Determinants of learners' perceived performance in and loyalty towards a micro-learning setting: A model integrating self-determination theory

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As digitalisation continues to reshape education and massive open online courses (MOOCs) gain popularity, micro-learning has emerged as a key strategy to enhance learning in both formal and informal settings. Recognising this potential, the present study investigated Vietnamese learners' psychological needs, engagement, satisfaction, perceived performance and loyalty within the context of MOOCs – courses designed around micro-learning principles. Through partial least squares structural equation modelling, the findings revealed that autonomy and competence significantly enhanced learner engagement, while relatedness showed no substantial effect. Engagement, in turn, strongly predicted satisfaction, which subsequently influenced both loyalty and perceived performance. Our model accounted for high levels of variance in all endogenous constructs, underscoring the theoretical robustness of self-determination theory in digital learning contexts. This research highlights the critical role of intrinsic motivation and satisfaction in shaping learner behaviour, offering practical implications for instructional designers and educational institutions seeking to enhance micro-learning experiences and foster long-term learner retention and loyalty.

Implications for practice or policy:

- MOOC providers should boost engagement by integrating self-paced, interactive and case-based learning into micro-learning environments.

- Educators should use tools like discussion boards and collaborative tasks to enhance learner-to-learner engagement, addressing the limited role of relatedness.
- Educational institutions and policymakers could support formalising micro-learning by embedding it as a core component of full-time hybrid curricula and interleaving it across all online and distance learning programmes.

Keywords: micro-learning, massive open online courses (MOOCs), self-determination theory, partial least squares structural equation modelling (PLS-SEM)

Introduction

Online learning, driven by technological advancements, has demonstrated its effectiveness as a powerful mode of instruction, significantly expanding learning opportunities beyond traditional campus settings (Rapanta et al., 2021). Among the initiatives facilitating this expansion are massive open online courses (MOOCs), which provide millions of learners each year with access to high-quality courses from leading universities (Literat, 2015).

A key feature that makes MOOCs particularly appealing is their foundation in micro-learning principles (Pham et al., 2024). This approach, which has garnered substantial attention, presents content in small, easily digestible units. Javorcik and Polasek (2018) found that students preferred micro-learning over traditional e-learning formats, suggesting its effectiveness in addressing the learning needs of modern students. This preference highlights micro-learning's potential to enhance intrinsic motivation, as it requires active participation and engagement from learners (De Gagne et al., 2019). Motivation, in turn, is closely tied to engagement, which is considered a vital prerequisite for effective learning (Monib et al., 2024).

Although the core principles of self-determination theory (SDT) psychological needs – competence, autonomy and relatedness – have been linked to learner engagement in online environments, research applying SDT to micro-learning remains limited (Nikou & Economides, 2018). A review by Taylor and Hung (2022) also noted that most micro-learning studies have focused only on specific fields like computing and healthcare, indicating the need for broader exploration across educational contexts.

Research on MOOCs has consistently shown a positive relationship between learner engagement and intrinsic motivation, leading to improved outcomes. Our study explored these dynamics within the Vietnamese context, with a particular emphasis on students' perceived performance and the under-explored concept of student loyalty. While loyalty – the degree to which students are willing to continue engaging with specific courses and recommend them to others – has been extensively studied in traditional classroom settings, it remains under-examined in online learning, especially within micro-learning environments (Dangaiso et al., 2022). A systematic review by Kostas et al. (2024) highlighted various outcomes associated with micro-learning, yet loyalty was notably absent from the variables investigated. This gap in the literature underscores the need for further research into student loyalty in micro-learning contexts.

Despite Vietnam's potential for e-learning, its higher education sector was slow to adopt it, facing significant challenges during the COVID-19 pandemic (Pham & Ho, 2020). In response, the government and the Ministry of Education and Training accelerated digital transformation efforts. Decision No. 131/QD-TTg mandates that by 2030, all institutions implement distance learning, with at least 30% of content delivered online (Prime Minister, 2022). In 2021, the Ministry of Education and Training increased the online component for bachelor's programmes to 30% and for joint master's and doctoral programmes to 20%; online testing for up to 50% of assessments is now permitted, supporting widespread e-learning adoption (Ministry of Education and Training, 2021a, 2021b). This policy shift has made exploring online learning methods, such as micro-learning, a key priority in Vietnamese higher education.

This study explored how micro-learning, when designed to meet learners' psychological needs, may foster greater students' engagement and increase student satisfaction. It also explored how these factors contribute to student loyalty and perceived academic performance. Grounded in SDT, the research aims msto provide a nuanced understanding of the potential benefits and challenges associated with this educational approach.

Literature review

Microlearning MOOCs

Broadly speaking, micro-learning is "learning activities on a small scale" (Fitria, 2022, p. 116). Micro-learning has been referred to as a training paradigm (Díaz Redondo et al., 2021), a learning technique (Drakidou, 2018), a form of learning (Souza & do Amaral, 2014) and a mode of instruction (Fitria, 2022). Among the diverse definitions, Hug and Friesen's (2007) framework, which defined micro-learning as a series of short, focused learning moments or episodes that involve specific tasks or content, is widely cited. Micro-learning is characterised by brief time commitments, small content units and adaptability across different pedagogies, media and learning contexts.

This research, in alignment with Nikou and Economides (2018) and Dolasinski and Reynolds (2020), views micro-learning as an approach that delivers small, focused learning units lasting 5–10 minutes, with specific objectives, often integrated into online, blended or mobile learning formats. Many modern MOOCs adopt these principles, using modular, multimedia-rich and mobile-accessible content to enhance learner flexibility and engagement (Díaz Redondo et al., 2021; Kustandi et al., 2024).

Grounded in cognitive learning theories, micro-learning focuses on attention, understanding, information processing, retrieval and the learner's awareness of acquired knowledge, all of which contribute to enhanced engagement and improved educational outcomes (Almalki, 2021). It differentiates itself from traditional e-learning by emphasising an informal learning context, which offers learners the flexibility to access content at their own convenience. It focuses on clear, self-contained learning objects that can be understood without requiring additional information, making the content more modular and adaptable (Susilana et al., 2022).

Several benefits of using micro-learning have been reported in the literature, including greater retention of concepts (Liu & Li, 2022); improved student confidence; better engagement for learners (De Gagne et al., 2019); improved learner self-efficacy (Zarshenas et al., 2022); engagement in collaborative learning (Garshasbi et al., 2021); and improved learning ability and performance (Mohammed et al., 2018).

However, these benefits depend on how micro-learning is designed and integrated. Its fragmented nature may not be suitable for all educational content (Mostrady et al., 2025) and requires instructors with advanced skills in pedagogy and technology (Nikkhoo et al., 2023). Additionally, the flexibility and self-paced structure of micro-learning may challenge autonomy and relatedness, leading to procrastination or disengagement (Ilham & Sari, 2025). Furthermore, the solitary nature of micro-learning modules may not fully support learners' sense of relatedness (Monib et al., 2024).

Despite the increasing popularity of micro-learning in MOOCs, research on its long-term impact remains limited. Bibliometric reviews of this field indicate that the number of publications on this topic remains relatively modest compared to other e-learning areas, with most of the research consisting of conference proceedings (Leong et al., 2019; Sankaranarayanan et al., 2023).

Learners' psychological needs and engagement in a micro-learning setting

SDT offers a robust framework for understanding intrinsic motivation, which plays a critical role in learner engagement, especially in environments like e-learning and micro-learning (Martin et al., 2018; Nikou & Economides, 2018). SDT posits that individuals are driven by three innate psychological needs: autonomy,

competence and relatedness. These needs, when satisfied, foster intrinsic motivation, leading to deeper engagement and sustained participation (Deci & Ryan, 2012).

Engagement itself is a multifaceted construct encompassing behavioural, cognitive and emotional dimensions (Reeve, 2013). Behavioural engagement reflects active participation and perseverance; cognitive engagement refers to mental effort and strategic learning; emotional engagement pertains to affective responses. Satisfaction of the three psychological needs defined by SDT strengthens these forms of engagement, cultivating a more active and motivated learner.

The relationship between SDT's psychological needs and engagement is clear: when learners' needs are met, intrinsic motivation increases, driving engagement (Deci & Ryan, 2012). Autonomy fosters engagement by providing psychological freedom, motivating effort and positive attitudes. Competence satisfaction boosts engagement by giving learners a sense of mastery, encouraging continued participation and positive emotions. Relatedness, achieved through peer and instructor interactions, enhances engagement by creating a supportive environment (Huang & Wang, 2023). Motivation plays a critical role in online learning (Hartnett, 2016) and often translated into engagement (Boekaerts, 2016), which is considered a prerequisite for successful learning (Fredricks et al., 2004). Through this process, learners' engagement is often considered as a mediator between psychological needs and learners' outcomes (Chiu, 2022).

In MOOCs, learners who perceive the material as both enjoyable and challenging – a hallmark of intrinsic motivation – tend to exhibit higher persistence and engagement (de Barba et al., 2016). Furthermore, SDT has been used to address high dropout rates in MOOCs by emphasising the importance of creating an environment that supports autonomy, competence and relatedness. Students who feel supported in these areas are more likely to remain engaged and complete courses, as they are motivated by internal satisfaction rather than external rewards (Martin et al., 2018).

Micro-learning has been proven effective in overcoming participation and motivation challenges in blended learning (Garshasbi et al., 2021). Micro-learning enhances learner motivation and engagement by offering flexible, interactive and gamified learning experiences (Perry et al., 2021). Research has shown that interactive elements significantly improve students' knowledge and engagement compared to traditional, non-interactive content (Denny et al., 2018). The integration of competition and time limits further boosts motivation, as students are driven by the desire to succeed in a game-like environment. Additionally, the autonomy provided by micro-learning, through self-paced, voluntary participation in daily exercises, enhances students' intrinsic motivation and self-confidence, ultimately leading to better learning outcomes. This approach has proven effective, particularly in medical education, where interactive, game-based exercises have been linked to increased participation and higher success rates (Sozmen, 2022).

Based on the theoretical foundations and empirical evidence discussed above, we proposed the following hypotheses to examine the relationships among learners' psychological needs, engagement and satisfaction within a micro-learning-based MOOC context:

- H1: Learners' psychological needs have a positive effect on learner engagement.
    - H1a: Learners' perceived autonomy has a positive effect on learner engagement.
    - H1b: Learners' perceived relatedness has a positive effect on learner engagement.
    - H1c: Learners' perceived competence has a positive effect on learner engagement.
- H2: Learners' engagement positively influences learner satisfaction.
- H3: Learners' engagement mediates the relationship between learners' psychological needs and learner satisfaction.
    - H3a: Learners' engagement mediates the relationship between perceived autonomy and satisfaction.
    - H3b: Learners' engagement mediates the relationship between perceived relatedness and satisfaction.

- H3c: Learners' engagement mediates the relationship between perceived competence and satisfaction.

Learners' satisfaction, perceived performance and loyalty in a micro-learning setting

Research has found that students' satisfaction mediates the relationship between their engagement and outcomes, such as academic achievement and perceived learning quality (Satuti et al., 2020). Students' active engagement in online learning has been found to contribute to their academic achievement, learning performance and academic self-efficacy (Huang & Wang, 2023).

Comparative studies have suggested that micro-learning often leads to higher knowledge gains across a semester compared to traditional methods (Han, 2019; Polasek & Javorcik, 2019; Wen & Zhang, 2014). Even when differences are not statistically significant, there is no evidence of inferior academic performance associated with micro-learning (Shatte & Teague, 2020). Pre- and post-intervention studies further support this, demonstrating significant improvements in subject-specific marks after short-term exposure to video-based micro-learning (Román-Sánchez et al., 2023).
This study, aligned with Bhattacherjee (2001), used perceived usefulness in the technology acceptance model (Davis, 1989) to operationalise the perceived performance construct.

Another outcome examined in this research is loyalty. While the concept has been extensively studied in the business domain, it has gained significant attention in the field of education, particularly as higher education worldwide undergoes a process of corporatisation (Pham & Lai, 2016). In the context of online learning, and specifically micro-learning, student loyalty is increasingly important, as this learning format is commonly used in informal learning environments and heavily relies on students' subjective choices.

Student loyalty in e-learning refers to the degree to which students are willing to continue using and recommend e-learning systems (Dangaiso et al., 2022); it is often seen as an outcome influenced by student satisfaction (Lwoga & Sife, 2018), institutional reputation and service quality (Martínez-Argüelle & Batalla-Busquets, 2016). Furthermore, recent studies have suggested that students' satisfaction functions as a mediator through which various antecedents influence continued use (Deng et al., 2023). Highly engaged learners are more likely to develop positive attitudes, which can lead to stronger intentions to re-enrol and recommend the platform.

However, a recent systematic review by Kostas et al. (2024) found that despite extensive research on micro-learning, student loyalty remains underexplored – highlighting a significant gap in the literature, particularly in relation to informal or modular learning environments. Moreover, Osman et al. (2024) found that satisfaction does not mediate the relationship between students' engagement and loyalty, suggesting that the mediating role of satisfaction may not be universal and warrants further investigation in different learning contexts. This mixed evidence points to the need to clarify whether engagement influences loyalty and performance directly, or whether its effects operate primarily through satisfaction in micro-learning-based MOOCs.

We proposed the following hypotheses based on the relationships between learner engagement, satisfaction, loyalty and perceived performance:

- H4: Learners' satisfaction positively influences learner loyalty.
- H5: Learners' satisfaction positively influences perceived performance.
- H6: Learners' engagement positively influences learner loyalty
- H7: Learners' engagement positively influences learners' perceived performance.
- H8: Learners' satisfaction mediates the relationship between learners' engagement and loyalty.
- H9: Learners' satisfaction mediates the relationship between learners' engagement and perceived performance.

Conceptual model

Figure 1 represents the conceptual model of this study, which incorporates all proposed hypotheses. Specifically, loyalty and perceived performance are the two endogenous variables; autonomy, relatedness and competence are the three antecedents; while engagement and satisfaction are the two mediating variables that connect the three antecedents with the two endogenous variables. Among the two mediators, engagement is a second-order construct, composed of three sub-constructs: cognitive engagement, behavioural engagement and emotional engagement.

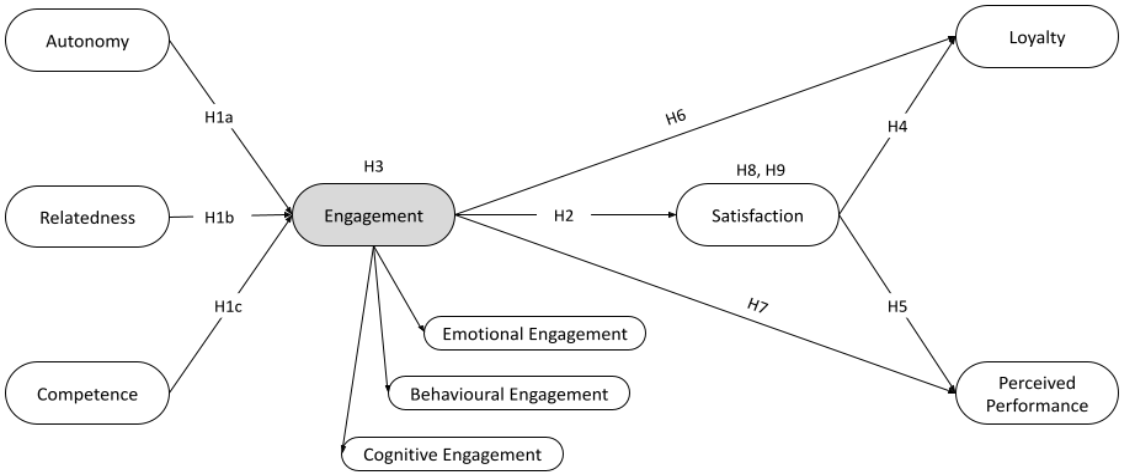

Figure 1. Conceptual model
Note. Grey fill: second-order variable.

Method

Participants and data collection

This study examined the relationship between psychological needs, engagement, satisfaction, loyalty and perceived performance in MOOC micro-learning environments among Vietnamese MOOCs learners. Data were collected via an online survey distributed over a 3-month period (October – December 2024) to learners who had undertaken at least one MOOC micro-learning course (e.g., Coursera, edX, Udemy). The research design and protocol, including all ethical considerations, were formally reviewed and approved by the Scientific Committee of the National Foundation for Science and Technology Development under Decision No. 06/QĐ-HĐQL. To ensure that participants correctly recognised micro-learning-based MOOCs, the questionnaire included a brief description of core micro-learning characteristics, such as short and focused learning units, modular content organised into small segments, and concise, easy-to-digest instructional materials. This clarification helped respondents determine whether the courses they had completed adhered to micro-learning features before answering the main items. Participants were recruited through university email systems and social media groups across multiple Vietnamese institutions. As MOOC-integrated learning is largely absent in the Vietnamese higher education context (Dang et al., 2017), it was assumed that participants engaged in MOOCs entirely by personal choice.

The final sample comprised 289 respondents, with a gender distribution of 63.3% female (N = 183) and 35.0% male (N = 101). The majority were under 21 years old (52.9%, N = 153) and currently undergraduate students (86.5%, N = 250). Most participants had completed one or two micro-learning courses (37.7%, N = 109), with 21.8% (N = 63) having taken five or more courses.

Table 1
Demographic information of participants

Variables		Frequency (*N* = 289)	Percentage (%)
Gender	Male	101	35.0
	Female	183	63.3
	Don't want to mention	5	1.7
Age	<21	153	52.9
	21 – 30	124	42.9
	>30	12	4.20
Education level	Undergraduate students	250	86.5
	Master's degree	29	10.0
	Doctorate	10	3.5
Number of MOOC micro-learning courses taken	1–2	109	37.7
	3–4	117	40.5
	5 and above	63	21.8

Instruments

The survey instruments were developed using established measurement scales, adapted for the MOOC micro-learning context. Engagement was operationalised through Reeve's (2013) multidimensional framework, capturing aspects of engagement: behavioural (e.g., active participation), cognitive (e.g., knowledge integration) and emotional (e.g., learning enjoyment). The self-determination construct, drawing from Nikou and Economides (2016), measured three fundamental psychological needs: autonomy (sense of choice), relatedness (social connection) and competence (mastery perception). Additional scales included satisfaction (Elshami et al., 2021), loyalty (Lai et al., 2019) and perceived performance (Chiu & Wang, 2008).

To tailor the instrument to the MOOC-based micro-learning context, the questionnaire provided a detailed explanation of micro-learning and clarified how MOOCs embody its core principles. It also included items capturing participants' prior MOOC experiences, such as the number of courses they had completed and the platforms they had used (e.g., Udemy, Coursera), with a screening question to ensure respondents referred to their previous MOOCs.

To ensure cultural and contextual appropriateness for Vietnamese learners, the instruments underwent rigorous translation using Brislin's (1970) back-translation protocol, ensuring conceptual equivalence.

The instrument employs a 7-point Likert scale, ranging from 1 to 7, where 1 represents *strongly disagree*, 2 represents *mostly disagree*, 3 represents *disagree to some extent*, 4 represents *neutral*, 5 represents *agree to some extent*, 6 represents *mostly agree* and 7 represents *strongly agree*. Each construct includes one reverse-item to ensure the reliability and consistency of the responses.

Two education science experts further reviewed the Vietnamese versions to establish face validity (Epstein et al., 2014), leading to minor wording adjustments to better reflect the MOOC micro-learning experience while maintaining theoretical meanings.

Data analysis

The study employed partial least squares structural equation modelling (PLS-SEM) using SmartPLS 3, an appropriate choice for analysing complex models that include both formative and reflective constructs (Hair, Hult, Ringle, & Sarstedt, 2021). This approach is suitable for examining the relationships among psychological needs, engagement, satisfaction, loyalty and performance outcomes in micro-learning environments.

The analysis followed a systematic four-stage process. First, confirmatory factor analysis was conducted to validate the measurement model and assess indicator–construct relationships. Second, reliability and

validity were examined through tests of internal consistency and convergent validity. Third, the structural relationships among latent variables were evaluated to test the hypothesised model. Finally, a bootstrapping procedure with 5,000 re-samples was implemented to establish the statistical significance of parameter estimates (Streukens & Leroi-Werelds, 2016), providing robust confidence intervals for all path coefficients.

Results

Model fit

The analysis began by assessing the model's goodness of fit, a key aspect of PLS-SEM evaluation (Henseler et al., 2016). Using the standardised root-mean-square residual, the estimated model reported a value of 0.057, which is below the accepted 0.08 threshold (Hu & Bentler, 1998), indicating a good fit. The saturated model also showed strong fit, with a standardised root-mean-square residual of 0.047. Together, these results confirmed that both the estimated and saturated models achieved robust and acceptable levels of fit.

Reliability and validity

This study conducted a psychometric evaluation to ensure the reliability and validity of all measurement scales, following established SEM guidelines (Hair, Hult, Ringle, Sarstedt, Danks et al., 2021). Confirmatory factor analysis showed strong indicator–construct relationships, with all standardised loadings exceeding the 0.70 threshold (Hair et al., 2010), confirming that each item effectively captured its intended construct.

The measurement model exhibited excellent psychometric properties (see Table 2). Reliability tests indicated strong internal consistency across all constructs, with Cronbach's alpha and composite reliability (CR) values well above the recommended 0.7 benchmark (Henseler et al., 2016). Convergent validity was confirmed, as all constructs had average variance extracted (AVE) values exceeding 0.5 (Chin, 2013), supporting the model's theoretical structure.

Table 2
Confirmatory factor loadings

Construct and item	Outer loadings	Cronbach's α	CR	AVE
Behavioural Engagement (BEH; Reeve, 2013)		.951	.962	.836
BEH1. When I'm engaged in a micro-learning session, I listen very carefully	.918			
BEH2. I pay attention when using micro-learning content	.942			
BEH3. I try hard to do well in each micro-learning task or activity	.936			
BEH4. During micro-learning, I work as hard as I can to understand the content	.926			
BEH5. When using a micro-learning platform, I participate in discussions or comment sections if available	.848			
Cognitive Engagement (COG; Reeve, 2013)		.961	.971	.894
COG1. When I study using micro-learning modules, I try to connect what I am learning with my own experiences	.956			
COG2. I try to make all the different ideas from micro-learning fit together and make sense	.942			
COG3. When doing work from micro-learning lessons, I try to relate what I'm learning to what I already know	.958			
COG4. I make up my own examples to help me understand important concepts I encounter in micro-learning	.926			
Emotional Engagement (EMO; Reeve, 2013)		.970	.977	.893
EMO1. When I complete a micro-learning activity, I feel interested	.938			
EMO2. The micro-learning content I use is fun	.952			
EMO3. I enjoy learning new things through micro-learning platforms	.955			
EMO4. When I engage in micro-learning, I feel good	.959			
EMO5. When doing micro-learning tasks, I get involved and immersed	.921			
Autonomy (AUT; Nikou & Economides, 2016)		.890	.948	.900
AUT1. I feel a sense of choice and freedom while participating in micro-learning-based courses	.944			
AUT2. Micro-learning-based courses provides me with interesting options and choices	.954			
Relatedness (REL; Nikou & Economides, 2016)		.966	.978	.936
REL1. I have the opportunity to be close to others when I participate in micro-learning-based courses	.964			
REL2. I feel close to others when I participate in micro-learning-based courses	.976			
REL3. I feel connected with my classmates when I participate in micro-learning-based courses	.963			
Competence (COM; Nikou & Economides, 2016)		.890	.932	.820
COM1. I think I am pretty good at micro-learning-based courses	.925			
COM2. I think I did pretty well at micro-learning-based courses, compared to other students	.850			
COM3. After studying micro-learning-based courses for a while, I felt pretty competent	.938			

Satisfaction (SAT; Elshami et al., 2021)		.954	.967	.879
SAT1. I will recommend this online learning experience to others	.928			
SAT2. I am more satisfied with online learning compared to face-to-face sessions	.942			
SAT3. My satisfaction level encourages me to register in other available online courses, such as online summer courses	.940			
SAT4. Overall, I am satisfied with this course	.940			
Loyalty (LOY; Lai et al., 2019)		.954	.977	.956
LOY1. I will say positive things about micro-learning-based courses to other people	.978			
LOY2. I will recommend micro-learning-based courses to people	.978			
Perceived Performance (PER; Chiu & Wang, 2008)		.890	.932	.820
PER1. Distance learning improves my performance in my learning activities	.959			
PER2. Distance learning enhances my effectiveness in learning activities	.967			
PER3. Distance learning increases my productivity in my learning activities	.957			

Table 3 presents the construct validity of Engagement as a second-order construct across its Emotional, Behavioural and Cognitive dimensions. All dimension weights are substantial and statistically significant, with p values below the standard threshold of .05, confirming their meaningful contribution. The variance inflation factor values for all three dimensions are 1.000, well under the recommended cutoff value of 3 (Hair et al., 2010), indicating no multicollinearity concerns and demonstrating that the dimensions remain distinct.

Table 3
Construct validity of Engagement as a second-order construct

Dimensions of engagement	Weights	*p* values	Variance inflation factor
Engagement → Emotional Engagement	.971	.000	1.000
Engagement → Behavioural Engagement	.963	.000	1.000
Engagement → Cognitive Engagement	.962	.000	1.000

Structural model and hypotheses testing

Moving to the final phase of the PLS-SEM analysis, we examined the structural model. As depicted in Figure 2, the R^2 statistics revealed the extent of variance in the endogenous latent variables accounted for by the model. Specifically, the model accounted for a substantial 75.1% of the variance observed in engagement, 76.6% of the variance in satisfaction, an impressive 90.1% of the variance in loyalty and 84.5% of the variance in perceived performance. Furthermore, the positive Q^2 values derived from the Stone-Geisser test underscore the model's capacity for prediction.

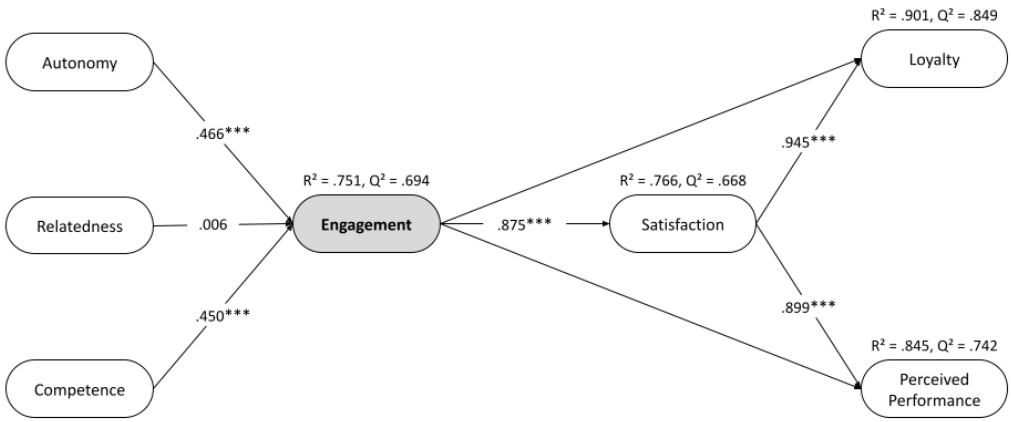

Figure 2. Structural equation model
Note. Grey fill: second-order variable.

Figure 2 displays the standardised path coefficients, and the bootstrapping results in Table 4 confirm the significance of these effects. Autonomy exerted a significant positive influence on perceived enjoyment, thereby supporting H1a, whereas relatedness did not significantly affect perceived enjoyment, so H1b was not supported. Competence also positively predicted perceived enjoyment, supporting H1c. In turn, perceived enjoyment strongly predicted satisfaction, confirming H2, and satisfaction subsequently had robust positive effects on both loyalty and perceived performance, thereby supporting H4 and H5, respectively. Engagement also showed a significant positive effect on loyalty, supporting H6, and a significant positive effect on perceived performance, supporting H7. Table 4 summarises for each path the β coefficient, *t* value, *p* value and the outcome of the hypothesis test.

Table 4
Direct effects

Hypothesis	β	*t* value	*p* value	Results
H1a. Autonomy → Engagement	.466	10.150	.000	Supported
H1b. Relatedness → Engagement	.006	0.115	.908	Not supported
H1c. Competence → Engagement	.450	7.800	.000	Supported
H2. Engagement → Satisfaction	.875	38.982	.000	Supported
H4. Satisfaction → Loyalty	.945	107.184	.000	Supported
H5. Satisfaction → Perceived Performance	.899	51.679	.000	Supported
H6. Engagement → Loyalty	.179	3.632	.000	Supported
H7. Engagement → Perceived Performance	.395	5.413	.000	Supported

Some latent constructs – autonomy, competence, relatedness and engagement – may exert indirect influences on satisfaction, loyalty and perceived performance via engagement and satisfaction. To capture the full picture, we examined these indirect paths. Table 5 reports the bootstrapped indirect effects and their significance. From Table 5, both autonomy and competence show robust indirect effects on satisfaction (supporting H3a & H3c), loyalty and perceived performance, whereas relatedness exhibited no significant indirect impact on any of these outcomes, therefore H3b was not supported. Engagement also demonstrated significant indirect effects on both loyalty and perceived performance through satisfaction, supporting H8 and H9.

Table 5
Indirect effects

Path	β	*t* value	*p* value	Results
H3a. Autonomy → Engagement → Satisfaction	.408	9.156	.000	Supported
H3b. Relatedness → Engagement → Satisfaction	.005	0.154	.877	Not supported
H3c. Competence → Engagement → Satisfaction	.394	7.596	.000	Supported
H8. Engagement → Satisfaction → Loyalty	.690	17.389	.000	Supported
H9. Engagement → Satisfaction → Perceived performance	.485	7.801	.000	Supported

Discussion

In this study, the aspects of micro-learning in MOOC platforms were selected as contexts for investigation. Specifically, we examined to what extent engagement and three components of SDT psychological needs (i.e., autonomy, relatedness and competence) impact on learner satisfaction and subsequently, loyalty and perceived performance in a micro-learning MOOC setting. Our analysis revealed that five of the six hypotheses were supported, with only one (H1b – the impact of relatedness on engagement) was rejected. These findings are in alignment with studies in both other educational settings (Chiu, 2022) as well as MOOC settings (Guo et al., 2014) and micro-learning settings (Nikou & Economides, 2018). However, the hypothesis concerning relatedness was not supported, indicating the need for further investigation into how peer and instructor interaction functions within micro-learning-based courses.

Our findings contribute to the existing literature on SDT and online learning, especially within the context of micro-learning MOOCs. While SDT research has largely focused on face-to-face settings, online learning has received less attention (Chiu, 2022), and to our knowledge, no studies have examined this relationship within the micro-learning context. The results suggest that learners' perceptions of autonomy and competence positively influence engagement. Specifically, increased levels of self-regulation and perceived task efficacy among students are associated with a greater degree of connection to the course material.

Engagement emerged as a robust mediator in the model, bridging the relationship between psychological needs and satisfaction. This supports other studies (e.g., de Barba et al., 2016; Reeve, 2013), suggesting that the fulfillment of autonomy and competence can catalyse engagement, which in turn leads to greater

satisfaction with learning experiences. The model's strong explanatory power affirms that SDT-driven engagement plays a crucial role in shaping learners' cognitive and emotional responses to micro-learning. Moreover, our results reaffirm that engagement is a multidimensional construct, comprising behavioural, emotional and cognitive engagement, and a critical factor in predicting online learners' satisfaction. These results highlight the importance of fostering a learning environment that addresses all dimensions of engagement to improve outcomes (Fredricks et al., 2004).

Interestingly, while SDT-based models in online learning contexts have not always predicted outcomes like academic performance (Chen & Jang, 2010), our study highlights that satisfying learners' psychological needs and enhancing learners' engagement significantly influenced their loyalty and perceived performance. This finding underscores the effectiveness of micro-learning in promoting not just engagement, but sustained learner loyalty and improved outcomes, particularly when learners feel autonomous and competent in their learning process. While studies have shown that applying the SDT framework can help explain e-learning continuance participation in a workplace context (Roca & Gagné, 2008), our study extends that finding to education. By incorporating satisfaction and loyalty as key outcomes, it enhances the theoretical understanding of how engagement fosters long-term commitment to learning.

Practical implications

This study yields several important implications for the design and implementation of micro-learning environments, particularly in MOOCs and digital platforms.

Since autonomy and competence significantly enhance learner engagement, instructional designers should prioritise elements that give learners greater control over their learning, such as self-paced modules, customisable learning paths and flexible content access. Additionally, providing scaffolded challenges, gamification elements, timely feedback and skill-based progression can bolster learners' perceptions of competence, encouraging continued participation and deeper engagement (Lee, 2023).

The non-significant effect of relatedness suggests that relatedness may play a lesser role in inherently individualised, self-paced micro-learning environments, or the micro-learning experience examined in this study lacked sufficient features for learner-to-learner interaction. In either case, fostering social connection remains important. Instructors should integrate activities like discussion boards, group tasks and social media tools to foster community and prevent isolation. The micro-learning artificial intelligence-integrated instructional design model proposed by Monib et al. (2025) has demonstrated that integrating adaptive and interactive elements can substantially improve engagement and learning outcomes. Additionally, Alias and Abdul Razak (2003) have highlighted the value of tools such as discussion forums and peer-feedback mechanisms in supporting collaboration and interaction among learners.

Engagement emerged as a key mediator between psychological needs and learner satisfaction. To enhance learner engagement in the online learning environment, instructors should create interactive activities, use real-world applications and foster communication among learners, peers and instructors (Martin & Bolliger, 2018). As engagement is multifaceted, instructors and developers should be mindful of addressing all dimensions.

Since satisfaction was a strong predictor of both loyalty and perceived performance, educational institutions and online course providers should prioritise continuous course improvement based on feedback to foster long-term loyalty. Satisfied learners are more likely to return and recommend the platform, impacting the growth of digital education.

Finally, the study also found that satisfaction plays a mediating role between learners' engagement and loyalty, as well as between learners' engagement and perceived performance. Although research has proposed examining satisfaction as a mediating variable between learning antecedents and learning outcomes, most empirical studies have reported no significant mediating effect (Kim & Kim, 2021; Osman,

2024). Our finding thus provides evidence that satisfaction can indeed function as a mediator, highlighting the need for research to further explore these relationships.

Limitations and suggestions for future studies

This study is subject to several limitations that should be acknowledged when interpreting its findings and designing future investigations.

First, the cross-sectional research design restricts the ability to infer causality. Although PLS-SEM enabled the examination of complex interrelationships, the results remain correlational in nature. Longitudinal or experimental studies are recommended to better capture the dynamic evolution of these variables over time.

Second, the modest sample size and convenience sampling limit generalisability. Future research should include larger, more diverse samples to improve external validity and capture a broader range of learners.

Third, while this study targeted MOOCs that incorporate micro-learning principles, it relied solely on self-reported identification by participants. Despite efforts to clarify micro-learning characteristics in the survey, respondents' subjective understanding may have varied, introducing the possibility of classification bias. In addition, certain aspects of learners' MOOC experiences were not fully examined, for example, their motivations for enrolling in specific MOOCs or the nature of the course content. Future research could benefit from more objective or expert validation of course structure and content, as well as conducting a more in-depth analysis of MOOC characteristics to enhance the accuracy and depth of interpreting learner experiences.

To enhance the model's explanatory power, future studies should consider incorporating variables related to micro-learning features, like interactivity and pacing flexibility, and explore broader outcomes like knowledge retention, persistence or emotional well-being.

Author contributions

Hiep-Hung Pham: Conceptualisation, Investigation, Supervision, Writing – review and editing; **Thai Binh An Nguyen:** Investigation, Formal analysis, Writing – review and editing; **Vu Cam-Tu:** Investigation, Funding acquisition, Writing – original draft; **Ha-Giang Thi Tran:** Formal analysis, Writing – original draft; **Thi Thanh Thao Phan:** Conceptualisation, Writing – review and editing; **Thi Phuong Thuc Doan:** Investigation, Formal Analysis; **Linh-Chi Nguyen:** Investigation, Methodology, Writing – orginal draft, Writing – review and editing.

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