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Development of an Instrument for Measuring Factors Affecting Self-Directed Learning in Blended Learning among First-Year Pre-Service Teachers

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Abstract

This study aimed to develop and preliminarily validate an instrument for measuring the factors affecting self-directed learning among first-year pre-service teachers in blended learning environments. Grounded in the literature on self-directed learning and blended learning, the instrument was designed around four proposed domains: student factors, lecturer factors, social factors, and environmental factors. The study followed an instrument development process, including content domain identification, indicator specification, item construction, expert review, pilot testing, reliability analysis, and exploratory factor analysis. Data were collected from 185 first-year pre-service teachers in a teacher education program. The results showed that the instrument achieved high internal consistency, with a Cronbach's Alpha of 0.939 for the full 19-item scale. The four subscales also demonstrated satisfactory reliability, including student factors (0.830), lecturer factors (0.932), social factors (0.904), and environmental factors (0.846). Exploratory factor analysis further supported a four-factor structure, with KMO = 0.916, Bartlett's test of sphericity reaching statistical significance ($\chi^2(171) = 2604.184$, $p < 0.001$), and the extracted factors explaining 72.038% of the total variance. These findings provide preliminary evidence that the proposed instrument is reliable and shows promising construct validity. The study contributes an initial measurement tool for assessing the factors affecting self-directed learning in blended learning environments and offers a basis for further confirmatory validation in teacher education research.

1. INTRODUCTION

In contemporary higher education, self-directed learning (SDL) is increasingly regarded as a core competence that enables students to cope with expanding knowledge, digital transformation, and the demands of lifelong learning. Rather than being understood simply as the ability to study independently, SDL competence refers to learners' capacity to identify learning needs, formulate goals, plan and implement learning activities, utilize relevant resources, monitor progress, and evaluate learning outcomes in a responsible and adaptive manner (Mai, 2020; Nguyen, 2023; Van Hien, 2016).

For pre-service teachers, this competence is especially important because it serves a dual function. Academically, it supports successful learning in higher education. Professionally, it provides a foundation for reflective practice, self-improvement, and continuous professional development throughout future teaching careers. Vietnamese studies have emphasized that SDL development among pre-service teachers is associated not only with academic achievement in higher education but also with long-term professional growth and adaptation to educational change (Mai, 2020; Van Hien, 2016).

At the same time, blended learning has become a prominent instructional approach in higher education. It is generally understood as the intentional integration of face-to-face and online learning experiences to enhance flexibility, accessibility, interaction, and learning effectiveness (Adinda & Mohib, 2020; George-Walker & Keeffe, 2010). More importantly, blended learning should not be reduced to a technical combination of two delivery modes. Rather, it represents a pedagogical approach that reconsiders the teaching-learning relationship and shifts the focus from technology to learner experience, participation, and support (George-Walker & Keeffe, 2010).

Within this context, first-year pre-service teachers constitute a particularly important group. As students transitioning from teacher-dependent school learning to more autonomous university learning, they often encounter difficulties in setting goals, planning, self-monitoring, and selecting appropriate learning strategies. Studies on pre-service teachers have shown that first-year students frequently struggle to identify effective self-study methods and evaluate their learning systematically (Mai, 2020; Thai et al., 2024). Therefore, understanding the factors influencing their SDL competence in blended learning environments is both theoretically and practically significant.

Although SDL in blended learning environments has been widely discussed in the literature, there remains a lack of validated instruments specifically designed to measure the factors affecting SDL among first-year pre-service teachers. Existing studies often focus either on SDL competence itself or on the general effects of blended learning, while relatively few studies systematically identify and operationalize the influencing factors into a reliable and valid measurement instrument. This gap is particularly significant in the context of teacher education, where first-year students experience the transition from teacher-dependent school learning to more autonomous university learning. Therefore, there is a need to develop and validate an instrument capable of measuring the factors influencing SDL of first-year pre-service teachers in blended learning environments.

This paper aims to develop and validate a measurement instrument for assessing the factors affecting SDL of first-year pre-service teachers in blended learning environments. More specifically, the study pursues two objectives, which are:

To develop a measurement instrument for identifying the factors affecting SDL of first-year pre-service teachers in blended learning environments.

To examine the reliability and validity of the proposed measurement instrument.

To achieve the above objectives, the study addresses the following research questions:

RQ1. What factors affect the SDL of first-year pre-service teachers in blended learning environments?

RQ2. Does the proposed measurement instrument demonstrate sufficient reliability and validity for assessing these factors?

Although several studies have examined SDL or developed instruments to assess SDL competence, most existing instruments were designed either for general higher education populations or to measure this construct as an individual competence rather than the contextual factors influencing it. In addition, few instruments have been specifically developed for first-year pre-service teachers in blended learning contexts, where the transition from dependent school learning to more autonomous university learning may create distinct challenges. Therefore, the present study addresses this gap by developing a context-sensitive instrument that focuses on four groups of influencing factors: student, lecturer, social, and environmental factors.

2. LITERATURE REVIEW

Previous studies have identified a wide range of variables related to SDL in technology-mediated environments. However, these variables are often organized differently depending on the theoretical lens adopted. Some studies emphasize learner attributes such as motivation and self-regulation, while others highlight contextual supports such as teaching presence, peer interaction, or technological affordances. In the present study, these strands are synthesized into four domains-student, lecturer, social, and environmental factors-to provide a more integrative framework for instrument development.

2.1. Factors Affecting SDL in Blended Learning for Pre-Service Teachers

The SDL concept has long been discussed in the literature on adult and higher education. Knowles (1975) viewed it as a process in which individuals take initiative in diagnosing learning needs, formulating goals, identifying resources, choosing and implementing learning strategies, and evaluating outcomes. Garrison (1997) later extended this perspective by emphasizing the interaction among self-management, self-monitoring, and motivation. These perspectives suggest that SDL is shaped not only by learner agency but also by contextual and instructional conditions, which is particularly relevant in blended learning environments.

A synthesis of the existing literature suggests that SDL competence of pre-service teachers in blended learning environments is shaped not by a single factor but by the interaction among multiple groups of influences.

First, learner-related factors play an important role. A substantial body of research has shown that learning motivation, sense of responsibility, learning goals, planning ability, self-efficacy, time management skills, digital competence, and self-regulation directly influence self-directed learning. Notably, some studies have found that blended learning positively affects SDL; however, when examined alongside self-efficacy, the latter appears to play an even more prominent role. Together, these two variables explain a considerable proportion of the variance in SDL. Studies on pre-service teachers also indicate that positive attitudes toward technology, frequency of technology use, and prior experience with technology-based learning significantly influence SDL with technology (Nguyen, 2023; Hidayah et al., 2024; Yeşiltaş & Taş, 2025; Başaran & Yalman, 2022).

Second, pedagogical factors and the role of lecturers are equally important. SDL in blended environments cannot be separated from the quality of instructional design provided by lecturers. The literature emphasizes that lecturers need to shift from the role of knowledge transmitters to that of facilitators. They are expected to design open learning tasks with appropriate scaffolding, guide students

in using LMS platforms and digital resources, organize feedback and peer assessment, and maintain a clear teaching presence. In some studies, activities such as online peer review and online forum discussions have been associated with noticeable improvements in students' SDL levels. From the perspective of the Person-Process-Context framework in combination with the Community of Inquiry model, teaching presence constitutes a critical link between the learner and the learning context, thereby exerting a strong influence on SDL development (Adinda & Mohib, 2020).

The proposed framework is also informed by broader perspectives on learning in context. In particular, the Community of Inquiry model helps explain the role of teaching presence and social interaction in supporting learning in blended environments, while person-process-context perspectives emphasize that SDL emerges from the interaction between individual readiness and contextual conditions. These perspectives do not function as formal causal models in the present study; rather, they provide theoretical justification for organizing the instrument into lecturer, social, and environmental domains alongside student-related factors.

Third, the learning environment and social relationships also play substantial roles. Although SDL is personal in nature, it tends to develop more strongly in blended learning environments when learners are situated within an interactive learning community. Previous studies have highlighted the roles of peer learning, peer assessment, a sense of belonging to the learning community, teamwork, and collaborative leadership. Notably, research on pre-service mathematics teachers found that peer learning did not exert a strong direct effect on SDL but did have a substantial indirect effect through collaborative leadership. This finding suggests that social relationships in blended environments not only provide emotional support but also create learning mechanisms that actively promote SDL (Gürbüz et al., 2026; Lee et al., 2022).

Fourth, technological factors and digital infrastructure are also crucial. The quality of the LMS, internet stability, access to devices, the user-friendliness of digital tools, and the availability of digital learning resources are all important conditions influencing the quality of SDL in blended learning environments. Several studies have confirmed that the use of information technology is a highly influential factor in SDL. Conversely, technical difficulties, digital inequality, and insufficient technological support may undermine the effectiveness of blended learning environments (Duong et al., 2022; Başaran & Yalman, 2022; Phung & Bui, 2025).

2.2. Research Gap and Analytical Framework

The present study conceptualizes the factors affecting SDL competence in blended learning environments among first-year pre-service teachers as a multidimensional construct comprising four interrelated domains: student factors, lecturer factors, social factors, and environmental factors. Student factors refer to learners' internal characteristics, such as motivation, self-efficacy, responsibility, self-regulation, and digital competence, which shape their readiness and SDL capacity. Lecturer factors encompass pedagogical design, teaching presence, scaffolding, feedback, and mentoring support that enable students to regulate and direct their learning more effectively. Social factors involve peer support, collaborative interaction, learning communities, and other interpersonal relationships that may foster or constrain SDL. Environmental factors pertain to the technological, material, and organizational conditions within the blended learning environment, including access to devices and the internet, platform usability, learning resources, flexibility, and study conditions. Collectively, these four domains provide the conceptual foundation for the development of a measurement instrument designed to examine the factors affecting SDL competence in blended learning environments among first-year pre-service teachers (Adinda & Mohib, 2020; Hidayah et al., 2024; Mai, 2020).

Based on the reviewed literature, the present study proposes a conceptual framework in which SDL in blended learning environments is influenced by four groups of factors: student, lecturer, social, and environmental factors (Figure 1).

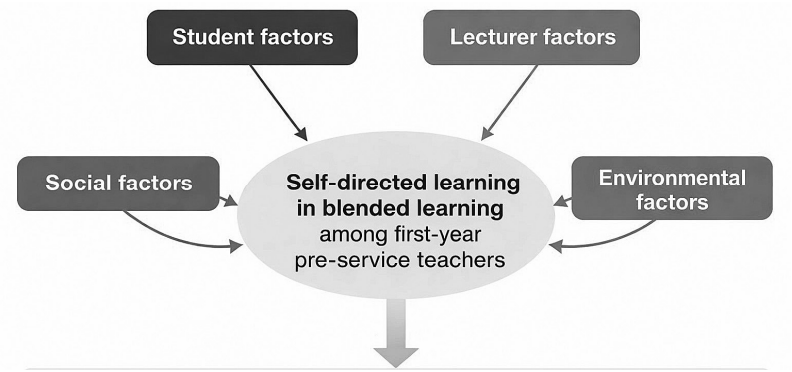

Figure 1. Conceptual Framework of Factors Affecting Self-Directed Learning in Blended Learning

Existing instruments such as the Self-Directed Learning Readiness Scale (SDLRS) and the Self-Directed Learning Instrument (SDLI) primarily focus on measuring SDL readiness or competence at the individual level. In contrast, the present instrument is designed to assess the perceived factors affecting SDL within a blended learning environment. Therefore, although previous scales informed the conceptualization of learner-related dimensions, the current study extends its focus to lecturer, social, and environmental conditions that may shape SDL among first-year pre-service teachers.

3. MATERIALS AND METHODS

3.1. Research Design

This study adopted an instrument development approach to construct and preliminarily validate a scale measuring the factors affecting SDL among first-year pre-service teachers in blended learning environments. Based on the literature review and the conceptual framework established in the preceding sections, the study followed a systematic process involving domain specification, indicator development, item construction, expert review, pilot testing, reliability analysis, and factor analysis. This approach is appropriate for educational measurement studies in which the objective is not only to conceptualize a construct theoretically but also to develop a practical instrument for empirical investigation.

Conceptually, the instrument was developed based on the assumption that the factors affecting SDL among first-year pre-service teachers in blended learning environments constitute a multidimensional construct comprising four components: student factors, lecturer factors, social factors, and environmental factors. On this basis, the study translated the theoretical domains into measurable indicators and subsequently examined the reliability and structural validity of the resulting instrument.

3.2. Instrument Development Procedure

The content domain of the instrument was identified from the literature on SDL and blended learning while also taking into account the specific characteristics of first-year pre-service teachers. Four groups of factors were specified. Student factors referred to learners' internal characteristics, such as motivation, initiative, planning ability, self-regulation, and learning responsibility. Lecturer factors encompassed the lecturer's role in orientation, instructional design, support, feedback, and the facilitation of SDL. Social factors reflected peer support, learning communities, peer interaction, and the broader social climate surrounding learning. Environmental factors pertained to technological conditions, learning resources, platform usability, flexibility, and the overall conduciveness of the blended learning

environment. Collectively, these four domains ensured that the instrument approached SDL not only from the learner perspective but also in relation to the pedagogical, social, and environmental conditions surrounding the learning process.

Based on these domains, an indicator specification table was developed to operationalize each factor into observable and measurable indicators. The initial item pool consisted of 19 observed variables distributed across the four theoretical domains: five indicators for student factors (SV1-SV5), five indicators for lecturer factors (GV1-GV5), four indicators for social factors (XH1-XH4), and five indicators for environmental factors (MT1-MT5). The questionnaire items were subsequently formulated as concise and clear statements appropriate for first-year pre-service teachers and closely aligned with the intended indicators. A five-point Likert scale was employed, with response options ranging from 1 to 5 to indicate increasing levels of agreement. This format was considered appropriate for capturing students' perceptions of the factors affecting their SDL in blended learning environments and for facilitating subsequent statistical analyses.

To strengthen content validity, the preliminary instrument was reviewed by experts. The review focused on the alignment between the items and the theoretical framework, as well as the clarity, wording, and representativeness of the content. Based on the experts' feedback, several items were revised in terms of wording and organization to improve clarity, comprehensibility, and contextual appropriateness prior to pilot administration.

3.3. Participants and Pilot Testing

The preliminary version of the instrument was reviewed by five experts in educational measurement, teacher education, and blended learning. The experts were selected based on their academic expertise and research experience in curriculum development, pedagogy, or educational assessment. They were asked to examine the relevance, clarity, representativeness, and wording of the items in relation to the proposed domains. Based on the experts' comments, several items were revised to improve linguistic clarity, reduce redundancy, and enhance contextual appropriateness for first-year pre-service teachers.

The revised instrument was piloted with 185 first-year students. The pilot data were used to examine the distributional characteristics of the observed variables, assess the internal consistency of the scale, and explore its factor structure. The pilot sample consisted of 185 first-year pre-service teachers recruited through convenience sampling from Hanoi National University of Education. In terms of sample adequacy, the pilot sample size was considered acceptable for exploratory factor analysis because the instrument included 19 observed variables, resulting in a participant-to-item ratio of approximately 9.7:1, which meets commonly recommended minimum ratios for initial scale development studies. All participants had experience with blended learning activities that combined face-to-face instruction with online learning support. According to the data processing report, all 185 responses were valid, and no cases were excluded due to missing data in the reliability and factor analyses.

3.4. Data Analysis

Internal consistency reliability was assessed using Cronbach's alpha for both the full scale and each subscale. The results indicated that the overall 19-item scale achieved a Cronbach's Alpha coefficient of 0.939, indicating very high reliability. At the subscale level, the student-factor subscale (5 items) yielded an alpha coefficient of 0.830, the lecturer-factor subscale (5 items) yielded 0.932, the social-factor subscale (4 items) yielded 0.904, and the environmental-factor subscale (5 items) yielded .846. In addition, the corrected item-total correlations for most items were acceptable. Although some items showed lower coefficients than others, none fell below the threshold requiring immediate deletion at the preliminary stage. Therefore, all 19 items were retained for exploratory factor analysis.

Following the reliability analysis, exploratory factor analysis was conducted to examine the internal structure of the proposed instrument. For this purpose, the instrument was preliminarily tested using data obtained from 185 valid responses. The results indicated that the overall scale demonstrated high internal consistency, while the exploratory factor analysis supported a four-factor structure corresponding to student, lecturer, social, and environmental factors. The following section presents the empirical findings related to reliability and construct validity in greater detail.

Exploratory Factor Analysis (EFA) was conducted using Principal Axis Factoring (PAF) with Varimax rotation to identify the underlying structure of the proposed instrument. Factors were retained based on statistical criteria, including eigenvalues greater than 1 and the proportion of variance explained by the extracted factors. Items with weak factor loadings, problematic cross-loadings, or low communalities were carefully examined before being retained in the preliminary scale.

4. RESULTS

4.1. Research Question 1: What factors affect the self-directed learning of first-year pre-service teachers in blended learning environments?

To address the first research question, the proposed instrument was administered to 185 valid respondents and subsequently examined using exploratory factor analysis (EFA).

Table 1. Rotated Factor Matrix

Item	Factor 1	Factor 2	Factor 3	Factor 4
SV1	0.679	0.202	0.467	-0.028
SV2	0.657	0.265	0.593	0.010
SV3	0.737	-0.024	0.054	-0.075
SV4	0.639	0.255	0.577	0.094
SV5	0.464	-0.203	0.184	-0.132
GV1	0.794	-0.311	0.037	0.224
GV2	0.747	-0.280	-0.115	0.337
GV3	0.751	-0.444	-0.006	0.293
GV4	0.788	-0.387	-0.079	0.133
GV5	0.768	-0.435	-0.027	0.123
XH1	0.805	-0.091	-0.105	-0.418
XH2	0.734	-0.094	-0.254	-0.434
XH3	0.792	-0.018	-0.028	-0.389
XH4	0.779	0.051	0.035	-0.246
MT1	0.632	0.285	0.013	0.090
MT2	0.637	0.323	-0.420	0.010
MT3	0.611	0.482	-0.397	0.169
MT4	0.712	0.282	-0.364	0.126
MT5	0.522	0.581	-0.059	0.225

Items with high factor loadings on the first factor, such as GV1, GV2, and GV3, suggest that lecturer-related factors play a particularly significant role in the blended learning environment. In contrast, other items, such as MT5 and SV5, exhibited relatively lower factor loadings, which may warrant further examination in future studies.

Table 2. Cross-Loadings and Threshold Factor Loadings

Item	Factor 1	Factor 2	Factor 3	Factor 4	Threshold Factor Loadings	Cross-Loadings
SV1	0.679	0.202	0.467	-0.028	≥ 0.50	No cross-loading
SV2	0.657	0.265	0.593	0.010	≥ 0.50	No cross-loading
SV3	0.737	-0.024	0.054	-0.075	≥ 0.50	No cross-loading
SV4	0.639	0.255	0.577	0.094	≥ 0.50	No cross-loading
SV5	0.464	-0.203	0.184	-0.132	< 0.50	No cross-loading
GV1	0.794	-0.311	0.037	0.224	≥ 0.50	Cross-loading on Factor 2 (-0.311)
GV2	0.747	-0.280	-0.115	0.337	≥ 0.50	Cross-loading on Factor 2 (-0.280)
GV3	0.751	-0.444	-0.006	0.293	≥ 0.50	Cross-loading on Factor 2 (-0.444)
GV4	0.788	-0.387	-0.079	0.133	≥ 0.50	Cross-loading on Factor 2 (-0.387)
GV5	0.768	-0.435	-0.027	0.123	≥ 0.50	Cross-loading on Factor 2 (-0.435)
XH1	0.805	-0.091	-0.105	-0.418	≥ 0.50	No cross-loading
XH2	0.734	-0.094	-0.254	-0.434	≥ 0.50	No cross-loading
XH3	0.792	-0.018	-0.028	-0.389	≥ 0.50	No cross-loading
XH4	0.779	0.051	0.035	-0.246	≥ 0.50	No cross-loading
MT1	0.632	0.285	0.013	0.090	≥ 0.50	No cross-loading
MT2	0.637	0.323	-0.420	0.010	≥ 0.50	No cross-loading
MT3	0.611	0.482	-0.397	0.169	≥ 0.50	No cross-loading
MT4	0.712	0.282	-0.364	0.126	≥ 0.50	No cross-loading
MT5	0.522	0.581	-0.059	0.225	≥ 0.50	No cross-loading

Items such as GV1 and GV3 exhibit high loadings on both factors 1 and 2, indicating that these items may need to be adjusted to avoid cross-loading. According to the item retention criteria, items with factor loadings below 0.50 and a difference in loadings between factors of less than 0.20 will be either removed or adjusted.

Items will be retained if their factor loadings are ≥ 0.50 and the difference in factor loadings across factors is ≥ 0.20. Items with communalities below 0.40 (such as SV5 and MT1) need to be reconsidered and may be removed or adjusted. Cross-loadings must ensure a minimum difference of 0.20 between factors to avoid ambiguity in the measurement process.

The dataset was suitable for factor analysis, as indicated by an excellent Kaiser-Meyer-Olkin index (KMO = 0.916) and a statistically significant Bartlett's test of sphericity, $\chi^2(171) = 2604.184$, $p < 0.001$ (Table 3). These findings confirmed that the correlation matrix was appropriate for factor extraction.

Table 3. KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.916
Bartlett's Test of Sphericity	Approx. Chi-Square	2604.184
	df	171
	Sig.	<0.001

The analysis included 19 observed variables representing four theoretically proposed domains: student factors (SV1-SV5), lecturer factors (GV1-GV5), social factors (XH1-XH4), and environmental factors (MT1-MT5). The extraction results supported a four-factor solution. The first four components had eigenvalues of 9.400, 1.784, 1.509, and 0.994, respectively, and together explained 72.038% of the total variance. Although the fourth factor had an eigenvalue slightly below 1, it was retained because it was theoretically meaningful and empirically interpretable as the environmental domain in the proposed framework. Overall, the extracted structure was consistent with the initial conceptualization of the instrument as a multidimensional measure. Although the fourth factor had an eigenvalue slightly below the conventional threshold of 1 (0.994), it was retained because it was theoretically central to the proposed framework and yielded an interpretable cluster of environmental items. Given the exploratory nature of the study, factor retention was based not only on eigenvalues but also on conceptual coherence and interpretability.

At the descriptive level, the item means ranged from 3.61 to 4.17, indicating that respondents generally perceived the examined conditions as moderately to highly present in their blended learning experience.

Table 4. Item Statistics

	Mean	Std. Deviation	N
SV1	3.72	0.831	185
SV2	3.63	0.895	185
SV3	3.95	0.761	185
SV4	3.61	0.897	185
SV5	3.86	0.854	185
GV1	4.06	0.749	185
GV2	4.17	0.709	185
GV3	4.06	0.727	185
GV4	4.09	0.720	185
GV5	4.13	0.733	185
XH1	4.07	0.723	185
XH2	3.98	0.718	185
XH3	3.90	0.822	185
XH4	3.99	0.726	185
MT1	3.81	0.835	185
MT2	4.08	0.779	185
MT3	3.90	0.857	185
MT4	4.03	0.695	185
MT5	3.71	0.914	185

Lecturer-related items tended to receive the highest mean ratings, particularly GV2 (M = 4.17, SD = 0.709), GV5 (M = 4.13, SD =0.733), and GV4 (M = 4.09, SD = 0.720). Social-factor items also showed relatively high means, including XH1 (M = 4.07, SD = 0.723) and XH4 (M = 3.99, SD = 0.726). In contrast, several student and environmental items recorded comparatively lower means, such as SV4 (M = 3.61, SD = 0.897), SV2 (M = 3.63, SD = 0.895), and MT5 (M = 3.71, SD = 0.914) (Table 4).

The inter-item correlation matrix showed clear clustering within the proposed domains. Within the student domain, the strongest correlations were observed between SV2 and SV4 (r = 0.841) and between SV1 and SV2 (r = 0.695). Lecturer-related items also displayed strong internal associations,

especially GV3-GV5 (r = 0.780) and GV3-GV4 (r = 0.778). In the social domain, XH1-XH2 (r = 0.787) and XH1-XH3 (r = 0.762) were among the highest correlations. In the environmental domain, MT3-MT4 (r = 0.698) and MT2-MT3 (r = 0.680) showed substantial associations. These patterns indicate that the items within each domain were empirically coherent and reflected shared underlying dimensions. This pattern suggests that first-year pre-service teachers may perceive lecturer guidance and peer support as more immediately available than their own self-regulatory readiness. Such a pattern is understandable in the early stage of university transition, where students are still adapting to greater autonomy in blended learning settings.

Table 5. Presents the Notable Within-Domain Inter-Item Correlations and Communality Values of the Observed Variables

Domain	Item	Notable inter-item correlations within domain	Communality
Student factors	SV1	SV1-SV2 = 0.695	0.721
	SV2	SV2-SV4 = 0.841; SV1-SV2 = 0.695	0.853
	SV3	-	0.552
	SV4	SV2-SV4 = 0.841	0.815
	SV5	-	0.308
Lecturer factors	GV1	-	0.778
	GV2	-	0.764
	GV3	GV3-GV5 = .780; GV3-GV4 = 0.778	0.847
	GV4	GV3-GV4 = 0.778	0.795
	GV5	GV3-GV5 = 0.780	0.795
Social factors	XH1	XH1-XH2 = 0.787; XH1-XH3 = 0.762	0.842
	XH2	XH1-XH2 = 0.787	0.800
	XH3	XH1-XH3 = 0.762	0.780
	XH4	-	0.671
Environmental factors	MT1	-	0.489
	MT2	MT2-MT3 = 0.680	0.686
	MT3	MT3-MT4 = 0.698; MT2-MT3 = 0.680	0.792
	MT4	MT3-MT4 = 0.698	0.734
	MT5	-	0.664

Communality estimates further showed that most items had acceptable to strong extracted variance. Several lecturer and social items demonstrated particularly high communalities, including GV3 (0.847), XH1 (0.842), XH2 (0.800), and GV4 (0.795). However, not all indicators performed equally strongly. SV5 had the lowest communality (0.308), while MT1 showed a comparatively modest communality (0.489) (Table 5). These results suggest that, although the overall four-factor structure was supported, a small number of items may require closer scrutiny in subsequent validation studies. These results suggest that SV5 and MT1 may not represent their intended domains as strongly as the other items. This may reflect either ambiguity in item wording or the possibility that these aspects are less salient to first-year students in the present context. These items should therefore be reconsidered in future revisions of the instrument.

Taken together, the EFA results support the organization of the instrument into four domains: student, lecturer, social, and environmental factors. Accordingly, the findings provide a positive answer to the first research question.

4.2. Research Question 2: Does the proposed measurement instrument demonstrate sufficient reliability and validity for assessing these factors?

To answer the second research question, the reliability and preliminary validity of the proposed instrument were examined.

Table 6. Reports the Reliability Statistics for the Full Scale

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.939	0.941	19

The full 19-item scale demonstrated very high internal consistency, with a Cronbach's Alpha of 0.939 and a standardized alpha of 0.941 (Table 6). The average inter-item correlation was 0.459, indicating strong coherence across items.

At the subscale level, all four domains also achieved acceptable to excellent reliability. The student-factor subscale reached 0.830, the lecturer-factor subscale reached 0.932, the social-factor subscale reached 0.904, and the environmental-factor subscale reached 0.846. These values indicate that the instrument functioned reliably not only as a full scale but also across its four constituent dimensions.

Item-total statistics further supported the retention of the observed variables. Corrected item-total correlations ranged from 0.415 to 0.758, suggesting that all items contributed positively to the overall scale. The strongest item-total relationships were found for XH1 (0.758), XH3 (0.748), GV1 (0.744), and XH4 (0.744), whereas SV5 (0.415) and MT5 (0.495) were comparatively weaker. Importantly, deleting any single item did not produce a meaningful increase in Cronbach's Alpha. This result suggests that no item required immediate removal on reliability grounds alone.

With regard to construct validity, the EFA results provided preliminary support for the factorial validity of the instrument. The factorability of the dataset, the substantial proportion of explained variance, and the overall alignment between the extracted solution and the proposed framework indicate that the instrument possesses an interpretable internal structure. However, the evidence should be regarded as preliminary rather than definitive because the present study relied on EFA only and did not yet include confirmatory factor analysis. The results of the exploratory factor analysis (EFA) support the classification of the observed variables into four factor groups: student factors, lecturer factors, social factors, and environmental factors. Although the fourth factor has an eigenvalue below the threshold of 1 (0.994), it was retained due to its clear theoretical significance and interpretability in the context of this study. However, items with low factor loadings, such as SV5 and MT1, should be reconsidered in future studies. The results of the cross-loadings analysis indicate that some items exhibit significant loadings on multiple factors and should be adjusted to avoid ambiguity.

Overall, the results provide a positive but cautious answer to the second research question. The instrument demonstrates strong reliability and promising preliminary validity, while still requiring further confirmatory testing before broader application.

5. DISCUSSION

The findings of this study indicate that the factors affecting SDL among first-year pre-service teachers in blended learning environments can be meaningfully organized into four domains: student, lecturer, social, and environmental factors. This result supports the view that SDL in blended contexts should be understood as a multidimensional phenomenon shaped not only by learner characteristics but also by pedagogical, relational, and contextual conditions (Adinda & Mohib, 2020; van der Westhuizen et al., 2022). In this sense, the present study extends prior work by translating these interrelated conditions into a preliminary measurement framework specifically designed for first-year pre-service teachers.

The student factor confirms that SDL is partly grounded in internal learner characteristics such as motivation, responsibility, planning, self-efficacy, and self-regulation. This interpretation is consistent with previous studies that conceptualize SDL as a learner's capacity to set goals, organize learning activities, monitor progress, and adjust strategies in a responsible and autonomous manner (Mai, 2020; Nguyen, 2023; Van Hien, 2016). At the same time, the comparatively uneven performance of some student-domain items, particularly the lower communality of SV5, suggests that learner readiness may not yet be fully stabilized at the beginning of university study. For first-year students, this pattern is understandable because the transition from teacher-dependent school learning to more autonomous university learning often requires substantial adjustment in learning habits and self-management (Mai, 2020; Mong et al., 2024).

The lecturer factor emerged as one of the strongest dimensions in the instrument, both in terms of descriptive ratings and internal consistency. This finding suggests that SDL in blended learning environments is strongly associated with the quality of pedagogical guidance that students receive. Such a finding is in line with earlier arguments that blended learning does not automatically promote learner autonomy unless lecturers provide effective scaffolding, clear instructional structure, timely feedback, and visible teaching presence (Adinda & Mohib, 2020; George-Walker & Keeffe, 2010; Adinda & Mohib, 2020). In other words, SDL in blended contexts should not be interpreted as unsupported independence; rather, it develops more effectively when teaching support gradually enables students to assume greater control over their own learning.

The prominence of lecturer-related factors may be particularly characteristic of first-year pre-service teachers. At this stage, students are still transitioning from highly structured school learning to the more autonomous expectations of higher education. In blended learning environments, this transition may be even more demanding because students must navigate both academic content and technological learning processes. As a result, lecturer guidance, instructional clarity, and timely feedback may be perceived not merely as external support, but as conditions that make SDL possible in the first place.

The strong performance of the social factor further indicates that SDL in blended learning environments is socially embedded rather than purely individual. The high inter-item correlations and communalities among the social indicators suggest that peer support, collaborative interaction, and a sense of learning community constitute important conditions that foster SDL. This interpretation is consistent with studies emphasizing that peer learning, collaboration, and online discussion can strengthen learner engagement and support the development of self-direction in technology-mediated environments (Lee et al., 2022; Gürbüz et al., 2026). For first-year pre-service teachers in particular, such social support may play both an academic role in helping students engage with learning tasks and an adjustment role in helping them adapt to the demands of university study. This finding is important because it challenges the assumption that SDL is purely individual. In blended learning, peer interaction and learning community may not reduce autonomy; rather, they may serve as social scaffolds that help students regulate learning more effectively.

While previous studies often emphasize learner attributes as the SDL core, the present study found lecturer-related conditions to be especially salient. This difference may be due to the specific characteristics of first-year pre-service teachers, who are still developing autonomy and may rely more heavily on structured pedagogical support than more experienced students.

The environmental factor was also retained as a meaningful domain, although its contribution appeared somewhat less pronounced than those of the lecturer and social domains. This pattern suggests that technological and organizational conditions such as access to devices, platform usability, learning resources, and flexibility may function more as enabling conditions than as the most immediately

perceived influences on students' SDL. Nevertheless, the retention of this domain remains theoretically and practically important because blended learning can only support SDL when the surrounding environment makes autonomous learning feasible and sustainable. This interpretation is consistent with previous studies showing that technological affordances, access conditions, and digital support shape learners' opportunities for autonomy and regulation in blended learning (Duong et al., 2022; Başaran & Yalman, 2022; Phung & Bui, 2025).

From a measurement perspective, the study provides encouraging evidence for the psychometric potential of the instrument. The high overall reliability and strong subscale reliabilities indicate that the scale captures its intended domains with substantial internal coherence. At the same time, the present findings should be interpreted as preliminary construct validation rather than full validation. The study establishes an empirically plausible four-factor structure, but additional validation work remains necessary before the instrument can be considered fully established for broader research use. In particular, weaker indicators such as SV5 and MT1 should be re-examined in subsequent analyses to determine whether revision or replacement is warranted.

The study also has practical implications for teacher education. If institutions aim to strengthen SDL among first-year pre-service teachers in blended learning environments, they should not focus exclusively on students' internal motivation or self-discipline. Equal attention should be given to lecturer support, peer interaction, and the design of supportive blended learning conditions. This implication is consistent with the broader literature, which suggests that SDL develops most effectively when learner-related, pedagogical, and contextual supports are aligned rather than treated as separate influences (Adinda & Mohib, 2020; Hidayah et al., 2024).

Several limitations should be acknowledged. *First,* the study relied on a single pilot sample, which limits the generalizability of the findings. *Second,* the instrument was examined through self-report data only, which may be influenced by response tendencies and subjective perception. *Third,* construct validation remains incomplete because the analysis did not include confirmatory factor analysis. Future research should therefore test the four-factor model on larger and independent samples, examine convergent and discriminant validity, and consider revising weaker indicators such as SV5 and MT1.

Overall, the findings suggest that SDL among first-year pre-service teachers in blended learning environments should be understood as a multidimensional and context-dependent process. The proposed instrument therefore provides a useful initial framework for investigating the conditions that shape SDL in teacher education settings (Adinda & Mohib, 2020; Mai, 2020). Practically, the instrument may be used by teacher education institutions as a diagnostic tool to identify which domains most strongly support or constrain students' SDL in blended courses. At the course level, the findings suggest the need for clear lecturer guidance, scaffolded task design, and structured feedback, especially for first-year students. At the institutional level, universities should strengthen LMS usability, digital resource access, and peer-learning opportunities in order to create a more supportive blended learning environment.

6. CONCLUSION

This study developed and preliminarily validated an instrument for measuring the factors affecting SDL among first-year pre-service teachers in blended learning environments. The findings support a four-factor structure consisting of student, lecturer, social, and environmental factors. The instrument demonstrated high overall reliability and satisfactory subscale reliability, while the exploratory factor analysis provided initial evidence for its structural validity. Taken together, these results suggest that the proposed instrument can serve as a useful initial tool for examining the conditions that shape SDL in blended learning contexts among first-year pre-service teachers.

The study also contributes to the understanding of SDL as a multidimensional and context-dependent construct. Rather than being explained solely by internal learner attributes, SDL in blended learning environments appears to be shaped by the interaction among learner readiness, lecturer support, peer relations, and environmental conditions. In this sense, the study offers not only a preliminary measurement tool but also an empirically grounded framework for investigating SDL conditions in teacher education.

From a theoretical perspective, the study contributes by operationalizing the factors affecting SDL into four measurable domains that are conceptually coherent and empirically supported. This provides a basis for future studies seeking to examine the relationships among these domains or to integrate them into broader models of SDL in blended learning environments.

From a practical perspective, the findings suggest that efforts to enhance SDL among first-year pre-service teachers should not focus solely on students' individual responsibility or motivation. Higher education institutions should also strengthen lecturer scaffolding, promote peer interaction and learning communities, and ensure supportive blended learning conditions in terms of technology, learning resources, and study flexibility. These dimensions appear to operate collectively in shaping how students experience and develop SDL during the early stages of university study.

Nevertheless, the study has several limitations. The data were drawn from a single pilot sample and relied on self-report measures, which may limit the generalizability of the findings and introduce subjective bias. In addition, the present validation remains preliminary because the instrument was examined only through reliability analysis and exploratory factor analysis. Future research should therefore test the scale using larger and more diverse samples, conduct confirmatory factor analysis, and further examine convergent and discriminant validity. Particular attention should also be given to weaker items such as SV5 and MT1 in order to refine the instrument for broader application.

Overall, the proposed instrument provides a promising foundation for assessing the factors affecting SDL among first-year pre-service teachers in blended learning environments and may support both future research and educational practice in teacher education.

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Institutional Review Board Statement: The study was conducted in accordance with institutional and research ethics principles for studies involving human participants. Participation in the survey was voluntary, and respondents were informed of the purpose of the study. All data were collected and analyzed anonymously for research purposes only.

Transparency: The authors confirm that this manuscript presents an accurate and transparent account of the research. All relevant aspects of the study have been reported, and no important information has been omitted.

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