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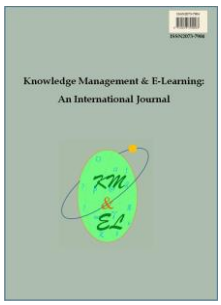

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Examining the role of personality traits and perceived need satisfaction in gamified learning

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Abstract: Grounded in self-determination theory, our study explored how personality traits interacted with perceived need satisfaction, influencing students' enjoyment and future participation intention in a leaderboard-based gamified learning context. A sample of 109 undergraduate students participated in a leaderboard-based math activity and completed surveys measuring their personality traits, perceived need satisfaction, enjoyment, and intention for future participation. The results indicated that the trait of emotional stability was a crucial moderator of the relationships between perceived need satisfaction and enjoyment. Additionally, the trait of agreeableness moderated the relationship between perceived autonomy and future participation intention. The study contributes to a more comprehensive understanding of the underlying mechanism of leaderboards and highlights the importance of theory-based

investigation into the influence of personality traits in gamified environments.

Keywords: Personality traits; Perceived need satisfaction; Leaderboard; Gamification; Mathematics

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1. Introduction

The integration of game elements within educational contexts has gained significant attention from educators and researchers in recent years. Gamification and serious games have been widely adopted to promote learner engagement and learning in a variety of settings (Abedi et al., 2018; Krath et al., 2021; Xu et al., 2021). Within the realm of STEM education, researchers have found that gamification and serious games have the potential to advance multiple STEM learning goals, including motivation to learn science, conceptual understanding, and scientific discourse (Honey & Hilton, 2011; Ibáñez & Delgado-Kloos, 2018). Studies have also suggested that the incorporation of game elements has the potential to benefit low-performing groups (Herodotou, 2018) and economically disadvantaged urban communities (Kim et al., 2012). However, gamification research presents a diverse spectrum of findings (Sailer & Homner, 2020), indicating that the application of uniform, one-size-fits-all approaches might not yield positive results for every learner and could sometimes even lead to adverse effects (Hanus & Fox, 2015). As a result, there is a need to develop adaptive gamification that can dynamically engage

individual learners by considering the interplay between gamification mechanisms and learner characteristics (Bennani et al., 2022).

Although gamification researchers have acknowledged the importance of developing personalized and adaptive gamification systems (Bezzina & Dingli, 2023; Xiao & Hew, 2024), limited research on how learner characteristics shape the effectiveness of gamified interventions has posed a significant challenge to advancing this agenda. Prior studies have documented substantial variation in learners' motivational responses to gamification (Bowey et al., 2015; Gao et al., 2023), yet few have investigated how specific learner characteristics contribute to these dynamics, and even fewer have sought to explain why certain traits exert stronger or weaker influences on learners' experiences. Advancing this line of research is crucial for building adaptive gamification systems that can accommodate individuals' unique traits and needs. To address this gap, the present study investigates the mechanisms linking personality traits and perceived need satisfaction in shaping learners' motivation within a leaderboard-based learning activity.

2. Literature review

2.1. Self-determination theory and gamification

Self-determination theory (SDT) is one of the most widely adopted theoretical frameworks in gamification research (Triantafyllou et al., 2025). By identifying key psychological elements that promote human motivation and well-being, SDT is particularly suitable to guide the examination of the underlying psychological processes in gamification. According to SDT, the satisfaction of the three basic psychological needs (i.e., autonomy, competence, and relatedness) is the basis for human development and wellness. Autonomy means "*being the perceived origin or source of one's own behavior*" (Ryan & Deci, 2002); competence means "*feeling effective in one's ongoing interactions with the social environment and experiencing opportunities to exercise and express one's capacities*" (Ryan & Deci, 2002); and relatedness is present when people feel cared for by others.

It is worth noting that, according to SDT, the same event may impact individuals' experiences of autonomy and competence differently (i.e., functional significance varies) depending on the context and individual characteristics (Ryan & Deci, 2017). This point is well illustrated by Van et al. (2019), who found that when provided badges, people experienced the functional significance of badges in different ways, which in turn shaped their motivations and behaviors differently. Thus, to effectively explore when and how gamification design meets the needs of individual learners, it is crucial to understand the intricate relationships of contextual factors, individual characteristics, and gamification features in shaping individuals' perceived need satisfaction. Fig. 1 illustrates how gamification works within the framework of SDT. The current study focuses on how a particular aspect of individual characteristics (i.e., personality traits) functions together with the perceived need satisfaction in a leaderboard-based gamified environment (i.e., gamification features) to influence learners' intrinsic motivation-related aspects, such as enjoyment and intention for future participation.

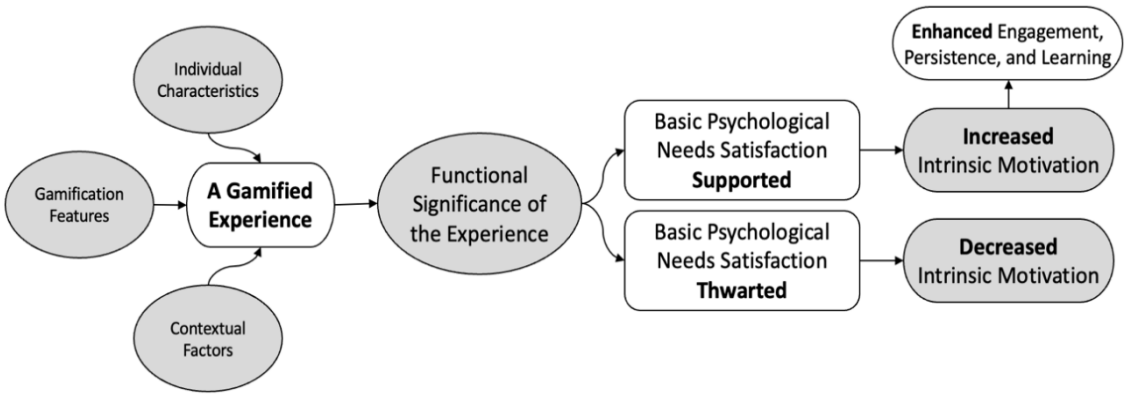

Fig. 1. Gamification mechanism under the SDT framework. Adapted from Gao (2024)

2.2. Research on gamification features and perceived need satisfaction

Although research on leaderboards suggests their positive effects on motivation, engagement, participation, and learning (Ortiz-Rojas et al., 2019; Saleem et al., 2022; Zainuddin, 2018), the results are sometimes mixed (Andrade et al., 2016; Nicholson, 2013; Ninaus et al., 2020). Research findings regarding leaderboards' effect on the satisfaction of psychological needs are inconclusive. Sailer et al. (2017), for example, found that participants in a game condition with badges, leaderboards, and performance graphs had significantly higher levels of perceived competence need satisfaction than participants in the control condition using points as the only game element. Zainuddin (2018), by comparing a gamified flipped classroom (with points, badges, and a leaderboard) condition with a non-gamified flipped classroom condition, suggested that the gamified flipped classroom condition successfully supported perceived need satisfaction in competence, autonomy, and relatedness, as well as engagement and learning. Similarly, Yeh et al. (2025), when examining the role of gamification in enhancing user engagement and behavioral intentions in tourism expositions, found that gamified experience is positively correlated with perceived competence, relatedness and autonomy as well as subsequent purchase intentions and word-of-mouth communication intentions. However, studies conducted by Mekler and her colleagues led to a different conclusion (Mekler et al., 2013, 2017). They found that, although the implementation of points, leaderboards, and levels increased tag quantities in an image annotation task, the intervention did not significantly increase perceived autonomy, perceived competence, or intrinsic motivation. A pilot study (Gao et al., 2024) involving 47 participants was conducted to investigate individuals' perceived need satisfaction and their enjoyment and intention for future participation in a leaderboard-based math activity. The results revealed significant variability in students' perceived need satisfaction. Furthermore, students' perceived competence and autonomy positively predicted their enjoyment and intention for future participation, while their actual competence had no significant relationship with these aspects. Building upon these insights, our current study aims to delve into the interaction between personality traits, perceived need satisfaction, and students' enjoyment and intention for future participation in a similar leaderboard-based math activity.

2.3. Research on personality traits and gamification

Research on personality traits and gamification has involved surveying learners' preferences for game elements/mechanisms and exploring the connections between their preferences and their personality traits. For example, Jia et al. (2016), by surveying students' preferences on game elements/mechanisms including points, badges, leaderboards, levels, challenges, rewards, and so on, found that extraverts were more likely to be motivated by points, levels, and leaderboards and individuals with high levels of imagination were less likely to be motivated by avatars. However, Mahoe's (2025) survey results suggested that extraversion was negatively correlated with participants' satisfaction with the use of badges and leaderboards. Codish and Gilad (2014), based on their survey results, concluded that introverts had a high preference level for badges, while individuals with agreeable personalities preferred feedback-based progress mechanics.

In addition to studying students' self-reported preferences on game elements/mechanisms, some research has been conducted to examine the impacts of personality traits on learners' experiences when learners were engaged with gamified systems. Codish and Ravid (2014) found that extraversion as a personality trait can moderate the perceived playfulness of gamified learning and concluded that leaderboards and points were effective for introverts but had a detrimental impact on extroverts. In contrast, the findings from Buckley and Doyle's study (2017) indicated that extraverted individuals tended to have a positive attitude toward gamification, whereas conscientious individuals appeared to be less motivated by it. Furthermore, Höllig et al. (2018) found that competitive individuals regarded gamified systems as more playful, useful, and enjoyable. There was also a mediated relationship between trait competitiveness and usage intention through perceived enjoyment (Höllig et al., 2020). Importantly, Denden et al. (2021) revealed that gender might play a moderating role in how personality influenced students' perceptions of gamified learning intervention: males with lower extraversion levels were more inclined to view badges as useful in gamified courses compared to their highly extraverted counterparts. On the other hand, among females, those with lower conscientiousness levels were more likely to derive enjoyment from feedback in contrast to their highly conscientious counterparts.

Finally, some researchers have examined how learners' behaviors might be different in gamified systems depending on their personality traits. Smiderle, et al. (2020) study showed that gamification had varying effects on students' behaviors, depending on their personality traits. For example, introverted students had a higher number of points, medals, and logins than extroverted students. In Denden et al.'s (2024) study, although effects of agreeableness, conscientiousness, and neuroticism personality traits were found on students' perception of points, no effect of personality traits was found on students' behaviors in the gamified course.

There are two limitations in the existing research on personality traits in gamification. First, most studies have been conducted within a gamified system where multiple game elements were integrated, making it difficult to tease out the effects of a specific game element. Second, limited research has examined the interactions between personality traits and perceived need satisfaction. Since perceived need satisfaction plays a critical role in motivation, understanding the interplay of personality traits and perceived need satisfaction will provide valuable insights into the mechanisms by which personality traits influence learners' motivation in gamified environments. Therefore, this study attempted to address the gap by examining the interactions between personality traits and

perceived need satisfaction in a leaderboard-only gamified environment. In addition, this study included two motivational outcomes: students' enjoyment and their intention for future participation. Enjoyment is a key indicator of intrinsic motivation (Ryan & Deci, 2017). Intention for future participation captures students' willingness to re-engage in similar activities, providing an important link between motivational processes and behavioral outcomes. Together, these constructs extend beyond the mechanism of motivation to show how personality traits and need satisfaction translate into both motivational (enjoyment) and behavioral (future participation) outcomes.

The two research questions are:

RQ1: How did personality traits and perceived need satisfaction function together to influence students' enjoyment in a leaderboard-based math activity?

RQ2: How did personality traits and perceived need satisfaction function together to influence students' intention for future participation in similar activities?

3. Method

3.1. Participants

In this study, our sample comprised 109 undergraduate students attending a public university in the midwestern region of the United States. These students were enrolled in 7 sections of a foundational mathematics course titled "*Real World Math Skills*", a mandatory quantitative reasoning course for undergraduates majoring in fields such as art, music, and other non-STEM disciplines. Among the participants, 25 were male, and 84 were female. The average age of the participants was 18.60, with a standard deviation of 0.87.

3.2. Procedures

The study was approved by the Institutional Review Board at a public Midwest university in the US. In a face-to-face class setting, students were instructed to complete a 24-item gamified math practice on their laptop or smartphone using the online learning platform Quizalize (https://www.quizalize.com/). At the beginning of the class, the course instructor informed students that this gamified math practice was designed to reinforce skills taught in previous sessions and that the scores would not impact their grades. Each student created a pseudonym for logging onto the quiz site. Throughout the practice, students could track their real-time rankings on a leaderboard projected at the front of the classroom. The procedures followed those described in our pilot study (Gao et al., 2024) with one modification: In the pilot study, students were not explicitly asked to check the leaderboard during the practice, and they chose when and how often to check the leaderboard. In this study, in contrast, to help students keep track of their rankings, students were prompted to check the leaderboard two times during the practice and type down their rankings. This was done once after students completed question 8 and then again after they completed question 16.

After completing the practice, all students took a survey consisting of four sections that measured students' (a) perceived need satisfaction, (b) enjoyment of the activity, (c) intention for future participation, and (d) personality traits. The survey items used to assess

students' perceived need satisfaction were adapted from the three subscales of the Basic Psychological Need Satisfaction and Frustration Scale (BPNSFS) (Chen et al., 2015), which measures perceived competence (four items), autonomy (four items) and relatedness (four items). Some examples include "*I felt competent when answering the questions*" (perceived competence); "*I felt like the gamified practice reflected how I want practices to be*" (perceived autonomy); and "*I felt close to the other participants*" (perceived relatedness). Four Likert-scale questions from the Interest/Enjoyment subscale of the Intrinsic Motivation Inventory (Ryan, 1982) were utilized to measure student enjoyment. An example question is "*I enjoyed doing this activity very much*". Three questions were used to measure students' intention for continued participation in similar activities in the future, an example of which is "*I intend to participate in such math practice games in future classes*". Finally, the 50-item International Personality Item Pool questionnaire (IPIP) (Goldberg et al., 2006) was used to measure five broad personality dimensions: conscientiousness, extraversion, agreeableness, emotional stability (the inverse of neuroticism), and intellect. Some examples are "*I feel comfortable around people*" (extraversion); "*I feel others' emotions*" (agreeableness); "*I pay attention to details*" (conscientiousness); "*I am relaxed most of the time*" (emotional stability); and "*I have a vivid imagination*" (intellect). These questionnaires have been validated and widely used by researchers (e.g., Costa et al., 2018; Gow et al., 2005; McAuley et al., 1989).

3.3. Data analysis

The scores of perceived need satisfaction and two outcome measures (enjoyment and intention) were calculated by adding up student ratings for all items under each subcategory, where 1 indicates "*not true at all*" and 7 "*very true*". The personality trait scores were derived by summing up student ratings for all items under each trait. Ratings ranged from 1 "*very inaccurate*" to 5 "*very accurate*". Items with negative wording were reverse-coded. A higher score reflected a greater expression of the respective personality trait. The internal reliability of all variables was notably high (see Table 1), indicating the consistency of the ratings. The scores of perceived competence, autonomy, and relatedness were centered using the mean scores to make it easier to interpret the results.

Multiple linear regression was conducted in STATA 15 to answer the research questions. The first step was to confirm the findings from the pilot study (Gao et al., 2024) by examining the relationship between perceived need satisfaction and two outcome variables – students' enjoyment and intention separately by considering the demographic covariates (i.e., age, gender, and class section). After that, we tested 30 models (5 factors of personality traits × 3 types of perceived need satisfaction × 2 outcomes) to identify the potential interactions between personality traits and perceived need satisfaction. The significance of both individual predictors and interactions was tested. The adjusted R-squared values, which were adjusted for the number of predictors in a model, were used to indicate the model fit. The following model assumptions were examined: (1) The independence, homoscedasticity, and normality of residuals were checked using the plot of studentized residuals and normality test (i.e., Shapiro-Wilk W test); (2) The linear relationship between each independent variable and the dependent variable was examined using scatterplots; (3) Multicollinearity was investigated using VIF (variance inflation factor) and values higher than 10 was problematic. When assumptions were violated, Tobit regression was selected based on the nature of the data (Long, 1997) to confirm the findings from the multiple linear regression. In these instances, we reported results from both Tobit regression and multiple linear regression.

4. Results

4.1. Preliminary analysis

The mean scores and standard deviations of all key variables, as provided in Table 1, indicated significant variations in mean scores both across and within the variables. The correlations between personality traits and enjoyment, as well as intention for future participation, were either low or insignificant, suggesting that personality traits were not directly influential. Consequently, we included them as potential moderators after assessing the direct effects of perceived need satisfaction on enjoyment and intention. Additionally, due to high correlations among perceived need satisfaction variables, we considered them separately in subsequent regression analyses.

Table 1
Descriptive statistics ($N = 109$)

	Mean (SD)	Range	Cronbach's alpha
Perceived need satisfaction			
Competence	21.57 (5.02)	6–28	.910
Autonomy	20.28 (5.83)	4–28	.915
Relatedness	15.01 (7.05)	4–28	.936
Personality traits			
Extraversion	30.60 (9.43)	10–50	.905
Agreeableness	41.55 (6.26)	26–50	.853
Intellect	35.05 (5.81)	18–49	.758
Conscientiousness	35.58 (7.46)	19–50	.852
Emotional stability	27.70 (7.60)	10–45	.840
Outcome measures			
Enjoyment	20.57(6.76)	4–28	.972
Intention	15.99 (4.84)	3–21	.942

4.2. Perceived need satisfaction, enjoyment, and intention for future participation

As Table 2 suggests, perceived competence, autonomy, and relatedness significantly predicted enjoyment and intention for future participation. For models that violated the modeling assumption, results from both linear regression and Tobit regression were presented. The Tobit regression results revealed stronger relationships. The strength of associations varied among predictors. Specifically, perceived relatedness emerged as the weakest predictor, whereas perceived autonomy exhibited the strongest predictive power for both outcomes.

4.3. The moderation effects of personality traits

After testing all the models with the interactions between personality traits and perceived need satisfaction, four models showing significant moderation effects were identified and reported below. First, the results in Table 3 suggested that there was a significant interaction between perceived competence and emotional stability ($t = -.2.76$, $p = .007$). As shown in Fig. 2, the association between perceived competence and enjoyment changed as the emotional stability scores varied. The positive relationship between perceived

competence and enjoyment was stronger when the emotional stability score was one standard deviation below the estimated mean. When the emotional stability scores were high (i.e., one standard deviation above the estimated mean), the relationship became weaker.

Table 2
Multiple regression models: Perceived need satisfaction on enjoyment and intention ($N = 109$)

	Regression	Estimate (SE)	*t*-statistics	95% CI	*F* (12, 96) value	*R*-square
Outcome: Enjoyment						
Perceived Competence	OLS Regression	.88 (.10)	8.74 ($p < .001$)	.68, 1.08	8.10	.44
	Tobit Regression	1.18 (.14)	8.70 ($p < .001$)	.91, 1.45	Na	Na
Perceived Autonomy	OLS Regression	.94 (.67)	14.12 ($p < .001$)	.81, 1.07	19.57	.67
	Tobit Regression	1.19 (.09)	12.97 ($p < .001$)	1.02,1.38	Na	Na
Perceived Relatedness	Tobit Regression	.60 (.08)	7.51 ($p < .001$)	.44, .76	6.23	.37
Outcome: Intention						
Perceived Competence	OLS Regression	.60 (.08)	7.99 ($p < .001$)	.44, .76	6.71	.39
	Tobit Regression	.81 (.10)	7.79 ($p < .01$)	.60, 1.02	Na	Na
Perceived Autonomy	OLS Regression	.68 (.05)	14.47 ($p < .001$)	.59, .78	20.10	.68
Perceived Relatedness	OLS Regression	.38 (.06)	6.23 ($p < .001$)	.26, .50	4.40	.27

Note. p-values of *F*-statistics < .001; demographics were controlled (age, gender, and class section)

Table 3
Multiple regression: Perceived competence and emotional stability on enjoyment ($N = 109$)

	Estimate (SE)	*t*-statistics	95% CI	*F*-statistics & *R*-square
Perceived competence	.78 (.10)	7.74 ($p < .001$)	.58, 98	$F(14, 94) = 8.58$
Emotional stability	.13 (.07)	1.93 ($p = .056$)	< .00, .26	*R*-square = .50
Perceived competence × Emotional stability	–.03 (.01)	–2.76 ($p = .007$)	–.06, –.01	

Fig. 2. Relationship between predicted enjoyment scores and perceived competence scores moderated by emotional stability

Second, the results in Table 4 showed there was a significant interaction between perceived autonomy and emotional stability ($t = -3.16$, $p = .002$). As suggested in Fig. 3, the positive relationship between perceived autonomy and enjoyment was stronger for students with lower emotional stability. As the emotional stability scores went high, the relationship was weaker.

Table 4
Multiple regression: Perceived autonomy and emotional stability on enjoyment ($N = 109$)

		Estimate (SE)	*t* statistics (*p* value)	95% CI	*F*-statistics & *R*-square
Perceived autonomy	OLS Regression	.86 (.07)	12.37 ($p < .001$)	.72, 1.00	
	Tobit Regression	1.11 (.09)	12.08 ($p < .001$)	.93, 1.30	
Emotional stability	OLS Regression	.08 (.05)	1.58 ($p = .118$)	–.02, .19	$F(14, 94)=18.59$
	Tobit Regression	.08 (.06)	1.19 ($p = .238$)	–.05, .20	*R*-square =.70
Perceived autonomy × Emotional stability	OLS Regression	–.02 (.01)	–.247 ($p = .015$)	–.04, >–.00	
	Tobit Regression	–.04 (.01)	–3.11 ($p = .002$)	–.07, –.02	

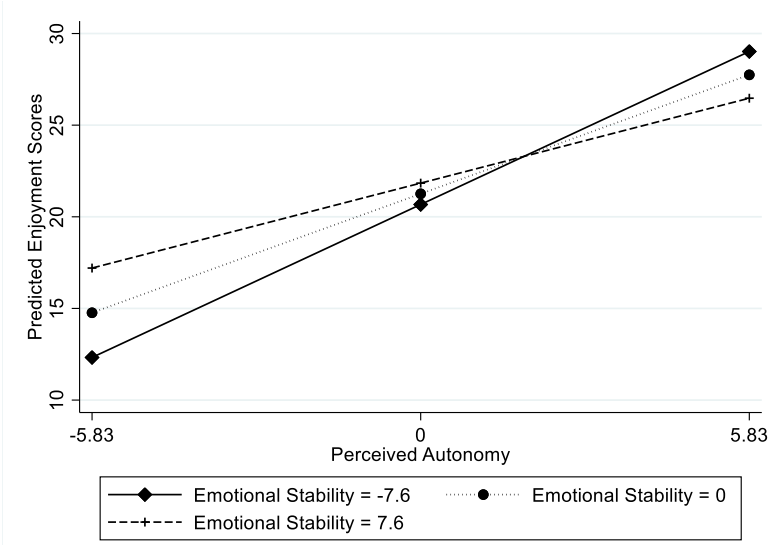

Fig. 3. Relationship between predicted enjoyment scores and perceived autonomy scores moderated by emotional stability

Third, as suggested in Table 5, perceived relatedness significantly interacted with emotional stability ($t = 3.70$, $p \leq .001$), influencing the overall experience of enjoyment. Similarly, the positive relationship between perceived relatedness and enjoyment was stronger when the emotional stability scores were lower (see Fig. 4).

Table 5
Multiple regression: Perceived relatedness and emotional stability on enjoyment (N = 109)

	Estimate (SE)	T statistics (p value)	95% CI	F-statistics & R-square
Perceived relatedness	.50 (.08)	6.49 (p < .001)	.35, .66	F(14, 94) = 7.45
Emotional stability	.18 (.07)	2.51 (p = .014)	.04, .32	R-square = .46
Perceived relatedness × Emotional stability	–.04 (.01)	–.3.70 (p < .001)	–.06, –.02	

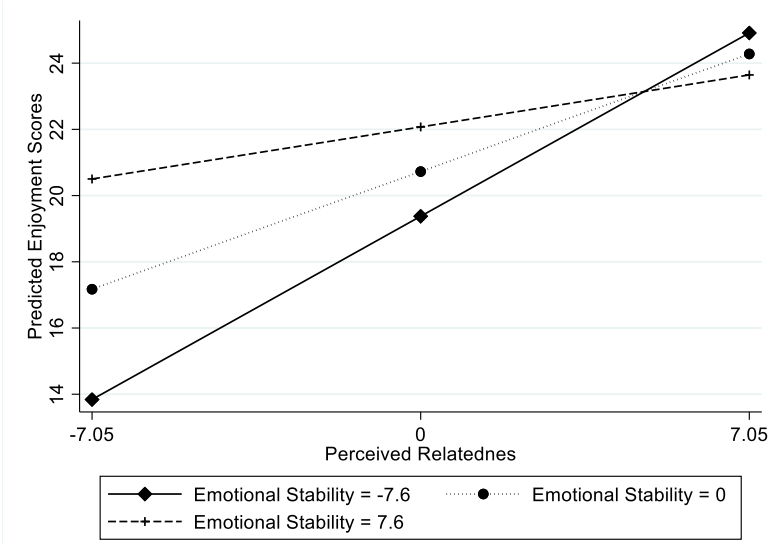

Fig. 4. Relationship between predicted enjoyment scores and perceived relatedness scores moderated by emotional stability

Finally, Table 6 shows that perceived autonomy and agreeableness interacted with each other to influence the intention for future participation (t = –2.46, p = .016). The positive relationship between perceived autonomy and intention was stronger with lower levels of agreeableness. When the agreeableness scores were higher, the relationship became weaker (see Fig. 5).

Table 6
Multiple regression: Multiple regression: Perceived autonomy and agreeableness on intention (N = 109)

	Estimate (SE)	T statistics (p value)	95% CI	F statistics & R-square
Perceived autonomy	.66 (.05)	14.04 (p < .001)	.57, .76	F(14, 94) = 18.64
Agreeableness	.04 (.04)	.81 (p = .422)	–.05, .13	R-square =.70
Perceived autonomy × Agreeableness	–.02 (.01)	–.2.46 (p = .016)	–.03, <.01	

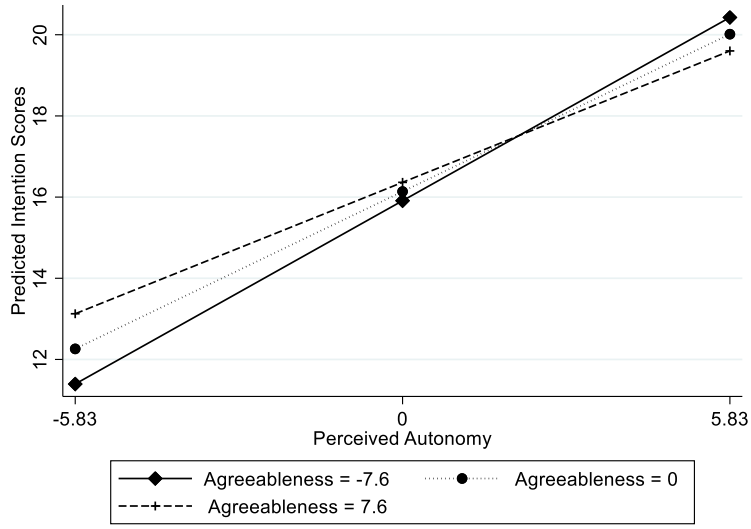

Fig. 5. Relationship between predicted intention scores and perceived autonomy scores moderated by agreeableness

4. Discussion

The study examined how students' perceived need satisfaction and personality traits interacted to influence students' enjoyment and intention for future participation in a leaderboard-based math activity. Our analysis showed that all three types of perceived need satisfaction – competence, autonomy, and relatedness – significantly predicted both enjoyment and intention for future participation. This contrasts somewhat with findings from our pilot study (Gao et al., 2024), where only perceived competence and perceived autonomy emerged as significant predictors, while perceived relatedness did not. Further examination revealed that, in the pilot study, students reported low perceived relatedness with limited variations, which likely contributed to its insignificance in predicting enjoyment. A key procedural difference between the pilot study and the current one was the explicit prompting for students to check the leaderboard twice during practice in the current study, whereas no such prompting occurred in the pilot study. This procedural change may have contributed to the observed differences in findings.

Unlike findings in the existing literature, which often show direct effects of personality traits on students' gamified learning experiences (e.g., Buckley & Doyle, 2017; Denden, et al., 2024; Ghaban & Hendley, 2019), this study suggested that the correlations between personality traits and students' enjoyment and intention for future participation are relatively weak. It's important to note that prior studies were conducted within gamified environments featuring multiple game elements, whereas our study focused exclusively on the leaderboard-based environment. It's possible that in environments with multiple game elements, personality traits may exert a more pronounced direct influence on students' experiences.

Similar to previous studies (Jia et al., 2016; Triantoro et al., 2020), we found that emotional stability or neuroticism (the opposite end of the emotional stability trait spectrum)

played an important role in learners' experiences within gamified contexts. In this study, emotional stability moderated the relationships of all three types of perceived need satisfaction and enjoyment in the leaderboard-based math activity. The findings suggested that, for emotionally stable learners, their perceived competence, autonomy, and relatedness had less of an impact on their enjoyment. Conversely, for learners with lower levels of emotional stability, their perceived need satisfaction exerted a stronger influence on their enjoyment. Emotional stability represents consistency in emotional reactions and reflects an individual's resilience to stress and tendency to experience fewer negative emotions. As a result, learners high in emotional stability may derive enjoyment from the activity regardless of whether their needs for competence, autonomy, or relatedness are fully satisfied, because they are less susceptible to frustration or anxiety. In contrast, learners lower in emotional stability rely more heavily on these need satisfactions to buffer against negative affect. This pattern aligns with SDT's emphasis on the functional significance of need satisfaction and suggests that personality traits shape how the basic psychological need satisfaction translates into enjoyment.

Agreeableness was found to be an important moderator for perceived autonomy to predict the intention for future participation, but not enjoyment. The perceived autonomy of less agreeable learners had a more significant impact on their intention for future participation compared to more agreeable learners. In other words, when perceived autonomy was low, learners with lower levels of agreeableness would be less motivated to participate in similar future activities. Agreeableness reflects tendencies toward trust and cooperation. Therefore, highly agreeable learners may value group participation and future collaboration, making their intention to re-engage less dependent on their own sense of autonomy. For less agreeable learners, however, the decision to participate in future activities is more strongly tied to whether they feel personally volitional and self-directed. This is probably why autonomy has a stronger influence on intention among less agreeable learners. Enjoyment, on the other hand, is an immediate affective outcome that may be less contingent on these interpersonal tendencies, which helps explain why agreeableness did not moderate the relationship between autonomy and enjoyment.

The findings of the study have significant theoretical implications. First, the findings shed light on the inconsistent results reported in the literature. For example, while Orji et al. (2017) found that highly neurotic learners (i.e., those with low emotional stability) are less likely to be motivated by gamification features, Ghaban et al. (2019) reported that such learners can, in fact, derive significant benefit from gamification, demonstrating higher motivation to complete the course. The present result suggests that these seemingly contradictory findings may be explained by learners' perceived need satisfaction. When perceived competence is low, for example, highly neurotic learners tend to show lower motivation than those with high emotional stability. In contrast, when perceived competence is high, these learners may be just as motivated, or even more motivated, by gamification features than their emotionally stable peers, thereby accounting for why some studies report negative effects while others show significant benefits. Second, although many previous studies have emphasized the important role of need satisfaction in gamified contexts (e.g., Sailer et al., 2017; Van et al., 2019), they have offered limited theoretical explanation for the mechanisms through which individual differences shape these effects. Our findings extend SDT-based gamification research by demonstrating that the effects of need satisfaction are not uniform across learners, and the functional significance of gamified experience is contingent on personality traits. By showing that emotional stability and agreeableness systematically moderate the relationships between need satisfaction and key outcomes, this study highlights that gamification research should more explicitly

integrate personality factors when theorizing about learner engagement. This integration helps move beyond a one-size-fits-all perspective and supports a more nuanced SDT-based framework for understanding learner differences in gamified environments.

The results of the study suggested several directions for future research. First, while the framework of Big Five Personality traits provides a widely accepted and comprehensive framework for personality assessment, research suggests that some of the more numerous facets or primary traits are more accurate at predicting and explaining actual behaviors than the Big Five Personality traits (Mershon & Gorsuch, 1988; Paunonen & Ashton, 2001). By exploring alternative personality trait models, researchers can enhance the granularity of their analyses and potentially uncover subtler relationships that may be overlooked by broader trait classifications. Thus, future studies may benefit from integrating diverse personality trait models to offer a more comprehensive understanding of the complex dynamics at play in gamified learning. In addition, this study focused specifically on learners' experiences in a gamified environment that employed only a leaderboard as the game element. While this design allowed us to isolate the effects of the leaderboard, it also limited the generalizability of our findings to other gamified contexts. Future research is needed to investigate the impact of individual game elements, such as badges, points, progress bars, as well as the ways these elements interact with one another. A deeper understanding of the distinct and combined effects of different game elements will be essential for creating gamified learning environments that are not only more engaging and effective but also better tailored to learners' diverse personalities and motivational profiles.

The moderation effects we observed in this study have meaningful practical implications for gamification design. For example, the stronger dependence of learners low in emotional stability on need satisfaction suggests that these individuals may be particularly vulnerable in gamified environments if their needs for competence, autonomy, or relatedness are not supported. In practice, this means that educators and designers may provide scaffolds, such as constructive feedback to support competence, meaningful choice to enhance autonomy, and structured collaboration to foster relatedness, to ensure these learners remain engaged and avoid negative emotional spirals. Similarly, the finding that perceived autonomy has a stronger influence on future participation among less agreeable learners indicates that adaptive gamification systems should provide flexible options that emphasize personal agency for such individuals. While highly agreeable learners may continue participating for social or cooperative reasons, less agreeable learners are more likely to disengage if autonomy is constrained. Thus, the observed moderations highlight personality-sensitive levers that can be acted upon in practice, offering concrete guidelines for designing gamified interventions that are better tailored to learners' personality traits.

The current study has several limitations. First, the study took place in an undergraduate mathematics course designed for non-STEM majors, with a sample of 109 participants. The majority of participants were female, and there was limited variability in age. By focusing on this specific course context, the study may not capture the dynamics present in other disciplines or learning environments. The overrepresentation of female participants may skew the results, and the limited age range restricts the ability to draw conclusions applicable to individuals at different stages of cognitive development. Since age has been shown to moderate the effects of gamified interventions (Kim & Castelli, 2021), and disciplinary context may influence learning experiences, caution is warranted when generalizing the findings. Future research that includes more diverse academic disciplines, gender representation, and age distribution will be important for validating and

extending these findings. Second, given the limited sample size and data features, we employed multiple regression analysis by considering key predictors, outcome variables, and moderator variables separately in multiple models. However, multiple regression may not be the most suitable approach for capturing complex interaction effects proposed in this study. Future investigations should explore the relationships using a structural equation modelling (SEM) framework using a larger sample size. This analytical approach has several advantages over our current method, such as scrutinizing complex relationships within a single model and offering greater flexibility in examining potential moderating and mediating effects (Kline, 2023). Ultimately, it enables a more nuanced understanding of the underlying relationships and provides a more robust validation of the proposed framework. Third, the study relied on self-reported survey data, which may be subject to self-report bias. Finally, the current study design limits the ability to establish causal relationships and possible confounding variables not accounted for in the analysis may have influenced the observed relationships. Future studies could mitigate these concerns by incorporating longitudinal or experimental designs, using behavioral or performance-based measures alongside self-reports, and controlling for a broader set of covariates.

5. Conclusion

Research has demonstrated the influences of personality traits on learners' gamification experiences, yet few have explored the reasons behind this phenomenon. Drawing upon the perspective of SDT, this study aims to pinpoint the underlying mechanism by which personality traits influence learners' gamification experiences. The findings revealed the moderating effect of emotional stability on the relationship between perceived need satisfaction and enjoyment, as well as the moderating effect of agreeableness on perceived autonomy in predicting future participation intention. Our study represents an initial step towards comprehending the influence of personality traits on the intricate dynamics of gamification through the lens of self-determination theory. Taken together, our findings suggest that gamified learning designs should not only aim to support basic psychological needs universally but also recognize the personality-dependent mechanisms through which these needs affect outcomes. Designers might consider adaptive elements, such as offering more explicit autonomy support to less agreeable learners or enhancing competence scaffolds for emotionally less stable learners. By embedding personality-sensitive supports, gamified interventions can more effectively enhance enjoyment and foster sustained engagement.

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