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Validation of the Activities' Scale in Higher Education Students' Personal Learning Environments

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Abstract

Background: Personal learning environments are the networks of tools, activities, and connections that each person uses for their learning. Although there have been increasing numbers of studies, measurement instruments in this regard are still limited. The aim of this study is to construct and validate a scale to assess the activities that make up Personal Learning Environments. **Method:** The sample comprised 1,187 students in their final year of undergraduate degrees. 64% were women and 36% men, with a mean age of 24 and a standard deviation of 4.21 years. **Results:** The scale consists of 27 Likert-type items responding to three factors according to the theoretical construct reviewed, and produced high coefficients in internal consistency tests. **Conclusions:** The analyses demonstrate a valid instrument with solid psychometric properties. More specifically, the results indicate suitable content validity. Exploratory and confirmatory factor analyses indicate appropriate construct validation, with consistency between the theoretical and factorial model.

Keywords: Personal learning environment, questionnaire validation, higher education, university students.

Resumen

Validación de la Escala de Actividades en los Entornos Personales de Aprendizaje de Estudiantes de Educación Superior. **Antecedentes:** los entornos personales de aprendizaje se definen como el entramado de herramientas, actividades y conexiones que cada persona utiliza para su aprendizaje. Los estudios sobre el tema han ido en aumento, sin embargo, son todavía escasos los instrumentos de medición al respecto. El objetivo de este trabajo es construir y validar una escala para evaluar las actividades que integran los Entornos Personales de Aprendizaje. **Método:** la muestra estaba formada por 1.187 estudiantes universitarios de último año de carrera. Un 64% eran mujeres y un 36% hombres, con una edad media de 24 años y una desviación típica de 4.21. **Resultados:** la escala queda formada por 27 ítems tipo Likert respondiendo a tres factores de acuerdo con el constructo teórico revisado, obteniendo coeficientes elevados en las pruebas de consistencia interna. **Conclusiones:** los análisis realizados muestran un instrumento válido y con propiedades psicométricas sólidas. Concretamente, los resultados arrojan una adecuada validez de contenido. Los análisis factoriales exploratorio y confirmatorio indican una pertinente validación de constructo, existiendo coherencia entre el modelo teórico y factorial.

Palabras clave: entorno personal de aprendizaje, validación de cuestionario, educación superior, estudiantes universitarios.

The use of Information and Communication Technologies (ICT) in formal, non-formal, and informal spaces is producing qualitative changes that have broadened people's learning environments and made them more flexible (García-Valcárcel & Hernández, 2013). The concept of Personal Learning Environments (PLE) arose from the requirements of a digital society. It is the framework of ICT—in particular web 2.0—, the activities, and the connections each person makes in order to learn (Adell & Castañeda, 2010). The concept is linked to a student-focused (Castañeda & Adell, 2013; Keereerat et al., 2019) teaching approach (Attwell et al., 2013), characterized by the social dynamics produced by virtual spaces, encouraging social, collaborative learning (Kompen et al., 2019). Other studies have also related PLEs to lifelong learning (Kühn, 2017) and to the decisions that encourage it (Salleh et al., 2019), as well as self-directed learning (Alharbi, 2018).

Initial analyses of PLE were carried out with the aim of unifying criteria surrounding its definition and configuration (Adell & Castañeda, 2010; Fiedler & Väljataga, 2013; García-Martínez & González-Sanmamed, 2017, 2019). There are basically two approaches to the conception of PLE that can be identified: one predominantly technological (Rahimi et al., 2015; Sahin & Uluyol, 2016) and the other with a greater pedagogical emphasis closely linked to the promotion of learning (Castañeda & Adell, 2013; Kompen et al., 2019). Beyond these two extremes, it is accepted that in the digital era, learning methods are heavily influenced by technology, and the articulation of technology and pedagogy will be key in any educational process (García-Martínez & González-Sanmamed, 2017, 2019).

In terms of how PLEs are configured, there is some disparity in the identification of their components (García-Martínez & González-Sanmamed, 2019; Chaves-Barboza et al., 2017; Dabbagh & Fake,

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2017; Marín et al., 2014; Prendes-Espinosa et al., 2016; Ramírez-Mera & Tur, 2019). The CAPPLE project (Prendes-Espinosa et al., 2016) included four large dimensions to structure PLEs: self-perception, information management, management of the learning process, and communication. Meza et al. (2016) identified six types of activities making up PLEs: seeking information, reflection, creating content, sharing information, organizing, and planning. Chaves-Barboza & Rodríguez-Miranda (2017) included seven categories for studying PLEs: success in self-management, self-management strategies, factors for incorporating ICT, factors of frustration in the use of tools, characteristics of tools, desirable characteristics in a PLE, and characteristics to support learning.

When reviewing studies about PLE, in addition to the lack of consensus around the structure of PLEs, there is another, no less important weakness, which comes from the scarcity of validated instruments for examining university students' PLEs. In the Spanish context, to be specific, the ones which stand out are the Questionnaire about Competencies for Permanent Learning based on the use of PLEs (CAPPLE, Prendes-Espinoza et al., 2016) and the Questionnaire about Personal Learning Environments (CPLE, Chaves-Barboza & Rodríguez-Miranda, 2017). In both cases there was a validation of the content and analysis of internal validity, however, they did not provide evidence of construct validation. These instruments have a range which makes them more difficult to apply, and were created without beginning from a theoretical approach that would have provided cover for decisions about methodology. In fact, these and other studies have highlighted the complexity of the PLE construct and the difficulty of operationalizing and measuring it. In this regard, Attwell et al., (2013) indicated that the approach followed in these studies was exhausted, and highlighted the need to include a constructivist view of learning within research into PLEs which would allow them to be analysed as the combination of resources and activities that encourage and reflect interconnected students' modes of learning (Drexler, 2010).

Within this framework, the general objective of our study is to construct and validate a scale that would allow the evaluation of university students' activities within their PLEs. We have chosen to use the structure proposed by Castañeda & Adell (2013) as it is one of the most widely recognized in research and because it includes in three components many of the dimensions pulled from prior research: seeking information, creating content, and sharing information. The first component considers how access to the huge amount of information available freely and instantly on the internet in various formats allows the student to create their PLEs and personalize them with different tools, based on their needs and circumstances (Kompen et al., 2019). To that end, students have to acquire new comprehension skills, strategies, and competencies that enable them to search for, filter, evaluate, and interpret information effectively and safely (Coiro & Dobler, 2007).

The second component evaluates that, from summarizing, thinking about, and organizing the information they collect, the students can create new content or modify existing content thanks to the use of certain tools (Castañeda & Adell, 2013). Time management is essential for content generation, as is knowledge and use of available resources, along with the establishment of one's own learning objectives (Kop, 2011). Similarly, the capacity for critical thinking, collaborative working, and creativity are individual variables that should be strengthened in students to promote their personal development (Meza et al., 2016), and in particular, to facilitate self-directed learning (Alharbi, 2018; Boza & Conde, 2015), something that is closely related to PLEs.

The third component addresses the idea that the tools, mechanisms, and activities for sharing information have become the most important part of PLEs (Castañeda & Adell, 2013), and have moreover, produced the idea of the Personal Learning Network (PLN), which are the resources and actions that allow connections, information exchange, and communication between people (Marín et al., 2014).

Within the PLE framework, the activities that are performed are mediated by the effective use of ICT tools, with social interactions in new learning scenarios being particularly important (Attwell et al., 2013). Many of the processes and strategies in these activities come out of and become effective via the use of ICT resources. This means reading a variety of formats, and in general varying the forms of learning, as well as frequently applying these activities and keeping them up to date in order to appropriately configure the PLE (Castañeda & Adell, 2013).

In summary, in our study, we create an instrument to help understand and evaluate the types of technology-mediated activities and processes that form the PLEs of university students. Following that we apply it to a sample of students and examine its psychometric properties; validity (construct and predictive) and reliability (by internal consistency). To analyse predictive validity we apply the ICT Tools scale (García-Martínez et al., 2020). Based on the theory described above, we start with the following hypotheses:

1. The PLEAS scale is based on a multidimensional construct with three factors (accessing information, generating content, and sharing information) that are positively interrelated.
2. The PLEAS scales significantly predicts how often students use technological tools within their PLEs. Specifically, high scores in the PLEAS scale will correspond to high scores in the ICT Tools scale.
3. The reliability of the factors of the PLEAS scale will be high.

Method

Participants

The study population was made up of 3165 students in the final year of degrees in all of the faculties in the Omar Dengo Campus at the National University of Costa Rica. The sample was made up of 1,187 students. We carried out a stratified probabilistic sampling by faculties (Table 1). To calculate the sample size we used the formula for finite populations (Arnal et al., 1992): considering the

Table 1
Distribution of the sample by faculties

Area	Population		Sample	
	Frequency	Percentage	Frequency	Percentage
Arts	178	5.6	60	5.1
Education	469	14.8	235	19.8
Philosophy and Letters	361	11.4	316	15.7
Earth and Ocean	255	8.1	69	5.8
Social Sciences	1319	41.6	316	26.6
Health Sciences	198	6.3	118	9.9
Exact and Natural Sciences	385	12.2	203	17.1
Total	3165	100.0	1187	100.0

population (N=3165); a sampling error of 5%; confidence levels of 95%; and the expected proportion (p=5%), for the whole sample. The distribution by strata was similar to the population, although the sample was not representative by strata. Almost two-thirds (64.1%) were women, 35.9% were men, and ages ranged from 20 to 57 years old (M= 24.0; SD= 4.21).

Instruments

The final PLEAS scale had 27 items (Table 3), in line with the PLE components: accessing information (α = .98, omega = .99; e.g., I use specific tools to find information online), creating content (α = .96, omega = .96; e.g., technological resources make it easier for me to create content), and sharing information (α = .96, omega = .97; e.g., I maintain online contact with professionals in my area of study). The items had a Likert-type structure with five response options from 1 (*completely disagree*) to 5 (*completely agree*).

To check predictive validity, we used the ICT Tools Scale (García-Martínez et al., 2020), which has 30 items that measure how often web 2.0 applications are used for actions that are key in the development of PLEs: accessing information (e.g., I use blogs, wikis, websites, etc., for reading; α = .73, omega = .74); creation (e.g., I use spreadsheets; α = .76, omega = .77), and sharing (e.g., I use microblogging networks; α = .75, omega = .76). These items are scored on a five-point Likert-type scale from 1 (*never*) to 5 (*always*).

Procedure

Following a review of the literature, and considering the aspects related to the definition of the domain, the representation of the items and their importance (Muñiz, 2003; Muñiz & Fonseca-Pedrero, 2019; Vigil-Colet et al., 2020), we produced a battery of 50 items, which were filtered by the members of the research team, university students in their final years, and university teachers, reducing the number of items to 40. We retained factors with eigenvalues $(\lambda) \geq 1$.

Subsequently, we used these 40 items to create an online questionnaire which was sent by email for validation to 68 people who were unconnected to its creation, postgraduates in different areas of education, higher education and educational technology. We received 44 valid responses from four countries (Spain, Costa Rica, the USA, and Mexico) and 20 different universities over the course of a month. The questionnaire included an introduction with the instructions, objective, data treatment, and approximately how long it would take to complete. We also added a booklet with the conceptualization of the variables to be measured, a block of demographic, and educational background questions, and a block with the 40 statements so that the experts could address two aspects: the level of *representativeness* of the items (*low = -1, medium = 0, high = 1*) and their importance, linking each statement to the variable that the expert thought that it measured (accessing information, creating content, and sharing information). Each item had a section for the experts' observations if needed.

The level of representativeness (Muñiz & Fonseca-Pedrero, 2019) was determined by calculating the Osterlind congruence index (*icO*) for each of the items using Libre Office, according to the equation (Osterlind, 1992): X_{ijk} = Assessment for indicator i in domain k by judge j; N = 3, number of domains considered by the instrument n = 44, number of judges assessing the indicator. The level of congruence is considered adequate (Sanduvete-Chaves et al., 2013) if the score is equal to or greater than 0.5 ($I_{ik} \geq 0.5$). Ten items were removed for scoring below this limit.

The importance was analyzed via the associations made by the experts between each item and the variable it aimed to measure. Table 2 shows the percentage response of the experts regarding the association for each item, which ranged from 45.5% to 100%, with the latter meaning that the experts were unanimous that the item measured the proposed domain. When making the decision to remove, modify, or keep the items, we considered both the association percentage, the *icO*, and any observations the experts had made for each item.

The number of items was reduced to 30 during the process of validating the content. Following that, we carried out a pilot study with a sample (n=232) of students in which, through applying

Table 2
Resutls of Item Importance, icO, and decisions taken.

Item	% Imp.	icO	Elim.	Modif.	Keep
1	97.5	.795		x	
2	100	.842			x
3	93.2	.421	x		
4	75.0	.711		x	
5	93.2	.711			x
6	81.8	.395	x		
7	84.1	.684		x	
8	45.5	.421	x		
9	52.5	.605		x	
10	100	.947			x
11	100	.947			x
12	84.1	.868			x
13	95.5	.605		x	
14	84.1	.816		x	
15	54.5	.158	x		
16	47.7	.632		x	
17	93.2	.816			x
18	65.9	.789			x
19	88.6	.947		x	
20	93.2	.500			x
21	90.9	.658		x	
22	93.2	.579		x	
23	79.5	.842		x	
24	90.9	.579		x	
25	77.3	.263	x		
26	50.0	.421	x		
27	90.9	.842			x
28	93.2	.737			x
29	81.8	.684			x
30	95.5	.711			x
31	95.5	.447	x		
32	95.5	.921		x	
33	86.4	.526		x	
34	93.2	.895			x
35	86.5	.789			x
36	36.4	.421	x		
37	79.5	.789			x
38	90.5	.447	x		
39	95.5	.737			x
40	13.6	.447	x		

exploratory factor analysis, we reduced the scale to 27 items. Lastly, the application of the final questionnaire took place in students' classrooms, using a printed format, in coordination with the university authorities and the teachers in the different faculties. Students had 20 minutes to complete the questionnaire. During the introduction to the instrument, in addition to indicating aspects related to the study objectives and the treatment of the data, we reiterated the fact that it was voluntary and anonymous. The data were collected over four months in the second semester.

Data Analysis

We performed various types of analysis depending on the phases of construction and validation of the scales (Izquierdo et al., 2014; Muñiz, 2003; Sireci, 1998). For the validity of the content, as explained in the section above, we used the Osterlind congruence index and the qualitative analysis of the observations made by 44 experts. Secondly, we analysed some descriptive statistics for the items, such as mean, standard deviation, asymmetry, and kurtosis to check item behaviour. Following that, we analysed the validity of the construct with the data from a pilot study (n=232), via exploratory factor analysis (EFA) with the maximum likelihood method with *oblimin* rotation, following the calculation of a Pearson correlation matrix. Prior to that, we performed the Kaiser-Meyer-Olkin (KMO) test and Bartlett's sphericity test as measures of sample suitability.

Following this, we performed a confirmatory factor analysis (CFA) with the full sample (n=1187) using the maximum likelihood method. The fit of the three models was assessed by considering various statistics and indices of fit, such as chi-square ($\chi 2$) and its associated probability (p<), the ratio of $\chi 2/df \geq 3$; comparative fit indices (CFI) and the Tucker Lewis index (TLI), both ≥ .95 (Hair et al., 2005); and the root mean square error of approximation (RMSEA) < .06 (Hu y Bentler, 1999) as it is considered one of the best indicators of fit (Marsh et al., 1996). We also used Akaike's information criterion (AIC) to compare alternative models, with lower values indicating better fit (Bentler, 1995). To compare the predictive validity of the PLEAS scale, we performed multiple regression analysis taking the components of the ICT Tools Scale as criterion variables. Lastly, we analysed internal consistency via Cronbach's Alpha and the Omega coefficient (values ≥ .70 indicate sufficient reliability) (Nunnally, 1978). For the data analysis, we used Libre Office, SPSS (v.21), and FACTOR (10.10.02) software (Lorenzo-Seva & Ferrando, 2006).

Results

Descriptive analysis of the items

To examine the behaviour of the items, we first analysed statistics of central tendency (mean), dispersion (standard deviation), and distribution (asymmetry and kurtosis) for each item (Table 3). The mean scores ranged from a minimum of 2.02 (item 20) and a maximum of 3.79 (item 4). The smallest standard deviation was 0.93 (item 24) and the largest was 1.36 (item 10), indicating normal behaviour in both statistics. The data for asymmetry ranged from 0.07 to 0.86, and Kurtosis ranged from 0.09 to -1.17. According to the criteria established by Finney & DiStefano (2006) (maximums of 2 for asymmetry and 7 for kurtosis), the variables in our study can be said to follow a normal distribution.

Table 3
Descriptive statistics for the items

Item	M	SD	Asymmetry	Kurtosis
1	3.73	1.00	-.55	.09
2	3.01	1.23	.73	-.91
3	2.03	1.07	.77	-.33
4	3.79	.95	-.43	-.16
5	2.58	1.34	.33	-1.01
6	2.12	1.19	.86	-.18
7	3.72	.94	-.32	-.37
8	3.03	1.22	.09	-.89
9	2.02	1.08	.83	-.22
10	3.04	1.36	-.50	-1.17
11	2.08	1.10	.84	-.11
12	3.77	.95	-.38	-.22
13	2.72	1.25	.25	-.97
14	2.72	1.34	.25	-1.08
15	3.76	.98	-.46	-.18
16	3.03	1.21	.07	-.87
17	2.03	1.08	.81	-.20
18	3.75	.97	-.38	-.29
19	3.13	1.25	-.27	-.97
20	2.02	1.07	.82	-.18
21	3.69	.95	-.36	-.22
22	2.04	1.09	.81	.16
23	2.76	1.21	.21	-.87
24	3.76	.93	-.37	-.27
25	2.25	1.06	.81	-.24
26	3.72	.96	-.37	-.24
27	2.76	1.20	.20	-.86

Evidence of construct validity

The KMO test gave a result of .927 and Bartlett's sphericity test was significant (χ^2 (N=232, 351) = 2546.2, p<.000), meeting the conditions required for the EFA.

The result of the exploratory factor analysis, using maximum likelihood with the 30 items remaining after content validation, showed extraction of 3 factors in the final solution by means of *oblimin* rotation and extraction by parallel analysis. We grouped the items by factor with greatest factorial loading, regardless of whether they loaded on other factors with lower values. In addition, we removed three items from the matrix for having values below 0.40 (Kline, 2011). The three factors explained 81.8% of the total variance, with saturations ranging from .42 to .99 (Table 4). The first factor, with an eigenvalue of 12.08, explained 44.77% of the variance and grouped together the items related to information-seeking activities, which is why we called it "accessing information". The second factor, with a total value of 6.30, explained 23.34% of the variance, and refers to items that share activities around interaction, which we called "sharing information". Finally, the third factor, with a value of 3.71, explained 13.74% of the variance and referred to students' activities to produce new information, which we called "creating content".

With the 27 items that resulted from the EFA, we performed a CFA with the total sample (n=1187), specifying three models. The starting model (Model 1) was made up of three first-order factors. Model 2 was unidimensional, and Model 3 was made up of three first-order factors and one second-order factor.

Table 4
Matrix Structure factor loadings

Ítems	EFA; n=232 Components			CFA N=1187
	1	2	3	
4. I think I am effective at finding information on the internet	**.962**	.194	.354	.758
26. I search for information online for research processes	**.955**	.132	.316	.724
7. I use various multimedia resources (videos, diagramas, podcast, etc.) to get information on the web	**.953**	.128	.207	.623
12. I search for information on the internet to satisfy my curiosity	**.949**	.203	.322	.575
15. I do searches for information in order to complement the information given in my courses	**.945**	.159	.320	.557
24. When I read online, I follow hyperlinks to better understand the topic I'm reading about	**.926**	.185	.340	.531
21. I use internet searches keep up to date about the national and international situation	**.923**	.126	.309	.524
18. I use academic social networks to find information that interests me	**.913**	.202	.336	.438
1. I use specific tools (specialized search engines, databases, etc.,) to find information online	**.750**	.086	.279	.569
3. I share the information I produce via the internet	.385	**.998**	.151	.765
9. I actively participate in online discussions, developing my skills of argumentation and consensus-seeking	.150	**.996**	.392	.698
25. I use various formats to spread information (video, podcast, images, text, etc.)	.389	**.926**	.162	.539
20. The information I share in my social networks is academic	.280	**.987**	.373	.552
17. I share information online in accordance with distribution and copyright aspects	.394	**.980**	.154	.507
11. I use online tools to learn with other internet users	.381	**.976**	.125	.618
22. I Exchange important information for my learning with online learning communities	.375	**.957**	.134	.731
6. I take part in online discussions about topics I study	.307	**.525**	.196	.761
14. I maintain online contact with professionals in my area of study	.185	**.434**	.182	.515
16. I use online tools to collaboratively créate content	.308	.394	**.939**	.623
8. I use online tools (concept maps, timelines, etc.,) to analyse information	.399	.309	**.934**	.508
2. I relate information gathered online with prior experience and knowledge	.391	.303	**.874**	.638
23. I créate multimedia material (viedeos, podcasts, etc.,) in my learning process	.240	.270	**.873**	.418
27. Technological resources make it easier for me to create content	.335	.262	**.869**	.508
13. Technology helps me to be creative in content creation	.321	.251	**.864**	.422
19. I think about the contribution of technology to my learning process	.288	.373	**.836**	.498
10. I organize and summarize ideas with technological tools	.331	.337	**.749**	.450
5. I compare information from different online sources to improve the analysis of a study topic	.278	.321	**.683**	.649

We obtained the following results:

Model 1 ($\chi2$= 834.921*;* $\chi2/df$ = 2.601; *df*= 321; CFI = .975; TLI=.966; RMSEA=.048; 90% CI [.047-.051]; SRMR=.030; AIC=1968.413); Model 2 ($\chi2$= 3029.474*;* $\chi2/df$ = 9.35; *df*= 324; CFI=.686; TLI= .660; RMSEA= .084; 90% CI [.081-.087]; SRMR=.082; AIC=3191.747), and Model 3, ($\chi2$= 2029.683*;* $\chi2/df$ = 6.323; *df*= 321; CFI = .783; TLI = .744; RMSEA = .069; 90% CI [.067-.072]; SRMR=.062; AIC=2321.513). Looking at the values for AIC, Model 1 presented the best fit, as it was the smallest. In addition to demonstrating the best fit of the three, the indices of fit for Model 1 were all good, meaning that it was not only the best of the three, but that it also had a good fit to the data.

Table 4 gives the factorial loadings from the CFA for model 1. Although the values were smaller than those in the EFA, they were above the 0.400 recommended by the theory (Izquierdo et al., 2014), with values between 0.418 and 0.765.

Evidence of Predictive Validity

As part of the validation, we examined the relationship of the variables in the PLEAS scale with the variables in the ICT Tools scale. To do this we performed a Pearson correlation analysis to determine both the strength of the relationship and whether there was a reliable association between the different variables. The results (Table 5) show significant, strong, positive relationships (ranging between .569 and .617) between all of them (p<.001).

To look into this relationship more deeply, and to estimate the predictive capacity of the components of the PLEAS scale (predictor variables), we performed a multiple regression analysis, with the technological tools in the PLE components as criterion variables. The data (Table 5) show that the PLEAS variables explained 24.4% of the variance in the tools for accessing information, 6.2% of the variance for creating content, and 1.9% of the variance in the tools for sharing information. The result of the ANOVA indicated that this was significant (F (3,1181) =184.4; p<.000).

Reliability of the PLEAS scale

The results of the tests for reliability for each of the factors indicated good reliability (McMillan & Schumacher, 2005). For the factor, accessing information (M=3.75; SD=.89) the alpha coefficient was .980 and the omega coefficient was .989. The creating content factor (M=3.75; SD=.89) produced an alpha of .960 and an omega of .964. Lastly, the sharing information factor (M=2.13; SD=.97) gave an alpha of .960 and omega of .966. These values would generally be classified as excellent (Nunnally, 1978).

Table 5
Pearson correlation coefficients and Standardized regression coefficients for the relationship of the PLEAS factors and the ICT Tools variables

PLEAS factors (predictors)	ICT Tools (criterion)								
	Accessing			Creating			Sharing		
	r	β	t	r	β	t	r	β	t
Accessing	.609**	.304	9.39**	.617**	.228	6.88**	.569**	.133	3.54**
Creating	.549**	.213	6.42**	.593**	.295	8.69**	.595**	.226	.194**
Sharing	.561**	.135	3.86**	.592**	.212	5.92**	.607**	.166	4.83**

Note: **significance level .01; *n* = 1187

Discussion

Understanding university students PLEs will contribute to understanding their learning processes, especially when students are faced with the changes occurring in education due to internet use and the proliferation of web 2.0 tools (García-Martínez & González-Sanmamed, 2017). In addition, it provides a route map for institutions indicating how to strengthen and enrich PLEs from formal education, incorporating skills developed from informal education in order to give the student the skills they need to self-direct their learning throughout their lives (Alharbi, 2018; Kuhn, 2017).

The Personal Learning Environment Activities Scale (PLEAS) is an important contribution in light of the instruments available to date about PLEs. It will allow the identification of capabilities of accessing information, creating content, and sharing it, all in a digital context characterized by the need for self-directed learning that fosters continual, lifelong learning.

Our review of the literature made it clear that there were few valid, reliable instruments that were able to assess and develop university students' PLEs. This may be in part because of the complexity of the theoretical construct, and the multidimensional nature of what it describes (Prendes-Espinoza et al., 2016). Considering the satisfactory statistical results, the PLEAS scale, designed for this study, allows a comprehensive approach to PLEs from both technological and pedagogical perspectives, resolving the paradigmatic dissociation that had made it so complicated to study (Castañeda & Adell, 2013; Kompen et al., 2019; Rahimi et al., 2015; Sahin & Uluyol, 2016).

It is worth highlighting the content validation, since it complies with the recommendations made by Sireci (1998) about literature review for defining the domain, as well as the representation of the items and their importance (Muñiz & Fonseca-Pedrero, 2019). Similarly, the Osterlind index demonstrated suitable functioning as part of the validation with expert judgement, which is recommended in processes such as this. We also confirmed the suitable behaviour of each item via measures of central tendency (mean and standard deviation) and distribution (asymmetry and kurtosis).

In terms of the internal structure of the scale, the factor analyses indicated the proposed three-factor first-order structure with 27 items, which exhibited strong congruence with the conceptual and factorial model, with loadings above .40 (Table 4). Similarly, the alpha and omega coefficients (McMillan & Schumacher, 2005; Nunnally, 1978) gave excellent scores in the tests for internal consistency for each of the factors.

In summary, the operationalization of the theoretical model proposed by Castañeda & Adell (2013) via a Likert-type scale produced an advance in the study of PLEs compared to other more extensive questionnaires which have not been through such exhaustive validation processes as this (Chaves-Barboza & Rodríguez-Miranda, 2017; Prendes-Espinosa et al., 2016). The relative brevity of the PLEAS scale compared to those other instruments is another factor in favour of its ease of use (Muñiz & Fonseca-Pedrero, 2019).

The literature notes both the mix of tools and activities as making up part of the scaffolding of PLEs (Adell & Castañeda, 2010). In this regard, the results around predictive validity demonstrate on the one hand a strong relation between the two dimensions, and on the other, that the PLEAS scale predicts the frequency of use technological tools by the students. In this respect, although there are no tools that are exclusive in the PLE components (Castañeda & Adell, 2013), the proliferation and effective use of ICT encourage activities that allow the development of university students' PLEs (García-Martínez & González-Sanmamed, 2017).

Bearing the above in mind, the PLEAS scale is a valid, reliable instrument for possible future studies that allows the identification of university students' activities within the framework of their PLEs, and in general, more in-depth study along this line of research. Finally, one note of caution, the PLEAS scale was validated in the Costa Rican environment, thus it would be advisable to adapt it and perform the appropriate analyses to show validity and reliability in other contexts.

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