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Competing to Learn: The Role of Competition in Students' Flow, Cognitive Load, and Learning Gains in Game-Based Learning

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Abstract. Game-based learning has emerged as a promising pedagogical approach to enhance student engagement and learning. However, the role of competition in game-based learning remains contested, with some studies highlighting its motivational benefits while others caution about its potential to induce stress and cognitive overload. This study investigates how competition influences students' learning experiences in game-based learning, focusing on flow state, extraneous cognitive load, and learning gains. A study with a quasi-experimental design was conducted with 179 undergraduate business students enrolled in a financial accounting course at a Spanish university. Students were randomly assigned to either a competitive condition (n=94) or a control group (n=85). The intervention involved a board game that simulated different financial accounting scenarios. The theoretical framework combined flow theory and cognitive load theory to examine the interplay between motivational and cognitive processes in competitive learning environments. Data were collected through pre- and post-tests assessing accounting knowledge, and a survey measuring flow and extraneous cognitive load. A multigroup structural equation modelling approach was employed to analyse the relationships among the variables and compare effects across experimental conditions. The findings revealed that competition significantly enhanced students' flow state and moderately reduced their extraneous cognitive load, resulting in higher learning gain in the competitive condition. These results suggest that the motivational benefits of competition-enhanced flow may outweigh the cognitive challenges it introduces.

Keywords: Game-Based Learning; competition; flow state; cognitive load; learning outcomes

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1. Introduction

Game-based learning (GBL) has gained attention as an effective instructional approach that enhances student motivation and learning outcomes (Ishak et al., 2023; Saprudin et al., 2019). By integrating game mechanics into educational settings, GBL fosters active participation, problem-solving, and knowledge retention (Hamari et al., 2016; Plass et al., 2015). Previous studies have established that flow state (FS) is a key driver of motivation in GBL experiences (Hamari et al., 2016; Perttula et al., 2017) and that it contributes to a sustained effort in the learning process (Admiraal et al., 2011; Kiili, 2005). According to flow theory (Csikszentmihalyi, 1975), learners experience a FS when: (1) the challenge of the task is optimally balanced with their skill level; (2) the goals are clear, and feedback is immediate; and (3) there is a sense of control over the learning process (Kiili, 2005; Hamari et al., 2016).

Another important theoretical tenet of GBL is cognitive load theory. According to cognitive load theory (Sweller, 1988), the learning efficiency of an instructional method such as GBL depends on the extent to which the particular game balances cognitive load by minimising unnecessary loads and facilitating schemata development within the context of the limited capacity of the working memory of the human brain. The cognitive load generated by GBL can be divided into three components: (1) intrinsic cognitive load, related to the complexity of the activity itself; (2) extraneous cognitive load (ECL), caused by irrelevant demands of the instructional method that do not add to learning; and (3) germane cognitive load, which supports the construction of schemata and their transfer to long-term memory (Sweller et al., 2019).

Among the various attributes that make educational games engaging, competition remains one of the most debated elements in the literature (Hwang & Chang, 2016; Prensky, 2001; Shaffer, 2006; Wei et al., 2018). From the perspective of flow theory, competition can offer important motivational benefits. It can help clarify goals and provide immediate feedback, both of which contribute to a state of focused engagement and optimal learning (Karakoç et al., 2022). Studies have shown that competition may enhance FS by fostering a sense of achievement and goal orientation, which encourages students to invest more effort in mastering content (Cagiltay et al., 2015; Vandercruysse et al., 2013).

However, flow theory also suggests that excessive competition can undermine the challenge-skill balance, a critical condition for the occurrence of FS. When the level of a particular challenge exceeds students' abilities, a competitive element to a task may instead generate stress, anxiety, and disengagement (Cagiltay et al., 2015; Chandler & Sweller, 1991; Li et al., 2022). From the perspective of cognitive load theory, competition introduces additional cognitive demands that may interfere with learning. In competitive environments, learners may need to monitor others' performance, manage pressure, and plan strategies to win, all of which consume working memory resources and may increase ECL (Nebel et al., 2016; Presbitero, 2020). If ECL becomes excessive, it can overload cognitive capacity, disrupt the construction of schemata, and ultimately impair learning outcomes (Chang et al., 2017; Chen et al., 2018). Thus, while competition has the

potential to support motivation and engagement, it also poses risks to cognitive efficiency. This highlights the need to balance its use carefully within educational game design.

Educators often face uncertainty about whether introducing competition will motivate students or distract them from learning. Thus, a clearer understanding of the role of competition in GBL is essential in order to improve its pedagogical effectiveness. Despite the growing interest in GBL, there remains a gap in understanding how competition interacts with motivational and cognitive processes during learning. This is particularly true for FS and ECL, both of which are known to influence learning performance. Moreover, the emphasis on digital GBL in current research has only deepened the lack of insight into how competition influences learning in non-digital environments.

This study addresses these gaps by exploring the cognitive and motivational effects of competition within a board GBL intervention. A quasi-experimental study was conducted with 179 undergraduate business students from a Spanish university who participated in a team-based learning experience using a board game as a financial accounting simulation. Students were randomly assigned to two groups: one experienced a competitive condition with a real-time leaderboard displaying teams' outcomes, while the control group played the same game without the competitive condition. Following the game, data were collected through a survey, and a multigroup analysis of a structural equation model was undertaken to evaluate whether the relationships between FS, ECL, and learning gain differed between the control and competitive groups. The difference between pre-and post-test scores for a multiple-choice test on financial accounting measured learning gain.

Although prior research has examined the effects of competition in GBL, most studies have treated its influence as either wholly positive or negative, without considering how competition might interact with other motivational and cognitive constructs. In particular, little is known about how competition simultaneously affects learners' motivational states (e.g., FS), cognitive processing (e.g., ECL) and learning gain. Few empirical studies have used integrated models to assess these relationships or adopted multigroup structural equation modelling to compare learning outcomes under different competitive conditions. As a result, a nuanced understanding of the dual role of competition, as both a motivator and a potential stressor, remains underdeveloped. To address this, the present study proposes a research model (Figure 1) that links FS, ECL, and learning gain, and examines how competition moderates these relationships. The relationships in the model suggest that FS, ECL and learning gain are interconnected. FS is expected to have a relationship with learning gain, while ECL is expected to affect FS and learning gain. Moreover, the model assumes that, due to the competition condition, these relationships will differ between the experimental and control groups. Building on this model, the study proposes the following research questions:

RQ1: How does competition influence the relationship between FS and learning gain?

- RQ2: How does competition influence the relationship between ECL and FS?
 RQ3: How does competition influence the relationship between ECL and learning gain?
 RQ4: How does competition influence students' learning gain?

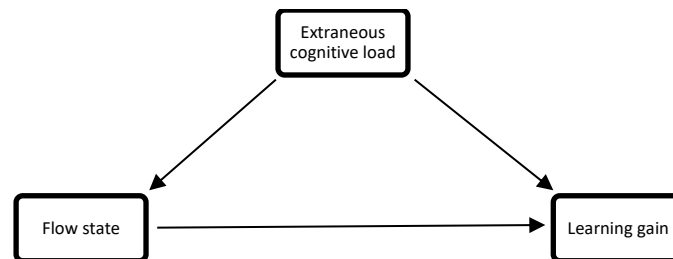


Figure 1: Research model

2. Literature review

2.1 Game-based learning and game attributes

GBL has been proposed as an instructional design that contributes to enhancing students' learning experience by increasing their motivation and improving their learning outcomes (Flemban, 2024; Krath et al., 2021). Several calls have been made in the literature to explore how different game attributes – such as rules, fantasy, feedback, or competition, among others – impact students' learning experience (Garris et al., 2002; Wilson et al., 2008). Attributes are a key factor explaining the educational value of games (Kageyama et al., 2022). Attributes are the features of a game that engage players to persist in the game while indirectly reinforcing learning (Hamari et al., 2016; Heintz & Law, 2015; Yusoff et al., 2010). Different proposals have been made to systematise game attributes. Malone and Lepper (1987) proposed challenge, fantasy, curiosity, and control, while Prensky (2001) added feedback, problem-solving, and competition. Garris et al. (2002) identified further attributes, such as clear rules and goals. Wilson et al. (2008) additionally contemplated surprise and interpersonal interaction. In a systematic literature review, Flemban (2024) analysed 25 studies to identify key educational game attributes influencing cognition, attitudes, and behaviours. The findings showed that clear goals, challenges, feedback, and immersion enhanced cognitive outcomes; intrinsic motivation and enjoyment supported affective outcomes; and skill practice and active participation steered behavioural outcomes.

2.2 Competition and game-based learning

Competition is one of the most debated game attributes influencing learning, with studies reporting both positive and negative effects. Vandercruysse et al. (2013) defined competition in GBL as structured contests among individuals or teams striving to achieve superior game performance. The GBL literature highlights several benefits of competition, particularly its ability to boost motivation, encourage learners to engage more vigorously, dedicate additional time, and exert significant effort in mastering educational content (Prensky, 2001; Shaffer, 2006). Zeng and McEaney (2022) and Zhan et al. (2024) found that competition fostered engagement by adding excitement and challenge to the learning

experience. Saprudin et al. (2019) suggested that the presence of points and leaderboards in a GBL experience could increase students' motivation. Cagiltay et al. (2015) studied the effects of competition in GBL and reported that students in a competitive environment exhibited greater motivation and higher post-test scores than those in non-competitive settings. Wei et al. (2018) found that competition enhanced students' sense of control, curiosity, and interest.

In other studies, competition required learners to apply knowledge in high-stakes scenarios, which improved focus and enhanced knowledge retention (Bounajim et al., 2020; Vandercruyssen et al., 2013). Brom et al. (2014) reported that competition positively influenced learning achievement, though it reduced enjoyment. A meta-analysis by Chen et al. (2020), covering 25 studies on competition in GBL, reported overall significant positive effect sizes for cognitive ($g = 0.368$) and non-cognitive ($g = 0.396$) learning outcomes. However, the effects were more pronounced in mathematics and STEM than in social sciences, suggesting that competition may be more effective in structured subjects which are oriented towards problem-solving than in disciplines that require discussion and critical reflection.

Despite the reported benefits, competition in GBL remains a debated topic, with studies reporting mixed or adverse effects. In Li et al. (2022), competition negatively impacted learning by inducing anxiety and diminishing students' sense of empowerment over their learning, particularly for lower-performing students (Chen et al., 2018). Ter Vrugte et al. (2015) observed that competition favoured high achievers but reduced participation among lower-achieving students. Bounajim (2020) noted that competition-induced anxiety hindered learning by affecting motivation and cognition. Competition has been shown to shift students' focus from learning to winning (ter Vrugte et al., 2015; Van Eck & Dempsey, 2002; Vandercruyssen et al., 2013), strain interpersonal relationships (Kohn, 1986) and encourage social comparison, potentially leading to lower self-efficacy (Stapel & Koomen, 2005). Moreover, Nebel et al. (2016) reported that monitoring competitors increased cognitive load, potentially reducing instructional efficiency.

Chen et al. (2018) reported that students in non-competitive conditions outperformed those in competitive settings in achievement tests, with no differences in FS experiences. Chang et al. (2017) found no significant differences in motivation or learning effectiveness between competitive and non-competitive groups, although both experienced knowledge gains due to GBL. In a systematic literature review about GBL in primary education, Arosquipa et al. (2023) cautioned that competition among students can increase their levels of anxiety, frustration, and discouragement.

Other studies suggest that the impact of competition in GBL is context-dependent, since different competition settings (e.g., individual vs. team-based or face-to-face vs. online) may generate different dynamics. For example, Eastin (2006) and Sepehr and Head (2018) observed that players competing against a computer exhibited lower levels of competitiveness than those competing against a real

person. Similarly, Van Eck and Dempsey (2002) observed that competition against a computer inhibited metacognitive skills, attention, and elaboration, and Weibel et al. (2008) found that students who played against a real person had more enjoyment than those who were in competition with computer-controlled opponents. Chen et al. (2020) discussed the limitations of individual competition – where each learner operated as an autonomous player, facing challenges independently – versus group competition, where learners were organised into teams competing against each other.

Considering all this evidence, it seems that competition in GBL can both enhance and hinder the learning experience, depending on how it interacts with learners' emotional and cognitive states. As a motivational driver, it may foster engagement and performance, but it can also lead to pressure or distraction. Given this dual potential, the present study examines whether competition acts as a moderator in the relationships between flow, cognitive load, and learning outcomes in GBL environments.

2.3 Flow and game-based learning

Flow is a psychological state of deep engagement, immersion, and focus (Csikszentmihalyi, 1997). FS has been widely studied in GBL, where it is seen as a key driver of motivation and learning (Chang et al., 2018; Hamari et al., 2016; Erdoğan & Kurt, 2024). In GBL, students may achieve an FS when game tasks are neither too easy nor too difficult and ensure a balance between challenge and skills without causing anxiety or apathy (Hamari et al., 2016). FS is supported by games that provide clear goals, feedback, and autonomy (Sweetser & Wyeth, 2005). In a study comparing digital GBL and traditional computer-based learning, Chang et al. (2018) found that games with adaptive difficulty enhanced FS by keeping players engaged at an optimal challenge level. Similarly, in a study comparing GBL and non-GBL groups, Chang et al. (2017) showed that GBL environments lead to significantly greater FS. Hamari et al. (2016) found that challenge levels directly influenced FS, with appropriately challenging games fostering higher motivation and knowledge retention. However, Rodríguez-Ardura and Meseguer-Artola (2017) argued that user control and ease of use better predict sustained FS than challenge alone. To synthesise the role of FS in GBL, Perttula et al. (2017) conducted a systematic literature review including 19 empirical studies. Their findings indicated that GBL positively impacted FS and engendered deeper cognitive engagement and better knowledge retention.

Understanding FS in GBL requires its relationship with cognitive load to be explored. FS has been found to negatively correlate with intrinsic cognitive load and ECL, meaning that FS decreases as these types of cognitive loads increase (Chang et al., 2017). Conversely, FS has been found to correlate positively with germane cognitive load, which is the mental effort directed towards learning and understanding, suggesting that FS enhances the capacity for meaningful learning (Chang et al., 2018). Chou et al. (2023) and Huang et al. (2013) reported that participants in GBL environments experienced higher FS and lower overall cognitive load than during traditional learning methods. In contrast, Erdoğan and Kurt (2024) found that FS did not mitigate mental effort. Rodríguez-Ardura

and Meseguer-Artola (2017) cautioned that extended FS may cause cognitive fatigue in demanding tasks.

Interestingly, Talan et al.'s (2020) meta-analysis, covering 154 studies, found that non-digital board games were more effective than digital games in enhancing FS and academic achievement. This greater effectiveness was attributed to the more substantial social interaction that board games foster, as they encourage face-to-face discussions, peer teaching, and cooperative problem-solving, which can deepen understanding and improve retention.

Collectively, these findings suggest that flow is a key mechanism through which GBL fosters engagement and learning. However, its emergence depends on a complex balance of cognitive, emotional, and design factors. Competition may influence this balance by either reinforcing immersion or disrupting it through excessive pressure. Given this dynamic, the present study investigates how competition affects the relationship between flow and learning outcomes, contributing to a better understanding of its role in motivational processes within GBL.

2.4 Cognitive load and game-based learning

Cognitive load theory explains how the brain processes and retains information (Sweller, 1988). It builds on the difference between long-term memory, where large amounts of information are stored semi-permanently, and working memory, which is responsible for temporarily processing information and has a limited capacity (de Jong, 2010). Working memory integrates new data with prior knowledge to form schemata, which are then stored in long-term memory (Sweller et al., 2019).

Cognitive load is a central concept in cognitive load theory and refers to the total amount of working memory required to process and integrate new information (Sweller, 2018). Cognitive load is influenced by: (1) intrinsic load, dictated by the complexity of the content and a learner's previous knowledge; (2) extraneous load, defined as the part of the cognitive effort that results from unnecessary complexity or inefficient instructional design; and (3) germane load, representing the mental effort devoted to the construction of schemata (Sweller et al., 2019). Effective instructional methods should minimise extraneous load to support the construction and retention of schemata (Chen & Liang, 2022; Hawlitschek & Joeckel, 2017; Sweller et al., 2019).

Earlier studies suggest that some game characteristics may inadvertently increase ECL (Davis, 2020). For instance, Kalyuga and Plass (2009) identified that digital games have unique features that demand higher cognitive resources than traditional direct-instruction approaches. These include 3D navigation, discovery-based tasks, hidden cues, and narrative contexts. A study by Huang (2011) suggested that the high interactivity of GBL environments frequently demands learners to process extra visual and auditory stimuli, which can result in increased ECL. Similarly, overuse of virtual tutors has been found to cause redundancy and increased ECL (Erdoğan & Kurt, 2024). However, Talan et al. (2020) found that

board games tend to impose a lower cognitive load than digital games, as they avoid potential distractions from complex interfaces, animations, or excessive visual and auditory stimuli, allowing students to focus more on the learning content.

Studies by Chen et al. (2015, 2022) found that social interactions in GBL could heighten cognitive demands, as learners needed to navigate interpersonal relationships while completing learning tasks. The authors report that competitive gaming environments can divert cognitive resources towards outperforming peers rather than processing instructional content. Crouzevialle and Butera (2017) argued that while competition can help learners focus and maintain task engagement, it can also create evaluative pressure, which may distract them and deplete their working memory resources during task performance. In the study by Nebel et al. (2016), the competitive nature of the experimental tasks overloaded working memory, leading to higher levels of perceived intrinsic cognitive load and ECL. In Presbitero's (2020) experiment, higher cognitive load due to competition was associated with increased anxiety, hindering learning and reducing retention. ECL may increase when irrelevant load, such as the competitors' rank relative to the student's position, is present, and thus, learning may be hampered (Sweller et al., 2019).

Other studies have reported that games may contribute to reduce ECL. For instance, Liao et al. (2019) noted that digital games including collaborative features and providing immediate feedback reduced ECL. Moreover, games including scaffolding mechanisms and gradually increasing complexity helped learners manage cognitive load, allowing them to build their knowledge progressively (Chen & Mokmin, 2024). In another study, Davis (2020) discussed how educational games manage intrinsic, extraneous and germane cognitive load to optimise working memory, arguing that games naturally structure instructional materials in a way that reduces ECL. Similarly, Turan et al. (2016) found that while gamified competitive learning environments resulted in higher cognitive load, it also led to improved academic achievement.

The literature discussed thus far seems to align broadly with Wouters et al.'s (2013) meta-analysis examining the role of cognitive load in GBL. According to Wouters et al. (2013) highly interactive environments and multitasking elements could impose ECL, potentially reducing instructional efficiency. However, games with clear guidance and scaffolding mechanisms may enhance learning by balancing engagement and mental demands. Group-based learning also led to more significant gains than single-session or individual learning.

Additionally, cognitive load can influence the learner's FS (Krath et al., 2021). When cognitive demands are moderate and well-structured, learners are more likely to experience FS (Sewell, 2018). In Su and Cheng (2019), the reduction of ECL led to increased FS, resulting in improved learning performance. Feedback mechanisms also help reduce cognitive load and enhance FS (Erdoğan & Kurt, 2024). Conversely, when cognitive demands are too high, FS can be disrupted, resulting in frustration and disengagement (Skulmowski & Xu, 2022). Presbitero

(2020) showed that anxiety from unbalanced challenges raised ECL and impaired learning.

Taken together, these findings suggest that the effectiveness of GBL depends on how well it manages learners' cognitive resources. While some game features may support cognitive processing, others can divert cognitive resources from learning content. Furthermore, the interaction between cognitive load and flow is particularly relevant, as excessive cognitive demands can disrupt immersion and reduce learning efficiency. The present study builds on this theoretical grounding to examine how competition may alter the balance between cognitive load and flow and ultimately influence academic performance.

3. Methodology

3.1 Research design

This study adopted a quasi-experimental, between-subjects design. Although participants were randomly assigned to either a competitive or a control group, the lack of full experimental control over all confounding variables (e.g., participants' previous exposure to GBL) qualified the design as quasi-experimental. Students were randomly allocated to the control or experimental groups using simple randomisation. Each participant was assigned a random number generated in Excel, and then students were placed into one of the two groups. Simple randomisation was considered appropriate for this study as it ensured that each participant had an equal probability of being assigned to either the control or experimental group, thereby reducing selection bias and strengthening the internal validity of the findings (Creswell & Guetterman, 2019). Given the relatively large and homogeneous sample, comprising undergraduate business students enrolled in a financial accounting course, simple random allocation was likely to yield balanced groups without requiring stratification. Moreover, the method is practical, transparent, and easy to replicate. Finally, because the focus of the study was on individual student outcomes rather than classroom-level effects, individual-level random assignment was both appropriate and methodologically sound.

3.2 Participants

Participants were recruited using convenience sampling, as they were enrolled in a financial accounting course where the intervention could be implemented during regular instructional time. This method was appropriate given the practical constraints of classroom-based educational research and the exploratory nature of the study. In particular, the study involved 179 undergraduate business students from a Spanish university who were enrolled on an introduction to financial accounting course. After obtaining full research ethics approval (Ref. No. 23DCF02), participants were informed about the study's objectives and the voluntary nature of their participation. No incentive or extra course credit was offered in return for participation. A total of 179 students out of 212 enrolled in the course volunteered to participate in the experiment (84.4%). The mean age of the participants was 18.7 years, with just over half being male (51.8).

3.3 The intervention

The study utilised a board game as the intervention which required players to make real estate investment decisions to grow their income. Players generated revenue by collecting rent from opponents and benefiting from random events while incurring expenses through rent payments and chance-based events. The learning objective of the intervention was to enhance students' skills in recording accounting transactions based on gameplay events. In the game, each round involved transactions that students were required to record in a spreadsheet facilitated by the instructor in a Google Sheets file. This file closely resembled the spreadsheets used in the regular classes, ensuring students were familiar with its functionality. The selection of the game was based on two key characteristics. First, it could provide a meaningful context for students to produce accounting records reflecting in-game transactions. Second, the game rules were relatively simple, minimising the cognitive load required to understand its mechanics[†].

3.4 Study procedures

Students who participated in the experiment were randomly assigned, irrespective of their class section, to either an experimental group (n = 94), which experienced a competitive condition, or a control group (n = 85), which experienced a non-competitive condition. To ensure consistency across experimental conditions, all game sessions were facilitated by the same instructor, who followed a standardised protocol (Appendix 1). This protocol included a checklist of procedures for explaining the game rules, managing time, guiding the use of the accounting spreadsheet, and responding to students' questions. During gameplay, the instructor provided clarifications and logistical support equally in both groups without offering advice or feedback that could influence learning outcomes. This approach helped maintain instructional equivalence between the competitive and control conditions and supported the internal validity and reproducibility of the study.

Every group was divided into teams of three students, with every four teams competing around the same board. The competitive condition was set through a real-time leaderboard that displayed a ranking of the profits of all the teams making up the experimental group. For students in the experimental group, the leaderboard was visible through their laptops and projected on two large whiteboards in the classroom. Meanwhile, students in the control group experienced the same game without the competitive element, ensuring that any observed differences in FS, ECL, and learning gain were due to the competitive condition.

At the beginning of the sessions, students were given time to sign informed consent and to respond to a pre-test accounting knowledge questionnaire. No significant differences were found between the groups' initial knowledge levels

[†] Only four students out of the 179 stated that they had never played the board game before the experiment, so prior familiarity with the game was high. This minimised the risk of a learning curve affecting cognitive load during the experience due to the need for participants to master the game mechanics.

($t= 0.36$, $p= 0.72$). This was followed by a five-minute introduction to the game mechanics. Then, for 90 minutes, students engaged in the game. At the end of the session, students responded to the post-test knowledge questionnaire and completed the surveys to gather their perceptions about FS and ECL.

3.5 Measurement of the variables

Data for this study were collected through three instruments: a paper-based pre-test and post-test assessing students' knowledge of financial accounting, and a paper-based survey administered at the end of the intervention. To measure students' perceptions of FS and ECL, the study adapted items from prior research, rewording some to better align with the study's context (Appendix 2). Participants expressed their level of agreement with the statements using a five-point Likert scale. All instruments were administered in class immediately before or after the intervention to ensure accurate measurement of the intervention's effects.

1) Flow state

FS was measured using five items from the Fu et al. (2009) scale, which assesses the degree to which participants experience immersion, concentration, and enjoyment during gameplay.

2) Extraneous cognitive load

ECL was measured using three items from Leppink et al. (2013). The original wording was modified to match the features of the teaching material in the present study.

3) Learning gain

Before playing the game, students completed a 20-question multiple-choice test to assess their accounting knowledge. After the game, they took another 20-question multiple-choice test to measure any changes in their understanding. The difference between post- and pre-test scores measured learning gain.

3.6 Data analysis

Responses from the paper-based surveys and tests were manually entered into an Excel spreadsheet to be organised and for initial data handling. Descriptive statistics, including means and standard deviations, were computed using SPSS Statistics-21. To assess the relationships among FS, ECL, and learning gains, and to examine differences across conditions, AMOS-21 was used to perform structural equation modelling and multigroup analysis to compare the structural model across the experimental and control groups.

To assess the potential presence of common method bias, which can arise when data are collected using self-report scales, Harman's single-factor test was conducted by entering the surveyed items into an unrotated exploratory factor analysis. The results revealed that the first factor accounted for 37.4% of the total variance. As this value is well below the commonly accepted threshold of 50% (Podsakoff et al., 2003), common method bias was unlikely to be a significant concern in this study.

4. Results

Table 1 presents the descriptive statistics for the studied variables as a preliminary analysis. Learning gain was calculated as the difference between the pre-post knowledge test, and FS and ECL as the mean score of their respective items.

Furthermore, means between the control and experimental groups were compared (Table 1).

Table 1. Descriptive statistics and group comparisons for flow state, extraneous cognitive load, and learning gain

Variable	Control mean	Experimental mean	t-statistic	p-value	Cohen's d effect size
ECL	3.12	3.45	-2.34	p<.05	0.35
FS	3.75	4.02	-3.12	p<.05	0.58
Learning gain	1.70	1.89	-2.89	p<.05	0.50

The t-test results indicated statistically significant differences between the control and experimental groups across all variables, with the experimental group exhibiting higher mean values in all cases with moderate to large effect sizes. These results suggest that, while differences between groups were statistically significant across all variables, the magnitude of these differences varied, with the largest effect observed in FS and the smallest in ECL.

A measurement model was employed to assess the reliability and validity of the scales measuring the latent variables. Following this, the model's fit was evaluated, and the path coefficients of the structural model were estimated. A multigroup analysis was conducted to assess the significance of the differences between the studied variables across the control and experimental groups.

Measurement model

The measurement model was evaluated through the reliability and validity metrics of the latent variables, FS and ECL. According to Fornell and Larcker (1981), convergent validity is supported when factor loadings exceed 0.7, and the average variance extracted (AVE) is greater than 0.5, both of which were met in this study. The item loadings for FS (0.799, 0.801, 0.847, 0.874, 0.880) and ECL (0.825, 0.882, 0.901) confirmed that each item strongly represented its respective construct. All loading factors were significant at the 0.01 level. Moreover, the AVE values (0.710 for FS and 0.763 for ECL) further validated their measurement.

Regarding reliability, composite reliability values were 0.858 for FS and 0.901 for ECL, exceeding the recommended threshold of 0.7 and confirming the robustness of these constructs (Fornell & Larcker, 1981). Similarly, Cronbach's α values (0.901 for FS and 0.892 for ECL) indicate strong internal consistency, as all values surpassed 0.8, aligning with Nunnally's (1978) criterion for high reliability. Discriminant validity of the latent variables was also confirmed since the square root of the AVE was greater than the correlations between constructs. The results indicated a significant negative correlation between ECL and FS ($r = -0.48$, $p < .01$), with the square root of the AVE for both constructs (ECL = 0.842, FS = 0.873) exceeding the inter-construct correlation, supporting discriminant validity.

Since the measurement model exhibited strong internal consistency, reliability, and discriminant validity, it could be confirmed that the observed indicators

demonstrated strong internal consistency and measurement reliability, thereby supporting the robustness of the subsequent structural analyses.

Structural model

The study assessed the proposed model's fit by examining the χ^2/df index, the comparative fit index (CFI), the standardised root mean square residual (SRMR), and the Root Mean Square Error of Approximation (RMSEA). Table 2 shows the values obtained for these indices. Collectively, these indices confirm that the model showed a structure which had a good fit with the data.

Table 2. Model fit indices

Fit index	Overall model	Control	Experimental	Threshold (*)
χ^2 / df	1.33	1.37	1.29	Between 1 and 3
CFI	0.96	0.95	0.96	≥ 0.90
RMSEA	0.042	0.045	0.042	≤ 0.06
SRMR	0.038	0.038	0.036	≤ 0.08

(*) Source: Hooper et al. (2008)

Table 3 presents the control and experimental groups' ECL, FS, and learning gain relationships. With respect to the study's research questions, the results revealed the following:

RQ1: How does competition influence the relationship between FS and learning gain? The analysis showed that FS significantly predicted learning gains in both conditions, with a stronger effect in the experimental group ($\beta = 0.61$) compared to the control ($\beta = 0.54$). The difference was statistically significant ($Z = 2.34$, $p < .05$).

RQ2: How does competition influence the relationship between ECL and FS? ECL had a significant negative impact on FS in both groups, with the effect being stronger in the experimental group ($\beta = -0.25$) than in the control ($\beta = -0.21$). This difference was statistically significant ($Z = -2.01$, $p < .05$).

RQ3: How does competition influence the relationship between ECL and learning gain? While ECL negatively predicted learning gain in both groups ($\beta = -0.32$ for control, $\beta = -0.29$ for experimental), the difference was not statistically significant ($Z = -1.10$, $p > .05$), suggesting no substantial moderating effect of competition on this path.

RQ4: How does competition influence students' learning gain? Independent-samples' t-tests indicated significantly higher learning gains in the experimental group (Mean = 1.89, SD = 1.32) compared to the control (Mean = 1.70, SD = 1.58), $t = -2.89$, $p < .05$, with a moderate effect size (Cohen's $d = 0.50$). Additionally, the structural model explained a greater proportion of the variance in learning gains for the experimental group ($R^2 = 0.37$) than for the control ($R^2 = 0.28$), with the difference reaching statistical significance ($Z = -2.43$, $p < .05$). This indicates that the predictors accounted for a greater proportion of variance in learning gain under the experimental condition, suggesting that the model had stronger explanatory power in the competitive setting than in the control.

Table 3. Standardised regression weights for the structural model and significance of the differences

Path	Control (β)	Control S.E.	Control C.R.	Experiment (β)	Experiment S.E.	Experiment C.R.	Z- score	P- value	Significance of the difference
FS→ Learning gain	0.54	0.06	9.33	0.61	0.05	10.45	2.34	0.02	Significant
ECL→ FS	-0.21	0.07	-6.43	-0.25	0.06	-7.89	-2.01	0.04	Significant
ECL→ Learning gain	-0.32	0.08	-4.00	-0.29	0.09	-3.22	-1.10	0.27	Not significant

5. Discussion

This study analysed whether competition enhanced learning gain in a GBL experience. The study's main finding is that introducing a competitive condition resulted in a significantly higher learning gain when comparing experimental and control groups. This result contributes to the ongoing debate in the literature regarding the role of competition in GBL, where prior research has yielded mixed results, with some studies reporting beneficial effects on motivation and learning outcomes (Bounajim et al., 2020; Brom et al., 2014; Cagiltay et al., 2015; Vandercruysse et al., 2013), and others highlighting potential drawbacks such as increased anxiety or reduced performance (Arosquipa et al., 2023; Chang et al., 2018; Chen et al., 2019).

The study confirmed that FS positively correlated with learning gain, which aligns with earlier studies discussing this relationship (Kiili, 2005; Perttula et al., 2017). Furthermore, and in line with previous research, the study confirmed that ECL had a negative effect on students' FS (Davis, 2020; Flemban, 2024) and learning gain (Nebel et al., 2016; Sweller et al., 2019; Zhan et al., 2024). Overall, these findings align with the patterns identified in the meta-analysis by Karth et al. (2021), which emphasised the crucial role of flow in enhancing learning outcomes and the disruptive impact of extraneous cognitive load in GBL contexts. Notably, in the current study, the positive effect of FS on learning gain was strong enough to counteract the negative impact of ECL.

The study also examined whether the observed relationships between FS, ECL, and learning gain differed between the competition and control groups. The results showed that although the structural model held for both groups, the strength of the relationships varied significantly between them, which helps explain the differences observed in learning gain between the two groups.

Regarding the relationship between FS and learning gain, both groups exhibited a positive relationship, as in Hamari et al. (2016). However, the literature discussed earlier has rarely examined how competition can influence this relationship. Prior research suggested that competitive pressure may disrupt

students' FS by disturbing the balance between challenge and skills and causing anxiety (Chen et al., 2018; Chen et al., 2019; Lin et al., 2017). However, aligning with Cagiltay et al. (2015) and Zeng and McEneaney (2022), the current study found that FS had a stronger effect on learning gain in the competitive condition than in the control group, with this difference being statistically significant. A possible explanation for this might be that participants in the competition group might have benefited from a more intense focus, one of the traits of FS (Chen et al., 2018). Another possible explanation is that the sense of accomplishment associated with the competition may have contributed to maintaining goal orientation, another of the features of the FS (Rodríguez-Ardura & Meseguer-Artola, 2017). Additionally, the social dynamics of team-based competition, such as inter-team collaboration and shared goals, may have helped sustain the FS of students in the experimental group despite the added pressure introduced by the competitive element (Admiraal et al., 2011). Moreover, the students' familiarity with the game before the experience along with certain game features (i.e., simple rules and clear objectives) might have mitigated the possible imbalance between challenge and skills that competition might have generated.

Concerning the connection between ECL and FS, the results confirmed a negative association in both the experimental and control groups. This is consistent with earlier studies that have found highly interactive environments or multitasking elements characteristic of GBL can overload students' working memory, generating ECL that disrupts FS (Erdoğan & Kurt, 2024; Huang, 2011; Wouters et al., 2013). This could be the case with this study, where ECL impaired FS more significantly in the competitive condition than in the control group, with this difference reaching statistical significance, as earlier reported in Chen et al. (2018) and Chen and Mokmin (2024). In the study context, specific game mechanics, such as negotiations, recordkeeping, chance elements, and time pressure, may have contributed to cognitive overload, increasing anxiety and reducing FS in both groups. However, students in the experimental group, in addition to managing game and recordkeeping mechanics, also had to track competitors' performance and adjust their decisions (Nebel et al., 2016). Furthermore, the pressure to outperform peers may have induced intensified anxiety, which, in turn, functioned as an additional source of ECL, potentially draining students' FS, as observed by Bounajim et al. (2020), Li et al. (2022), Nebel et al. (2016) and ter Vrugte et al. (2015).

With regard to the relationship between ECL and learning gain, the study confirmed, consistent with the principles of cognitive load theory, that ECL negatively impacted learning gain (Chen & Liang, 2022; Liao et al., 2019; Liu et al., 2023). Regarding the influence of competition on the relationship between ECL and FS, an unexpected finding was that this negative relationship was stronger for the control group than for the experimental group, although the difference did not reach statistical significance. This lack of significance suggests that the presence of competition had little to no effect on how ECL influenced learning outcomes. According to cognitive load theory, performance is typically impaired only when extraneous load exceeds a certain threshold (Sweller et al., 2019). Given that the game used in the intervention was relatively simple and familiar to

students, it is possible that, even with the introduction of the competitive condition, the cognitive demands in both groups remained below that threshold. Additionally, the team-based format may have distributed cognitive demands among group members, reducing the individual impact of ECL, as reported by Li et al. (2022). This may have been particularly relevant in the case of the experimental group, where students may have felt a stronger sense of team responsibility, leading to more active collaboration and shared problem-solving strategies, thereby alleviating individual ECL more effectively than in the control group as was the case in ter Vrugte et al. (2015). It is also possible that the motivational benefits of competition, particularly the heightened FS observed in the experimental group, helped buffer the negative effects of extraneous cognitive load. This compensatory effect of engagement has been noted in prior research; for instance, Chen and Mokmin (2024) found that moderate levels of cognitive load do not hinder learning when students are highly motivated and immersed in the learning environment. In this study, the large positive effect of FS suggests that competitive environments may have supported learners in managing cognitive demands more effectively.

From a theoretical perspective, this study contributes to the field by integrating flow theory and cognitive load theory to offer a more comprehensive understanding of how competition influences learning in GBL. Overall, the findings of the study suggested that the motivational benefits of competition-induced FS were more influential in the achievement of learning gain than the cognitive challenges it created. Specifically, the study concluded that competition heightened students' FS while also being associated with a small but statistically significant reduction in ECL. Although only ECL was measured, these findings suggest that certain competitive elements—such as clear goals, immediate feedback, and social engagement—may help reduce some aspects of unnecessary cognitive effort during gameplay. Overall, the study provides empirical support for the pedagogical value of incorporating moderate competitive elements into GBL experiences, further informing the ongoing debate in the literature on the benefits and drawbacks of competition in educational games (Chen et al., 2020). Moreover, this study extends prior GBL research by employing a non-digital game, an area that remains relatively underexplored in comparison to digital games (Talan et al., 2020).

Three areas for future research are suggested. First, future studies should enhance the generalisability of these findings by examining competition across diverse educational contexts, including different age groups, disciplines, personality types, and cultural backgrounds. Such research could provide deeper insights into how competition impacts learner profiles. Second, this study used a board game, while most GBL research has focused on digital games. Future studies could examine whether competition influences students' learning experiences differently in digital and non-digital game environments. Third, further research is needed to assess how various forms of competition – such as individual vs. team-based or human vs. artificial intelligence – influence learning outcomes. Understanding these differences could provide insights into optimising the effects of competition in GBL.

This study has several limitations. The research used a relatively simple board game that required low mental effort to master its mechanics. In contrast, video games or business simulations, which often involve more complex scenarios or make greater use of visual or auditory stimuli, may generate a level of cognitive load that was not present in this study, potentially leading to a different impact from competition. The study also employed a convenience sampling approach which, although common in educational research, limits the generalisability of the findings beyond the sample population. In this study, all participants were undergraduate business students enrolled in the same course at a Spanish university, which restricts the generalisability of the results to other educational contexts, academic disciplines, or cultural settings.

Moreover, the study focused on the learning gain of a specific highly structured discipline: financial accounting. It is possible that competition may have different consequences in disciplines that require more discussion and critical reflection. Additionally, while students' perceptions cannot be disregarded when investigating the relationship between GBL and learning outcomes, the study relied on self-reported measures, which may introduce subjective bias effects. In this vein, the use of a five-point Likert scale for measuring ECL and FS may have limited the granularity of participants' responses. Future research could explore the use of broader scales, such as seven- or ten-point formats, to better capture finer variations in these constructs.

6. Conclusions

This study set out to examine how competition affected learners' experiences and outcomes in a GBL environment. Specifically, it investigated the relationships among flow state, extraneous cognitive load, and learning gain, and whether these relationships differed between competitive and non-competitive conditions. The findings provided evidence that although students in both conditions improved their learning, those exposed to the competitive setting demonstrated significantly greater learning gains, higher levels of flow, and lower extraneous cognitive load compared to their peers in the control group. Moreover, flow was confirmed as a stronger predictor of learning gain, with its effect more pronounced in the competitive context. These results suggest that the motivational advantages of competition-enhanced flow outweighed the extraneous cognitive load that competition might have imposed. The study's findings highlight the importance of designing GBL environments in which competition serves as a motivational element without inducing excessive extraneous cognitive load. Educators and game designers should consider incorporating carefully balanced competitive elements that foster motivation while minimising extraneous cognitive load. Future research should explore how these dynamics operate across other disciplines, cultural contexts, and game types, particularly in less structured learning scenarios. Doing so will help refine the pedagogical potential of competition in both digital and non-digital GBL.

7. References

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Appendix 1

Session protocol

1. Pre-session setup
 - Ensure all physical game materials (boards, cards, tokens) are prepared and spreadsheet runs (Google Sheets files).
 - Confirm visibility of the leaderboard on the whiteboards (only for the competitive condition).
2. Introduction
 - Welcome students and thank them for their participation.
 - Review the session goals: apply accounting knowledge through a game-based simulation.
 - Distribute and collect pre-test knowledge assessment (paper).
 - Briefly explain game mechanics (e.g., rent, chance cards, expenses); the task: record financial transactions based on game events using a spreadsheet.
 - Emphasise that the spreadsheet format matches class practice, and that accurate recording is part of the learning goal.
 - Encourage peer discussion during gameplay.
3. Game facilitation
 - During gameplay, the instructor:
 - Monitors team progress and provides neutral clarifications of:
 - a. Game rules (e.g., how to move, when to collect rent);
 - b. Spreadsheet use (e.g., which cells to fill, how to label entries).
 - Refrains from giving hints or feedback related to game strategy or performance and does not highlight differences between the two conditions.
 - Keeps time:
 - a. Uses a visible timer or gives time warnings every 20 minutes.
 - b. Ensures all teams proceed at a similar pace.
 - c. In the competitive group, briefly reminds teams every 20 minutes that rankings are updated.
 - d. In the control group, avoids any reference to rankings or performance comparison.
 - 4. Gives a wrap-up signal when the last round is complete.
 - a. Asks students to stop playing and turn to the post-test and survey.
 - b. Distributes and collects (paper): Post-test knowledge assessment; Flow and extraneous cognitive load survey.
 - 5. Thanks participants again and reminds them that individual data will remain anonymous.

Appendix 2

Research instruments

Flow scale. Items from Fu et al. (2009).

1. Generally speaking, I could remain concentrated in the game.
2. I felt emotionally involved in the game.
3. I received information on my success (or failure) immediately.
4. I enjoyed the game without feeling bored or anxious.
5. I felt a sense of control over my actions during the game.

Extraneous cognitive load scale. Items from Leppinck et al. (2013)

1. The game and/or explanations during the gameplay were very unclear.
2. The game and/or explanations were, in terms of learning, very ineffective.
3. The game and/or explanations were full of unclear language.