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Eddy Triswanto Setyoadi,
Institut Informatika Indonesia, Indonesia

*CORRESPONDENCE
Nadine Nicole Koch
nadine.koch@iste.uni-stuttgart.de

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Exploring gender as a determinant of game element effectiveness

Nadine Nicole Koch[1,2]*, Robin Gebert[2], Niklas Meißner[1] and Maria Wirzberger[2,3]

[1]University of Stuttgart, Department of Software Quality and Architecture, Stuttgart, Germany, [2]University of Stuttgart, Department of Teaching and Learning with Intelligent Systems, Stuttgart, Germany, [3]University of Stuttgart, Interchange Forum for Reflecting on Intelligent Systems, Stuttgart, Germany

Student diversity, for example, in terms of gender, characterizes higher education learning settings and presents a challenge for optimally supporting all learners. Digital learning settings are increasingly employed to provide a personalized learning experience. To enhance motivation, game elements, such as points, badges, leaderboards, avatars, and feedback, are commonly used in these settings. However, their impact on performance and motivation appears to vary across genders, and empirical evidence on the effects of individual game elements remains limited. This study systematically examines gender differences in performance, motivation, self-efficacy, and anxiety in response to specific game elements. Therefore, participants solved logical problems in a digital learning setting featuring different combinations of game elements. Results reveal a significant gender difference in the influence of game elements on experienced external regulation, a dimension of motivation. Related research suggests that cultural factors and the learning context might shape gender differences, underscoring the importance of context-sensitive gamification design in digital learning settings.

KEYWORDS
anxiety, digital learning settings, gamification, gender differences, motivation, performance, personalized learning, self-efficacy

1 Introduction

Higher education is characterized by students' diversity, including variation in gender. This heterogeneity poses challenges for educators in addressing individual learners' needs. Therefore, digital learning settings (DLSs) are used to support educators in individualizing and adapting learning content based on learners' characteristics and preferences (Chen et al., 2016; Hsu et al., 2012; Zhang and Zhang, 2014). Characteristically, DLSs often incorporate game elements, such as points, to improve motivation (Hamari et al., 2014; Saleem et al., 2021; Zainuddin et al., 2020). The implementation of such game-inspired elements in contexts not associated with games is referred to as gamification (Deterding et al., 2011).

Current research indicates that gamification in education can enhance learners' performance, motivation, and enjoyment (Alsawaier, 2018; Bai et al., 2020; Huang et al., 2020; Li et al., 2023; Sailer and Homner, 2020; Zhang and Yu, 2022; Zeng et al., 2024). The beneficial effects of gamification are explained by various theories, which identify mechanisms such as goal setting, feedback, reinforcement, rewards, social comparison, and social support as factors contributing to its effects (Krath et al., 2021). Among them, the most popular theory is the Self-Determination Theory (SDT; Ryan and Deci, 2000), which indicates that game elements enhance motivation by satisfying one or more of the three fundamental human needs for competence, autonomy, and relatedness (Krath et al., 2021). However, gamification may also have no or even negative effects, such as increased anxiety, task demands, and stress (Almeida et al., 2023; Bai et al., 2020; Dichev and Dicheva, 2017; Hanus and Fox, 2015; Sailer and Homner, 2020; Toda et al., 2018).

To effectively support learners and prevent negative effects, it is important to understand the mechanisms underlying these consequences. Yet, existing gamification research faces several limitations that make it challenging to draw clear conclusions about those mechanisms. Exemplary challenges include differences in definitions (Hallifax et al., 2023), sets of game elements (e.g., Toda et al., 2019a; Tondello et al., 2017), educational levels (e.g., Dichev and Dicheva, 2017), and subjects (e.g., Dichev and Dicheva, 2017; Dicheva et al., 2020). To achieve a clearer understanding of divergent impacts, individual game elements must be investigated separately within the same participant samples (Dichev and Dicheva, 2017; Mekler et al., 2017; Seaborn and Fels, 2015).

Thereby, points, badges, and leaderboards are the most commonly used game elements in education, making them key to understanding the impact of gamification on learning (Hamari et al., 2014; Saleem et al., 2021; Zainuddin et al., 2020). While points are awarded for achievements (Codish and Ravid, 2017), badges are visual indicators of achieved goals, learned skills, or acquired knowledge (Fanfarelli and McDaniel, 2019; Gibson et al., 2015). Leaderboards show learners' rankings based on their scores (Denden et al., 2021). Avatars are visual representations of the learner in DLSs (Hallifax et al., 2023) and enhance social relatedness (Sailer et al., 2017). The game element feedback provides information about learners' performance (Denden et al., 2021) and offers social support (Hernandez et al., 2021).

Not only do game elements influence performance and motivation, but recent reviews on gamification also show that learner characteristics such as gender, culture, age, user type, or personality constitute important moderators (Bai et al., 2020; Klock et al., 2020; Oliveira et al., 2023). This highlights the need to design learning systems that effectively support diverse learners' needs and preferences. Gender is an especially relevant variable for DLS adaptation in higher education contexts, as student populations are typically gender-diverse and gender can be assessed with a single self-report item, requiring minimal extra effort from learners. Therefore, understanding whether and how gender influences the impact of game elements on motivational and performance-related outcomes is crucial.

In addition to performance and motivation, self-efficacy and anxiety also play a critical role in educational contexts. Motivational and performance-related aspects control whether and how effectively someone learns. Furthermore, self-efficacy influences motivation and performance (Zimmerman, 2000), while anxiety can hinder learning (Cassady, 2004; Soltanlou et al., 2019). Taking a look into related research, existing evidence indeed suggests that the effects of gamification on motivation and performance differ between genders (Denden et al., 2017; Mellado et al., 2024; Rodrigues et al., 2022).

Regarding performance, studies report either an increase (Rodrigues et al., 2022) or decrease (Mellado et al., 2024) only for female participants, performance increase only for male participants (Pedro et al., 2015), or performance gains for both genders (Zahedi et al., 2021) due to combinations of game elements. Regarding motivation, sometimes subsumed under the broader concept of user experience, male participants report being more motivated by gamification than female participants (Mellado et al., 2024; Pedro et al., 2015). Male participants also report greater enjoyment and perceived usefulness of gamification compared to female participants (Mellado et al., 2024; Pedro et al., 2015). Similarly, female participants mostly did not enjoy the gamification (Zahedi et al., 2021). Because these studies employed different combinations of game elements, it is impossible to draw conclusions about the effects of individual elements. However, there is some evidence on gender differences for the individual game elements (see Table 1 for a summary).

For *points*, no consistent differences between genders regarding enjoyment, perceived usefulness and relevance, or intention to use points were found (Codish and Ravid, 2017; Denden et al., 2017, 2021; Toda et al., 2019b).

Badges were disliked by male learners, and working with badges negatively influenced their perceived need-satisfying (Schürmann and Quaiser-Pohl, 2022). For female learners, no comparable patterns were found. Even more, in two of three semesters, female learners enjoyed badges more than male learners (Codish and Ravid, 2017). Similarly, Denden et al. (2017) conclude that female learners have a higher perception of badges than male learners. In contrast, studies indicated no differences in enjoyment, usefulness of, and intention to use badges (Denden et al., 2017, 2021). Similarly, visualizing the progress, for example, with badges, was perceived as equally relevant for different genders (Toda et al., 2019b).

The presentation of *leaderboards* increased the performance of male but not of female learners (Lovász et al., 2023). Similarly, competition, including a leaderboard, was perceived as more relevant by male learners than by female learners (Toda et al., 2019b). Moreover, no differences between genders were found in enjoyment, perceived usefulness, and the intention to use a leaderboard (Denden et al., 2017, 2021). Codish and Ravid (2017) found varying patterns of perceived playfulness across three student cohorts, with female learners scoring higher in one, male learners in another, and no gender differences in the third cohort.

For *avatars*, no differences between genders in preferences for avatars compared to other game elements were found (Denden et al., 2017).

Feedback was perceived as more useful by female learners compared to male learners, but for enjoyment, no difference between genders was found (Denden et al., 2021). Similarly, encouragement increased performance for female learners and decreased it for male learners (Lovász et al., 2022). In contrast, Denden et al. (2017) found no gender differences in the preference for feedback compared to other game elements.

These results may, among other explanations, reflect gender differences in motivational aspects. For instance, female learners

TABLE 1 Evidence for gender differences regarding the individual game elements.

Paper	Points	Badges	Leaderboard	Avatar	Feedback
Denden et al. (2017)	x	Female/x	x	x	x
Toda et al. (2019b)	x	x	Male		
Denden et al. (2021)	x	x	x	x	Female/x
Codish and Ravid (2017)	x	Female/x	x		
Schürmann and Quaiser-Pohl (2022)		Female			
Lovász et al. (2022)					Female
Lovász et al. (2023)			Male		

"Female" indicates that this game element resulted in more positive results for female participants. "Male" indicates that this game element resulted in more positive results for male participants. "x" indicates that no relationship was found. An empty cell indicates that the respective study did not investigate the game element.

were found to be generally less attracted to competitive game elements than male learners (Buckley et al., 2017; Hartmann and Klimmt, 2006; Toda et al., 2019b), whereas male learners tend to associate competition with more positive outcomes (Kesebir et al., 2019). Leaderboards, which introduce competition (Michinov and Michinov, 2025), may thus particularly benefit male learners. Male learners also tended to be more performance-oriented, whereas female learners showed a stronger mastery orientation (D'Lima et al., 2014). Similarly, male learners' flow experiences was shown to be largely driven by competence, whereas female learners' flow was more strongly linked to positive emotions and playfulness (Rodríguez-Ardura and Meseguer-Artola, 2021). This orientation toward mastery and enjoyment offers a potential explanation for female learners' preference for feedback as it supports self-improvement processes, and for badges as they function as visible indicators of skill mastery and learning progress (Abramovich et al., 2013). Importantly, these gender differences may reflect socially constructed norms rather than inherent traits and other individual, contextual, or cultural factors may also contribute to the observed patterns.

Taken together, existing research indicates that female and male learners differ in the perception of gamification in general (Denden et al., 2017; Mellado et al., 2024; Rodrigues et al., 2022), badges (Codish and Ravid, 2017; Denden et al., 2021; Schürmann and Quaiser-Pohl, 2022), leaderboards (Lovász et al., 2023; Toda et al., 2019b), and feedback (Denden et al., 2021; Lovász et al., 2022). While few studies systematically examined how specific game elements impact learning (Codish and Ravid, 2017; Denden et al., 2017, 2021; Toda et al., 2019b), the results are inconsistent. Furthermore, most of those studies focused on aspects of user experience, such as perceived usefulness and enjoyment of individual elements, thereby lacking a more concise inspection of motivational and/or performance-related outcome variables. Most limiting, we could not find any research investigating the influences of individual game elements on self-efficacy or anxiety. Consequently, the limited body of research highlights the need for a more systematic investigation of the differential impacts of individual game elements on learners identifying with different genders.

To address this research gap, the current experiment systematically examines whether gender moderates the effects of game elements (i.e., points, badges, leaderboards, avatars, and feedback) on performance, motivation, self-efficacy, and anxiety. Due to the exploratory nature of the present investigation, no specific hypotheses were formulated. Points, badges, and leaderboards were selected because they represent the most commonly used game elements in education (Hallifax et al., 2023; Hamari et al., 2014; Saleem et al., 2021; Zainuddin et al., 2020). Avatars were included for their potential to enhance social relatedness (Sailer et al., 2017), while feedback was considered for its role in fostering social support (Hernandez et al., 2021). Performance and motivation control whether and how effectively someone learns, while self-efficacy influences performance and motivation (Zimmerman, 2000), and anxiety can hinder learning (Cassady, 2004; Soltanlou et al., 2019). The current experiment employed a controlled design to minimize confounding factors and isolate the effects of gamification. To this end, participants engaged in a simple logical reasoning task, which reduced variability arising from task complexity. Game elements were systematically varied, while distracting elements were minimized. This setup ensured that any observed differences in outcomes could be attributed primarily to the presence of the game elements. Additionally, rather than asking participants directly about their perceptions of the game elements without having them experience these elements, they interacted with different game elements and subsequently indicated their motivation, self-efficacy, and anxiety through questionnaires based on their experience. This approach reduced social desirability bias (Edwards, 1957).

2 Methods

2.1 Participants

The data sets from 117 students ($M = 21.91$ years, $SD = 2.38$ years, range: 18–27 years), including 83 (70.94%) men and 34 (29.06%) women, collected at the University of Stuttgart, were included in the data analysis. Participants were recruited through on-campus direct address and were mostly enrolled in computer science ($n = 68$), engineering ($n = 37$), or other technical and non-technical programs ($n = 12$). Each participant gave informed consent prior to participation and received €15 as compensation for spending 30 to 60 minutes on the experiment.

2.2 Design

The randomized controlled experiment employed a 3 × 8 factorial within-between-subjects design, examining the effects of participants' gender and game elements on performance, motivation, self-efficacy, and anxiety in a digital setting. Gender was assessed categorically, with participants identifying as male, female, or other. To examine the effects of individual game elements systematically, participants were randomly assigned to three of eight sets of game elements, including no gamification (None), Points (P), Badges (B), Leaderboards (L), Avatars (A), Feedback (F), Points-Badges-Leaderboards-Avatars (PBLA), and Points-Badges-Leaderboards-Avatars-Feedback (PBLAF).

2.3 Materials

To ensure comparability with existing findings, this experiment was based on the digital setting and tasks from Albuquerque et al. (2017), with only minor adaptations. It represents a possible design for task or quiz components in tutoring systems or digital learning setting. Figure 1 illustrates an exemplary configuration of the setting using the PBLA set and an example logical problem. Further examples of logical problems are available in the Supplementary material. Logical problem-solving tasks were chosen for their relevance across a wide range of exercises and for requiring no prior knowledge. The implementation of the game elements represents one possible design and is expected to engage learners solely through visual presentation. Participants solved three blocks of 20 logical problems. The problems from Albuquerque et al. (2017) were altered for rounds two and three. Alterations included changes in the position or rotation of matrix elements, as well as adjustments to the five answer options.

The game elements were implemented as follows. One point was awarded for each correctly solved problem. Badges were awarded for 1, 5, 10, and 18 correctly solved problems as a visual recognition of achievement. The leaderboard displayed fictitious learners with fixed scores and the learner's ranking. In the leaderboard condition, the avatars on the leaderboard were hidden. In our experiment, each learner always received feedback regarding the correctness of their responses directly after providing an answer (knowledge of results feedback; Attali and van der Kleij, 2017). In the feedback condition, a speech bubble containing a randomly selected piece of praise or encouragement was also presented at the bottom right. For example, after incorrect answers, the feedback might have said, "You're learning, and that's what matters!" while after correct answers, it could have said, "Great job! I knew you could do it." Hence, this feedback represented supportive feedback from other persons. In conditions with only one game element, the logic problems and the respective game element were presented while all other game elements were hidden. In PBLA and PBLAF conditions, avatars were presented on the leaderboard. In the PBLAF condition, the feedback message was assigned to an avatar. The avatars were generated using ChatGPT (OpenAI, 2023) to represent individuals of different genders, cultures, and ages.

Motivation was assessed using the 16-item Situational Motivation Scale (SIMS, Guay et al., 2020). It uses a 7-point Likert scale from "does not correspond at all" to "corresponds exactly". The SIMS measures four subscales: *Intrinsic motivation* describes the extent to which a participant engages in an activity for the pleasure and satisfaction of the task itself. *Identified regulation* describes how much a behavior is interpreted as chosen and valued by oneself. In contrast, *external regulation* is experienced when behavior is expected to be rewarded or to avoid negative consequences. *Amotivation* describes a lack of contingencies between behavior and outcomes (Guay et al., 2020). In previous research, the subscales all showed high reliability, (intrinsic motivation: Cronbach's $\alpha = .93$; identified regulation: Cronbach's $\alpha = .81$; external regulation: Cronbach's $\alpha = .75$; amotivation: Cronbach's $\alpha = .78$; Guay et al., 2020). The 8-item New General Self-Efficacy Scale (NGSE), with reliability of Cronbach's $\alpha > .85$ in previous studies, captured self-efficacy on a 5-point Likert scale reaching from "strongly disagree" to "strongly agree" (Chen et al., 2001). State anxiety was measured using the 6-item shortened form (Court et al., 2010) of the State-Trait Anxiety Inventory (STAI-6, Marteau and Bekker, 1992). Items are rated on a 4-point Likert scale from "not at all" to "very much so." The STAI has shown a reliability of Cronbach's $\alpha = .82$ in previous research (Marteau and Bekker, 1992).

2.4 Procedure

In the experiment, participants first provided informed consent and indicated their gender, age, and the study program to which they enrolled to. Subsequently, they began the main part of the experiment, consisting of three blocks, each featuring a different set of game elements. If the condition included an avatar, participants began the block by selecting one from 15 available avatars. They completed the indicated set of 20 logical problems in each block, followed by assessments of STAI, NGSE, and SIMS. In conditions involving feedback, participants received an appropriate message after every three problems. Afterward, participants were debriefed and received compensation for their participation.

2.5 Scoring

Performance was measured by the percentage of correct responses to logical problems. Motivation was assessed via average SIMS subscale scores (Chen et al., 2001). Our sample showed high reliabilities for intrinsic motivation ($\alpha = .89$), external regulation ($\alpha = .88$), and amotivation ($\alpha = .81$), but a lower reliability for identified regulation ($\alpha = .60$). Anxiety scores were derived from STAI item responses. These were weighted following the procedure described by Court et al. (2010) to create a continuous scale. Mean scores were then calculated for each participant, with higher values indicating higher levels of anxiety. We observed a medium scale

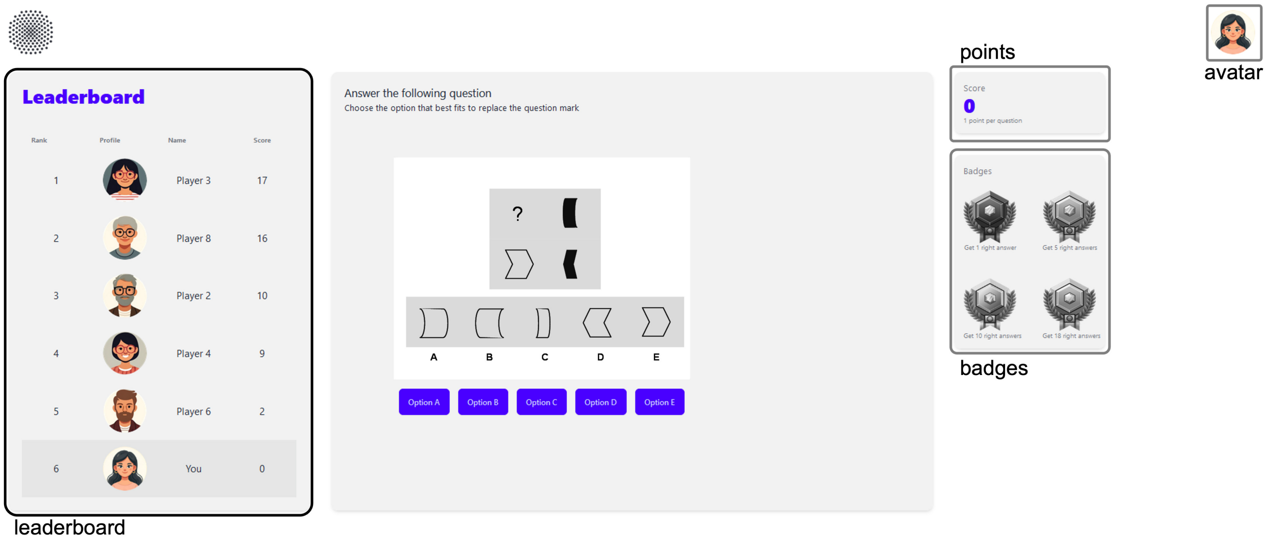

FIGURE 1
DLS in PBLA condition. The dark gray borders highlight the different game elements.

reliability in our sample ($\alpha = .70$). Finally, self-efficacy scores were computed as averages of NGSE items (Chen et al., 2001), with high reliability in our sample ($\alpha = .83$).

3 Results

For data analysis, data sets from two participants who identified as "other" were excluded due to insufficient sample size for meaningful statistical inference, resulting in the analysis of gender across two rather than three conditions. All remaining participants performed beyond chance level (20% with five response alternatives), so no further exclusions were necessary. This resulted in 117 participants, with 10 to 18 female participants and 25 to 37 male participants per condition. The descriptive results are shown in Table 2. The data, the analysis scripts, and details on the distribution of participants across conditions are provided in the Supplementary material.

Despite model assumptions being violated (e.g., non-Gaussian distribution of residuals), we employed linear mixed-effects models (LMMs) for all dependent variables (i.e., performance, motivation, self-efficacy, and anxiety), given their demonstrated robustness to such violations (Schielzeth et al., 2020). The LMMs specify gender, game element, their interaction, and block as fixed effects, while participant was included as a random effect. Block was integrated to account for position effects.

We investigated the interaction effects of gender and game elements using F-tests based on restricted Maximum Likelihood estimation of the parameters (Kuznetsova et al., 2017) and type II sums of squares (Langsrud, 2003; Smith and Cribbie, 2014). *Post-hoc* t-tests were calculated based on estimated marginal means using the *emmeans* *R*-package (Denden et al., 2017). We corrected the degrees of freedom for LMMs using Kenward-Roger correction (Kenward and Roger, 1997) as suggested by Luke (2017) and controlled the false discovery rate using the Benjamini-Hochberg procedure (Benjamini and Hochberg, 1995) for *post-hoc* analyses.

As we focus on gender differences in the effects of game elements on outcome variables, we subsequently focus on the interaction between gender and game elements. Detailed results are provided in the Supplementary material. We found a significant interaction between gender and game element influencing external regulation ($F(7, 225.35) = 2.24$, $p = .032$, $\eta_p^2 = .07$). *Post-hoc* analyses comparing genders for each game element showed more external regulation perceived by male participants compared to female participants in the PBLAF condition ($\beta = -1.03$, $SE = 0.33$, $t(231) = -3.16$, $p = .014$, 95%-CI = [−1.67, −0.39]). Although some beta weights were substantial, no other comparisons reached significance (none: $b = -0.14$, $SE = 0.31$, $t(210) = -0.45$, $p = .654$, 95%-CI = [−0.76, 0.48], points: $b = -0.32$, $SE = 0.31$, $t(211) = -1.02$, $p = .654$, 95%-CI = [−0.94, 0.30], badges: $b = 0.20$, $SE = 0.33$, $t(234) = -0.61$, $p = .654$, 95%-CI = [−0.84, 0.45], leaderboard: $b = -0.29$, $SE = 0.33$, $t(236) = -0.88$, $p = .654$, 95%-CI = [−0.94, 0.36], avatar: $b = -0.17$, $SE = 0.33$, $t(230) = -0.52$, $p = .654$, 95%-CI = [−0.81, 0.47], feedback: $b = -0.51$, $SE = 0.32$, $t(216) = -1.61$, $p = .440$, 95%-CI = [−1.13, 0.12], PBLA: $b = -0.19$, $SE = 0.33$, $t(201) = -0.62$, $p = .654$, 95%-CI = [−0.80, 0.42]). Further, the external regulation of female participants exposed to PBLAF was lower compared to none ($b = 0.73$, $SE = 0.23$, $t(225) = 3.24$, $p = .003$, 95%-CI = [0.29, 1.18]), points ($b = 0.82$, $SE = 0.24$, $t(229) = 3.39$, $p = .003$, 95%-CI = [0.34, 1.30]), badges ($b = 0.74$, $SE = 0.26$, $t(229) = 2.82$, $p = .007$, 95%-CI = [0.22, 1.26]), leaderboard ($b = 0.53$, $SE = 0.25$, $t(226) = 2.10$, $p = .043$, 95%-CI = [0.032, 1.02]), avatar ($b = 0.81$, $SE = 0.25$, $t(227) = 3.21$, $p = .003$, 95%-CI = [0.31, 1.30]) and PBLA ($b = 0.82$, $SE = 0.21$, $t(223) = 3.91$, $p = .001$, 95%-CI = [0.40, 1.24]). No significant difference was found between feedback and PBLAF ($b = 0.45$, $SE = 0.23$, $t(225) = 1.93$, $p = .055$, 95%-CI = [−0.01, 0.91]). For male participants, no differences were found between the PBLAF and other game element sets

TABLE 2 Means and standard deviations for each game element and gender for each dependent variable.

			Motivation											
	Performance		IM		IR		ER		AM		SeEf		Anxiety	
Element	F	M	F	M	F	M	F	M	F	M	F	M	F	M
None	0.85	0.84	4.00	3.74	3.45	3.65	1.95	1.79	2.95	2.36	3.76	3.77	−1.30	-1.62
	(0.11)	(0.12)	(1.72)	(1.39)	(1.08)	(1.19)	(1.27)	(1.36)	(1.36)	(1.18)	(0.55)	(0.41)	(0.73)	(1.10)
Points	0.81	0.86	2.95	3.91	3.20	3.81	1.82	2.25	3.21	2.46	3.75	3.95	−1.49	−1.34
	(0.11)	(0.12)	(0.99)	(1.42)	(0.86)	(1.25)	(1.23)	(1.47)	(1.43)	(1.26)	(0.34)	(0.47)	(0.78)	(1.21)
Badges	0.84	0.84	3.98	3.87	3.45	3.65	1.50	2.25	3.10	2.72	3.69	3.85	−1.03	−1.57
	(0.09)	(0.16)	(1.30)	(1.13)	(0.69)	(1.14)	(0.66)	(1.56)	(1.33)	(1.34)	(0.18)	(0.57)	(1.32)	(1.01)
Leader-board	0.72	0.84	3.65	3.90	3.55	3.52	1.73	1.82	2.83	2.56	3.75	3.93	−0.80	−1.19
	(0.17)	(0.13)	(1.42)	(1.31)	(0.73)	(0.97)	(0.79)	(1.07)	(0.87)	(1.34)	(0.54)	(0.47)	(1.45)	(1.27)
Avatar	0.85	0.85	4.39	3.67	3.86	3.70	1.77	2.16	2.30	2.77	3.84	3.91	−1.91	−1.40
	(0.10)	(0.13)	(1.35)	(1.26)	(0.90)	(1.11)	(0.92)	(1.53)	(1.35)	(1.17)	(0.46)	(0.40)	(0.67)	(1.00)
Feedback	0.88	0.88	4.37	3.78	3.63	3.41	1.71	2.10	2.79	2.64	3.93	3.86	−1.46	−1.46
	(0.09)	(0.09)	(1.39)	(1.44)	(1.14)	(1.09)	(0.94)	(1.68)	(1.22)	(1.58)	(0.42)	(0.63)	(1.06)	(1.31)
PBLA	0.82	0.87	4.32	4.13	3.40	3.53	2.06	2.52	2.99	2.66	3.72	3.90	−1.34	−1.29
	(0.14)	(0.09)	(1.30)	(1.45)	(0.96)	(1.17)	(1.11)	(1.57)	(1.10)	(1.31)	(0.30)	(0.57)	(1.16)	(1.21)
PBLAF	0.78	0.83	4.23	4.17	4.09	3.65	1.70	2.27	2.86	2.89	3.65	3.71	−1.53	−1.45
	(0.13)	(0.13)	(1.37)	(1.36)	(0.94)	(0.98)	(0.83)	(1.43)	(1.34)	(1.24)	(0.48)	(0.50)	(0.91)	(1.06)

Standard deviations are presented in parentheses. SeEf, self-efficacy; IM, intrinsic motivation; IR, identified regulation; ER, external regulation; AM, amotivation; F, female; M, male.

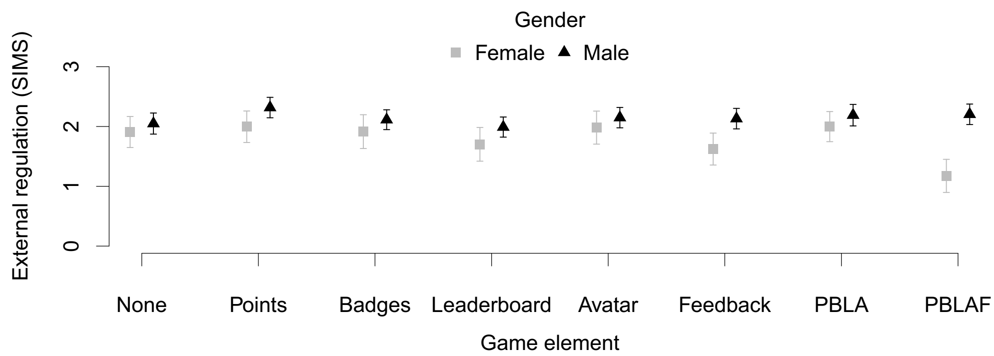

FIGURE 2
Estimated marginal means for the perceived external regulation depending on the game element for each gender predicted by the LMM.

($|b| \leq 0.22$; $p \leq .821$; see Supplementary material for complete results). Figure 2 shows estimated marginal means and standard errors for each game element separated by gender.

Interactions between gender and game elements regarding performance ($F(7, 237.96) = 1.65$, $p = .122$, $\eta_p^2 = .05$), intrinsic motivation ($F(7, 227.55) = 0.74$, $p = .636$, $\eta_p^2 = .02$), identified regulation ($F(7, 231.61) = 0.21$, $p = .982$, $\eta_p^2 = .01$), amotivation ($F(7, 231.44) = 1.66$, $p = .121$, $\eta_p^2 = .05$), self-efficacy ($F(7, 227.24) = 1.39$ $p = .209$, $\eta_p^2 = .04$), and anxiety ($F(7, 248.72) = 1.28$, $p = .259$, $\eta_p^2 = .03$) did not reach significance. Taken together, the present findings suggest that game elements may influence external regulation differently across genders. No significant effects were detected for the remaining dependent variables.

4 Discussion

Gamification is frequently used in DLS to motivate learners (Saleem et al., 2021; Zainuddin et al., 2020), yet its effect on performance and motivation varies across genders (Denden et al., 2017; Mellado et al., 2024; Rodrigues et al., 2022). Building on this, the current experiment examined how specific game elements (i.e., points, badges, leaderboards, avatars, feedback, and selected combinations of these elements) influence performance, motivation, self-efficacy, and anxiety of female and male students. Therefore, participants solved logical problems while different sets of game elements were presented. We found a significant interaction between genders and game elements on external regulation as a motivational dimension. Interaction effects of gender and game element on performance, anxiety, self-efficacy, intrinsic motivation, intrinsic regulation, and amotivation did not reach significance.

Post-hoc analyses show lower external regulation among female participants compared to male participants in the PBLAF condition. Similarly, for female participants, external regulation was lower when presenting this set of game elements than when presenting other sets, except for feedback. For male participants, no difference was found. Feedback might satisfy the need for social relatedness, as described by SDT. When feedback is combined with an avatar, it may strengthen the sense of relatedness. Although mixed findings regarding gender differences were reported (Chen et al., 2015; Martela and Ryan, 2015; Mouratidis et al., 2015), our interpretation aligns with those suggesting that female participants may be more sensitive to relatedness than male participants (Chen et al., 2015). The increased feelings of relatedness when feedback was presented, combined with avatars, may, in turn, have diminished the perceived extrinsic reward.

The non-significant results align with previous studies showing no gender differences regarding perception, enjoyment, relevance, and usefulness of points, badges, leaderboards, avatars, and feedback (Codish and Ravid, 2017; Denden et al., 2017, 2021; Toda et al., 2019b). At the same time, they contradict studies observing gender differences in performance, perceived motivation, or usability for badges, leaderboard, or feedback (e.g., Lovász et al., 2022; Lovász et al., 2023; Toda et al., 2019b).

However, there are important differences between previous studies and the current one. Several earlier studies examined courses including a combination of different game elements and used retrospective questionnaires to assess perceptions of each game element (Codish and Ravid, 2017; Denden et al., 2017, 2021). Similarly, Toda et al. (2019b) asked participants in a questionnaire how relevant they considered different game elements, without presenting them visually. In contrast, Schürmann and Quaiser-Pohl (2022) used a controlled setting and compared the need satisfaction and frustration in a seminar with and without badges. Lovász et al. (2022) investigated the effect of adding leaderboards and feedback individually and in combination. Similarly, we also conducted a controlled experiment by presenting no game element, each game element individually and combinations of game elements. Such a controlled setting allowed participants to experience game elements independently. Unlike the other controlled experiments, we observed gender differences only for feedback, but no differences for badges or leaderboards.

The contrasting results regarding gender differences in the perception of game elements could also be due to differences in the samples. For example, previous studies included participants from various regions, including Germany (Schürmann and Quaiser-Pohl, 2022), Europe (Lovász et al., 2023; Lovász et al., 2022), Israel (Codish and Ravid, 2017), and Tunisia (Denden et al., 2017, 2021). While studies from Europe reported gender differences, those from Israel and Tunisia did not. This could be explained by the use of experimental manipulations in studies from Europe. In contrast, studies outside Europe used retrospective questionnaires. Additionally, the differences could arise from cultural factors, as previous research indicates that culture plays a role in the effect of gamification (Klock et al., 2020; Silva Barbosa et al., 2023), and this is also empirically confirmed (Bai et al., 2020; Toda et al., 2022). As we did not collect information on participants' cultural backgrounds, we cannot analyze potential cultural effects in this sample. Hence, future research should also investigate cultural influence on gender differences in the impact of game elements on learning outcomes.

Additionally, two studies included participants with broader educational backgrounds (Lovász et al., 2023; Lovász et al., 2022), whereas Schürmann and Quaiser-Pohl (2022) and the current experiment investigated only students. Schürmann and Quaiser-Pohl (2022) examined education students, whereas our sample consisted primarily of computer science and engineering students. As Schürmann and Quaiser-Pohl (2022) found evidence of gender differences in badges, this could indicate the influence of study areas on these differences. Students in STEM fields (science, technology, engineering, and mathematics) have been shown to exhibit distinct interest profiles, including lower social orientation compared to students in most other disciplines (Ertl and Hartmann, 2019). Consequently, perceptions of and responses to game elements may differ between STEM students and students from other academic fields. In summary, contextual factors such as culture and educational background may moderate gender differences in the perception of game elements, which could explain the heterogeneous findings across studies. Future research should systematically investigate these effects.

Statistical power to detect gender-related interaction effects was limited by the gender imbalance in our sample (71% male participants), resulting in only ten female participants in some conditions. However, sensitivity analyses support the robustness of our results (see Supplementary material). Future research should replicate these findings with larger and more gender-balanced samples across diverse academic fields.

Even more, our experiment relies on self-reports to assess motivation, self-efficacy, and anxiety. Although such instruments are often used in psychological research, their results may be influenced by response biases, like social desirability (Edwards, 1957). Future work could strengthen robustness by adding behavioral or physiological measures. Still, our instruments were adequate to achieve the aim of this experiment, namely, conducting a controlled experiment providing initial insights into gender differences while minimizing influences beyond gender.

Additionally, we implemented only one version of each game element, though different versions may yield different outcomes. For example, leaderboards were presented with all other fictive learners (absolute leaderboard) instead of only those immediately above and below the participant (relative leaderboard) (Ćwil, 2020). Future studies should compare alternative implementations of the same elements to identify the aspects responsible for the effects of gamification. Similarly, our experiment examined the short-term effects of game elements. As the effects of gamification on motivation change over time (Dichev and Dicheva, 2017; Sailer and Homner, 2020; Van Roy and Zaman, 2018), future studies should investigate the long-term evolution of gender differences in the impact of game elements on motivation.

In conclusion, our experiment suggests that the impact of game elements on external regulation differs significantly between genders. Although previous research reports mixed findings, closer examination reveals that these discrepancies may arise from variations in cultural and contextual factors. Consistent with prior studies, our discussion underscores that both the learner's cultural background and the study program might play a role in shaping whether gender differences emerge. Future research should examine how game elements interact with gender, culture, and context to influence learning outcomes. Moreover, the design of gamified DLS should account for these factors to enhance the support for learning for all users.

Data availability statement

The data sets collected and analyzed in this study, the analysis script and the Supplementary material can be found in online repositories. The names of the repository/repositories and accession number(s) can be found below: https://osf.io/qcvh2/?view_only=c1e768716edb4b18b5761d842e22a42c.

Ethics statement

The plan for data collection and analysis was approved by the Committee for Responsibility in Research (Ethics Committee) at the University of Stuttgart (approval number Az. 22-012). The experiment was conducted in line with local institutional and legal requirements. The participants provided their written informed consent to participate in this study.

Author contributions

NK: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Visualization, Writing – original draft, Writing – review & editing. RG: Conceptualization, Investigation, Methodology, Resources, Software, Writing – original draft, Writing – review & editing. NM: Conceptualization, Methodology, Writing – original draft, Writing – review & editing. MW: Conceptualization, Funding acquisition, Methodology, Project administration, Supervision, Validation, Writing – original draft, Writing – review & editing.

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Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that Generative AI was used in the creation of this manuscript. During the preparation of this work, the author(s) used Grammarly, Claude, and ChatGPT to improve the quality of language in the manuscript. Afterwards, the author(s) reviewed and edited the content as needed and take full responsibility for the content of the published article.

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Supplementary material

The Supplementary material for this article can be found online at: https://osf.io/qcvh2/?view_only=c1e768716edb4b18b5761d842e22a42c.

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