Development and Validation of a PLEs Scale from the Learner and Learning Perspective in Tertiary Education

Desarrollo y validación de una escala PLEs desde la perspectiva del alumno y el aprendizaje en la educación terciaria

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Abstract
The study's goal is to create and validate a Personal Learning Environments Scale (PLEsS) from the learner and learning perspective (named PLEsS-LL) to ensure effective learning in Chinese tertiary education. 657 undergraduates participated in the study after completing scale development steps. Six factors were extracted from the PLEsS-LL using Exploratory Factor Analysis (EFA). Confirmatory Factor Analysis (CFA) supported the six-factor scale with 22 items. Furthermore, the PLEsS-LL was redesigned as a questionnaire to assess learners' readiness for PLE learning. The findings indicated that participants were comfortable when learning in PLEs in general. They were mostly positive in terms of learning motivation and problem-solving abilities. They did, however, report less confidence in Self-directed Learning. Meanwhile, male participants outperformed female participants in all categories except learning motivation. The reasons were explained, and suggestions for future PLEs design were made. The PLEsS-LL could be used as a resource or guide for learner preparation in the PLEs context in higher education around the world.
Key words: Personal Learning Environment, PLE, scale, learner, Tertiary education

Resumen
El objetivo del estudio es crear y validar una Escala de Entornos Personales de Aprendizaje (PLEsS) desde la perspectiva del alumno y el aprendizaje (llamada PLEsS-LL) para garantizar un aprendizaje efectivo en la educación terciaria china. 657 estudiantes universitarios participaron en el estudio después de completar los pasos de desarrollo de escala. Se extrajeron seis factores del PLEsS-LL mediante Análisis Factorial Exploratorio (EFA). El Análisis Factorial Confirmatorio (AFC) apoyó la escala de seis factores con 22 ítems. Además, el PLEsS-LL fue rediseñado como un cuestionario para evaluar la preparación de los alumnos para el aprendizaje

PLE. Los hallazgos indicaron que los participantes se sentían cómodos al aprender en PLE en general. En su mayoría fueron positivos en términos de motivación de aprendizaje y habilidades para resolver problemas. Sin embargo, informaron menos confianza en el aprendizaje autodirigido. Mientras tanto, los participantes masculinos superaron a las participantes femeninas en todas las categorías, excepto en la motivación de aprendizaje. Se explicaron las razones y se hicieron sugerencias para el diseño futuro de PLE. El PLEsS-LL podría utilizarse como un recurso o guía para la preparación del alumno en el contexto de los PLEs en la educación superior de todo el mundo.
Palabras clave: Entorno personal de aprendizaje, PLE, escala, alumno, educación terciaria

1. Introduction

Personal Learning Environments (PLEs) reflects the social material entanglement involved in people's learning and the method of formulating contemporary ideas about how people learn (Dabbagh & Castaeda, 2020). PLEs enable the integration of formal, non-formal, and informal learning experiences through an effective process in which students choose their learning styles and paces (Castaeda et al., 2022; Tochon et al., 2014). From the standpoint of the online system, PLEs are regarded as new constructs in the e-learning field that are supported by social media and are steadily gaining traction as effective platforms for student learning (Dabbagh & Kitsantas, 2012). PLEs are defined as a multidimensional space (Van Harmelen, 2006) or "a central node of a network" (Downes, 2010, p.30). Dabbagh (2007) stated that in order to be an academically successful online learner, one must be self-motivated, self-directed, and have an internal locus of control, as well as above-average executive functioning, communication, interaction, and technological skills. PLEs, as adaptive, personalised online systems, also require learners to be skill-based; for example, they should have above-average creativity, critical thinking, entrepreneurship, collaboration, a growth mindset, global competence, and so on (Duckworth & Yeager, 2015).

Muilenburg & Berge (2005) examined perceived online learning barriers for adult learners engaged in diverse digital learning settings using a self-reported survey, revealing that time management and lack of motivation were significant underlying barriers. Secondary barriers included technical skills, which matched DeTure's findings on technology self-efficacy and online learning outcomes. For similar reasons, with the implementation of PLEs in higher education, are students prepared to learn in PLEs? The use of PLEs at various educational levels is still being tested, according to Berg et al. (2015). In terms of learners, how can they configure and structure their own PLEs based on their preferred learning styles? Can they choose the tools and resources that are best suited to their learning? What abilities are required? And how can they track the effectiveness of their PLEs over time? All of the issues mentioned above have yet to be resolved. How can tertiary institutions develop PLEs that are appropriate for the real needs of higher education and the learners when implementing PLEs in higher education? Alternatively, how do we prepare students to use, develop, manage, and implement their PLEs in higher education? If the learner-constructed system to better support their learning is the fundamental principle of PLEs, and if our goal is to aid effective learning

through the use of PLEs, we should strive to clarify what PLEs mean and identify what competencies the learner requires.

As many researchers (Wu, 2000; Yu, 2002) have identified, web-based learning construction and design should consider multiple criteria, including curricula, learning styles, interactive design, and a multimedia application. Over the last few years, researchers have focused on developing a readiness scale for online learning (Smith et al., 2003; Chung et al., 2020). The development and application of PLEs in higher education also necessitate criteria/scales involving various stakeholders to agree on the purpose and requirements of PLEs implementation, as well as to provide quality control and assurance. This study attempted to develop and validate the PLEs scale from the learner and learning perspectives in order to ensure learners' readiness in the PLEs context.

2. Literature review

2.1. PLEs and learners' capacities

Over the past decade, many researchers proposed numerous definitions for PLEs, ranging from a technological perspective (Van Harmelen, 2008) to a more organic perspective, regarding PLEs as the technical components and social factors. Alamri, et al. (2020) suggested that PLEs provided learning choices and tailored learning content according to individuals' learning needs, interests, goals, and prior experiences to enhance knowledge and skills acquisition and supported psychological need satisfaction and intrinsic motivation. Attwell (2021) claimed that PLEs was essentially a social pedagogic approach to using technology for learning. This research referred to the definition made by Kalz, et al. (2011) which described PLEs as "a type of e-learning system that is structured on a model of e-learning itself rather than a model of the institution" and defined PLEs as "a knowledge-based, learner-centered teaching assistance platform, where users can customize resources, they need in a virtual community to share and co-construct knowledge".

Learning in PLEs was realized not through knowledge transmission but through students-directed defining, working out and solving the tasks, conducting self-analysis, self-control, and self-assessment of their learning process. Therefore, PLEs were believed to contribute to developing higher-order thinking and student satisfaction (Elfeky, 2019) and provided extensive use of infinite authentic resources and up-to-date context. PLEs could also allow learners to see connections between fields, ideas, and concepts and update the learning process according to the alterations in incoming information (Taragh Siemens, 2004).

2.2. PLEs and Learners' Online Learning Readiness

Because research in PLEs was still in its infancy (Torres-Kompten, 2015), little research on learners' competencies for learning in PLEs could be found. However, since PLEs were new types of online learning systems/platforms that required learners to have

sufficient online learning skills to create and manage their learning resources, applications, and tools (Attwell, 2007; Martindale & Dowdy, 2010), the other well-developed online learning scales could be referred to for the PLEsS-LL development. The Online Learning Readiness (OLR) scales were recommended because the fundamental skills required for learning in PLEs were similar to the OLR skills. Students' perceptions of course delivery, self-confidence in E-communication channels, and autonomy in learning participation were defined as OLR (Warner et al., 1998). As a result, the PLEsS-LL categories could be divided based on the learners' Online Learning Readiness scales.

A review of the literature revealed that some research was specifically focused on developing and validating measures to assess online learner readiness for college students. For example, Cheon et al. (2021) defined online learning readiness as a multidimensional construct that includes self-regulation, technology skills, motivation, interaction, and attitudes. Other studies found that OLR scales were primarily organised around five categories: Self-directed Learning, digital competence, online communication self-efficacy, learning motivation, and learning engagement (e.g., Cho, 2012; McVay, 2001; Hung et al., 2010).

Self-directed Learning

Knowles (1975) defined Self-directed Learning (SDL) as a process in which learners took the initiative to diagnose their learning needs, establish their learning goals, identify and implement learning strategies appropriately, and evaluate learning outcomes. In terms of SDL in PLEs, Carnerio et al. (2011) believed that PLEs could promote Self-directed Learning and meet the needs of self-directed learners for multi-source learning content. Some researchers conducted empirical studies in PLEs-based self-organized learning and used PLEs as a valuable technical tool for improving students' independent learning (Kompen et al., 2019).

Digital competences

Digital competences/skills were another critical factor in online classes' readiness instruments (Blayone, 2018). Digital management is related to students' level of proficiency in using technology relevant to online courses, such as the use of learning management systems, software, and applications, as well as the essential mastery of troubleshooting skills to solve technological problems (Hung et al., 2010; Cho, 2012). In PLEs, learners were required to have digital skills to build or manage their PLEs and interact with other learners in the social network (Van Harmelen, 2008).

Online Communication Self-efficacy (OCS)

Online Communication Self-efficacy was defined as students' ability to develop their own personal and purposeful relationships through computer-mediated communication (Alqurashi, 2016). Online communication could be categorized as instructor-student interaction and student-student interaction, which was highly valued and desired the online learners (Cheon et al., 2021). Previous research has also found that online communication could promote collaborative learning, promote the social construction of knowledge, and foster critical thinking skills (Li et al., 2014), all of which were essential for successful learning in PLEs. According to empirical studies, online communication efficacy was one of the top-ranked factors that significantly affected students' e-learning readiness (Kalkan, 2020; Demir & Yurdugul, 2015).

Learning motivation

The motivation was widely acknowledged as one of the most important factors influencing students' perceptions, attitudes, and behaviours toward learning (Ryan & Deci, 2000). Students who were motivated to learn outperformed those who were not (Ryan & Deci, 2000). According to Zalts et al. (2021), intrinsic motivation was related to positive learning environment perceptions and was positively correlated with perceived academic rank. A well-designed PLE would consider student motivation and readiness to learn (Hussain & Ng, 2013).

Learning engagement

For more than 40 years, student engagement has been the subject of extensive research (Appleton et al., 2008). Researchers and academics all regarded learner engagement as a multidimensional construct encompassing several dimensions of participation in learning activities, which played a critical role in successful learning and teaching (Deng et al., 2019). A higher level of engagement has been linked to better learning outcomes (Lee, 2014), whereas disengagement has been linked to lower academic achievement (Henry et al., 2012). Engagement and participation were common characteristics of PLEs. To have the potential of PLEs into full play in tertiary education, learners as the creators and users PLEs should be trained according to the PLEsS-LL to guarantee successful learning in PLEs. By referring to the OLR scales, the PLEsS-LL could be composed of the above five categories which were closely connected to PLEs.

3. Research Method

3.1. Research design

An exploratory sequential mixed-method approach was employed for the development of the PLEsS-LL. Based on the sequence suggested by Clark & Creswell (2010) for scale development, a five-phase approach was designed. In the first phase, the literature review approach was used for the development of the PLEsS-LL item pool (altogether 22 categories and 143 items), followed by a structured interview of five experts, which resulted in the second version scale (altogether six categories and 76 items; among them, "Computer and Internet self-efficacy" was a newly added category, and the rest five were the same as the five categories of the OLR scale).In the second phase, a focus group meeting was organised online to check the understandability and proneness of the items, which formed the third version of the scale (altogether six categories and 61 items). In the third phase, a pilot test of 70 questionnaires was administered to test the understandability of the Chinese version scale, which generated the fourth version; For the fourth phase, EFA in the form of a current situation questionnaire based on the fourth version scale was carried out, with the fifth version of the scale (altogether six categories and 22 items; among them, "Computer and Internet Self-efficacy" was removed, and "Learning Engagement" was divided into two, namely "Learning Engagement" and "Problem Solving"). The final validation of the PLEsS-LL (six categories and 22 items, including "Self-directed learning," "Digital competence," "Online communication self-efficacy," "Learning motivation," "Problem-solving," and "Learning engagement") was achieved through CFA in the final phase.

3.2. The scale item pool

The scale item pool was developed with an emphasis on brevity, simplicity, and the use of an understandable vocabulary. As an item-generation strategy, this study used a literature review approach, referencing peer-reviewed academic papers that investigated relevant online learning scales and PLEs learner and learning factors. More specifically, the first version of the scale was developed by taking into consideration six relevant scales, namely, the PLEs competence scale developed by the CAPPLE project (Competencies for Lifelong Learning based on the use of PLEs), the MOOC learner engagement scale (Deng et al., 2019), the Learner Readiness for Online Learning scale (Hung et al., 2010), the online collective efficacy scale (Glassman, et al., 2021), the self-regulated online learning questionnaire (Jansen, et al., 2017), and the Sustainability of Personal Learning Environments (PLEs) questionnaire (Díaz-García et al., 2015). Meanwhile, 13 learner and learning factors highlighted in PLEs' peer-reviewed papers were also included as scale items. Referring to the categories of the six scales mentioned above, the first version of PLEsS-LL was composed of 22 categories and 143 items.

3.3. Participants

The selection of subjects involved in the study was made through non-probabilistic convenience sampling (McMillan et al., 2005). A non-random sample composed of five interviewees in a structured interview and six experts in the focus group was used. As for the pilot test of the questionnaire, 70 participants were involved.
Regarding the primary questionnaire sample size, it can vary between 5 to 15 subjects per question, with a size of no less than 120 people (Velicer & Fava, 1998; Field et al., 2012). In this study, 698 questionnaires were administered to examine the internal consistency, reliability, and construct validity of the PLEsS-LL via Cronbach's analysis, EFA and CFA.

3.4. Validation of the Instrument

3.4.1. Structured interview

According to Crocker & Algina (1986), expert judgment allowed the validation of a research instrument, being a useful procedure to realize its content validity. For this paper, A structured interview was performed using the method of individual aggregates. A group of five experts in education and ICT was selected in China. The criteria used for selection were: a) Have doctoral-level or Ph.D. academic studies; b) Be a university professor; c) Have experience in educational research and related to new technologies. Each one received the validation format of the instrument through e-mail, consisting of a table of categories and items.

Among these five experts, three of them were females, and the rest two were males; all of them held Ph.D. degrees, while 75% of them were aged between 30-50; all of them were teachers and ICT experts from five different universities in China.

These experts independently assessed the categories and items according to three criteria:

a) relevance of the dimensions to PLEs learner and learning perspective;
b) consistency of language and clear and unique interpretation;
c) relevance and uniqueness of the item raised in its dimension.

In addition, there was a space for observations so that the evaluators could write the comments they deemed pertinent.

The main observations and comments received from the five experts were:

a) Minimize the dimensions of the scale to no more than seven;
b) Keep the following most important dimensions in online learning: "Self-directed learning," "Online communication self-efficacy," "Computer and Internet self-efficacy," "Learning motivation," and "Learning engagement";
c) Improve or reformulate the wording of items 1, 3, 5, 7, 10, 16, 17, 18, 19, 24, 25, and 26;
d) Reduce the item number of the "digital competence" dimension;
e) Add items "I feel confident in seeking technical help if I get stuck" and "I feel confident in applying higher-level skills in troubleshooting and solving technical problems while using the internet" in the computer and Internet self-efficacy dimension;
f) Add an example to the item" I am good at engaging in citizenship through digital technologies";
g) Separate item "I can protect myself and others from possible dangers in digital environments, and I am aware of digital technologies for social well-being and social inclusion" into two. Separate "I feel confident in organizing, managing, and monitoring my learning content, activities, and resources" into three;
h) In the learning engagement dimension, items should be verified under the PLEs context.

Revisions to the item pool were made accordingly, which generated the second version of the PLEsS-LL, with 76 items and six categories, namely Self-directed learning, Digital competences, Online Communication Self-efficacy, Computer and Internet self-efficacy, Leaning Motivation, and Learning Engagement.

3.4.2. Focus group meeting

A group of eight experts in education and information technology was purposely selected in China. The criteria used were the same as the structured interview. All eight experts were required to rate the importance of each item based on the second version of the rubric by answering a Likert scale from 1 to 5 (1=Minimum importance, 5=Maximum importance). The result indicated that 15 out of 76 items got scores under 3.0. An online focus group meeting was then held to determine whether to delete or keep those items. After an hour of discussion, six out of eight experts agreed to delete the 15 items for the following reasons: (1) overlapping in meaning (e.g., item 13 "I like to be in charge of what I learn and when I learn it" overlapped with "I carry out my own study plan"); (2) beyond Chinese public awareness (e.g., item 19 "I am good at engaging in citizenship through digital technologies); (3) not necessary as PLEs learners (e.g., item 26 "I am good at programming"); (4) belong to general competencies for all online learners (e.g., item 70 "I was inspired to expand my knowledge in the PLEs").

The third version of the PLEsS-LL was made up of six dimensions with 61 items.

3.4.3. Pilot test of the questionnaire

A pilot-test questionnaire of the 61 remaining items was conducted among undergraduates (N=70). The questionnaire was in Chinese and generated on the third version of PLEsS-LL. The questionnaire consisted of two parts; the first demographic part included variables such as gender, student grade, and major (Arts, Science, or Engineering). In the second part, the participants were asked to describe themselves in reference to a 5-point Likert scale, with anchors ranging from 1 (strongly disagree) to 5 (strongly agree). The final questionnaire was administered via a survey platform named Wen Juan Xing platform.

The result showed that the average time range for answering the questionnaire was 100 seconds-1000 seconds. Students' average age was 19 (SD= 4), 11% were male, and 89% were female. The reliability analysis of the instrument yielded a Cronbach's alpha coefficient =0.954 and the Kaiser–Meyer–Olkin measure of sampling adequacy (.854). The results suggested the scale had an internal consistency and was reliable. Meanwhile, the approximate chi-square value of Bartlett's test of sphericity was considerable (3161.344), and the significant Bartlett's test of sphericity $p < .001$ (Sig.=0.000) indicated that the sample was appropriate for CFA. Some revisions were made, for instance, explaining "feel connected to PLEs" in item 49 by giving an example.

3.4.4. Exploratory Factor Analysis

Participants

The study participants were university/college undergraduates across China who had at least one semester's online learning experience. A sample of 698 usable responses was obtained, among which 111 answers were deleted due to the extraordinary time range ($\leqslant$100 seconds or $\geqslant$ 1000 seconds). As Anderson (2010) pointed out, an appropriate sample size for factor analysis was five times the number of items in the questionnaire. Thus, 305 participants were recommended for a 61-item questionnaire. Therefore, the number of valid 587 participants fit the general recommendation for factor analysis.

Instruments

The questionnaire was the same as the pilot test. Participants have been approached through the personal contacts of the researchers as well as the snowball method. The collected data were imported to Statistical Package for Social Sciences (SPSS) version 22 for the necessary statistical analyses.

Demographics

More participants are female respondents (66.33%) than male respondents (33.67%). Regarding their grade level, 57.74% of participants were first-year students, whereas 33.67% were sophomores and 8.6% were juniors. 37.82% of participants were from Arts,

48.85% were from Science, and 13.32% were from engineering. 75.21% of participants reported familiarity with PLEs, 17.77% declared a well-understanding of PLEs, and only 7.02% claimed they did not know PLEs.

Results

The Kaiser–Meyer–Olkin measure of sampling adequacy (0.92) and approximate chi-square value of Bartlett's test of sphericity was large (6939.355) and the significant Bartlett's test of sphericity $p < .001$ (Sig.=0.000) indicated that the sample was appropriate for EFA. For the first round of EFA, 39 items were cross-loaded, highly inter-correlated, or low factor loaded and thus were deleted. A final round of EFA was conducted on the remaining 22 items. These items produced six factors: Self-directed Learning (n=6), Digital Competences (n=4), Online Communication Self-efficacy (n=3), Learning Motivation (n=3), Problem Solving (n=3), and Learning Engagement (n=3). Compared with the initial theoretical model, the factor "Computer and Internet Self-efficacy" was removed due to the low factor loading, and the factor "Learning Engagement" was divided into two, namely "Learning Engagement" and "Problem Solving." (see table 1)

The final EFA analysis produced a six-factor 22-item scale, which comprehensively accounted for approximately 38.213% of the variance (M=76.640545, SD=10.837550, kurtosis=0.980504, skewness=0.327965). The comprehensive scale produced high internal reliability of α=0.921.

The first factor (Self-directed Learning) accounted for approximately 16.859% of the variance (eigenvalue=8.407, M=19.2794, SD=3.79828, kurtosis=0.685, skewness=0.159) with a Cronbach alpha of 0.861851; The second factor (Digital Competence) accounted for approximately 12.433% of the variance (eigenvalue =2.197; M=14.2487, SD=2.75374, kurtosis=0.219, skewness=-0.028) with a Cronbach alpha of 0.824860; The third factor (Online Communication Self-efficacy) accounted for approximately 10.877% of the variance (eigenvalue=1.767; M=9.7734, SD= 2.11643, kurtosis=0.928, skewness=0.095) with a Cronbach alpha of 0.860795; The fourth factor (Learning Motivation) accounted for approximately 10.718% of the variance (eigenvalue=1.339; M=10.7172, SD=2.01659, kurtosis=0.345, skewness =0.169) with a Cronbach alpha of 0.863743; The fifth factor (Problem Solving) accounted for approximately 10.562% of the variance (eigenvalue=1.098; M= 11.1601, SD=1.98155, kurtosis=0.594, skewness=-0.021) with a Cronbach alpha of 0.855438; The sixth factor (Learning Engagement) accounted for approximately 10.426% of the variance (eigenvalue=1.004; M=11.4617, SD=2.1385, kurtosis =-0.471 skewness =-0.015) with a Cronbach alpha of 0.855840.

Table 1

PLEsS-LL with factor loadings

	SL	DC	OCS	LM	PS	LE
A1 I manage time well	0.768					
A2 I set up learning goals	0.726					
A3 I regularly learn things on my	0.745					
A4 I am better at learning things on	0.797					
A5 I am very good at finding out	0.676					
A6 I am very motivated to learn on	0.671					
B1 I am fully aware of the copyright		0.768				
B2 I am good at protecting personal		0.745				
B3 I can protect myself and others		0.811				
B4 I am aware of digital		0.701				
C1 The PLEs provides the chances				0.791		
C2 The PLEs offer the opportunity				0.774		
C3 The PLEs provide enough				0.77		
D1 I am motivated to learn when I						0.865
D2 I am motivated to learn when I						0.865
D3 I am glad that I feel connected to						0.657
E1 I often searched for further					0.729	
E2 When I had trouble					0.784	
E3 If I watched a video lecture that I					0.756	
F1 I often responded to other			0.848			
F2 I contributed regularly to the			0.788			
F3 I shared learning materials with			0.791			

Extraction method: Principal Component Analysis
Rotation method: maximum variation method with Kaiser normalization.
a. Rotation after six iterations to converge.
Note: Self-directed learning (SL), Digital competences (DC), Online communication self-efficacy (OCS), Learning motivation (LM), Problem-solving (PS), and Learning engagement (LE).

3.4.5. Confirmatory Factor Analysis

The validity, reliability, and correlation matrix of the scale

A CFA yields a series of indexes that estimate how the sample data can fit the a priori assumptions in different ways. In the CFA of this data, 22 items were retained. The model was composed of 22 items (see Figure 1). Table 2 shows the fitting indexes corresponding to the model. The values of these indexes indicated that the scale had good structural validity.

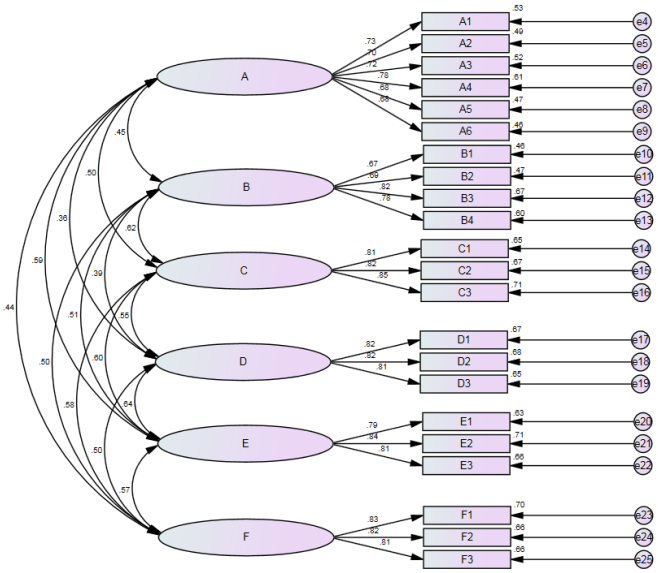

Figure 1 CFA for the PLEsS-LL

Table 2

Fitting indexes of the scale

	CMIN/DF	GFI	AGFI	NFI	RFI	IFI	TLI	CFI	RMSEA	SRMR
Value	2.380	0.934	0.914	0.934	0.922	0.961	0.953	0.961	0.049	0.0421
Threshold	<3	>0.9	>0.9	>0.9	>0.9	>0.9	>0.9	>0.9	<0.05	<0.08

The data collection instrument's construct validity was assessed using the convergent and discriminant forms of validity. Composite reliability (CR) and Average Variance Extracted (AVE) were calculated. The value of CR was calculated, and the resultant value of all the dimensions was more than 0.80. In contrast, the resultant values of AVE ranged from 0.5357 to 0.6552. The values of CR and AVE were above the threshold value of CR = 0.60 and 0.50 = AVE suggested by Byrne (2016) (See table 3).

Table 3
Correlation, validity, and reliability of measures

SN	CR	AVE	a value	A	B	C	D	E	F
A	0.8734	0.5357	0.861851	1					
B	0.8647	0.6167	0.824860	0.379**	1				
C	0.8218	0.6059	0.863743	0.436**	0.525**	1			
D	0.8417	0.6427	0.855840	0.314**	0.341**	0.477**	1		
E	0.8006	0.5725	0.855438	0.518**	0.438**	0.522**	0.553**	1	
F	0.8506	0.6552	0.860795	0.377**	0.421**	0.502**	0.433**	0.490**	1

Cohen's criterion: r=0.10 (small effect); r=0.30 (medium effect), and r=0.50 (large effect).
***Correlation is significant at the 0.01 level (two-tailed)*

The Cronbach's alpha value was calculated to check the internal consistency and reliability of the 22 scale items. The alpha value was 0.85, above the recommended value of ≥0.70 (Hair et al., 2018), which indicated good consistency between the various items of the scale. Dimension-wise alpha value was also calculated, as shown in Table 3.

Pearson's Moment Correlation was applied to determine the relationship between the six dimensions of the PLEsS-LL. The results revealed that all of the dimensions were positively and significantly correlated at a p-level of 0.01. Further, Cohen's (1988) criterion was used to assess the strength of the association between these dimensions. According to this criterion, Self-directed Learning was strongly correlated with Digital Competences (r=0.379**), Online Communication Self-efficacy (r=0.436**), and Learning Motivation (r=0.314**), Problem Solving (r=0.518**), and Learning Engagement (r=0.377**) (see Table 3).

In summary, the results of the data analysis above showed that the scale had excellent reliability and validity, so the PLEsS-LL could be considered a feasible tool as quality control for successful learning in PLEs. The final version of the scale is contained in Appendix 1.

4. Findings and Discussion

In this study, the PLEsS-LL was developed and validated to guide successful learning in PLEs. Referring to previous research on online learning readiness and PLEs, questionnaires and interviews were used in the study. The EFA produced a six-factor 22-item scale, which comprehensively accounted for approximately 38.213% of the variance. Among these six factors, "Learning Engagement" was divided into two; one kept the name "Learning engagement," involving the interaction among learners and learning course since student engagement was developed through interaction (Anderson, 2003); the other factor was named "Problem Solving," the items involved were about the ways to deal with difficulties raised during learning in the PLEs.

In the CFA phase, the value of CR was calculated, and the resultant value of all the dimensions was found to be more than 0.80. The alpha value was 0.85, which indicated good consistency between the various items on the scale. The resultant values of AVE ranged from 0.5357 to 0.6552. Pearson's Moment Correlation revealed that all the dimensions were positively and significantly correlated.

In addition, for the current status of learners' readiness for learning in PLEs, the data in Table 4 revealed the participants felt confident (Mean=3.48). They were confident in their Learning Motivation, with the greatest perceived strength in "I am glad that I feel connected to PLEs, e.g., reaction and feedback" (3.84). They also reported having strong Problem-solving skills, with an average score of 3.72. However, they felt less confident in Self-directed Learning (Mean=3.215, SD = 0.823), and Learning Engagement (Mean=3.26, SD = 0.798). This result was consistent with the findings made by Cho et al. (2010) and Sun & Rueda's (2012), indicating that SRL was challenging to many students in an online learning environment, where they may lack immediate support and

feel lost or socially isolated. Low retention and engagement were continuous challenges for online learning such as MOOC (De Freitas, et al., 2015). Moreover, the male participants reported higher scores in all categories except Learning Motivation compared with female participants. This result was consistent with previous findings of the gender gap in digital gender (Grande-de-Prado et al., 2020; Jiménez-Hernández et al., 2020; Chuang et al., 2015). Previous research discovered a consistent pattern of high confidence in ICT abilities in boys from elementary school to university (Broos, 2005; Broos & Roe, 2006). Males had higher levels of Internet self-efficacy and confidence than females (Chang et al., 2014; Gunn et al., 2003). They also reported better information management and online collaboration skills when using digital media than females (Grande-de-Prado et al., 2020). Females reported more internet anxiety (Chuang et al., 2015). They had fewer positive perceptions of digital learning and lower satisfaction with digital learning than male students (Ong & Lai, 2006). Previous research tended to attribute the "digital gender gap" to societal gender stereotypes that began in early childhood that regarded computers as a traditionally male domain. This was reinforced by the research findings that computer use for both educational and entertainment purposes was more frequent among boys (Drabowicz, 2014), while girls were obviously more active in online discussion participation, indicating that they use computers and the internet more for communication and social networking (McSporran & Young, 2001). McSporran & Young, (2001) indicated advantages for girls when it came to learning motivation in digital contexts. Women seemed to be more motivated, and better at communicating online and at scheduling their learning (Young & McSporran, 2001), while males were more likely to be influenced by others in the Internet-based environment (Chuang et al., 2015). These findings may explain the higher scores for female participants in the motivation category.

Table 4

Descriptive statistics for the PLEsS-LL questionnaire

N	Mean	SD	Skewness	Kurtosis
A1	3.18	0.813	0.2	0.39
A2	3.37	0.81	0.002	0.414
A3	3.32	0.819	0.217	0.023
A4	3.06	0.843	0.148	0.274
A5	3.09	0.79	0.134	0.191
A6	3.27	0.862	0.157	-0.074
B1	3.36	0.912	-0.05	-0.065
B2	3.92	0.836	-0.365	-0.346
B3	3.44	0.841	0.103	-0.154
B4	3.52	0.808	0.034	-0.098
C1	3.58	0.73	0.14	-0.073
C2	3.57	0.781	-0.064	0.047
C3	3.56	0.763	0.102	-0.152
D1	3.87	0.829	-0.274	-0.392
D2	3.75	0.82	-0.277	0.059

D3	3.84	0.778	-0.132	-0.335
E1	3.72	0.723	-0.039	0.113
E2	3.73	0.746	-0.044	-0.021
E3	3.71	0.779	-0.127	0.159
F1	3.18	0.809	0.141	0.535
F2	3.24	0.781	0.022	0.514
F3	3.35	0.803	-0.018	0.441

The result implies that teachers may need to scaffold tasks in PLEs to help students establish their time-management skills. When dealing with relatively weak students in learner control and self-study skills, teachers can provide instructions for them individually or create a learning community to encourage peer and group learning.

In addition, as Banna et al. (2015) declared, learning engagement plays an essential role in stimulating online learning today. To promote learning engagement in PLEs, teachers may focus on classroom management, setting diversified learning activities (Dixson, 2010), and creating realistic scenarios to apply content (Martin & Bolliger, 2018). The principle was to promote extensive discussions, inspire brave thoughts, and create an atmosphere of help-seeking and quick and supportive intervention when facing problems in PLEs.

Moreover, the data indicated that the participants believed a harmonious relationship among learners themselves, teachers, and classmates helped promote learning motivation in PLEs, since learners' enthusiasm for learning increased when they got attention from both peers and teachers, which increased their learning satisfaction (Pantziara et al., 2014).

In terms of problem-solving, learners believed the ability to inquire was important for PLEs learning. This lent support to previous studies (e.g., Wang et al., 2015, Aslan, 2017) in which inquiry skills were listed as one of the 21st-century skills and were encouraged to develop in recent years.

In sum, the findings of the study implied that the PLEsS-LL could be used to assess whether learners were ready to be engaged in PLEs, and to define their deficiencies or weakness in PLEs learning skills, the result of which could be used for practical training designs, curriculum design, or PLEs platform design. Teachers/instructors could use the scale to design personalized learning paths in the PLEs according to learners' strength and weakness reports to facilitate learners' Self-regulated Learning in the PLEs. Although the study of the PLEsS-LL was carried out in China, the methodology for scale development could be applied to other relative studies in and outside China. Meanwhile, the scale could be a reference for PLEs learners and learning studies worldwide.

5. Conclusion

Successful learning in PLEs calls for a scale to measure or guide learners' readiness. The current study proposed and examined the PLEsS-LL using mixed methods, such as

interviews, focus groups, and questionnaires. A total of 587 undergraduates from diverse backgrounds joined the EFA and CFA process, with another 70 participants involved in the pilot study. A six-factor scale with 22 items (Self-directed learning, n=6; Digital competences, n=4; Online communication self-efficacy, n=3; Learning motivation, n=3; Problem-solving, n=3; and Learning engagement, n=3) was confirmed with EFA and CFA methods. Meanwhile, the PLEsS-LL was applied to investigate the current status of learners' readiness for learning in PLEs; the result revealed most of the participants felt confident about learning in PLEs (Mean = 3.48); specifically, they reported being highly confident in learning motivation and problem-solving skills. However, they were less optimistic about Self-directed Learning. Moreover, the male participants reported higher scores in all categories except learning motivation compared with female participants. Our findings are consistent with the previous research on the digital gender gap in which males reported higher confidence and significantly more positive attitudes than females toward the Internet (Grande-de-Prado et al., 2020; Jiménez-Hernández et al., 2020; Chuang et al., 2015). The males also revealed better Internet self-efficacy and digital competence than females (Chang et al., 2014; Gunn et al., 2003). As is proved by quite a lot of previous research, gender stereotypes may play an important part in modeling the pattern of online learning for different genders (Drabowicz, 2014; Korlat et al., 2021). The implication is that we should take gender differences into consideration in designing the PLEs platform. It is anticipated that the PLEsS-LL will contribute to the development and implementation of PLEs in higher education

6. Limitations and future research

This research has certain limitations. Firstly, there is a limited number of participants in the EFA and CFA of the study, which may not be generated nationwide. However, to a certain degree, the participants' diversified majors compensate for the representatives of the data. Secondly, the study adopts the self-assessment method to collect data about the students' perceived PLEs readiness, which may raise the issue of bias.

The present study suggests some topics for future research, such as the PLEs scale from the other stakeholders' perspectives, e.g., teacher and teaching, academic, administrative, and technological perspectives. All these perspectives compose a whole picture for the successful implementation of PLEs in tertiary education, which is a worthy endeavor.

Disclosure statement

No conflict of interest exists in submitting this manuscript, and all authors approve the manuscript for publication. I would like to declare on behalf of all the co-authors that the work described is original research that has not been published previously and is not under consideration for publication elsewhere, in whole or in part.

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