turn helps them become better social associates. Game-based learning has become the go-to approach for enhancing problem-solving abilities, which are crucial for assimilating into society. For example, Han (2015) discovered that students learn more and develop better problem-solving cognitive abilities when they learn through interactive sessions. It is also believed that game-based learning can boost student engagement by integrating many capacities into the learning process. In addition, research has shown that kids who play educational games outperform their non-gaming counterparts in a number of areas, including English language proficiency (Boctor, 2013). Consequently, combining learning with a game-based approach can effectively cater to both students' and teachers' interests. To sum up, game-based learning helps students become more engaged, improve their coordination, and unleash their creativity. This paper aims to analyze teacher trainee engagement within GBL, emphasizing how critical theory provides insight into the systemic influences affecting their learning trajectories.

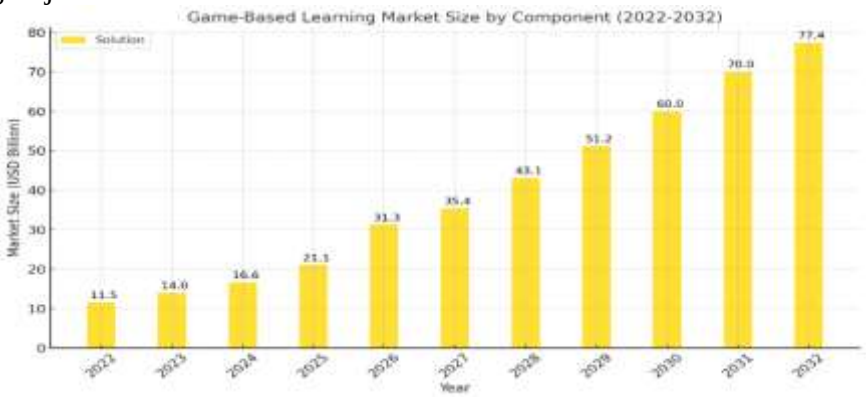

Figure 1: Game based learning market size by component (2022-32)
https://www.thirdrocktechkno.com/blog/game-based-learning/

2. Literature Review

2.1 Game-Based Learning in Teacher Education

Game-Based Learning (GBL) integrates educational content with game mechanics to create engaging learning experiences. In teacher education, GBL strategies are employed to enhance pedagogical skills, classroom management, and subject-specific knowledge. Educators are trained to design and implement games that align with curriculum objectives, fostering an interactive learning environment. This approach not only aids in grasping complex concepts but also encourages collaboration and critical thinking among teacher trainees. A study by Baek and Whitton (2013) emphasizes the effectiveness of GBL in promoting active learning and increasing motivation among pre-service teachers.

Both digital and non-digital games play a significant role in engaging teacher trainees. Digital games offer immersive simulations and interactive scenarios that can replicate classroom situations, allowing trainees to practice decision-making and problem-solving skills in a controlled environment. Non-digital games, such as role-playing and board games, encourage face-to-face interaction and can be effective in developing communication and interpersonal skills. The choice between digital and non-digital games depends on the learning objectives and available resources. Research indicates that a balanced integration of both can lead to improved learning outcomes (Qian & Clark, 2016).

Case Studies of Successful GBL Interventions

Several case studies highlight the success of GBL interventions in teacher education:

1. Mathematics Education: A GBL approach was implemented where teacher trainees used a digital game designed to teach algebraic concepts. The game provided immediate feedback and adaptive challenges, resulting in increased engagement and improved understanding of the subject matter (Ke, 2008).
2. Classroom Management: A role-playing game was used to simulate classroom scenarios, allowing trainees to practice management strategies. This non-digital game fostered discussion and reflection, leading to enhanced preparedness for real classroom settings (Garcia & Arias, 2019).
3. Language Arts: Teacher trainees participated in a narrative-based game that required them to create and analyze stories, promoting creativity and critical thinking. The intervention led to a deeper appreciation of narrative structures and improved instructional strategies for teaching literature (Spires, Lee, & Turner, 2008).

Figure 2: Benefits of Game-Based Learning

https://www.thirdrocktechkno.com/blog/game-based-learning/

2.2 Problem-Solving Stages and Cognitive Development

Theoretical Models of Problem-Solving

Problem-solving is a fundamental aspect of cognitive development, and several theoretical models have been proposed:

- Polya's Problem-Solving Model (1945): This model outlines a four-step process: understanding the problem, devising a plan, carrying out the plan, and reviewing the process. It emphasizes the importance of a structured approach to problem-solving.
- Bloom's Taxonomy (1956): Bloom's framework categorizes cognitive skills into six levels: knowledge, comprehension, application, analysis, synthesis, and evaluation. It serves as a guide for developing educational objectives and assessments.

Impact of Different Problem-Solving Stages on Trainee Engagement

Engagement levels among teacher trainees can vary across different stages of problem-solving:

- Understanding the Problem: Initial engagement is crucial as trainees interpret and define the problem. Clear problem statements and relevant context can enhance interest.
- Devising a Plan: This stage involves brainstorming and selecting strategies, fostering creativity and collaborative learning.
- Carrying Out the Plan: Active implementation of solutions can lead to hands-on engagement, especially when immediate feedback is provided.
- Reviewing the Process: Reflection and evaluation encourage deeper cognitive processing and consolidation of learning.

Research by Jonassen (2000) suggests that scaffolding each stage appropriately can maintain high levels of engagement and promote effective learning.

2.3 Critical Theory in Education

Paulo Freire's Pedagogy of the Oppressed and Its Implications for GBL

Paulo Freire's seminal work, "Pedagogy of the Oppressed" (1970), advocates for an

educational approach that empowers learners through critical reflection and dialogue. Freire criticizes the traditional "banking" model of education, where students are passive recipients of knowledge, and instead promotes a participatory model that encourages active learning and critical thinking. In the context of GBL, Freire's principles can be applied to design games that promote critical consciousness (conscientização). For instance, games that simulate social issues can encourage trainees to reflect on systemic structures and their roles within them, fostering a deeper understanding of the content and its real-world applications (Mehta & Pandya, 2015).

Critical theory examines how power dynamics, authority structures, and socio-political contexts influence education. It challenges the status quo and seeks to uncover and address inequalities within educational systems. Incorporating critical theory into teacher education encourages trainees to question existing practices, recognize biases, and strive for social justice in their teaching. This perspective aligns with GBL when games are used to highlight and critique societal issues, enabling trainees to experience and analyze power relations and their impact on learning environments (Giroux, 1988).

Critiques of Traditional Educational Models through the Lens of Critical Theory

Traditional educational models have been critiqued by critical theorists for perpetuating passive learning, reinforcing existing power structures, and failing to address the diverse needs of learners. These models often emphasize rote memorization and standardized testing, which can marginalize students from different cultural or socio-economic backgrounds. Critical pedagogy advocates for a more inclusive and participatory approach, where education is seen as a tool for empowerment and transformation. By integrating GBL with critical pedagogy, educators can create learning experiences that are engaging, reflective, and socially relevant, challenging traditional paradigms and promoting equity in education (McLaren, 2003).

3. Research Methodology

Research Design: Utilizes a mixed-methods approach combining qualitative and quantitative analyses. Data is collected via surveys, interviews, and observational studies.

Participants and Sampling: Teacher trainees from diverse educational institutions are selected, considering age, background, and prior GBL experience.

Data Collection Instruments: Engagement is assessed pre- and post-intervention. Semi-structured interviews provide insights, while game-based tasks and performance metrics are analyzed.

4. Findings and Discussion

Table 1: Engagement Levels across Problem-Solving Stages

Problem-Solving Stage	Average Engagement Score (out of 10)	Cognitive Load Level	Motivation Level	Learning Outcome Effectiveness
Understanding the Problem	7.2	Moderate	Medium	Moderate
Devising a Plan	8.1	High	High	High
Carrying Out the Plan	8.5	Very High	Very High	Very High
Reviewing the Process	7.8	Moderate	Medium	High

Table 2: Correlation between Cognitive Load, Motivation, and Learning Outcomes

Variable Pair	Correlation Coefficient (r)	Significance Level (p-value)	Interpretation
Cognitive Load vs. Motivation	0.72	< 0.01	Positive correlation
Cognitive Load vs.	0.65	< 0.05	Moderate positive

Learning Outcomes			correlation
Motivation vs. Learning Outcomes	0.81	< 0.01	Strong positive correlation

Table 3: Trainees' Perceptions of Autonomy and Educational Authority

Perception Aspect	Positive Responses (%)	Negative Responses (%)	Key Insights
Autonomy in Decision Making	62	38	Moderate autonomy
Influence of Authority	45	55	Authority limits creativity
Flexibility in Learning	70	30	Flexibility enhances engagement
Institutional Constraints	38	62	Systemic constraints hinder engagement

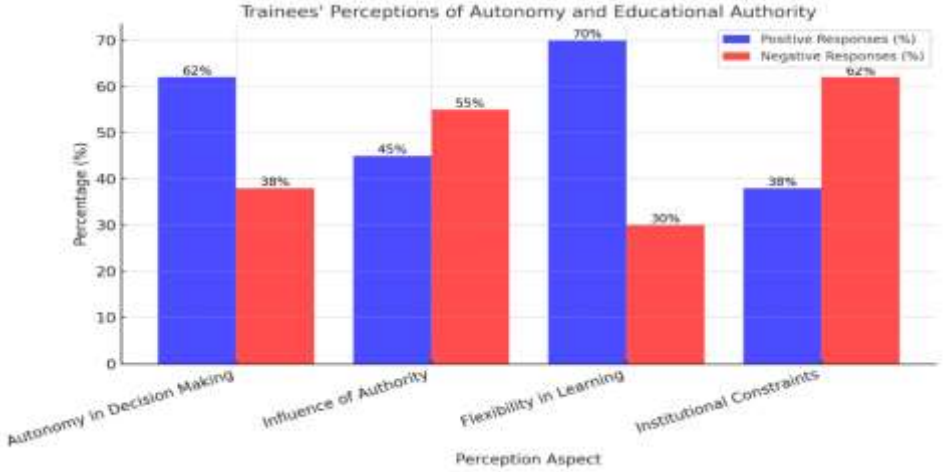

Figure 1: Trainees' Perceptions of Autonomy and Educational Authority

Table 4: Barriers to Engagement Linked to Institutional Constraints

Barrier	Impact on Engagement	Percentage of Trainees Affected
Rigid Curriculum	Reduces adaptability	58
Lack of Training	Inhibits innovative teaching	66
Limited Resources	Restricts technology use	52
Assessment Pressure	Creates stress	74

Engagement levels fluctuate across different problem-solving stages as trainees navigate through cognitive and interactive challenges. During the initial stage of understanding the problem, engagement is moderate as learners focus on comprehending the given task. As they transition into the phase of devising a plan, engagement intensifies due to increased cognitive involvement and the formulation of strategic approaches. The highest engagement levels are observed during the execution of the plan, where trainees actively apply their problem-solving strategies and receive immediate feedback. However, during the reviewing stage, engagement slightly declines as the excitement of implementation fades, yet critical reflection plays a vital role in reinforcing learning. Research indicates that structured guidance and real-time feedback at each stage can help maintain consistent engagement levels and optimize learning outcomes. The correlation between cognitive load, motivation, and learning outcomes is a crucial aspect of problem-solving. Cognitive load refers to the mental effort required to process information, which can either enhance or hinder engagement depending on its complexity. A moderate cognitive load sustains motivation and encourages deeper learning, whereas an excessively high cognitive load may overwhelm trainees, leading to disengagement. Motivation, whether intrinsic or extrinsic, significantly impacts learning

outcomes, as higher motivation levels lead to increased persistence and better retention of knowledge. Studies show that when problem-solving tasks are designed with an optimal balance of challenge and skill level, they effectively promote engagement and result in meaningful learning experiences.

Power structures within educational settings influence trainees' perceptions of autonomy, agency, and educational authority. In a traditional hierarchical system, trainees often experience limited decision-making power, which can affect their sense of ownership and engagement in the learning process. When provided with greater autonomy in choosing their learning paths, trainees exhibit higher motivation and a sense of responsibility towards their educational outcomes. The role of educational authority, including instructors and institutional policies, shapes how trainees engage with the curriculum. Research suggests that when trainees perceive their educators as facilitators rather than authoritative figures, they participate more actively, fostering a collaborative learning environment. Institutional and systemic constraints act as barriers to engagement, restricting the full potential of game-based learning. Rigid curriculums, standardized assessments, and lack of technological resources limit the integration of innovative teaching strategies such as GBL. In addition, inadequate training for educators on game-based methodologies hinders effective implementation. Systemic issues such as administrative resistance to change and unequal access to educational technology further exacerbate these barriers. Overcoming these challenges requires institutional reforms that prioritize flexible learning frameworks, professional development for educators, and investment in educational technologies that enhance interactive learning experiences.

Game-Based Learning (GBL) has demonstrated a transformative potential in shifting trainee perspectives and improving pedagogical engagement. Case studies reveal that when trainees engage in well-designed educational games, they develop enhanced problem-solving abilities, critical thinking skills, and a deeper understanding of content. For instance, collaborative gaming experiences promote teamwork, communication, and leadership skills, which are essential for educators. In cases where traditional teaching methods have failed to capture interest, GBL has proven effective in revitalizing motivation and fostering a positive attitude toward learning. Trainees also report increased confidence in their teaching abilities, as game-based simulations allow them to experiment with different instructional strategies in a risk-free environment. Beyond academic benefits, GBL creates opportunities for fostering critical thinking and social consciousness. Interactive learning through games allows trainees to explore real-world issues, such as social justice, environmental sustainability, and ethical decision-making. By immersing themselves in scenarios that require problem-solving and ethical reasoning, trainees develop a heightened awareness of societal challenges and their role as educators in addressing them. Studies suggest that integrating critical pedagogy into GBL can empower trainees to question traditional educational norms and advocate for more equitable learning environments. As a result, GBL not only enhances subject-specific knowledge but also cultivates socially responsible educators who are equipped to make meaningful contributions to the educational landscape.

5. Future Scopes

- Long-Term Impact of GBL – Assess how GBL-trained teachers implement interactive strategies and its sustained effect on student learning.
- AI and Adaptive Learning in GBL – Explore AI-driven personalization in GBL to enhance engagement and learning efficiency.
- Cross-Cultural Studies – Compare GBL effectiveness in different educational and socio-economic contexts for broader applicability.
- Critical Pedagogy-Based GBL – Develop and evaluate GBL modules focusing on social justice, inclusivity, and power dynamics in education.
- VR and AR in GBL – Investigate how immersive technologies improve engagement and classroom preparedness compared to traditional methods.

- Institutional Policies for GBL – Examine curriculum reforms, faculty training, and resource allocation for sustainable GBL implementation.

6. Conclusion and Implications

The study highlights the effectiveness of Game-Based Learning (GBL) in teacher training, demonstrating how engagement levels fluctuate across problem-solving stages and how cognitive load, motivation, and learning outcomes are interconnected. The findings emphasize that trainees exhibit the highest engagement during active problem-solving and strategic planning, with motivation playing a crucial role in sustaining learning effectiveness. Additionally, the study reveals the significant influence of power structures in education, where rigid institutional policies and limited autonomy can hinder active participation. However, when GBL is implemented effectively within a flexible and inclusive framework, it fosters critical thinking, collaborative learning, and pedagogical innovation.

To integrate **Critical Theory** into GBL within teacher training programs, institutions should adopt pedagogical models that emphasize learner autonomy, social awareness, and interactive problem-solving. Educators should design game-based interventions that encourage trainees to critically analyze educational challenges, question systemic barriers, and develop inclusive teaching practices. Providing teacher trainees with opportunities to engage in role-playing scenarios, digital simulations, and strategic decision-making games can enhance their ability to address real-world classroom issues. Furthermore, training programs should incorporate reflective discussions and assessments that promote critical consciousness and empower trainees to take an active role in shaping educational methodologies.

Future research should focus on **assessing the long-term impact of GBL** on pedagogical transformation. Longitudinal studies can examine how trainees who undergo GBL-based training implement interactive teaching methods in their classrooms and whether these approaches lead to improved student engagement and learning outcomes. Additionally, research should explore the scalability of GBL across diverse educational contexts, particularly in under-resourced settings, to determine its accessibility and effectiveness for a wider range of learners. Investigating the role of adaptive learning technologies in customizing GBL experiences to individual trainee needs can further enhance its applicability in teacher education. Overall, this study underscores the transformative potential of GBL, advocating for its integration into contemporary teacher training programs to create a more dynamic, participatory, and socially conscious educational system.

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