

THE EFFECTS OF GAMIFICATION FEATURES ON LEARNERS' MOTIVATION IN USING DUOLINGO: A SELF-DETERMINATION THEORY PERSPECTIVE

ẢNH HƯỞNG CỦA CÁC TÍNH NĂNG TRÒ CHƠI HÓA ĐẾN ĐỘNG LỰC HỌC TẬP CỦA NGƯỜI HỌC KHI SỬ DỤNG DUOLINGO: GÓC NHÌN TỪ THUYẾT TỰ QUYẾT

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Abstract - The rapid growth of mobile-assisted language learning has increased interest in how gamified applications support learners' motivation. This study examines how gamification features in Duolingo influence students' learning motivation. It also investigates whether autonomy, competence, and relatedness, as proposed by Self-Determination Theory, mediate this relationship. A quantitative cross-sectional survey was conducted with 247 students who had experience using Duolingo. Data were analyzed using reliability testing, exploratory factor analysis, correlation, regression, and mediation analysis. The findings show that gamification features positively influence learning motivation mainly through competence and relatedness. Autonomy was not a significant mediator. The study concludes that Duolingo's gamified design motivates learners primarily by helping them feel capable and socially connected.

Key words - Gamification; Duolingo; learning motivation; Self-Determination Theory

Tóm tắt - Sự phát triển của việc học ngoại ngữ thông qua thiết bị di động làm gia tăng sự quan tâm đến vai trò của các ứng dụng có yếu tố trò chơi hóa đối với động lực học tập. Nghiên cứu này xem xét cách thức các tính năng trò chơi hóa trong Duolingo ảnh hưởng đến động lực học tập của sinh viên, đồng thời kiểm tra vai trò trung gian của sự tự chủ, năng lực và sự kết nối theo lý thuyết Tự quyết. Nghiên cứu sử dụng phương pháp định lượng với khảo sát cắt ngang trên 247 sinh viên đã có trải nghiệm sử dụng Duolingo. Dữ liệu được phân tích bằng kiểm định độ tin cậy, EFA, tương quan, hồi quy và phân tích trung gian. Kết quả cho thấy trò chơi hóa ảnh hưởng đến động lực học tập chủ yếu thông qua năng lực và kết nối, trong khi tự chủ không có vai trò trung gian đáng kể.

Từ khóa - Trò chơi hóa; Duolingo; động lực học tập; Lý thuyết Tự quyết

1. Introduction

The rapid development of digital learning platforms has substantially transformed foreign language learning. These platforms provide learners with flexible and personalized beyond the classroom. Within this context, Duolingo has become one of the most widely used applications in mobile-assisted language learning. A distinctive feature of Duolingo is its extensive use of gamification, which was defined by Deterding et al. [1] as the use of game design elements in non-game contexts to promote engagement. Various features of Duolingo, including points, levels, streaks, and leaderboards, are embedded to encourage learner participation [2] [3].

Recent studies confirm that gamification significantly enhances learner motivation and engagement. Specifically, Ameen [4] emphasizes that individualized gamification elements promote learner autonomy and intrinsic motivation, whereas collaborative and competitive features stimulate extrinsic motivation and social interaction. Similarly, Dar, Nandi, and Rather [5] demonstrate that gamified features align well with educational goals to enhance students' participation and motivation.

Despite these positive findings, methodological gaps still remain in the existing literature. Adams and Du Preez [6], alongside Grabner-Hagen and Kingsley [7], argue that while gamified features initially attract learners, it remains unclear whether these elements can overcome the novelty effect to

sustain long-term engagement. This challenge is also evident in localized contexts, where gamified tools such as Quizlet have been shown to perform well in short-term vocabulary recognition but struggle to maintain long-term memory retention over time [8]. Additionally, Dar, Nandi, and Rather [5] identify a lack of solid theoretical foundations in many gamified interventions. While the previous studies mostly focus on basic game features or final learning results, the exact psychological reasons why gamification influences learner motivation are still not well understood.

To address the existing research gaps and examine how surface-level gamification elements translate into long-term motivation, this study adopts Deci and Ryan's Self-Determination Theory (SDT) [9] as its core framework. SDT asserts that motivation is driven by the fulfillment of three basic psychological needs: autonomy, competence, and relatedness. The premise was also supported by Grabner-Hagen and Kingsley [7], who found that need-supporting designs effectively foster autonomous learning. By investigating the specific mediating role of these needs, the present study analyzes how distinct features in Duolingo function as mechanisms that may help learners feel agentic, capable, and socially connected.

Based on this objective, the study addresses the following research questions:

1. How do gamification features in Duolingo influence students' learning motivation?

2. To what extent do the three basic psychological needs proposed by Self-Determination Theory, namely autonomy, competence, and relatedness, mediate the relationship between gamification features and learning motivation?

2. Theoretical Foundation

2.1. Gamification in Education

Gamification has been widely adopted in educational settings to enhance learner engagement and motivation. Deterding et al. [1] define gamification as the use of game design elements in non-game contexts, thereby distinguishing it from game-based learning. Rather than turning an activity into a complete game, gamification incorporates game-like features into non-game environments to create engagement and support desired outcomes.

Besides, Dichev and Dicheva [10] describe gamification as an educational approach that seeks to increase learners' motivation and engagement through the integration of game design elements. These perspectives indicate that gamification is not merely the addition of points, badges, or rewards but a pedagogical strategy that should be connected to meaningful learning purposes.

2.2. Gamification Features

Werbach and Hunter [11] classify gamification elements into three levels: dynamics, mechanics, and components. In Duolingo, common gamification features include points, levels, streaks, rewards, leaderboards, and progress indicators. These elements are designed to make learning progress more measurable and engaging.

However, gamification features should not be examined as separate tools. Their motivational value depends on how learners experience them in their learning process. Sailer et al. [12] argue that gamification elements can influence learners' perceptions of competence, autonomy, and relatedness. From this perspective, Duolingo's gamification features may affect motivation not only by making learning more entertaining but also by shaping learners' psychological experiences.

2.3. Self-Determination Theory (SDT)

Self-Determination Theory provides a useful framework for explaining how gamification may contribute to sustained learning motivation. Deci and Ryan [9] argue that individuals have a tendency toward growth and learning naturally, but the quality of their motivation depends on whether the surrounding environment supports their psychological needs. Ryan and Deci [13] further distinguish between autonomous motivation, which is personally valued, and controlled motivation that is driven by external factors.

Within SDT, Basic Psychological Needs Theory emphasizes autonomy, competence, and relatedness as the three core psychological needs that support human motivation. When these needs are satisfied, learners are more likely to adopt learning goals and maintain motivation. In Duolingo, progress indicators, levels, and points may enhance competence by making achievement visible. Flexible pacing and individual learning pathways may support autonomy by allowing learners to control their learning process. Social features such as leaderboards may

foster relatedness through shared participation and constructive competition.

Previous studies also support this relationship. Sailer et al. [12] found that game design elements can strengthen learners' perceptions of competence and autonomy, while Xi and Hamari [14] showed that gamification can positively affect all three psychological needs. In the Vietnamese higher education context, the incorporation of technology within supportive frameworks has similarly been demonstrated to improve students' engagement and autonomy by giving individuals greater control over their learning pace [15].

2.4. Hypothesis Development and Research Model

According to SDT, proposed by Deci and Ryan [9], sustainable motivation depends on the satisfaction of three basic psychological needs: autonomy, competence, and relatedness. This framework classifies motivation into intrinsic motivation, which involves doing an activity for its inherent enjoyment, and extrinsic motivation, which targets separate outcomes. In Duolingo, features like immediate feedback and optimal challenges enhance inherent interest, driving intrinsic motivation. Meanwhile, points, badges, and leaderboards act as external rewards, stimulating extrinsic motivation.

Crucially, Ryan and Deci [16] argue that extrinsic motivation varies in autonomy and is not merely controlled. In this study, gamification features (GFs) are proposed to directly and indirectly affect learning motivation (LM). By fulfilling the psychological need satisfaction (PNS) for autonomy (AUT), competence (COM), and relatedness (REL), these features allow learners to internalize external rewards. Therefore, the study captures both intrinsic and extrinsic motivation, demonstrating how Duolingo's features foster personal satisfaction alongside external rewards. Accordingly, the following hypotheses are proposed:

Hypothesis H1a: GFs positively influence AUT.

Hypothesis H1b: GFs positively influence COM.

Hypothesis H1c: GFs positively influence REL.

Hypothesis H2a: AUT positively influences LM.

Hypothesis H2b: COM positively influences LM.

Hypothesis H2c: REL positively influences LM.

Hypothesis H3: GFs positively influence LM.

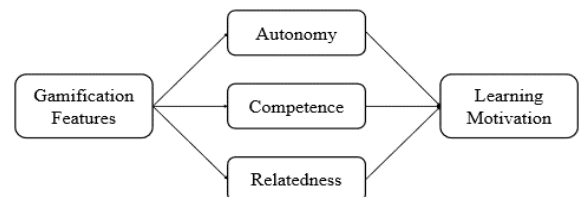


Figure 1. Proposed research model (Source: Author's Proposal)

To test these hypotheses, regression analyses were conducted to examine the effects of GFs on the three psychological needs, the effects of these needs on LM, and

the direct effect of GFs on LM. Full and refined models were then compared to determine whether learning motivation was better explained by GFs directly or through PNS. Based on these hypotheses, the proposed research model is illustrated in Figure 1.

3. Research Methodology

3.1. Research Design

This study employed a quantitative research design with a cross-sectional survey approach to examine the relationships among GFs, PNS, and LM among Duolingo users. This approach was considered appropriate because the study aimed to test the proposed hypotheses and investigate the associations among variables in the research model.

The research model was grounded in SDT. In this study, GFs were treated as the independent variable, while AUT, COM, and REL served as mediating variables. LM was examined as the dependent variable. Accordingly, the study adopted a mediation model to explore whether Duolingo's GFs influence learners' motivation directly or indirectly through PNS.

3.2. Participants and Data Collection

The participants for this study comprised students at FPT Polytechnic College who had completed the Learning Skills course, where Duolingo was recommended for out-of-class language practice. A convenience sampling method was employed to efficiently reach this targeted population of experienced users. To minimize potential sample bias and provide a comprehensive institutional view, participants were recruited from various majors of study within the institution.

To collect valid data from this sample, a 5-point Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree) was developed using a hybrid approach. Measurement items for basic psychological need satisfaction and learning motivation were adapted from established SDT instruments proposed by Deci et al. [17], while gamification features were framed around Sailer et al.'s taxonomy [12]. To tailor these concepts to Duolingo, 29 experienced student users were asked an open-ended question about their favorite features. Subsequently, their feedback was combined with the literature to yield an initial pool of 31 Vietnamese items. Next, this scale underwent refinement with a pilot test. The test was conducted with 30 students to evaluate clarity and relevance, while language teachers and educational technology experts provided feedback on content validity. Based on the pilot results and expert consensus, 7 problematic items were removed and the phrasing was revised. The finalized 24-item questionnaire, alongside items collecting demographic and usage background, was then administered through an online platform, ultimately yielding a total of 270 responses. After excluding invalid ones, 247 valid responses were retained for analysis.

3.3. Measurement and Data Analysis

The questionnaire measured five main constructs: GFs, AUT, COM, REL, and LM. All items were rated on a five-point Likert scale ranging from 1, strongly disagree, to 5, strongly agree.

The data were analyzed using JASP 0.95.4. First, descriptive statistics were used to summarize the main characteristics of the data. Reliability was then assessed using Cronbach's Alpha, with values of 0.70 or above considered acceptable. Exploratory Factor Analysis was also conducted to examine the factor structure of the scales. Before conducting factor analysis, the Kaiser–Meyer–Olkin (KMO) measure and Bartlett's Test of Sphericity were used to assess data suitability.

After confirming reliability and factor structure, Pearson correlation analysis was performed to examine the relationships among the variables. Regression analyses were then conducted to test the proposed hypotheses, including the effects of GFs on PNS, the effects of AUT, COM, and REL on LM, and the direct effect of GFs on LM. Multicollinearity was checked using the Variance Inflation Factor (VIF) before interpreting the regression results.

Finally, mediation analysis was employed to examine whether PNS explained the relationship between GFs and LM. This procedure allowed the study to clarify the direct, indirect, and total effects in the proposed research model.

3.4. Regression Model Specification

To test the proposed research model, several regression equations were specified to examine the relationships among GFs, PNS, and LM.

First, the effects of GFs on the three psychological needs were examined using the following equations:

$$Y_2 = \beta_{20} + \beta_{21}X + U_2$$

$$Y_3 = \beta_{30} + \beta_{31}X + U_3$$

$$Y_4 = \beta_{40} + \beta_{41}X + U_4$$

Next, the effects of PNS on LM were tested through the following multiple regression model:

$$Y_1 = \beta_{10} + \beta_{11}Y_2 + \beta_{12}Y_3 + \beta_{13}Y_4 + U_1$$

To examine the direct effect of GFs on LM, the following regression model was estimated:

$$Y_1 = \beta_{50} + \beta_{51}X + U_5$$

In addition, a full regression model was used to assess whether GFs still directly predict LM after controlling for PNS:

$$Y_1 = \beta_{60} + \beta_{61}X + \beta_{62}Y_2 + \beta_{63}Y_3 + \beta_{64}Y_4 + U_6$$

Finally, mediation analysis was conducted to examine whether the effect of GFs on LM is transmitted through COM and REL. The mediation paths were specified as follows:

$$X \rightarrow Y_3 \rightarrow Y_1$$

$$X \rightarrow Y_4 \rightarrow Y_1$$

Notes on Model Symbols:

X: Gamification Features; Y_1 : Learning Motivation; Y_2 : Autonomy Satisfaction; Y_3 : Competence Satisfaction; Y_4 : Relatedness Satisfaction.

β : Regression coefficients, including model intercepts and the estimated effects of the predictors.

U: Model error terms, representing unexplained variance beyond the predictors included in each model.

4. Results and Discussion

4.1. Descriptive Statistics

Tables 1 and 2 present the demographics, Duolingo usage habits, and descriptive statistics of the 247 valid responses retained after data screening, establishing the baseline for subsequent analyses.

Table 1. Demographic and Usage Characteristics of the Sample

Variable		Frequency	Percentage (%)
Gender	Male	119	48.2%
	Female	128	51.8%
Language Studied on Duolingo	English	194	78.5%
	Chinese	46	18.6%
	Korean	5	2%
	Others	2	0.9%
Duration of Duolingo Use	Less than 1 month	72	29.1%
	1-6 months	118	47.8%
	6-12 months	35	14.2%
	More than 1 year	22	9%
Total		247	100%

Table 2. Descriptive statistics of study variables

Variable	Mean (M)	Standard Deviation (SD)
GFs	3.906	0.655
AUT	3.662	0.797
COM	3.845	0.746
REL	3.672	0.746
LM	3.892	0.726

As shown in Table 2, the mean scores for all variables ranged from 3.662 to 3.906, indicating a relatively positive perception among learners. GFs recorded the highest score ($M = 3.906$, $SD = 0.655$), closely followed by LM ($M = 3.892$, $SD = 0.726$). This suggests that learners highly value the gamified design and maintain strong motivation while using the application. In contrast, AUT received the lowest score ($M = 3.662$, $SD = 0.797$).

A deeper analysis of these data reveals relationships that both support and challenge the core assumptions of SDT within a mobile-assisted language learning environment. First, the peak scores for GF ($M = 3.906$) and LM ($M = 3.892$) provide preliminary empirical evidence that the gamified structure strongly urges students. However, from an SDT perspective, this initial engagement does not equate to long-term commitment. As shown in Table 1, while 76.9% of users had used the app for less than six months, the retention rate beyond one year was only 9%. This decline illustrates the "novelty effect" of gamification noted by Adams and Du Preez [6] that extrinsic rewards may fail to foster intrinsic habits once the initial novelty wears off.

This lack of long-term commitment is further explained by the low score for AUT, which potentially stems from Duolingo's strict linear progression and its nature as a course-recommended tool. In contrast, COM yields a robust score ($M = 3.845$, $SD = 0.746$). This result suggests that Duolingo's scaffolding features effectively satisfy learners' need to feel competent. Meanwhile, REL remains moderate ($M = 3.672$, $SD = 0.746$), indicating that initial social engagement features are relatively weak. However,

this variance also implies that for users who actively participate in competitive features like leaderboards, REL could act as a latent driver of motivation.

4.2. Reliability Analysis

As presented in Table 3, all constructs achieved Cronbach's Alpha values above 0.70, indicating acceptable to good internal consistency. The corrected item-total correlations ranged from 0.447 to 0.708, all exceeding the recommended minimum value of 0.30. In addition, the "Cronbach's Alpha if Item Deleted" values did not suggest that removing any item would substantially improve the reliability of the scales. Therefore, all items were retained for subsequent analyses.

Table 3. Results of scale reliability testing using Cronbach's Alpha

Construct	Item	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	Overall Cronbach's Alpha
Gamification Features	GF1	0.471	0.727	0.754
	GF2	0.563	0.694	
	GF3	0.572	0.691	
	GF4	0.553	0.699	
	GF5	0.447	0.738	
Autonomy	AUT1	0.708	0.760	0.822
	AUT2	0.622	0.786	
	AUT3	0.592	0.795	
	AUT4	0.564	0.802	
	AUT5	0.596	0.793	
Competence	COM1	0.585	0.758	0.798
	COM2	0.475	0.762	
	COM3	0.553	0.769	
	COM4	0.682	0.727	
	COM5	0.642	0.740	
Relatedness	REL1	0.510	0.746	0.769
	REL2	0.590	0.706	
	REL3	0.604	0.696	
	REL4	0.583	0.707	
Learning Motivation	LM1	0.614	0.807	0.835
	LM2	0.628	0.803	
	LM3	0.677	0.790	
	LM4	0.576	0.818	
	LM5	0.682	0.787	

Notably, the Gamification Features (GFs) scale yielded the lowest Cronbach's Alpha in the model (0.754). Within this construct, item GF5 showed the lowest corrected item-total correlation (0.447), whereas GF3 (0.572) and GF2 (0.563) performed better. Structurally, this slight drop in internal consistency stems from the hybrid approach used to build the scale, following Sailer et al.'s taxonomy [12]. The GFs scale aggregates features with very different characteristics on Duolingo, ranging from individual elements (points, streaks) to social ones (leaderboards). Because learners do not experience these elements uniformly, their acceptance and responses to such complex gamification designs vary widely, aligning with the warnings raised by Dichev and Dicheva [10].

4.3. Exploratory Factor Analysis

4.3.1. Kaiser–Meyer–Olkin (KMO) and Bartlett's Test

As shown in Table 4, the KMO values ranged from 0.759 to 0.822, indicating acceptable sampling adequacy for all constructs. Bartlett's Test of Sphericity was significant for all scales at $p < .001$, confirming that the items were sufficiently correlated for factor analysis.

Table 4. KMO and Bartlett's Test Results

Construct	KMO	Bartlett's Test (χ^2)	df	Sig.
GFs	0.762	266.724	10	<.001
AUT	0.822	393.682	10	<.001
COM	0.808	358.454	10	<.001
REL	0.759	253.733	6	<.001
LM	0.802	447.860	10	<.001

4.3.2. EFA Results

Table 5 shows that each construct was represented by a single factor, with eigenvalues greater than 1. The percentage of variance ranged from 48.66% to 70.98%, suggesting that the extracted factors accounted for a meaningful proportion of variance in their respective scales. The factor loading ranges also indicated that all items loaded adequately on their intended constructs. These results support the factor structure of the measurement scales and provide a basis for the following correlation, regression, and mediation analyses.

The EFA results in Table 5 show that the Relatedness (REL) scale achieved the highest variance extracted in the system (70.98%, Eigenvalue = 2.839), indicating high consistency in how students perceived this construct. Meanwhile, the Competence (COM) and Learning Motivation (LM) scales showed robust variance extracted values of 66.34% and 50.58%, respectively, with all factor loadings exceeding the 0.525 threshold, confirming strong convergent validity. This clean, single-factor structure demonstrates that participants clearly understood the survey items without confusion or misinterpretation.

Table 5. Exploratory Factor Analysis Results

Construct	Items	Eigenvalue	Variance (%)	Factor Loading Range
GFs	5	2.945	58.9%	0.638 – 0.761
AUT	5	2.433	48.66%	0.631 – 0.815
COM	5	3.317	66.34%	0.525 – 0.804
REL	4	2.839	70.98%	0.592 – 0.730
LM	5	2.529	50.58%	0.638 – 0.761

4.4. Correlation Analysis

As shown in Table 6, all study variables are positively correlated with high statistical significance ($p < .001$). The Pearson correlation coefficients (r) range from 0.421 to 0.749, indicating moderate to strong linear relationships between the constructs. Notably, LM correlates most strongly with REL ($r = 0.560$) and COM ($r = 0.554$), but has the weakest correlation with GFs ($r = 0.421$). Through the lens of SDT, this pattern indicates that learner motivation is tied more closely to PNS, particularly REL and COM, than to technological features alone. This finding aligns with Sailer et al. [12], confirming that

gamified elements act merely as external motivators, and their value must be processed through learner perception to satisfy internal psychological needs. Furthermore, since none of the correlation coefficients exceed the 0.80 threshold, the results indicate no serious concerns regarding discriminant validity or excessive overlap among the constructs, justifying their inclusion in the subsequent regression analysis.

Table 6. Pearson correlation matrix

Variable	GF	AUT	COM	REL	LM
GF	1	0.637***	0.608***	0.541***	0.421***
AUT		1	0.749***	0.570***	0.448***
COM			1	0.666***	0.554***
REL				1	0.560***
LM					1

Note on Table 6: * $p < .05$, ** $p < .01$, *** $p < .001$

4.5. Regression Analysis

Tables 7 and 8 present the results of the linear and multiple regression analyses used to test hypotheses H1a through H3.

Table 7. Model Fit Statistics for Regression Analysis

Regression Path	R ²	Adjusted R ²	p	Model Conclusion
GF → AUT	0.406	0.404	<.001	Significant
GF → COM	0.369	0.367	<.001	Significant
GF → REL	0.293	0.290	<.001	Significant
AUT + COM + REL → LM	0.373	0.364	<.001	Significant
COM + REL → LM	0.372	0.367	<.001	Significant
GF → LM	0.177	0.173	<.001	Significant
GF + AUT + COM + REL → LM	0.375	0.364	<.001	Significant
GF + COM + REL → LM	0.375	0.367	<.001	Significant

Table 8. Regression Coefficients for Hypothesis Testing and Model Comparison

Hypothesis	Regression Path	β	t	p	VIF	Decision
H1a	GF → AUT	0.637	12.651	<.001	1.000	Supported
H1b	GF → COM	0.608	11.705	<.001	1.000	Supported
H1c	GF → REL	0.541	9.840	<.001	1.000	Supported
H2a	AUT → LM	0.021	0.267	.790	2.326	Rejected
H2b	COM → LM	0.312	3.570	<.001	2.821	Supported
H2c	REL → LM	0.340	4.828	<.001	1.834	Supported
Refined Model	COM → LM	0.326	4.685	<.001	1.796	Significant
Refined Model	REL → LM	0.343	4.927	<.001	1.796	Significant
H3	GF → LM	0.421	7.094	<.001	1.000	Supported
Full Model	GF → LM	0.063	0.889	.375	1.872	Not significant
Full Model	AUT → LM	-0.003	-0.037	.971	2.600	Not significant
Full Model	COM → LM	0.300	3.390	<.001	2.888	Significant
Full Model	REL → LM	0.328	4.561	<.001	1.906	Significant

As shown by the R² values in Table 7, GFs explained 40.6% of the variance in AUT, 36.9% in COM, and 29.3%

in REL. The positive and significant coefficients indicate that stronger perceptions of Duolingo's GFs were associated with higher levels of AUT, COM, and REL satisfaction. Therefore, H1a, H1b, and H1c were supported.

Regarding the effects of psychological needs on Learning Motivation (LM), the overall model explains 37.3% of the variance in the dependent variable ($R^2 = 0.373$, $p < .001$). However, Table 8 reveals that only Competence ($\beta = 0.312$, $p < .001$) and Relatedness ($\beta = 0.340$, $p < .001$) significantly predict LM, while AUT is non-significant ($\beta = 0.021$, $p = .790$). Thus, H2b and H2c are supported, whereas H2a is rejected. This contradictory finding warrants a critical examination through the lens of SDT [9]. The failure of AUT to predict LM stems from a combination of external expectations and structural constraints. While institutional recommendations may turn app usage into a required task, the primary barrier is Duolingo's structural design, which restricts the volitional choice Ryan and Deci [16] emphasized as essential for sustained motivation. Although it allows flexible pacing, the core progression enforces a strict, linear pathway where users must complete specific modules to unlock subsequent ones [2]. According to SDT [9], autonomy is only satisfied when learners experience a genuine sense of choice and control over their learning process. This rigid mechanic fundamentally restricts true psychological autonomy, preventing it from translating into sustained learning motivation. In the refined model retaining only COM and REL, the explanatory power remains nearly unchanged ($R^2 = 0.372$), but the model becomes more concise with slightly higher path coefficients ($\beta = 0.326$ and $\beta = 0.343$, respectively, $p < .001$).

For the direct effect of GFs on LM, hypothesis H3 is initially supported ($R^2 = 0.177$, $\beta = 0.421$, $p < .001$). However, when all variables are entered into the full model, this direct effect drops sharply and loses statistical significance ($\beta = 0.063$, $t = 0.889$, $p = .375$). This reduction of the direct effect suggests that while features like streaks or leaderboards receive high baseline ratings and account for 17.7% of motivation independently, their direct impact is superficial. Once deep psychological experiences (COM and REL) are accounted for, the direct role of technology diminishes. This finding strongly aligns with Adams and Du Preez's warnings about the "novelty effect" [6], whereby learners quickly abandon a gamified application if it fails to convert surface rewards into competence and relatedness satisfaction. This is empirically evident in Table 1, where only 9% of the sample sustained usage beyond one year.

Finally, since all VIF values are well below the threshold of 5.0 (ranging from 1.000 to 2.888), serious multicollinearity is ruled out, ensuring the mathematical reliability of these regression estimates.

4.6. Mediation Analysis

Mediation analysis was conducted to examine the roles of AUT, COM, and REL in the relationship between GFs and LM. Since AUT did not significantly predict LM in the preceding regression analysis, it was excluded from the final mediation model. As shown in Table 9, GFs exert a positive effect on both retained mediators, namely COM

($\beta=0.608$, $p<.001$) and REL ($\beta=0.541$, $p<.001$). Conversely, after controlling for GFs, both COM ($\beta=0.308$, $p<.001$) and REL ($\beta=0.339$, $p<.001$) significantly predict LM. Notably in Table 8, although the direct path from GFs to LM is highly significant when evaluated independently ($\beta = 0.421$, $p < .001$), it drops sharply and loses statistical significance once the psychological variables are introduced into the model ($\beta = 0.065$, $p = .391$).

Table 9. Path Coefficients of the Mediation Model

Path	Estimate	SE	β	z/t	p	Conclusion
GF $\rightarrow$ COM	0.692	0.059	0.608	11.755	<.001	Significant
GF $\rightarrow$ REL	0.616	0.062	0.541	9.882	<.001	Significant
COM $\rightarrow$ LM	0.290	0.063	0.308	4.599	<.001	Significant
REL $\rightarrow$ LM	0.319	0.060	0.339	5.350	<.001	Significant
GF $\rightarrow$ LM	0.069	0.081	0.065	0.857	.391	Not significant

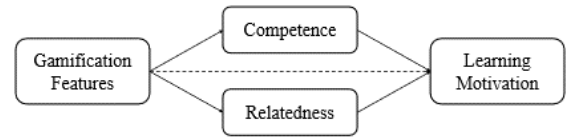


Figure 2. Final Mediation Model

The bootstrap analysis in Table 10 further clarifies these mechanisms. While the total effect of GFs on LM is positive and significant (Estimate=0.466, 95% CI [0.335, 0.604], $p<.001$), the direct effect controlled for the mediators is completely neutralized (Estimate=0.069, 95% CI [- 0.086, 0.223], $p=.391$) as the confidence interval spans across zero. In contrast, both indirect effects through COM (Estimate=0.201, 95% CI [0.082, 0.320], $p<.001$) and REL (Estimate=0.196, 95% CI [0.091, 0.325], $p<.001$) remain statistically robust, with the total indirect effect accounting for the majority of the variance (Estimate=0.397, 95% CI [0.273, 0.528], $p<.001$). This empirical pattern establishes a full mediation effect.

Table 10. Direct, Indirect, and Total Effects

Effect Type	Path	Estimate	SE	95% CI Lower	95% CI Upper	p	Conclusion
Total effect	GF $\rightarrow$ LM	0.466	0.063	0.335	0.604	<.001	Significant
Direct effect	GF $\rightarrow$ LM controlling for COM and REL	0.069	0.081	-0.086	0.223	.391	Not significant
Indirect effect	GF $\rightarrow$ COM $\rightarrow$ LM	0.201	0.047	0.082	0.320	<.001	Significant
Indirect effect	GF $\rightarrow$ REL $\rightarrow$ LM	0.196	0.042	0.091	0.325	<.001	Significant
Total indirect effect	GF $\rightarrow$ COM/REL $\rightarrow$ LM	0.397	0.063	0.273	0.528	<.001	Significant

Through the lens of SDT [9], this full mediation offers a profound insight: Duolingo's GFs do not inherently or directly generate LM. Instead, interface design elements such as points, leaderboards, and streaks act merely as environmental stimuli. To effectively translate into actual LM, these GFs must be processed and internalized through the learners' cognitive filters to satisfy the two core psychological needs of feeling capable and socially connected. Empirically, this finding aligns fully with Sailer et al. [12] and Xi and Hamari [14], who argued that gamified structures yield sustainable motivational value only when they successfully connect extrinsic rewards with basic PNS. Consequently, because AUT failed to operate as a meaningful bridge, these findings provide only partial support for the SDT-based mediation model in this specific learning context.

5. Conclusion and suggestions

This study addresses the two core research questions regarding the intersection of gamified mobile learning and Self-Determination Theory. In response to the first research question, empirical evidence demonstrates that Gamification Features in Duolingo significantly drive students' learning motivation. However, this influence operates almost entirely through indirect channels. Regarding the second research question, these structural mechanisms do not promote psychological need satisfaction equally. Competence and Relatedness fully mediate the relationship between GFs and LM, whereas Autonomy fails to yield a statistically significant mediating effect. Therefore, this study concludes that Duolingo's gamified environment effectively sustains motivation by fostering a sense of capability and social belonging, rather than by offering self-direction to learners.

Theoretically, these findings offer important insights to the application of SDT within educational gamification. This full mediation through Competence and Relatedness confirms the arguments of Sailer et al. [12] and Xi and Hamari [14] that basic rewards fail to directly drive long-term motivation unless they are processed through psychological needs. However, the insignificance of Autonomy exposes a critical contextual boundary condition of SDT [9]. In learning contexts where technological tools are integrated as course recommendations, the linear progression of gamified software restricts authentic psychological autonomy. Consequently, the motivational mechanism becomes structurally dependent on outcome-based feedback and external social comparisons.

Practically, educators should use Duolingo as a supplementary learning tool while emphasizing features that enhance students' sense of progress, achievement, feedback, and peer connection. Teachers may also design classroom activities that combine Duolingo tasks with collaborative reflection or friendly challenges.

This study has some limitations. It used a cross-sectional survey and convenience sampling from one college, so the results may not be widely generalizable. Future research should use longitudinal or mixed-method designs, include more diverse learner groups, and examine how specific Gamification Features affect motivation over time.

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