Journal of Information Systems Education

Volume 36
Issue 2
Spring 2025

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Recommended Citation: Patwary, M. M. I., John, A., Park, S., Zhao, Y., Kwak, D.-H., & Patuwo, B. E. (2025). Can Gamification Change Learners' Ability and Motivation? Role of Eustress in the Context of Gamified ERP Training. *Journal of Information Systems Education*, 36(2), 148-165. https://doi.org/10.62273/UIIM2219

Article Link: https://jise.org/Volume36/n2/JISE2025v36n2pp148-165.html

Received:	September 23, 2024
First Decision:	December 2, 2024
Accepted:	February 5, 2025
Published:	June 15, 2025

ISSN: 2574-3872 (Online) 1055-3096 (Print)

Journal of Information Systems Education, 36(2), 148-165, Spring 2025
https://doi.org/10.62273/UIIM2219

Can Gamification Change Learners' Ability and Motivation? Role of Eustress in the Context of Gamified ERP Training

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ABSTRACT

Gamification, using game elements in nongame contexts, is widely recognized for its efficacy in training individuals within organizational and academic environments. Specifically, it has gained significant attention in training to operate complex systems like enterprise resource planning (ERP). However, research has generally overlooked how gamified training changes users' ability and motivation through eustress (challenging and positive stress). To address this gap, this study proposes that gamified training can increase users' ability and motivation. Self-efficacy and involvement are examined as representations of ability and motivation, respectively. Furthermore, we hypothesize that users' pre-training self-efficacy and involvement positively affect eustress experienced during gamified training, subsequently affecting post-training self-efficacy and involvement. To test research hypotheses, data were collected from 205 graduate students who participated in an ERP simulation game. The findings indicate a significant increase in self-efficacy and involvement after gamified training, substantiating the potential of gamification to enhance these aspects. Moreover, the study demonstrates that initial self-efficacy in learning ERP systems influences the experience of eustress during gamified training, ultimately impacting post-training self-efficacy and involvement. Our research sheds light on the transformative impact of gamified training and eustress in learning complex systems, providing valuable insights for gamification implementation in training practices.

Keywords: Gamified training, Eustress, Self-efficacy, Involvement, ERPsim

1. INTRODUCTION

Previous research has raised questions regarding the efficacy of traditional pedagogical approaches in motivating learners (Dicheva et al., 2015; Hattie, 2008; Pink, 2011). Inefficacy in motivating learners is not limited to traditional schooling but also exists in organizational contexts, especially in training employees in the use of new enterprise resource planning (ERP) systems. *Gamification*, the use of game elements in nongaming contexts (Deterding et al., 2011), has emerged as a new approach to address this issue. Gamification has been shown to promote engagement and motivation among users (Suh et al., 2017). Therefore, gamification is gaining popularity in various fields, including education (Sailer & Sailer, 2021) and employee training (Armstrong & Landers, 2018). The vast opportunities and advantages of gamification are reflected in its market size (USD 9.1 billion in 2020), which is projected to grow exponentially (annual growth rate of 27.4%) in the coming years (USD 30.7 billion in 2025) (Markets and Markets, 2022). With the increasing financial value of gamification in education and other sectors, it has become a pressing issue for academia and industry to explore its potential benefits.

Organizations have come to rely on ERP systems as vital tools to manage their various business processes and operations. However, for their successful implementation, employees must be trained properly and effectively in their use (Cronan & Douglas, 2012). Effective training not only increases employees' ability to operate these systems but also improves their motivation to use them (Nikou et al., 2022; Sekhar et al., 2013). A gamified ERP training system has received significant attention in ERP training and gamification research, as it aligns with collaborative learning models and simulates real-world ERP scenarios. Utilization of gamification in the context of ERP training has been shown to bolster motivation and engagement among learners (Kiryakova et al., 2014), leading to better performance and higher productivity. Investigation of gamification in the context of ERP training is crucial for organizations that aim to maximize the potential of their ERP systems and enhance their overall performance.

Although the effectiveness of gamified systems has been demonstrated in ERP training contexts, learners have been shown to experience varying degrees of stress in the process. Building on the potential benefits of gamified training, it is important to explore the role of *eustress*, a form of challenging and positive stress known for its ability to enhance performance, motivation, and learning (LePine et al., 2004). Eustress can be manifested in gamified training by presenting learners with challenging yet attainable goals, offering rewards, and providing constructive feedback (Hamari et al., 2014; Pinheiro et al., 2015). Despite the presumed potential payoffs of eustress, few researchers have delved into how learners' preexisting abilities and motivations can influence the level of eustress they experience during gamified training. Moreover, little is known about whether experiences of eustress during training have carryover benefits for post-training abilities and motivation. By examining the nuanced dynamics of eustress in the context of gamified training, while also accounting for individual differences, we can strive to optimize ERP training experiences, leading to more effective and personalized gamified training programs (Lee, 2019) with potential ramifications for the overall field of training.

The purpose of this study is twofold: first, to explore the impact of gamified training on enhancing users' ability and motivation; and second, to examine the intricate interplay of pre-training ability/motivation, eustress experienced during gamified training, and post-training ability/motivation. Based on prior research on gamification, self-efficacy and involvement are used as proxies for ability and motivation based on established literature (Astin, 1984; Bandura, 1977). These constructs directly relate to learning behaviors and motivation, making them appropriate representations in the context of ERP gamification. We propose that gamified training can improve users' self-efficacy (i.e., ability) and involvement (i.e., motivation). Also, drawing upon the eustress literature, we posit that users' self-efficacy and involvement before gamified training (T1) positively influence the level of eustress they experience during the training, subsequently affecting their self-efficacy and involvement after completing the gamified training (T2).

To achieve our research purposes, we selected gamified ERP training, focusing especially on the ERP simulation game (ERPsim) for several reasons. ERP systems are powerful tools designed to streamline operations, reduce costs, enhance efficiency, and provide improved visibility into organizational performance (Muscatello et al., 2003). However, their inherent complexity requires comprehensive employee training to fully leverage their capabilities (Hwang & Cruthirds, 2017). This complexity also makes ERP systems an ideal setting for evaluating the effectiveness of gamification in training. To address the need for innovative training solutions, the faculty at HEC Montreal developed ERPsim, a gamified approach to ERP system training (Léger, 2006). Its success is evident in its widespread popularity. It is now being taught in over 200 universities in 26 countries. Additionally, ERPsim has been a focal point of extensive research related to online learning, ERP training, and gamification (Hwang & Cruthirds, 2017; Kwak et al., 2019; Zhao et al., 2021).

2. THEORETICAL BACKGROUNDS

2.1 Gamified Training and ERPsim

Gamification has gained significant attention and application in education and training research (see Appendix A for a literature review). Prior research has found that the incorporation of gamified training provides both trainers and learners with various benefits. For example, by infusing an enjoyable aspect into the learning process, gamification captures learners' interest and generates enthusiasm, creating a positive and engaging environment that facilitates knowledge acquisition and retention (Chen et al., 2020; Jagušt et al., 2018; Kwak et al., 2019). Furthermore, previous research has shown that gamified training goes beyond the traditional instructional methods in fostering learners' motivation to complete the learning path (Borrás-Gené et al., 2016; Uz Bilgin & Gul, 2020). Gamification creates a collaborative, engaging, and competitive environment that motivates learners and individuals to actively participate, collaborate, and expend more effort to achieve better learning outcomes (Darban et al., 2016; Hasan et al., 2019; Jagušt et al., 2018; Ramírez-Donoso et al., 2017).

Trainers and educators can incorporate various game elements (e.g., points, teams, leaderboards, competitions) to create an immersive and interactive learning environment (Riar et al., 2022; Werbach & Hunter, 2012). Incorporation of these elements can transform the training process into a game-like experience (Riar et al., 2022; Santhanam et al., 2016; Zhao et al., 2021). In particular, much research on gamified training has found a positive impact of gamification on user engagement, motivation, attitudes, knowledge acquisition, and learning performance in various training contexts (Awais et al., 2019; Felszeghy et al., 2019; Garcia-Sanjuan et al., 2018; Sailer & Sailer, 2021).

Among various gamified training systems, ERPsim, a team-based gamified ERP training system, has received significant attention in ERP training and gamification research (ERPsim Lab, 2025). Prior studies have demonstrated the effectiveness of ERPsim (Cronan & Douglas, 2012; Hwang & Cruthirds, 2017; Kwak et al., 2019; Zhao et al., 2021). For example, Hwang and Cruthirds (2017) showed that students who completed three rounds of ERPsim had improved attitudes toward SAP software and ERP knowledge. In addition, Kwak et al. (2019) found that perceived quality and enjoyment of ERPsim positively influence students' intention to learn about ERP systems. Likewise, Zhao et al. (2021) showed that flow experiences while playing ERPsim lead to improved learning outcomes and motivation.

A notable gap persists in the literature regarding the intricate interplay between initial user characteristics, such as pre-training self-efficacy and motivation, the experience of eustress during training, and its subsequent impact on post-training self-efficacy and involvement. In ERP learning literature, effectively managing the stress associated with ERP usage has been crucial in enhancing learning outcomes (Léger et al., 2014a; Léger et al., 2014b). While the positive effects of eustress—motivating and energizing stress that leads to improved performance—on learning outcomes are recognized (LePine et al., 2004; Seaward, 2017), there is still a lack of comprehensive research on how individual differences in learners' initial states influence their eustress experience in gamified training settings. Furthermore, the potential of eustress experiences to improve post-training outcomes has not been fully explored. Our study aims to bridge this gap by investigating how pre-training levels of self-efficacy and motivation influence the eustress experienced during gamified training, and how this, in turn, affects learners' post-training self-efficacy and involvement. This investigation is expected to provide novel insights into optimizing gamified training programs, ensuring they are tailored to meet individual learner needs and effectively enhance ERP system education and training initiatives.

2.2 Ability and Motivation

Ability and motivation have been important constructs in various theories, such as the Technology Acceptance Model (Venkatesh et al., 2003), the Theory of Planned Behavior (Ajzen, 1991), and the Elaboration Likelihood Model (ELM) (Petty et al., 1981). For example, the ELM posits that ability and motivation are important likelihood states that help people expend more cognitive efforts (Bhattacherjee & Sanford, 2006). Likewise, Abramovich et al. (2013) argued that learners' ability and motivation should be considered in gamification in designing educational badges awarded for education and learning. In the context of gamified learning, we have focused especially on self-efficacy and involvement as proxies for ability and motivation.

Self-efficacy refers to individuals' belief in their ability to perform a specific task or achieve a specific goal; it is closely related to users' behaviors. It can be a good proxy for ability in a learning context because it reflects individuals' perceptions of their own competence, which is a key determinant of their behavioral intention to learn (Bandura, 1977). Many studies have shown the importance of self-efficacy in learning and achievement, and research has demonstrated that it can be developed and strengthened by various interventions (Stajkovic & Luthans, 1998). Bandura (1977) underscored the important role of self-efficacy in shaping behavior, emphasizing the importance of personal agency and self-regulation in achieving goals within his social-cognitive theoretical framework. Furthermore, the stress and coping theory lends additional support to the importance of self-efficacy in managing stress and navigating adverse circumstances (Lazarus & Folkman, 1984). Individuals with high self-efficacy are more likely to view stressors as challenges to be overcome rather than as insurmountable obstacles. They may also be more likely to engage in problem-focused coping strategies, such as seeking support or taking action to address the source of stress instead of avoiding or denying the problem.

Involvement is another important construct that explains how individuals engage in a specific activity or behavior. Involvement is a good proxy for motivation in the learning context because it reflects an individual's investment in the learning process. Students who are highly involved in their education are more likely to be motivated to learn and to engage in behaviors that promote their academic success. Prior research has demonstrated the importance of involvement in predicting academic outcomes. For example, Astin (1984) found students' involvement was a stronger predictor of academic success than standardized test scores or high school grades. Similarly, Tinto (1997) found that students who were more involved in their college experience were more likely to persist and graduate.

Despite the importance of self-efficacy and involvement, prior research has not examined how self-efficacy and involvement in learning before playing gamified systems influence eustress during playing gamified systems. Furthermore, it is not clear how eustress experienced during gamified training affects self-efficacy and involvement in learning.

2.3 Eustress

Stress, a natural physical and emotional response to challenges or demands, has often been studied for its negative effects (The American Institute of Stress, 2023). It can be understood as a complex psychological and physiological reaction to perceived threats or challenges. Lazarus and Folkman (1984) define stress as "a particular relationship between the person and the environment that is appraised by the person as taxing or exceeding his or her resources and endangering his or her well-being" (p. 19).

Occupational stress, in particular, has been a significant concern for organizations, as rapidly changing workplace dynamics continue to heighten its relevance (Le Fevre et al., 2003). This type of stress has far-reaching impacts, affecting employees' personal lives, productivity, and attendance (Atkinson, 2000; Cartwright, 2000; Midgley, 1997).

Within the context of training employees, stress plays a pivotal role in shaping learning outcomes. While excessive stress can impair learning and memory retrieval, it can also interfere with attention, problem-solving, and decision-making, which are critical for effective learning (Arnsten, 2009; Joëls et al., 2006). However, not all stress is detrimental. Research has shown that moderate levels of stress can enhance cognitive performance and memory consolidation, highlighting the importance of managing stress for optimal learning outcomes. For individuals experiencing chronic stress, targeted interventions are particularly essential.

Although stress has traditionally been viewed in a negative light, it has a multifaceted impact, and research reveals that a reasonable amount of stress is crucial for better performance. Without pressure or anxiety, individuals tend to underperform, which is why managers aim to maintain an optimal level of stress rather than eliminate it entirely (Benson et al., 1974; Hargrove et al., 2015; Masicampo & Baumeister, 2011; Petersen & Posner, 2012). This beneficial form of stress, known as eustress, contrasts with distress, which occurs at either extremely high or low levels of stress (Selye, 1956).

The relationship between eustress and distress is often depicted as a U-shaped or inverted U-shaped curve, depending on perspective (Chrousos, 2009). While distress results from insufficient or excessive stress, eustress occupies the moderate range, representing the balance necessary for peak performance. This suggests that managing stress levels to achieve this balance is critical for both individual well-being and effectiveness (Le Fevre et al., 2003).

Prior research suggests eustress has several positive effects on physical and mental well-being. According to Milsum (1985), eustress represents a state of optimal functioning within the homeostatic system. Lazarus (1993) described eustress as a positive cognitive response to a stressor that can lead to positive outcomes for both mental and physical well-being; conversely, distress is a type of stress that can have negative effects on both mental and physical states. In addition, Edwards and Cooper (1988) identified eustress as a surplus or positive difference in which an individual's perceived stress is less than what was expected in a particular situation. Furthermore, O'Sullivan (2011) found positive correlations between eustress, hope, and self-efficacy with life satisfaction. In the context of healthcare information technology, Califf et al. (2020) discovered that employees in industry viewed it as cumbersome to use, leading to job dissatisfaction. However, they also found that eustress is positively associated with higher job satisfaction.

In summary, gamified systems have the potential to promote employees' eustress in the workplace by providing a safe and challenging environment for learning and growth. However, despite the benefits of eustress in gamified training, it has received little attention in the gamification literature. Therefore, it is worthwhile to examine the role of eustress in gamified training, including its determinants and its impact on learners' ability and motivation.

3. RESEARCH MODEL AND HYPOTHESES

Figure 1 presents the research model proposed in this study. Figure 1A is about perception improvement, describing that following gamified training, learners will demonstrate increased self-efficacy and involvement in learning ERP systems compared to before undergoing gamified training. Figure 1B illustrates the causal relationships between self-efficacy and involvement in learning ERP systems before gamified training (T1), eustress during gamified training (T2), and self-efficacy and involvement in learning ERP systems after gamified training (T2). This study proposes that T1 self-efficacy and involvement positively influence eustress. Finally, drawing upon the eustress literature, we contend that eustress during gamified training positively influences self-efficacy and involvement in learning ERP systems after the gamified ERP training (T2). We do not hypothesize the effect of T1 constructs on T2 constructs because previous research has established those relationships (e.g., Khansa et al., 2017; Kim & Malhotra, 2005; Kwak et al., 2022).

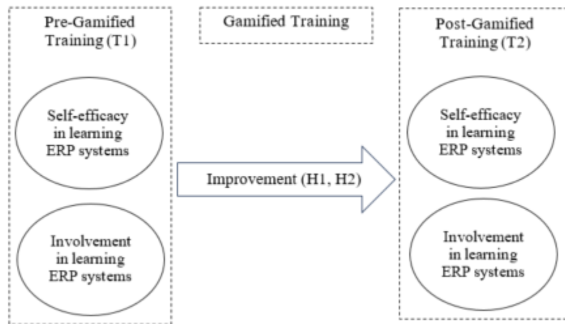


Figure 1A. Research Model for Perception Improvement

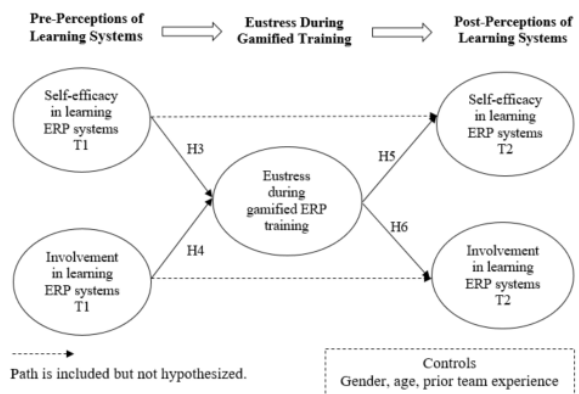


Figure 1B. Research Model for Role of Eustress

3.1 Improvement in Self-Efficacy and Involvement

As a construct closely related to users' behaviors, *self-efficacy* is defined as individuals' belief in their ability to perform a specific task or achieve a specific goal. Bandura (1986) noted that self-efficacy influences an individual's motivation, behavior, and achievement in a specific domain, such as learning. Prior research has shown that individuals who used gamified learning systems, such as ERPsim, have a greater understanding of the underlying concepts and processes in these systems and feel more confident in using them (Cronan & Douglas, 2013; Hwang & Cruthird, 2017). For example, Cronan and Douglas (2013) showed that playing ERPsim improved students' knowledge of business processes, transaction skills, and enterprise systems management. Similarly, Hwang and Cruthird (2017) found that students who participated in ERPsim showed significant improvement in their knowledge of business processes and ERP concepts. Moreover, Polo-Peña et al. (2021) found that individuals who participated in gamification programs experienced higher perceived self-efficacy, even in domains like exercise and sports. While these contexts differ from ERP training, they illustrate the broader potential of gamification to enhance self-efficacy by engaging participants through structured challenges and rewards, which supports the idea that gamified learning can positively impact self-efficacy. Based on these findings, gamified ERP training will significantly improve an individual's self-efficacy in learning ERP systems. Therefore, we hypothesize that:

- *H1: There will be a significant improvement in self-efficacy in learning ERP systems after gamified ERP training.*

Involvement reflects an individual's engagement and investment in the learning process and is a good proxy for motivation in the learning context. Prior research has shown that gamified educational systems increase users' motivation (Bonde et al., 2014; Bouchrika et al., 2021; Hamari et al., 2014). According to Bonde et al. (2014), gamified biotech laboratory simulations are a powerful means to increase students' motivation and engagement for future studies of biotech. Likewise, prior research on ERPsim found participants who played ERPsim showed a greater level of engagement and interest in learning about ERP systems as well as a deeper understanding of the systems' functionalities and capabilities (Elliot & Harackiewicz, 1994; Hwang & Cruthird, 2017). By using ERPsim, users not only gained a better understanding of ERP systems and their functionalities but also became more engaged in the learning processes. This heightened engagement and knowledge can lead to a deeper appreciation of the practical applications of ERP systems and their potential benefits for organizations. Such an appreciation may increase the users' motivation to learn more about ERP systems. Thus, we hypothesize that:

- *H2: There will be a significant improvement in involvement in learning ERP systems after gamified ERP training.*

3.2 Effects of Self-Efficacy and Involvement on Eustress

Self-efficacy has been shown to be an essential factor in reducing stress in the educational context (Chemers et al., 2001; Pajares, 1996; Richardson et al., 2012; Schunk & Pajares, 2002). In the context of learning ERP systems, high self-efficacy can be associated with a growth mindset toward ERP learning, suggesting that individuals see learning ERP systems as an opportunity for growth and self-improvement (Blackwell et al., 2007; Dweck, 1986). This positive attitude would lead to a more enjoyable and productive learning experience from gamified training, resulting in higher levels of eustress (Lazarus & Folkman, 1984). In summary, the literature supports the idea that self-efficacy is crucial in determining an individual's type of stress in a learning context. High self-efficacy can lead to a more positive and productive learning experience, but low self-efficacy can lead to anxiety and frustration (Blackwell et al., 2007; Chemers et al., 2001; Pajares, 1996). Those learners with high self-efficacy in learning ERP systems before their gamified training are more likely to approach challenging tasks within the game with a positive attitude and motivation to succeed. Thus, we propose:

- *H3: Self-efficacy in learning ERP systems positively influences eustress during gamified ERP training.*

ERP systems are essential tools for managing a wide range of business processes, including accounting, finance, logistics, sales, and human resources. These systems streamline operations, reduce costs, enhance efficiency, and provide improved visibility into organizational performance (Muscatello et al., 2003). However, their inherent complexity makes learning ERP systems challenging (Cronan & Douglas, 2013). Comprehensive employee training is crucial to fully leverage their capabilities (Hwang & Cruthirds, 2017). Additionally, involving learners in the process of mastering these systems can foster increased eustress, especially when gamified learning approaches are employed. Eustress is a form of stress that is motivating and energizing, leading to improved performance and feelings of accomplishment (Seaward, 2017). Prior research has shown that employees who receive training and support while learning any system report higher levels of eustress, job satisfaction, and perceived competence (O'Sullivan, 2011), all of which can apply to the context of ERP learning. Furthermore, active involvement in the learning process has been linked to a greater sense of control, which can positively influence eustress levels (Le Fevre et al., 2003; Opdenakker & Minnaert, 2011). McCombs (2013) also argued that learners' engagement and motivation in the subject matter could lead them to emphasize their ability and effort for success in the learning process. Thus, we propose:

- *H4: Involvement in learning ERP systems positively influences eustress during gamified ERP training.*

3.3 Effect of the Eustress on Self-Efficacy and Involvement

Eustress results in positive outcomes for individuals, including improved performance and enhanced creativity (Califf et al., 2020). It can also make them feel excited, engaged, or challenged by a task (O'Sullivan, 2011). However, too much stress can engender distress, which is the opposite of eustress and a negative type of stress that can cause feelings of anxiety, being overwhelmed, or threatened, leading to decreased productivity and negative health outcomes (Califf et al., 2020; Stults-Kolehmainen & Bartholomew, 2012).

Given the positive characteristics of eustress, we predict that eustress during gamified training leads to increased self-efficacy in learning ERP systems. This is attributed to the engaging and interactive nature of the gamified systems that provide a safe and controlled environment for experimentation and skill development (Deterding et al., 2011; Hamari, 2013). Participants experience a sense of challenge and excitement during the use of gamified systems (Nisula & Pekkola, 2012). Such experiences motivate trainees to persist and improve their skills and knowledge. Furthermore, the nature of gamified training can create a challenging and positive stress response that motivates individuals to persist and improve their knowledge about business processes and ERP systems (Hwang & Cruthird, 2017), thus leading to increased self-efficacy in learning ERP systems. Similarly, O'Sullivan (2011) showed that eustress and self-efficacy are positively correlated. Therefore, we hypothesize that:

- *H5: Eustress during gamified ERP training positively influences self-efficacy in learning ERP systems.*

We also expect that the eustress experienced during gamified training can increase engagement and interest in learning about ERP systems. Prior research has shown a relationship between stress and learning. Enhancing engagement and motivation has always been a focus of gamification in learning (Dickey, 2007). Arnsten (2009) found that moderate stress levels can enhance motivation, focus, and engagement with a task. Furthermore, simulations and games have improved motivation by enhancing eustress (Southern, 2017). Likewise, Fleige (2017) showed that eustress leads to higher motivation or engagement at work. Thus, we propose:

- *H6: Eustress during gamified ERP training positively influences involvement in learning ERP systems.*

4. METHODS

4.1 Subjects and Procedures

To test our research model, we conducted a laboratory study at a midsize public university in the southeastern United States. The participants were graduate students enrolled in an online ERP overview class. The course included an introduction to fundamental business processes as well as instruction on the different modules of SAP ERP systems. At the end of the semester, the students were required to participate in ERPsim to understand how different business processes are integrated into the ERP systems. Among various ERPsim games, we specifically selected the Maple Syrup game, which is intended for beginners (Léger, 2006). A week before the ERPsim session, students were asked to complete a pre-game survey that measured self-efficacy and involvement in learning ERP systems and to submit demographic information. A total of 316 students filled out the pre-game survey. The sample comprised 174 males (55.1%) and 142 females (44.9%). The average age of the participants was 31.3 years old.

Before the ERPsim session began, the instructor (one of the authors) randomly assigned the students to teams consisting of four to five members in three different sessions. A total of 249 students participated in the game. After the students arrived, the instructor gave instructions to each team on ERPsim in terms of interfaces, modules, and team objectives. Then, each team played three rounds of games against other teams to maximize profit. At the end of each round, the instructor showed a leaderboard that included financial results and performance for all teams in the game.

After the final round, the students were asked to complete a post-game survey that included eustress, self-efficacy, and involvement. Several students completed the pre-game survey, but not the post-game survey, and others did the opposite. Only the surveys that could be matched were used in the analysis, resulting in 205 usable responses. The final sample comprised 112 males (54.6%) and 93 females (45.4%). The average age of the participants was 31.9 years old. We examined nonresponse bias; we found no significant differences in gender and age between pre- and post-games, suggesting nonresponse bias was not problematic.

4.2 Measures

To ensure construct validity, all measures were adapted from previously validated scales whenever possible (see Table 1). Three items for self-efficacy in learning ERP systems were adapted from Wang et al. (2017); three items for involvement in learning ERP systems were adapted from Bhattacherjee and Sanford (2006). Based on O'Sullivan (2011), four items for eustress during playing ERPsim were adapted. Self-efficacy and involvement were measured in both pre- and post-game surveys, but eustress was measured only in the post-game survey.

5. RESULTS

To test H1 and H2 (which predict an improvement in self-efficacy and involvement, respectively), we used paired t-tests to compare the mean scores of the pre- and post-game surveys. To test H3-H6, we used a two-step approach based on Gefen et al. (2000): (1) a confirmatory factor analysis (CFA) to assess the measurement model, and (2) structural equation modeling (SEM) to test research hypotheses.

Construct (Source)	Survey Time	Items
Self-efficacy in learning ERP systems (Wang et al., 2017)	T1, T2	SE1: I have confidence in my ability to learn about ERP systems. SE2: I have the expertise to learn about ERP systems. SE3: If I wanted to, I could easily learn about ERP systems.
Involvement in learning ERP systems (Bhattachjee & Sanford, 2006)	T1, T2	INV1: I have a strong interest in learning about ERP systems. INV2: Learning about ERP systems is very important to me. INV3: Learning about ERP systems matters a lot to me.
Eustress during playing ERPsim (O'Sullivan, 2011)	T2	EUS1: I could successfully deal with irritating hassles while playing ERPsim. EUS2: When faced with stress in playing ERPsim, I find that the pressure makes me more productive. EUS3: I feel that I perform better in playing ERPsim when under pressure. EUS4: I feel that stress from playing ERPsim has a positive effect on the results of ERPsim.
Gender	T1	What is your gender?
Age	T1	How old are you?
Prior team experience	T1	Have you had team experiences?

Notes: T1: Pre-game; T2: Post-game

Table 1. Measurement Items

5.1 Measurement Model

For the measurement model, various psychometric properties of the scales were evaluated through CFA. We assessed model fit through several fit criteria such as the goodness-of-fit index (GFI), the adjusted goodness of fit (AGFI), the standardized root mean square residual (SRMR), and the root mean square error of approximation (RMSEA) (Gefen et al., 2000; Hu & Bentler, 1999). As shown in Table 2, the results indicate an acceptable level of fit of the measurement model.

Then, we tested construct reliability, convergent validity, and discriminant validity. Reliability was evaluated using composite reliability and average variance extracted (AVE) with threshold values of .70 and .50, respectively (Nunnally & Bernstein, 1994). The results indicated acceptable reliability for all constructs (see Table 3). All factor loadings exceeded .707, the cutoff value recommended by Hair et al. (2009), suggesting convergent validity in the measurement model. Discriminant validity was assessed by comparing the square root of AVE for each construct against its correlations with other constructs (Gefen & Straub, 2005). As shown in Table 3, the square root of AVE for each construct exceeded its correlations with other constructs, demonstrating the discriminant validity of all the constructs.

5.2 Common Method and Social Desirability Biases

We examined common method bias (CMB) using Harmon's single-factor test (Podsakoff et al., 2003) and the marker-variable technique (Malhotra et al., 2006). First, if CMB is high, a factor analysis would generate a single factor accounting for a majority of the variance. The first extracted factor explained 26.8% of the overall variance, indicating that CMB is not a major concern. Second, we examined CMB using the marker-variable technique. While the traditional marker-variable technique involves adding a separate, theoretically unrelated variable specifically for CMB detection, we economized on survey items by using an existing unrelated scale—the impression management (IM) scale—as a proxy marker variable. The IM scale, which has been commonly used to assess social desirability (SD) bias, served as an appropriate marker variable for this analysis since it is theoretically unrelated to the key constructs in our study. The lowest correlation is .03 (IM and eustress). Based on these diagnostic analyses, CMB is an unlikely issue in our data. We also examined social desirability (SD) bias. Prior research noted that when both independent and dependent variables are susceptible to SD bias, SD bias can distort the causal relationship (Kwak et al., 2021). Because there is no significant correlation between eustress and the IM scale, our hypothesized relationship will not be affected by SD bias.

5.3 Paired T-Test

To test H1 (improvement in self-efficacy) and H2 (improvement in involvement), we conducted paired t-tests. As shown in Table 4, significant increases in self-efficacy and involvement occurred. These results suggest support for H1 and H2. We further examined the role of eustress in improving self-efficacy and involvement by dividing it into two halves. We found no significant differences in the low eustress group, but significant improvements occurred in the high eustress group. This suggests that experiencing a high level of eustress during gamified training is beneficial in improving individuals' confidence in their ability and their engagement in learning ERP systems.

	χ^2 (df)	χ^2/df	CFI	GFI	AGFI	SRMR	RMSEA
Good model fit ranges		< 3.00	>.90	≈.90	>.80	<.06	<.08
Measurement Model	277.98 (127)	2.19	.96	.88	.82	.036	.076
Structure Model	282.25 (129)	2.08	.96	.88	.82	.041	.076

Table 2. Goodness of Model Fit

	1	2	3	4	5	6	7	8
1. Self-efficacy T1	***.82***							
2. Involvement T1	.55	***.96***						
3. Eustress T2	.28	.21	***.87***					
4. Self-efficacy T2	.48	.40	.45	***.90***				
5. Involvement T2	.36	.69	.36	.63	***.96***			
6. Gender	-.12	-.06	-.13	-.07	-.07	-		
7. Age	-.01	-.04	-.07	-.08	-.09	.15	-	
8. Prior team experience	.05	-.07	.12	-.04	-.10	.10	.07	-
Mean	5.37	5.21	4.80	5.61	5.50	1.45	31.94	4.39
Standard deviataion	5.21	1.67	1.65	1.40	1.62	.50	9.35	2.27
Composite reliability	.86	.97	.92	.93	.97	-	-	-
Average variance extracted	.66	.92	.75	.81	.92	-	-	-

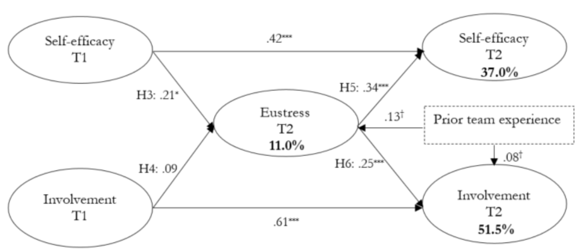
Notes: T1: Pre-training; T2: Post-training

Table 3. Correlation Matrix, Reliability, and Validity

Sample	Construct	Pre-game		Post-game		Differences		t	p
		Mean	SD	Mean	SD	Mean	SD		
All (n=205)	Self-efficacy	5.37	1.38	5.61	1.40	.24	1.50	2.31	022
	Involvement	5.20	1.67	5.50	1.62	.29	1.31	3.19	.002
Low eustress (n=108)	Self-efficacy	5.15	1.41	5.12	1.49	-.03	1.56	-.19	.854
	Involvement	4.91	1.63	4.97	1.66	.06	1.29	.47	.638
High eustress (n=97)	Self-efficacy	5.62	1.31	6.16	1.07	.54	1.37	3.90	.000
	Involvement	5.54	1.66	6.09	1.34	.55	1.30	4.20	.000

Table 4. Results of Paired T-Tests

5.4 Structural Model
Figure 2 shows the results of the research hypotheses H3-H6. As expected, self-efficacy in learning ERP systems before playing ERPsim positively influenced eustress during playing it (H3: $\gamma = .21$, $p < .05$), demonstrating support for H3. Unlike our expectation, however, involvement did not have a significant effect on eustress (H4: $\gamma = .09$, p = .ns), meaning H4 was not supported. However, eustress during playing ERPsim positively increased self-efficacy (H5: $\beta = .34$, $p < .001$) and involvement (H6: $\beta = .25$, $p < .001$) in learning ERP systems, demonstrating support for H5 and H6.



*** $p < .001$; ** $p < .01$; * $p < .05$; † $p < .10$
Only significant results of control variables were included.

Figure 2. Results of Structural Model

6. DISCUSSION AND CONCLUSIONS

6.1 Summary of Results
The purpose of this study was to analyze the effect of gamified training in developing learners' self-efficacy and involvement in learning ERP systems and the mediating role of eustress in the process. The summary of results is shown in Table 5. We hypothesized that learner's self-efficacy and involvement in learning ERP systems would significantly increase after gamified training (H1 and H2). Paired t-tests found strong support for H1 and H2. Our findings are consistent with prior research suggesting that gamification can enhance users' abilities and engagement (Bonde et al., 2014; Hwang & Cruthird, 2017; Polo-Peña et al., 2020).

We hypothesized that self-efficacy (H3) and involvement (H4) in learning ERP systems before gamified training would have a positive influence on eustress during gamified ERP training. This, in turn, would affect self-efficacy (H5) and involvement (H6) in learning ERP systems after the gamified training. To test H3-H6, we used SEM and found support for H3, H5, and H6. However, H4, which suggested that involvement in ERP learning positively influences eustress during gamified ERP training, was not supported. One plausible explanation for this is that self-efficacy was too strong and overshadowed the effect of involvement on eustress levels during the training. To support our explanation, we conducted an SEM analysis excluding self-efficacy, which showed a significant effect of involvement ($\gamma = .22$, $p < .05$).

Hypothesis	Result
H1: There will be a significant improvement in self-efficacy in learning ERP systems after gamified ERP training.	Supported
H2: There will be a significant improvement in involvement in learning ERP systems after gamified ERP training.	Supported
H3: Self-efficacy in learning ERP systems positively influences eustress during gamified ERP training.	Supported
H4: Involvement in learning ERP systems positively influences eustress during gamified ERP training.	Not supported
H5: Eustress during gamified ERP training positively influences self-efficacy in learning ERP systems.	Supported
H6: Eustress during gamified ERP training positively influences involvement in learning ERP systems.	Supported

Table 5. Summary of Results

In summary, the findings of this study provide support for the effectiveness of using ERPsim in gamified ERP training to improve self-efficacy and involvement in learning ERP systems. The study also highlights the importance of eustress in enhancing learners' ability and motivation during the gamified training.

6.2 Theoretical Contributions
This study makes several theoretical contributions. First, our study contributes to the literature on gamified training by analyzing the concept of eustress, or challenging and positive stress, in the context of ERP training. Although previous research on gamification has largely focused on game elements (e.g., points, badges, leaderboards) to increase users' motivation and engagement, our study extends existing research by examining the role of eustress in enhancing learning outcomes. Prior research has shown that eustress can increase cognitive and psychological arousal, which, in turn, enhances attention, motivation, and performance (Brulé & Morgan, 2018; Li et al., 2016; Maier & Seligman, 1976). Building on these findings, our study explores how eustress, induced through gamified elements, can positively influence learning outcomes and motivation in gamified training contexts. This approach provides a new perspective on how incorporating stress-

inducing game elements can enhance the positive effects of gamification on learning and motivation.

Second, our research builds upon prior research on gamification by showing that gamified training can increase ability (e.g., self-efficacy) and motivation (e.g., involvement) in learning (Kiryakova et al., 2014; Landers & Landers, 2014). Furthermore, our study extends prior research by demonstrating that the effect of the intervention of gamification in changing ability and motivation is not uniform across all levels of eustress. Specifically, our findings suggest the improvement of self-efficacy and involvement in learning is contingent on the level of eustress induced by the gamified training intervention. We found participants who reported a high level of eustress during ERPsim also reported a significant increase in self-efficacy and involvement, but those who reported a low level of eustress did not show any differences. Our results suggest incorporating elements that induce high eustress may be more effective in enhancing learning outcomes in gamified training environments than those that induce little or no eustress. These findings have important theoretical implications for the design of effective gamified learning interventions.

Third, we contribute to the existing literature by examining the determinants of eustress in the context of gamified training. Specifically, we examined self-efficacy and involvement in learning ERP systems as determinants of eustress during gamified training. We found self-efficacy is a significant determinant of eustress, but has no significant effect on involvement. Moreover, we found that involvement had a significant effect on eustress only when self-efficacy was not included in the model. This provides new insights into how individual differences affect eustress, which can inform the design of gamified training interventions.

6.3 Practical Contributions

In addition to theoretical contributions, this study offers several practical contributions. First, in the context of training and learning, ability and motivation are two crucial concepts. Thus, organizations need to invest significant effort and resources into this area. Our findings suggest that incorporating gamification into the design of training programs can enhance the effectiveness of training by promoting learners' self-efficacy and involvement. Moreover, to effectively implement gamified training systems that can enhance learners' ability and motivation, organizations should carefully consider which game elements to incorporate in different contexts.

Second, the study showed that experiencing eustress during training can enhance self-efficacy and involvement in learning ERP systems after gamified ERP training. Many businesses that rely on the successful implementation and training of complex systems like ERP are also concerned with employee wellness and have programs to promote it. Based on our findings, companies with employee wellness training programs might well consider incorporating eustress-inducing activities into their programs to enhance employees' motivation and involvement in adopting healthy lifestyles. To increase eustress, firms can use various methods such as group activities (e.g., team-based competition) and interactive and immersive learning experiences (e.g., virtual reality) as well as gamification.

Finally, this study indicates that self-efficacy in learning ERP systems has a positive influence on eustress experienced during the gamified training period. Therefore, organizations should consider identifying learners with different levels of self-efficacy and creating separate groups. For low self-efficacy users, a pre-training session could be provided to boost their confidence before the gamified training. This approach can lead to better outcomes by inducing eustress and prompting greater involvement in the learning process.

6.4 Limitations and Future Research

This study has several limitations that require consideration. First, the study used a sample of graduate students, which may limit the generalizability of the findings to other populations. Thus, future research should test our model in different samples, such as working professionals.

Second, among the various ERPsim games, the study used only the Maple Syrup game. Future research needs to test our model in different ERPsim games (e.g., Logistics or Manufacturing) or other gamified learning (e.g., Duolingo). Third, this study examined self-efficacy and involvement as proxies of ability and motivation, respectively. While these are commonly used, they may not fully capture the complex constructs of ability and motivation. Future research might consider using other constructs to fully understand ability and motivation.

Fourth, the study examined the immediate effects of playing the game on self-efficacy and involvement. Thus, we are not sure if the findings are applicable to long-term effects. Future research could investigate whether the effects of playing ERPsim persist over time and whether they lead to improved ability and motivation. Fifth, this study missed a control group for comparison, such as learners trained through traditional classroom methods. Future research should incorporate control groups to isolate the effects of gamification on eustress, self-efficacy, and involvement.

This study has provided valuable insights into the relationship between gamified training, eustress, self-efficacy, and involvement in pre- and post-training contexts. However, there is still much to explore to better understand the causal relationships and underlying mechanisms of these constructs. Thus, some possible future research directions are discussed here. First, to identify the causal relationships between the constructs, future studies can use a control group in addition to the intervention group. This can help isolate the effects of the intervention and provide more concrete evidence of causality. Moreover, a longitudinal study design can also help to further establish the causal relationships and also can focus on the long-term effect of this intervention. Second, although we highlighted the importance of eustress in our study, further research can explore the specific role of eustress in different group settings. For example, researchers can examine how eustress affects individuals with high self-efficacy compared with those with low self-efficacy. Such studies can provide more nuanced insights into how eustress can impact different types of individuals. Third, future researchers can focus on the design aspects of gamified learning systems that can induce eustress among participants. They can explore how different game elements, such as rewards, challenges, and competition, impact the level of eustress individuals experience in a learning context. Such studies can help to identify the most effective gamification design elements that can enhance eustress and, ultimately, improve learning outcomes. Finally, future studies can also examine the moderating and mediating factors that influence the relationships between gamified training with eustress, self-efficacy, and involvement. For example, researchers can explore how job experience, age, educational background, and other individual characteristics impact the relationship between eustress and learning outcomes. Moreover, moderating factors, such as cash or noncash rewards or interpersonal skills, can also be explored to better understand the underlying mechanisms of the observed effects.

This study has provided a foundation for future researchers to further explore the relationship between gamified training and related constructs, especially eustress. By using rigorous research designs and exploring the nuances of these relationships, future studies can provide valuable insights that can inform the development and design of more effective learning interventions.

7. ACKNOWLEDGEMENTS

We thank the Bart and Martye Simmons Endowment in the College of Business at Lamar University and the ERPsim Lab at HEC Montréal for their research sponsorship.

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Journal of Information Systems Education, 36(2), 148-165, Spring 2025
https://doi.org/10.62273/UIIM2219

APPENDIX

Selected Research on the Effects of Gamified Training and Learning

Author	Context	Theory	Gamified system	Game elements	Outcome variables	Key finding
Awais et al. (2019)	E-learning	Not specified	Adaptive feedback system	Feedback, incentives (points, levels, badges, quests, leaderboards, rewards)	Performance, engagement	- Significantly increased student performance. - Engaged students more in the learning process and they felt more motivated to collaborate with their peers
Borras-Gene et al. (2016)	Engineering education	Self-determination	Gamification cooperative massive online open course (MOOC)	Virtual learning community, Instagram contest, Hangouts, certificates, and badges	Motivation, learning, completion rate	- Improved participants' learning motivation and completion rates in MOOCs - Deepened students' learning and involvement in the course
Chen et al. (2020)	Reading	Social constructivist theory	Web-based collaborative reading annotation system (WCRAS)	Levels, leaderboards, design principles: achievement, visual status, clear goals, and feedback	Annotation behaviors, collaborative interactive relationship, reading performance, immersion experience	- Encouraged students to make more and higher quality annotations - Promoted their engagement in the collaborative annotation, and interacted more with each other Differences in reading comprehension performances were not significant.
Darban et al. (2016)	ERP training	Self-determination social information processing mechanism	ERPsim	Collaboration	Intention to learn	- Team collaboration leads to learners' perceived knowledge update, improving intention to learn about ERP systems.
Dindar et al. (2021)	English vocabulary learning	Social interdependence theory	Mobile-assisted language learning system	Gamified cooperation, Gamified competition	Task effort, learning achievement, task interest and enjoyment, Social relatedness	- Social relatedness in the gamified cooperation group was significantly higher than in the gamified

						competition group
Felszeghy et al. (2019)	Medical and dental histology course	Bauman's layered-learning model	Kahoot® (a game-based learning platform)	Online competition	Performance, player attrition, knowledge retention, engagement	- Better performance along with better satisfaction, interest, and collaboration. - Led to a more relaxed learning atmosphere and improved sustained retention of information
Garcia-Sanjuan et al. (2018)	Collaborative learning in primary education	Not specified	Collaborative gamified quiz application	Requirements of joint intervention, discussion, continuous coordination of actions, Items to play (keys, walls, bombs)	Performance, Users' experiences and quality of collaboration	- Led to a state of flow, characterized by full involvement and enjoyment in the learning process. - The tangible version of Quizbot was also rated higher in terms of time management, as children were more precise in controlling the robot and not colliding as much with the walls and bombs
Hasan et al. (2019)	Online discussion	Not specified	Learning management systems (LMSs)	Dashboard, Gamified lessons, Completion progress, Level up, GISMO analytics, Game mechanics	Engagement	- Increased student engagement and motivation - Provided with opportunities to collaborate with their peers and to receive feedback on their work
Jagušt et al. (2018)	Mathematics	Flow theory	Competitive, adaptive, and collaborative gamified application	Real-time feedback, Reporting of individual score, Reporting of others' scores, Reporting of group scores, Adaptive to individual performance, Adaptive to group performance, competition, collaboration,	Task completion, time	- Significantly higher performance levels appeared in a gamified condition combining competition, a narrative, and adaptivity with individual performance game elements.

				narratives, leaderboard, time limit awareness		
Kwak et al. (2019)	ERP training	Elaboration likelihood model	ERPsim	Leaderboard, Team	Attitude intention to learn	- Perceived quality and usefulness of learning from ERPsim positively influenced attitude toward learning.
Mavridis et al. (2014)	Computer Science Education	Not specified	3D collaborative game as a midterm assessment	OpenSim (in the form of a treasure hunt)	Performance, attitude toward collaboration	- Statistically significant correlation between the performance of the students on the game and their performance on the final paper-based examination
Ramírez-Donoso et al. (2017)	Massive Open Online Courses (MOOCs) and Small Private Online Courses (SPOCs)	3C model: cooperation, coordination, communication	MyMOOCSpace (A cloud-based mobile system aimed at supporting effective collaboration in MOOCs)	Working in teams, Levels, tasks against time, points, scoreboards, badges	Usability, collaborative problem solving (CPS), team dimension training (TDT)	MyMOOCSpace is easy to use, and participants felt pleased with while using it - Managed to enhance interaction and collaboration among students.
Sailer and Sailer (2021)	Higher Education (Educational Science)	Theory of gamified learning, self-determination theory	Gamified quiz	points, team-leaderboards,	Learning process performance	- A positive indirect effect of gamification on application-oriented knowledge that was mediated by learning process performance. - Positive effects of gamified in-class activities on intrinsic motivation and social relatedness
Sanina et al. (2020)	Higher Education (Social science)	Game-based Learning	Digital simulation game with co-create option	Co-creation, simulation	Performance, course evaluation, attitudes toward their future profession	- Developed students' generic and professional skills. - Improved students' performance, course outcomes, and course evaluation. - Encouraged a more conscious and motivated

						approach to their future profession.
Stoeffler et al. (2020)	Collaborative Problem Solving (CPS) Skills Assessment	Item response theory	First- person maze environment-based game	Interdependence, Challenges: locked gates, doors, or barriers	CPS skills	- Engaging and motivating for students, and it led to improved performance on a subsequent collaborative problem- solving task.
Uz Bilgin and Gul (2020)	Group learning environments	Not specified	Gamified learning system named Edomodo	Badges, scores, leaderboard, competition	Attitude toward group learning environments and course, group cohesion. academic performance	- Promoted group cohesion and achievement in collaborative learning environments. Promoted learning performance.
Zhao et al. (2021)	ERP training	Flow theory	ERPsim	Team	Flow experiences learning outcome, intention to learn	- Team cohesion while playing ERPsim increased learner's flow experiences. - Flow experiences increased learning outcome and intention to learn.

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All papers published in the ***Journal of Information Systems Education*** have undergone rigorous peer review. This includes an initial editor screening and double-blind refereeing by three or more expert referees.

ISSN: 2574-3872 (Online) 1055-3096 (Print)