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Digital Tools and Personal Learning Environments: An Analysis in Higher Education

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Abstract: The effective use of Information and Communications Technology (ICT) and the discussion surrounding its educational contributions in formal settings are key elements in the analysis of personal learning environments (PLE). The aim of this study was to analyze the tools that students use to access information, create content, and share and interact in the framework of higher education. The study took a quantitative approach, using an ex post facto, transactional design. Data collection was via the application of a questionnaire to a stratified probabilistic sample (n = 1187) of university students on different courses at the National University (Costa Rica). Analysis of the data showed moderate use of tools in students' PLEs. Students made more frequent use of resources aimed at accessing information, followed by applications for sharing and interacting, and, to a lesser extent, content creation. We also found significant differences in the use of tools depending on sex, previous education in technology, and academic performance. We recommend the inclusion of open, flexible learning strategies in university education which incorporate the various technological resources available in the digital era to ensure the development of PLEs and lifelong learning.

Keywords: ICT; personal learning environment; web 2.0; university students; formal education; higher education

1. Introduction

Formal education in general, and higher education in particular, are witnessing a technological revolution resulting in significant changes to pedagogical processes and to the way education is conceived and organized in line with the current demands of the knowledge society [1]. The inclusion of Information and Communications Technology (ICT) in higher education may produce a deep transformation [2] that would be beneficial in a variety of aspects: on the one hand, the development of new metacognitive skills [3] in response to the dynamic learning styles required of current university students, and on the other, in line with the paradigm of sustainable development, the encouragement of growth in all aspects and areas of society [4].

Access to and effective use of ICT can promote the democratization of education, supporting teaching processes that encourage equality and integration of less advantaged social groups, to construct

a fairer, more sustainable society. Factors which contribute to this include access to and management of information, content creation, the possibility of sharing information quickly and free of charge, and the ease of online iteration [5]. However, despite the many studies on this topic, use of ICT in higher education does not guarantee that the benefits these tools may produce in the teaching/learning process will be taken advantage of [6]. In some cases, this is due to poor teacher training [7] as well as a lack of instructional design linking teaching strategies, tools, and underlying pedagogical theory [8].

Various international bodies, such as the Organization for Economic Cooperation and Development (OECD) and the United Nations Educational, Scientific and Cultural Organization (UNESCO), have proposed breaking the paradigm of higher education institutions in order to move the axis of learning from the educational institution to the student, promoting an active, conscious process on the part of the learner [9]. In this regard, the effective use of ICT may facilitate the development of skills and abilities for self-directed, lifelong, and life-wide learning [10,11] which may help reduce the various gaps between different levels in society and help address some of the current challenges in the work environment [12] which are largely based on the knowledge economy [13].

2. Personal Learning Environment

The development of ICT—especially web 2.0—has made a great expansion of knowledge possible, now that people have been able to move from a merely receptive role and become active agents in the creation and diffusion of content. Learning is an activity that continues throughout life, nourished by various sources of knowledge in formal, non-formal, and informal settings. Nowadays, thanks to the ease of access and the huge development and spread of ICT, technological mediation is a common resource in learning processes regardless of the level, environment, or system in which they take place. It is in this framework that higher education institutions must face the challenges of transforming and reassessing education and training programs for their students in response to society's demands [14]. Although we can find antecedents from several decades ago, technological proliferation makes a reawakening of what some authors consider a new educational approach [15], called the Personal Learning Environment (PLE).

In recent years, the idea of the PLE has given rise to much debate, and has had a significant impact in the field of educational technology [16]. Consequently, there is no consensus in the scientific community regarding the definition [17]. On the one hand, there are the authors who defend the position of a pedagogical approach, and on the other those who advocate a more technical meaning, as a set of tools. In the framework of this research, a more holistic perspective corresponded in which the PLE is composed of tools, activities, and connections [15] that are used to learn, from a perspective that is inseparably both pedagogical and technological. In other words, a PLE allows one to make the most of the potential of ICT and incorporate it into both formal and informal learning processes [16], giving prominence to student learning [18].

There have also been discussions about the components of PLE. For this study, we considered the structure proposed in [15], which defined three PLE components: tools and strategies for accessing information, content creation, and interaction and information exchange.

3. The Components of PLE

Given the amount of online information we are exposed to nowadays, as well as the many formats that are adapted to different learning styles [19], information access is a particularly important component in PLEs. Effective searching, along with filtering and information management are essential for university students, particularly in order to produce more autonomous, lifelong, learning processes which can and should be continued after university. Various studies have indicated that this is one of the most helpful components for university students' PLEs [20–22]. Results of those studies noted that the most commonly used tools were general search engines and video channels, whereas podcasts, newsletters, RSS readers, and microblogging were used less frequently [20].

Content generation tools and strategies are another PLE component. Nowadays, students have an enormous range of applications (many of which are free) for creating their own content. In this regard, the multiplicity of resources allows skills to be developed which are related to reflection, summarizing ability, structuring ideas, and creativity, among others [15]. Given the individual nature of PLEs, there are no absolutely required tools for them; however, some studies [23,24] refer to resources such as blogs, wikis, and social networks, among others, as useful resources for developing PLEs. Other studies [21,25,26] indicate that this component (focused on content creation) is less well-developed in university student PLEs due to students not being aware of many web 2.0 resources, as well as the use of traditional desktop tools that make interaction, collaborative working, and rapid content diffusion difficult [25].

Lastly, the most social component of PLEs is about sharing information and interacting with other users [27]. In this regard, the nodes that can be created between various connection options are important, giving rise to personal knowledge networks (PKN) which transcend formal education, and provide autonomous, lifelong learning [28]. As with the previous components, there are many resources that allow interaction, exchange of content, and collaborative learning [5,29]. Previous studies have indicated that the most commonly-used tools for communication and publishing focus on social networks and video channels [30], particularly via mobile phones [31], although they also note that the use of these tools is not necessarily linked to formal education or educational aims [32].

4. Higher Education and PLE

As noted above, PLEs support self-directed and lifelong learning, and one characteristic of this educational approach is the decentralization of learning from the higher education institute towards the student [33]. PLEs can be included in formal and informal educational settings; however, right from the start, they can lead to a path that means including ICT through appropriate teaching design [8] which benefits various subject curricula and has a positive impact on the students.

Various studies have linked the use of ICT with academic performance, with students making more frequent and effective use of it having higher grades [34]. Similarly, [35] related talented students with familiarization with digital data, along with the conscious design of their PLEs, characterized by interest in sharing and discussing their knowledge during the educational process. However, the construction and development of PLEs is not without obstacles which may be technical or pedagogical [8]. Students need new skills and abilities [36] to make the most of the potential of ICT in their PLEs, and these skills may be affected if the students do not see the benefits, or if their teachers lack training [7,22].

In addition, some studies have warned that traditional mediation strategies in the teaching/learning process in formal settings, and particularly universities, may be at the detriment of student PLEs due to poor inclusion of ICT [37]. In contrast, there is a range of ICT possibilities that can complement formal education which may be realized via the development of PLEs, characterized by being practical, open, dynamic, and allowing socialization and collaborative working [18].

5. Methodology

This study is part of a broader project analyzing PLEs in university students. The study was undertaken from a quantitative perspective. We used a non-experimental [38], transactional design, as we did not manipulate variables, and data were collected at a single timepoint [39].

5.1. Objective and Hypothesis

Bearing in mind the above, our overall study objective is to analyze Costa Rican university students' PLEs based on the tools they use in the context of higher education in each of the PLE components (accessing information, content creation, and communication). We hypothesize the following:

1. There will be significant differences with respect to sex in the frequency of ICT use in each of the PLE components.
2. Education in ICT will produce significant differences in the development of student PLEs.

3.　　There will be significant differences in student academic performance in accordance with the development of PLEs.

5.2. Population and Sample

The overall population (N = 3165) comprised final-year university students carrying out either bachelor's or licentiate degrees at the Costa Rica National University (UNA) on the Omar Dengo and Benjamin Núñez campuses.

The sample (n = 1187) was stratified and probabilistic [39], with the strata being the faculties making up the UNA. To calculate the sample, we used the finite population formula [40]: error 3%, 95% confidence level, and the expected proportion (*p* = 5%). We also considered representativeness, gathering data from 51 courses in the seven knowledge areas in the UNA.

The age of the students in the sample ranged from 20 to 57 years old, with a mean of 24 years (SD = 4.18). Almost two-thirds (64.1%) were women; the remaining 35.9% were men. In terms of academic performance, 30.0% had never failed a course and had a mean grade over 9; 26.6% had never failed a course but had a mean grade below 9; and 43.5% had failed at least one course.

5.3. Data Collection Instruments and Techniques

We used a survey to collect data via a questionnaire created ad hoc following a thorough review of the literature and bearing in mind the theoretical and methodological guidelines for creating these types of instruments [41]. The instrument was constructed in different blocks of closed questions. In this study, we present data from the block related to ICT in formal education, which had 30 Likert-type items measuring the three PLE components: finding, creating, and sharing information. Each item had 5 response options (from 1 = never to 5 = always). Internal consistency testing via Cronbach's alpha gave a coefficient of $\alpha = 0.83$.

5.4. Procedure and Data Analysis

To ensure content validity, we submitted the questionnaire for expert validation. It was reviewed by 20 professionals in higher education, research methodology, and educational technology. Based on their assessment, we created the first version of the scale. That was submitted to a pilot study with 45 students with similar characteristics to the final sample. The results of that test allowed us to confirm that the scale functioned in that context. A printed version of the questionnaire was given out in classrooms, and students were given 20 min to complete it. The first page of the instrument informed students of the research objectives; the procedures for handling data; and the voluntary, anonymous, and confidential nature of the study, as well as informing them that they could drop out of the study at any time without giving any explanation. As they were all adults, we obtained oral informed consent, and them handing in the completed questionnaire implied their consent for us to use the data for the study objective.

Once we had collected the information, we produced a database using SPSS v.21. We performed descriptive tests about position and distribution. Following that, we carried out Pearson correlations between the study variables. Finally, we performed comparisons between groups using MANOVA, ANOVA, and the Student *t* test, following confirmation of normality (using the Kolmogorov–Smirnov test for different groups) and equality of variance (using Levene's test).

6. Results

6.1. Descriptive Analysis of the ICT Tools in Formal Learning Scale

First, we calculated statistics of central tendency and distribution of the items making up the scale (Table 1). In the accessing information component, the most often-used tools were general search engines with a mean of 4.29 (SD = 1.11), advanced search engines (M = 4.15, SD = 1.20), and video channels (M = 3.78, SD = 1.18). The least-used tools for finding information were massive open online courses (MOOCs) (M = 1.48, SD = 0.97), information management applications (M = 1.77, SD = 1.18), and the National University archives (M = 2.70, SD = 1.48).

Table 1. Descriptive statistics organized by personal learning environments (PLE) components.

	1		2		3		4		5		M	SD
	n	%	n	%	n	%	n	%	n	%		
Accessing information												
1. Blogs, wikis, websites … for reading	85	7.2	157	13.3	299	25.3	324	27.4	316	26.8	3.53	1.22
4. Video tutorials (Youtube, Vimeo, etc.)	54	4.6	96	8.2	338	28.9	345	29.5	337	28.8	3.70	1.11
17. Institutional archives	379	32.8	156	13.5	238	20.6	193	16.7	188	16.3	2.70	1.48
18. Video Channels (YouTube, etc.) searching for information	67	5.7	92	7.8	297	25.2	300	25.4	424	35.9	3.78	1.18
20. Advanced search engines (Google scholar, etc.)	80	6.8	53	4.5	129	11.0	263	22.4	651	55.4	4.15	1.20
23. "Read later" applications (Pocket, Instapaper, etc.)	740	62.7	168	14.2	142	12.0	68	5.8	63	5.3	1.77	1.18
24. Massive Open Online Courses (MOOC)	878	74.2	147	12.4	87	7.4	36	3.0	35	3.0	1.48	0.97
26. Specialist databases in your area of study	111	9.5	93	8.0	240	20.5	297	25.4	428	36.6	3.72	1.29
27. General search engines (Google, Bing, Yahoo, etc.)	52	4.5	52	4.5	117	10.2	219	19.0	710	61.7	4.29	1.11
35. Podcast listening tools (SoundCloud, iVoox, Spotify, etc.)	544	44.2	148	12.6	188	15.9	117	9.9	205	17.4	2.44	1.54
Content creation												
3. Image editors (Photoshop, Gimp, iMovie, etc.)	3282	32.4	267	22.6	303	25.7	142	12.0	86	7.3	2.39	1.11
5. Audio editing tools (Audacity, Adobe Audition, SoundForge, etc.)	605	51.0	264	22.4	165	14.0	91	7.7	54	4.6	1.92	1.17
6. Multimedia creation resources (Prezi, Glogster, Powtoon, etc.)	164	13.9	176	14.9	276	23.4	269	22.8	297	25.1	3.30	1.36
13. Text processors (Word, Write, Wordpad, etc.)	21	1.8	19	1.6	42	3.6	112	9.5	986	83.6	4.71	0.76
14. Spreadsheets (Excel, etc.)	152	13.0	158	13.5	253	21.6	252	21.5	356	30.4	3.43	1.38
19. Digital task managers (Evernote, Trello, WunderList, Google Tasks, etc.)	592	49.9	207	17.5	182	15.3	121	10.2	84	7.1	2.07	1.30
21. Digital project management (MS Project, Basecamp, Gantt PV, etc.)	780	66.1	181	15.3	136	11.5	55	4.7	28	2.4	1.62	1.02
28. Information creation tools (blog, wiki, YouTube)	292	25.4	238	20.7	259	21.8	164	14.3	197	17.1	2.77	1.41
29. Data analysis programs (SPSS, Atlas ti, etc.)	598	50.8	171	14.5	206	17.5	120	10.2	82	7.0	2.08	1.31
32. Collaborative document creation (Google Docs, etc.)	108	9.3	70	6.0	132	11.3	231	19.8	623	53.5	4.02	1.31
36. Presentations (PowerPoint, Keynote, etc.).	52	4.4	20	1.7	110	9.3	258	21.9	737	62.6	4.37	1.03
Sharing information												
2. Microblogging networks (Twitter, etc.)	598	52.3	261	22.8	157	13.7	70	6.1	58	5.1	1.89	1.16
7. Networks for gathering and commenting on content (Tumblr, Pinterest, ScoopIt)	580	49.2	235	19.9	193	16.4	87	7.4	83	7.0	2.03	1.26
8. Professional networks (LinkedIn, etc.)	588	50.1	218	18.6	201	17.1	103	8.8	64	5.5	2.01	1.23
9. General social networks (Facebook, Instagram, Google+)	245	20.9	215	18.4	239	20.4	174	14.9	298	25.4	3.06	1.48
10. Mobile messaging (WhatsApp, etc.)	45	3.9	42	3.6	157	13.5	229	19.7	687	59.2	4.27	1.07
11. Email, calendar, task, and contact managers, etc. (Outlook, Gmail, etc.)	19	1.6	19	1.6	60	5.1	203	17.1	883	74.6	4.61	0.79
12. Videoconferencing (Skype, etc.)	405	34.1	243	20.6	265	22.5	167	14.2	99	8.4	2.42	1.31
15. Social bookmarking (Delicious, Diigo, etc.)	966	82.3	113	9.6	53	4.5	23	2.0	19	1.6	1.31	0.79
22. Storing and exchanging files in the cloud (Dropbox, Drive, Box, Onedrive)	41	3.5	50	4.2	136	11.5	256	21.6	703	59.3	4.29	1.05

Note: n = 1187; response options 1 = "never"; 2 = "almost never"; 3 = "occasionally"; 4 = "almost always"; 5 = "always"; M = mean; SD = standard deviation.

For content creation, students most often used text processors (M = 4.71, SD = 0.76), resources for creating presentations (M = 4.37, SD = 1.03), and resources for collaborative working (M = 4.02, SD = 1.31). The tools they used least often were digital task managers (M = 2.07, SD = 1.30) and data analysis programs (M = 2.08, SD = 1.31).

Lastly, the most commonly used tools for sharing information were email (M = 4.61, SD = 0.79), applications for cloud storage and exchange of information (M = 4.29, SD = 1.05), and mobile messaging (M = 4.27, SD = 1.07). The tools students used least often were social bookmarking (M = 1.31, SD = 0.79), microblogging networks (M = 1.89, SD = 1.16), and professional networks (M = 2.01, SD = 1.23).

We calculated Pearson correlations between the overall scale and the components. Table 2 gives the coefficients, which were positive and high, ranging between 0.57 and 0.87. With regard to internal consistency, Cronbach alpha coefficients were satisfactory. Finally, it is worth noting that the highest scoring component was information access (M = 3.34; SD = 0.62), followed by sharing information (M = 3.04; SD = 0.59), and lastly content generation (M = 2.97; SD = 0.59). The mean in the overall scale was M = 3.00 (SD = 0.50).

Table 2. Correlation matrix and descriptive statistics for the overall scale and components.

	1	2	3	4	Alfa	M	SD	Sk	Rku
Access (1)	1	0.617 **	0.569 **	0.848 **	0.73	3.34	0.62	−0.15	0.15
Creation (2)	0.617 **	1	0.595 **	0.870 **	0.76	2.97	0.59	0.12	0.18
Sharing (3)	0.569 **	0.595 **	1	0.802 **	0.75	3.04	0.59	0.01	0.07
Overall scale (4)	0.848 **	0.870 **	0.802 **	1	0.83	3.00	0.50	0.15	0.60

Note: ** The correlation is significant at the level of 0.01 (bilateral). 1 = "access"; 2 = "creation"; 3 = "sharing"; 4 = "overall scale"; Alfa = Cronbach alpha coefficient; M = mean; SD = standard deviation; Sk = skewness; Rku = kurtosis.

6.2. Analysis of Sex-Related Differences in the Use of ICT

We used the Student *t* test to identify sex-related differences in the use of ICT. We first tested normality, using the Kolmogorov–Smirnov test ($p > 0.05$) for both groups (men and women), and the equality of variance using Levene's test (p value > 0.05). As Table 3 shows, women had higher mean scores, with significant differences in the overall scale and its three components.

Table 3. Results of the Student *t* test with respect to sex.

Variable "Sex"	Group Statistics			T Test for Equivalence of Means		
	Sex	Mean	SD	t	df	Sig. (Bilateral)
Access	M	3.31	0.61	2.469	1183	0.014
	F	3.41	0.66			
Creation	M	2.98	0.62	2.967	1183	0.003
	F	3.09	0.68			
Sharing	M	3.01	0.64	3.745	1183	0.000
	F	3.15	0.64			
Overall scale	M	3.00	0.54	3.441	1183	0.001
	F	3.11	0.60			

Note: SD = standard deviation; df = degrees of freedom; Sig = significance.

6.3. Analysis of Differences Related to the Variable Education in ICT

The majority of students (80.9%) reported having carried out specific courses in ICT, while 19.1% had not. Of those who had received ICT training, 38% had done so as part of their degree curriculum,

while the other 62% had done so in informal settings. Only 13.4% reported having carried out a virtual course, formal or otherwise.

First, we tested normality using the Kolmogorov–Smirnov test, giving a non-significant "*p*" level ($p > 0.05$) for the two groups (with and without ICT training). We also performed Levene's test (*p*-value > 0.05) to test the equality of variances. The results of the Student *t* test (Table 4) comparing the means between groups showed that students who had previously been educated in ICT had higher scores in the overall scale as well as in each of the components. This confirms that there were differences in the use of each of the PLE components with regard to the variable education in ICT.

Table 4. Group statistics and results of Student *t* test with respect to the variable education in ICT.

Variable "ICT Education"	Group Statistics			T Test for Equality of Means		
	ICT Education	Mean	SD	t	df	Sig. (Bilateral)
Access	Yes	3.37	0.63	3.184	1180	0.001
	No	3.21	0.57			
Creation	Yes	3.00	0.59	3.616	1180	0.000
	No	2.84	0.56			
Sharing	Yes	3.07	0.60	3.759	1180	0.000
	No	2.91	0.55			
Overall scale	Yes	3.03	0.51	3.923	1180	0.000
	No	2.88	0.46			

Note: SD = standard deviation; df = degrees of freedom; Sig = significance.

6.4. Analysis of Differences in the Use of ICT in Higher Education in Relation to the Variable Academic Performance

We performed a unidirectional multivariate analysis of variance between groups to examine the differences in students' academic performance (independent variable) in regard to the ICT use scale, using the components of that scale as the dependent variables. Before carrying out the MANOVA for the academic performance variable, we examined the homogeneity of covariance using Box's M test, the result of which (Box M = 247.9 F = 12.3 $p = 0.000$) showed that the assumption was not met. Due to that, we chose to use Pillai's Trace to analyze the multivariate significance of the main effects, following the recommendations from [42]. The MANOVA showed a significant main effect for academic performance: Pillai's Trace = 0.064, $F_{(8,2346)} = 9.727$, $p = 0.000$, $\eta 2 = 0.032$. Subsequent univariate ANOVA tests demonstrated that students who had not failed any courses and who had mean grades above 9 scored significantly higher in the use of ICT ($F_{(2,1175)} = 29.65$, $p = 0.000$) than those who had not failed any courses but had mean grades below 9, and those who had failed courses. We found the same for each of the components: accessing information ($F_{(2,1175)} = 6.506$, $p = 0.002$), content creation ($F_{(2,1175)} = 30.73$, $p = 0.000$), and sharing information ($F_{(2,1175)} = 6.438$, $p = 0.002$). As Table 5 shows, we found differences in both the overall scale and each of the PLE components. The results show greater use of ICT resources by students who have mean grades above 9 than either of the other two groups.

Table 5. Descriptive statistics (mean and standard deviation) of use of ICT tools in relation to academic performance.

	Mean Grade over 9 (no fails)		Mean Grade under 9 (no fails)		Failed At Least One Course	
	M	SD	M	SD	M	SD
Access	3.50	0.69	3.23	0.61	3.24	0.63
Creation	3.26	0.78	2.96	0.59	2.96	0.58
Sharing	3.30	0.69	3.00	0.58	3.01	0.63
Overall scale	3.26	0.70	3.00	0.48	2.98	0.52

7. Discussion and Conclusions

Bearing in mind the changes in educational processes from the inclusion of ICT [1,2], it is important to analyze the PLEs of university students—who will soon be joining the labor force—to understand the contribution of higher education. In this regard, developing PLEs can stimulate and strengthen skills that modern society needs [3,36], in addition to what it can contribute to various areas of society [4].

Our results show how university students use different tools in their PLEs during the formal learning process during higher education. Students had moderate scores in the overall scale, in line with indications from some authors [7] about the use of ICT in higher education not necessarily leading to improvements to the educational process [32]. In this regard, it is necessary for the university to encourage the development of PLEs via designs that include strategies, tools, and emerging theories [8], and which also facilitate autonomous, lifelong, and life-wide learning [10,11].

Specifically, we found the highest scores in the accessing information component, although they were moderate, in line with other similar studies [21,22]. The most commonly-used tools were general search engines, advanced search engines, and video channels, while the least-commonly used were MOOCs, information management applications, and institutional archives. This is consistent with the results of previous studies [20]. The lack of awareness and scant use of resources such as podcasts, newsletters, RSS readers, or professional networks shows that students were not making the most of the potential of ICT in searching for and accessing information in higher education. This is an important aspect considering the vast amount of information available to students, the many formats that align with different learning styles [19], and the need to filter and manage it in order to properly incorporate it into the learning process [18].

Content generation produced the lowest scores, as previous research has also reported [21,25,26]. This may be detrimental to activities within the PLE such as reflection, summary, creativity, and organization [15], and is something that should be reinforced in formal educational settings. Within content generation, the most commonly-used resources were text processors, applications for producing presentations, and resources for collaborative working. Little-used resources included digital task management and programs for management and analysis of data. Although PLEs are characterized by being flexible, dynamic, and individual, some authors [23,24] have suggested resources that would facilitate their construction and reinforcement. It is notable how students only used web 2.0 resources aimed at creating collaborative content, and were much more likely to use desktop resources that make it harder to share information or interact with other users, which is in line with findings from other studies [25]. This may be reinforced by traditional higher education practices in which ICT hardly features [37] despite the many possibilities it offers.

As with the other components, we found moderate scores in sharing information, something which affects the social structure of PLEs [27]. Students were not making the most of the strengths of ICT for interaction and exchange of content, with the idea that no one learns alone, and they were failing to take advantage of collaborative learning opportunities [5,15]. The most commonly-used resources were email managers, and resources aimed at cloud storage and information exchange, and mobile applications, which is similar to results from other studies [30,31]. The scant use of social bookmarking, microblogging, and professional networks may negatively affect the creation of PKNs [28] outside the university setting. This may lead to stagnation of students' autonomous learning in the different areas of performance [13].

Our analysis confirmed all of our hypotheses. In terms of sex, there were significant differences in the frequency of use of ICT tools in each of the PLE components, with women making more use of them. This finding supports the results of other similar studies [43]. However, it is important to highlight what is more controversial from our analysis in the face of a lack of conclusive studies, and the conflicting results in that regard.

Our data analysis confirmed that education in ICT produced significant differences in students' PLEs. More specifically, students who had received some training in ICT scored higher in the overall PLE scale and in each of the components. The competencies needed to effectively use ICT are changing

as the tools proliferate [36], especially web 2.0 and the semantic web 3.0 [37]. Given that, and as long as higher education does not integrate open, flexible strategies with study plans [18], it becomes necessary to provide training through specific courses which address technical, and particularly pedagogical, aspects [37].

There were also significant differences in students' academic performance according to the development of PLEs. Students who made more use of ICT in their PLEs had higher mean grades. This is in line with findings from other studies [34,35] which also note the importance of conscious construction and development of PLEs, and that their potential lies, beyond the resources used, in a comprehensive, pedagogical approach to the idea [15,37].

It is worth noting that to address some of the limitations of this study, it would be useful to broaden the sample to other universities and higher education institutions in Costa Rica, and even to extend the research to other countries, to allow comparisons to be made. It would also be interesting to implement a longitudinal study that would allow us to see how student use of ICT tools changes over time in formal learning environments. In addition, complementing this study with a more qualitative study would allow us to triangulate data, producing richer, more valid results.

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References

1. Casillas, M.A.; Ramírez Martinell, A.; Morales, C. Los saberes digitales de los bachilleres del Siglo XXI. *Rev. Mex. Investig. Educ.* **2020**, *25*, 317–350.

2. Casillas, M.A.; Ramírez, A. Digital culture and institutional change in universities. *Rev. Educ. Super.* **2019**, *48*, 97–111. [CrossRef]

3. Boza, A.; Conde, S. Web 2.0 in higher education: Attitude, training, use, impact, challenges and tools of web 2.0. *Digit. Educ. Rev.* **2015**, *28*, 45–58.

4. Brown, A.J.; Snower, D.J. Skills Development: Rethinking the Future. Organization for Economic Cooperation and Development. The OECD Observer 2012. Available online: https://bit.ly/2XRiZCh (accessed on 9 August 2020).

5. Vlachopoulos, D.; Makri, A. Online communication and interaction in distance higher education: A framework study of good practice. *Int. Rev. Educ.* **2019**, *65*, 605–632. [CrossRef]

6. Castañeda, L.; Esteve, F.; Adell, J. Why rethinking teaching competence for the digital world? *Rev. Educ. A Distancia* **2018**, *56*, 1–20. [CrossRef]

7. Esfijani, A.; Zamani, B.E. Factors influencing teachers' utilisation of ICT: The role of in-service training courses and access. *Res. Learn. Technol.* **2020**, *28*, 1–16. [CrossRef]

8. Romero, J.J.; Moreno, A.; Sola, T. Training needs assessment of andalusian teachers in educational digital resources authoring for virtual learning environments. *J. Educ. Teach. Train.* **2012**, *3*, 92–108.

9. Rejón-Guardia, F.; Polo-Peña, A.I.; Maraver-Tarifa, G. The acceptance of a personal learning environment based on Google apps: The role of subjective norms and social image. *J. Comput. High. Educ.* **2020**, *32*, 203–233. [CrossRef]

10. Aoki, K. Technologies for Lifelong and Lifewide Learning and Recognition: A Vision for the Future. In *Emerging Technologies and Pedagogies in the Curriculum*; Yu, S., Ally, M., Tsinakos, A., Eds.; Springer: Singapore, 2020; pp. 41–52.

11. González-Sanmamed, M.; Sangrà, A.; Souto-Seijo, A.; Estévez, I. Learning ecologies in the digital era: Challenges for higher education. *Publicaciones* **2020**, *50*, 83–102. [CrossRef]

12. Martínez, C.; Riopérez, N.; Lord, S.M. Lifelong learning competences development program for higher education. *Pedagog. Soc. Rev. Interuniv.* **2013**, *22*, 137–151.

13. León-Pérez, F.; Bas, M.C.; Escudero-Nahón, A. Self-perception about emerging digital skills in Higher Education students. *Comunicar* **2020**, *62*, 91–101. [CrossRef]

14. Ordaz-Guzmán, T.; González-Martínez, J. Analysing knowledge building strategies in personal learning environments. *Apertura* **2019**, *11*, 6–21. [CrossRef]

15. Castañeda, L.; Adell, J. *Entornos Personales de Aprendizaje: Claves para el Ecosistema Educativo en Red*; Marfil: Alcoy, Spain, 2013.

16. Castañeda, L.; Tur, G.; Torres-Kompen, R. Impacto del concepto PLE en la literatura sobre educación: La última década. *Rev. Iberoam. Educ. A Distancia* **2019**, *22*, 221–241. [CrossRef]

17. Fiedler, S.H.; Väljataga, T. Personal learning environments: Concept or technology? *Int. J. Virtual Pers. Learn. Environ.* **2011**, *2*, 1–11. [CrossRef]

18. Yen, C.J.; Tu, C.H.; Sujo-Montes, L.E.; Harati, H.; Rodas, C.R. Using personal learning environment (PLE) management to support digital lifelong learning. *Int. J. Online Pedagog. Course Des.* **2019**, *9*, 13–31. [CrossRef]

19. Kompen, R.T.; Edirisingha, P.; Canaleta, X.; Alsina, M.; Monguet, J.M. Personal learning Environments based on Web 2.0 services in higher education. *Telemat. Inform.* **2019**, *38*, 194–206. [CrossRef]

20. García-Martínez, J.A.; González-Sanmamed, M. Personal Learning Environments of Costa Rican Education Students: Analysis of Information Search Tools. *Rev. Investig. Educ.* **2017**, *35*, 389–407. [CrossRef]

21. Şahin, S.; Uluyol, Ç. Preservice Teachers' Perception and Use of Personal Learning Environments (PLEs). *Int. Rev. Res. Open Distrib. Learn.* **2016**, *17*, 141–161. [CrossRef]

22. Tirado, P.; Roque, M.d.P. ICT and educational contexts: Frequency of use and function of university students. *Rev. Electrónica Tecnol. Educ.* **2019**, *67*, 31–47. [CrossRef]

23. Attwell, G. Personal learning environments-the future of elearning. *Elearning Pap.* **2007**, *2*, 1–7.

24. Ñáñez-Rodríguez, J.J.; Solano-Guerrero, J.C.; Bernal-Castillo, E. Ambientes digitales de aprendizaje en educación a distancia para la formación inicial de docentes: Percepciones acerca de su pertinencia. *Rev. Investig. Desarro. E Innovación* **2019**, *10*, 107–119. [CrossRef]

25. García-Martínez, J.A.; González-Sanmamed, M. How do Costa Rican education students generate and manage content: A contribution to the study of their personal learning environment. *Digit. Educ. Rev.* **2019**, *36*, 15–35. [CrossRef]

26. López, P.; González, V.; Aguiar, M.; Artiles-Rodríguez, J. La gestión de la información en entornos personales de aprendizaje: Estudio exploratorio en alumnado de último curso de grado. *Rev. Complut. Educ.* **2017**, *28*, 35–52.

27. Cabero, J.; Arancibia, M.L.; Valdivia, I.; Aranedas, S.M. Typologies for Technological Innovation in Teachers of Higher Education based on an analysis of conglomerates: An exploratory study. *RED: Rev. Educ. A Distancia* **2017**, *5*, 1–21. [CrossRef]

28. Chatti, M.A.; Dakova, S.; Thüs, H.; Schroeder, U. Tag-based collaborative filtering recommendation in personal learning environments. *Trans. Learn. Technol.* **2013**, *6*, 337–349. [CrossRef]

29. Hernández-Sellés, N.; Muñoz-Carril, P.C.; González-Sanmamed, M. Interaction in computer supported collaborative learning: An analysis of the implementation phase. *Int. J. Educ. Technol. High. Educ.* **2020**, *17*, 1–13. [CrossRef]

30. García-Martínez, J.A.; González-Sanmamed, M. Communication and Interaction as Key Aspects of Personal Learning Environments: Perspectives of Costa Rican Education Students. *Rev. Electrónica Educ.* **2020**, *24*, 1–20. [CrossRef]

31. Núñez, J.P.; Almenara, J.; Meza, L. Personal Learning Environments (PLE) in College Students of Pedagogy. *RELATEC: Rev. Latinoam. Tecnol. Educ.* **2018**, *17*, 25–39. [CrossRef]

32. García-Martínez, J.A.; Fallas-Vargas, M.A.; Gamboa-Jiménez, A. Development of Personal Learning Environment: Assessment of an experience with university students. *Summa Psicológica UST* **2016**, *13*, 83–94.

33. Johnson, M.W.; Prescott, D.; Lyon, S. Learning in Online Continuing Professional Development: An Institutionalist View on the Personal Learning Environment. *J. New Approaches Educ. Res.* **2017**, *6*, 20–27. [CrossRef]

34. Pogrebnikov, A.K.; Shestakov, V.N.; Yakunin, Y. Personal learning environment as a tool for improving students' performance. *Perspect. Sci. Y Educ.* **2019**, *42*, 473–483. [CrossRef]

35. Kamińska, A. Personal Learning Environment of the Talented Student—Based on Their Own Experiences. *J. Educ. Cult. Soc.* **2019**, *10*, 76–84. [CrossRef]

36. Dabbagh, N.; Fake, H. College students' perceptions of personal learning environments through the lens of digital tools, processes and spaces. *J. New Approaches Educ. Res.* **2017**, *6*, 28–36. [CrossRef]

37. Ordaz, T.; González-Martínez, J. Hacia una visión aglutinadora del concepto de PLE. *Rev. Ciències L'educació* **2020**, *2*, 21–37. [CrossRef]

38. Mateo, A. La investigación ex post-facto. In *Metodologìa de la Investigación Educativa*; Bisquerra, R., Ed.; La Muralla: Madrid, Spain, 2014; pp. 195–229.

39. Hernández, R.; Fernández, C.; Baptista, P. *Metodología de la Investigación*, 2nd ed.; Editorial Mc Graw Hill: México DF, México, 2014.

40. Arnal, J.; Del Rincón, D.; Latorre, A. *Investigación Educativa: Fundamentos y Metodología*; Labor: Barcelona, Spain, 1992.

41. Muñiz, J.; Fonseca-Pedrero, E. Ten steps for test development. *Psicothema* **2019**, *31*, 7–16.

42. Tabachnick, B.G.; Fidell, L.S. *Using Multivariate Statistics*, 4th ed.; HarperCollins: New York, NY, USA, 2001.

43. González-Sanmamed, M.; Estévez, I.; Souto-Seijo, A.; Muñoz-Carril, P.C. Digital learning ecologies and professional development of university professors. *Comunicar* **2020**, *28*, 9–18. [CrossRef]