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Abstract: This volume represents the proceedings of the Workshops co-located with the 15th International Conference on ICT in Education, Research, and Industrial Applications, held in Kherson, Ukraine, in June 2019. It comprises 82 contributed papers that were carefully peer-reviewed and selected from 218 submissions for the five workshops: 3L-Person, CoSinE, ITER, RMSE, and TheRMIT. The volume is structured in five parts, each presenting the contributions for a particular workshop. The topical scope of the volume is aligned with the thematic tracks of ICTERI 2019: (I) Advances in ICT Research; (II) Information Systems: Technology and Applications; (III) ICT in Education; and (IV) ICT Cooperation in Academia and Industry.

Keywords: ICT, Advances in ICT Research, ICT Research Infrastructure, Information System, Technology, ICT Application, ICT n Education, ICT-Enabled Cooperation

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Attitude to the Digital Learning Environment in Ukrainian Universities

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Abstract. Needs of digital transformation requires specific flexibility from modern universities to ensure the society demands implementation through innovative teaching and IC-technologies. Modern universities create a digital learning environment to support studying activities. This research presents an experts' estimate of the current condition and perspectives of universities digital studying environments in Ukraine. We verified the theoretical model structure of the university digital studying environments by means of the empirical data factor analysis. We studied the components of the existing learning environment and enabling environment and compared them to the results of our previous research. We proved the digital learning environment theoretical model was correct. We proved that visions of students and teachers correspond to the key trends accelerating higher education technology adoption. We assume the digital learning environment development benefits overcoming significant challenges impeding higher education technology adoption.

Keywords: Digital Learning Environment, University, Survey, Factor Analysis, Education.

1 Introduction

The biggest digital transformation ever occurs right now. Unfortunate countries and enterprises those won't be able to adapt are done for. The Global Competitiveness Report 2018 claims that the promise of leveraging technology for economic leapfrogging remains largely unfulfilled [1, p.9]. A number of organizations require help to envision, structure, and sequence successful digital transformation efforts [2]. Strong institutions are a fundamental driver of both productivity and long-term growth. Their benefits extend well beyond economics, affecting people's well-being on a daily basis. Thus the question of the educational system improvement and transformation becomes more than urgent, as it's connected to preparing the competitive professionals at the observed tendency for digital technologies development [3].

Needs of digital transformation requires the flexibility of modern universities to ensure the implementation of society demands through innovative teaching and IC-technologies. Leveraging these technologies requires not only the creation of the digital learning environment [4], but also changes in the educational process.

The tools to assess competitiveness, along with traditional concepts (such as ICT and physical infrastructure, macroeconomic stability, property rights, years of schooling) become crucially important concepts those go in a row with an entrepreneurial culture, multi-stakeholder collaboration, critical thinking, and social trust [1, p.7]. All these factors together influence the universities' competitiveness. Under a condition of the education system digital transformation enabling environment is meant to become the university digital learning environment (DLEs) with its following integration to the global digital environment.

Digitalization of the educational environments will improve the university competitiveness, that is important both for the students who decide on what university to choose and for the universities interested in attracting potential students, best teachers and researches, investments and grants.

This research aims to prove the theoretical model of the university digital environment structure and evaluate its relevance and perspectives for universities in Ukraine.

2 Theoretical Background

Existing research studies in higher education proved that it's easier to engage students to learn with when ICT [5, 6]. The universities' key priority is improving their digital environment, that would support new academic policy, practices and technological landscape [7]. Accepting the digital learning environment in many ways depends on the educational trends and the most recent educational requirements. However, the technologies are also important for DLEs development. Digital learning environments include any set of digital tools and technology-based methods that can be applied to support learning and instruction [8]. We can claim that DLE is a next stage for the e-learning environment and the virtual learning environment [9], however, some researchers use these terms as synonyms. Universities and non-commerce organizations research on designing and developing digital learning environments and their effectivity. The digital learning environment Manifesto from the Edutainme aims to proclaim the principles of how to create digital learning environments, where the student will be a performer of his own learning, entitled to influence his own growth [10]. DUCAUSE (e.g., https://library.educause.edu/topics/teaching-and-learning/next-generation-digital-learning-environment-ngdle) helps elevate the impact of IT, thus the next generation digital learning environment (NGDLE) concept seeks for a balance between the openness of learning and the need for coherence in the environment and emphasizes personalization, collaboration, and accessibility/universal design – all essential to learning.

The university digital learning environment on different levels can be indicated by electronic scientific and educational resources, communication in the scientific and educational environment, management of scientific and educational activities, the formation of new scientific and educational relations, competences. An international Project IRNet studied its participants' evaluation indicators of the digital environment in various universities and IC-competencies [11].

Herewith, the projects on improving the digital learning environments require both the teachers and students to participate in (https://www.plymouth.ac.uk/news/connect/spring15/digital-learning-environment). As soon as the students order educational service, and the teachers are responsible to provide these services at a great level, they become the categories to ask for an expert estimate of the higher education level and its components [12].

This assumption corresponds to the quality management principles of ISO quality management standards [13], namely QMP 1 – Customer focus and QMP 3 – Engagement of people.

3 Methodology of Research

3.1 General Design

There exist various approaches to define the university digital environment components [14]. This paper considers the university digital learning environment as a cluster of components, which structure was modeled and proved by Ukrainian researcher L. Panchenko [15]. The author distinguishes such components as available equipment and Internet access (space-semantic component), students and teachers information competency (competency component), communication, and organization of the learning process (technological). As far as the received results validity depends on the research reproducibility [16] we conduct the repeated expertise on the mentioned components, taking into account the changes occurred lately. The MC Horizon Report claims there exist consistent educational trends, new trends appear all the time, and some trends and issues reappear over time [3, pp. 4-5]. For example, the need in growing focus on measuring learning and redesigning learning space is still immediate. The requirements to the open educational resources (OER) and their proliferation change the requirements of cross-institution & cross-sector collaboration; rise of new trend. The new forms of interdisciplinary studies step forward. The modern universities react to the changing requirements. The technology development (open source software for scientific communication), wider access to the external resources (scientific platforms and databases), rising demands and educational requirements from the students and such objectives as academic mobility and scientific cooperation, including the international cooperation, lead to specifying the components of the suggested theoretical model. The common tendencies rely on the transformation of the educational and information environments into the digital one, information competency into the digital competency, communication in education, that is not limited to the university environment. Scientific researches in the field of advancing cultures of innovation, advancing digital equity plays an even more important part.

To understand the attitude of the Ukrainian teachers and students to the universities' digital learning environment we put together a set of the theoretical model components.

- *Space-semantic*: Available Internet access, good traffic, equipped studying rooms, hostings, and educational platforms, particularly LMS, e-library, institutional repository, e-conference system, access to the wiki-portal and corporate accounts, etc.
- *Technological*: educational resources integration (e-library, OJS edition, repositories, etc.), content development and delivery, access to the external educational sources, scientific databases, well- organized consultation and expert estimation system, creating the educational program according to the educational requests from the students, monitoring and tweaking the processes of using the environments for individual work, applying e-learning, project-based learning, blended learning, collaborative learning, combined formal and informal learning, shared research work, etc.
- *Communicative*: scientific and educational communication through email, corporate resources (websites of departments professors, and conferences, corporate clouds, e-libraries, etc.), external resources (social networks and services, forums and communities, e-conferences, etc.), consulting, experts' evaluations.
- *Competency-based*: the level of digital competencies through self-evaluation, peer-to-peer evaluation, e-portfolio, achievements recognition, motivation and training those who can improve the level of digital competency.

The authors of the article claim, that the defined challenges impeding higher education technology adoption can be solved by building and applying the digital learning environment. Thus, the digital learning environment contributes authentic learning experiences, improving digital literacy, adapting organizational designs to the future of work, advancing digital equity.

Research Tasks:

1. Provide a theoretical model of the university digital educational environment expertise and to build a statistical factor model of the university digital environment.
2. Analyze if the digital educational environment of the Ukrainian universities corresponds to the digital and educational trends.

Assumptions:

1. The digital environment model planned to build using the statistical methods and models corresponds to the suggested theoretical model.
2. The universities digital environments development reacts to modern technologies and educational trends. That is also one of the tools to overcome the challenges impeding higher education technology adoption and to improve on the higher education quality.

3.2 Instruments and Participants

We performed the expert estimate of the university digital environment by means of online inquiry and in-depth interview (in case if we needed elaborateness). We distributed the survey (https://forms.gle/7h56MAxf5JAGQ9Eh6) with mailout and specific-purpose contacts with the educational institutions.

To perform the expertise of the university digital environment for our research we invited masters and teachers (professors) from the best universities of Ukraine (where 70% are research universities). Mostly, our respondents' occupations lie in the field of Mathematics, Computer programming, IT (28%), Education (22%), those are considered to be the top-priorities in Ukraine. The age, gender, and positions of the sampled population represent the real situation in the educational institution: there are more students and teachers, the age of students and teachers corresponds to the age-grade in general, there are more women among the respondents that is natural gender correlation for the educational institutions in Ukraine. The research didn't take into account the connections between the features, fields of occupation and the educational institutions, that is why it can't be considered from that point of view. Mostly, our respondents had assessed to the computers and to the international scientific databases. The non-sampling error on the studied features didn't exceed 9% (123 person). The full list of the estimated features that reflect personal data of respondents is provided in Table 1. Every feature has calculated beforehand descriptive statistics and constructed frequency distributions.

Table 1. The main characteristics of the respondents

Feature	Category of a feature	Meaning	Percent / Descriptive statistics
Gender	1	Male	**26,00%**
	2	Female	**74,00%**
Status	1	Student (Magister)	**59,00%**
	2	Teacher (Professor)	**41,00%**
The University	1	National University of Life and Environmental	**40,00%**
	2	Boris Grinchenko Kyiv University	**20,00%**
	3	National Aerospace University "KhaI"	**7%**
	4	Taras Shevchenko National University of Kyiv	**6,00%**
	5	National Pedagogical Dragomanov University	**11%**
	6	National Technical University «Kharkiv Polytechnic	**5,00%**
	7	Lviv Polytechnic National University	**6%**
	8	Others	**5,00%**
Availability of mobile and technical devices	1	Always	**67,00%**
	2	Not always	**32%**
	3	The availability is restricted, I can hardly use devices	**1,00%**
Access to international science and technology databases	1	Always	**18,00%**
	2	Not always	**62,00%**
	3	The availability is restricted as the full access requires money	**20,00%**
Age		Age of respondents	**Mean=31,01**
			Median=23,5
			Mode=22,0

Knowing the level of the respondents' digital competency is essential to conduct an estimation of the digital educational environment. Mostly, our respondents evaluated heir levels as middle and advanced proficiency [17]. In addition to the questions on the research topic, they had to answer if they had registered profiles in the scientific databases such as Web of Science (WOS) or Scopus, personal profiles in the ResearchGate social network, publications in the online journals or experience in informal education. We added these questions to understand if our experts are ready to overcome such challenges as advancing digital equity and participating cross-institution & cross-sector collaboration. The answers we received were mostly positive. Those respondents who had no profiles in scientific databases or experience with online conferences and courses claimed they wished to have that experience and believe in its importance. Herewith, we observe an obvious statistical connection between the estimated level of the respondents' digital competencies and the answers to the mentioned questions. Table 2 contains answers of our respondents.

Table 2. Distribution of answers to questions about the level of competencies gained by respondents

Feature	Category of a feature	Meaning	Percent / Descriptive statistics
Participation in online conferences and webinar	1	I participated in a conference/webinar	55,00%
	2	I organized a conference/webinar	8,00%
	3	No. I intend to take part in a conference/webinar	21,00%
	4	No. I intend to organize a conference/webinar	4,00%
	5	I don't think it's necessary	12,00%
Publications in online-journals	1	Yes, I have	46,00%
	2	Yes I have, and I am also an editor, reviewer, etc	3,00%
	3	No, I don't, but I intend to make publications	38,00%
	4	No, I don't. I don't think it's necessary	13,00%
Profile in the ReserchGate social network	1	Yes, I am an active member	6,00%
	2	I have a profile, but I hardly use it	18,00%
	3	I don't have a profile, though I plan to create it	42,00%
	4	I don't have a profile, I don't think it's useful	34,00%
Profile in the WOS or Scopus databases	1	Yes, I have publications in these databases	19,00%
	2	I have a profile, but I don't have my own	23,00%
	3	I don't have any publications yet, but I have them in my plans	28,00%
	4	I don't have any publications, I don't think I need them	30,00%
Experience in informal studying	1	Yes, I am. I am an active listener of MOOCs	44,00%
	2	Yes, I am an author for MOOCs	5,00%
	3	No, I don't, but I have it in my plans	38,00%
	4	No, I don't. I don't think I need it	13,00%
Own level of the digital competency	1	0	3,00%
	2	1	4,00%
	3	2	27,00%
	4	3	51,00%
	5	4	15,00%

Thus, we can claim that aggregated values on the selection that we received correspond to the goals of our research. The level of competencies allows teachers and students (masters) who participated in our survey to be the experts.

The questionnaire contained two question pools considering the students and teachers attitude to the educational information environment of the university, the need for the environment development, and the questions considering the respondents' personal data and competency level.

The questions consider the university digital learning environment, which our theoretical model consider as 4 interacting components. The questionnaire has 4 sections that correspond to 4 components: space-semantic, technological, communicative, and competency-based. Each section contains from 6 to 14 assertions. The respondents estimated if the mentioned components are available in their educational environments (1st group of questions) from 1 to 4 points (where 1 stand for the poor level of availability, 2 is for middle level of availability, 3 is the enough level and 4 stands for the expert level). The respondents estimated the importance and availability of improvement for the mentioned components (2nd group of questions) from 1 to 3 points (where 1 stands for low, 2 for the middle, 3 for high). For example, respondents have a request "Please rate the proposed components of the environment on a scale of 0-4" and several assertions such as: "Your university has access to broadband internet", "You can access the internet in every lecture hall in your university", etc.

3.3 The Methods and Models of Data Processing

The choice of methods is determined by the purpose of the study. We needed to process a rather large array of statistical data and identify the main patterns. During the research, we applied the methods of descriptive statistics to find the frequency distribution and to define the central tendency rates. To prove the hypothesis we stuck to the statistical inferences methods and models. The method selection based either on the type of the scale used for estimation or on the datatype of the features we had to estimate. To analyze connections between the features we applied the methods of correlation and regression analysis. The calculations were conducted based on the sampled population, and the statistical results were verified at the 95% integrity level.

During the study, it was necessary to consider a large number of variables that describe the digital environment of the universities. However, it is difficult to identify patterns in a large array of features without data reduction. With factor analysis, we managed the empirical data received in the survey, performed the data reduction and shortened the number of features, in order to study the received model structure of the educational environment of the university. The factor analysis was performed in accordance with the basic stages: defining the preliminary features to be reduce, building a correlation matrix to find the connection between the elements, defining the methods of data reduction, choice and explanation of the main factors, calculations and interpretation of the results we received.

The analysis is not reliable if the basic requirements for the reliability of data and measurement scales are not taken into account. To estimate the reliability of suggested scales we used the intraclass correlation coefficients so that later we could calculate the 'intra respondents' estimates of reliability. To find out the internal consistency in the survey we found the Cronbach's alpha and Spearman-Brown coefficient. The calculations were done mostly using SPSS software [18, 19].

4 Results of Research

4.1 The Results of a Survey Reliability Estimate

At the first stage of our research, we estimated the reliability if the respondents' answers and analyzed what different kind of analysis we can apply.

For the questions on the university digital learning environment, we performed separate analysis considering the availability of required components in their learning environments. Just the same we performed a separate analysis on the components' level of development and on ways to improve some component.

For both these questions the Cronbach's alpha and Spearman-Brown coefficients were quite good: Cronbach's alpha — 0.981 and 0.978; Spearman-Brown — 0.902 and 0.861. According to the correlation matrix we built, the correlation of some points of the survey was equal to 0.78-0.79. That means, that the features used to build the theoretical model shared common agents that can be combined. The received numbers are reliable, that we proved with the Fisher coefficient equal to $p<0.05$.

4.2 Using Factor Analysis to Model the Informational and Educational Environment of the University

At the next stage, we leveraged the factor analysis based on the method of main components [20, 21]. This method allows reducing the number of features that describe the university digital learning environment in accordance with a theoretical model build before. The factor analysis validity was proved both when evaluating the respondent's answers and based on query obtained from the Kaiser-Meyer-Olkin measure of sampling adequacy and Bartlett's test of sphericity [18].

Besides that, we calculated these criteria for the questions that consider the availability of the required components (group 1) and the importance of components development and improvement (group 2).

The Kaiser-Meyer-Olkin measure of sampling adequacy for the questions in the 1st group is equal to 0.9. High criteria value (from 0.5 to 1) proves that the factor analysis was viable in this case. Low values (less than 0.5) prove that the factor analysis is not beneficial for the specific situation. Thus, for our case, we can use the factorial analysis. The Bartlett's value of sphericity is equal to 9132.97 at df=2080, that is large for the $p<0.001$ level, and also proves that factorial analysis is beneficial for this specific case.

The value of Kaiser-Meyer-Olkin criteria for the questions of the 2nd group is equal to 0.802. The Bartlett's value of sphericity is equal to 8599.164 at df=2080, that is large for the $p<0.001$ level. This group is also appropriate to use the factor analysis.

At the next stage, we defined a number of factors. There are several methods to do so, such as to calculate the proper values, or to use a scree plot and Kaiser's criterion [18]. However, for this research, we considered the worked through the information of the problem structure that we received from the previous stages of the research and confirmed that structure with statistics (namely, with the sampling variance percentage). As a rule, the researchers recommend selecting the number of factors that samples at least 60% of the variance.

Based on the environment expertise results and theoretical analysis we received before, we selected the 4 factor model of the university digital learning environment that has such components as special equipment and Internet access, educational websites and portals, teachers' and students' digital competencies and communication, and a well-organized process of education.

According to the sampling variance percentage criteria, we can claim that 4 factors for the 1st group of questions sample over 60% of the variance (63.51%), and almost 60% for the 2nd group 58.27% (see tables 3 and 4). In these tables, you can also find the sampling variance percentage after we turned the matrix of main components. The numbers in the 'variance %' column proves that the components we've built are quite informative.

We can see that in the 1st group of questions 3 groups of components sample the part of variance (20.85%, 17.07% , 16.2%), while for the 2nd group the distribution is more smooth between 2 first components (16.76%, 16.53%) and 2 following components (13.82% , 11.16%). Thus, some factors in the information environment correlate more, and so explain the percentage of the factors variation, while the importance of development is the same for all components. For the factor rotation, we utilized a common rotation method "varimax" that minimizes the number of variables with high values and increases the possibility for factor interpretation.

Table 3. The percentage of sampling variance for the 1st group of questions that consider the availability of required components in the learning environments

Component	Load sum of squares extraction			Load sum of squares after rotation		
	Total	Whole % variance	Summary %	Total	Whole % variance	Summary %
1	30.156	46.394	46.394	13.554	20.852	20.852
2	5.399	8.306	54.7	11.097	17.072	37.924
3	3.248	4.997	59.697	10.529	16.199	54.122
4	2.48	3.816	63.513	6.104	9.391	63.513

Table 4. The percentage of sampled variance for the 2nd group of questions that consider the importance of the development of components and the ways of how can be improved

Component	Load sum of squares extraction			Load sum of squares after rotation		
	Total	Whole % variance	Summary %	Total	Whole % variance	Summary %
1	28.019	43.106	43.106	10.894	16.76	16.76
2	4.35	6.692	49.798	10.741	16.525	33.285
3	3.022	4.649	54.447	8.985	13.824	47.109
4	2.482	3.818	58.265	7.251	11.156	58.265

At the following stage, we received rotated solutions of the factor matrix, that allowed us to combine the features according to the results of the factor values of the 4 separate components. In tables 5 and 6 you can see the fragments of the factor loadings, as they were quite a lot of features for every group. We should also mention that the features for the groups 1 and 2 were grouped with different approaches, so the main components were interpreted separately.

Table 5. A part of the factor loads matrix of the learning environment model those correspond to the availability of components in their learning environments (Group 1)

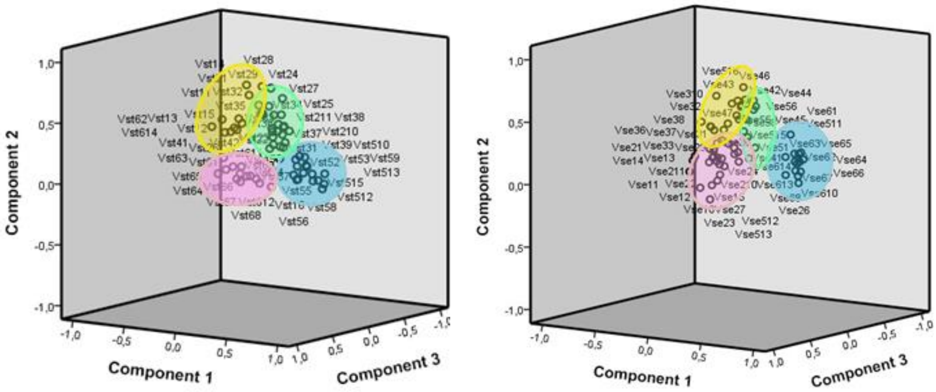
Features	Components			
	1	2	3	4
Teachers' usage of Internet social services	0.825	0.066	0.211	0.107
Participation in scientific communities in the university	0.806	0.024	0.209	0.283
Students' participation in scientific social networks	0.806	0.143	0.175	0.196
Teachers' participation in scientific social networks	0.801	0.1	0.26	0.116
Teachers' participation in the professional Internet-communities	0.778	0.158	0.311	0.162
Students' participation in the professional Internet-communities	0.738	0.298	0.357	0.075
Searching and inviting the experts (scientific consultants, mentors, etc.)	0.734	0.226	0.33	0.264
Consultations and reviewing, in particular at the webinars and in Internet-communication	0.696	0.305	0.369	0.098
Students' publications in online journals	0.687	0.116	0.377	0.146
Students' participation in online conferences	0.684	0.223	0.385	-0.108
Students' usage of Internet social services	0.681	0.069	0.161	0.004
Teachers' publications in online journals	0.677	0.111	0.381	0.075
Teachers' participation in online conferences	0.675	0.156	0.421	-0.021
Teachers' usage of emails, in particular, the corporate accounts	0.602	0.131	0.182	0.25
Students' usage of emails, in particular, the corporate accounts	0.594	0.174	0.12	0.161
Systematic publications of records about the completed plans, scientific activities, cooperations, etc.	0.537	0.367	0.2	0.366

Table 6. A part of a matrix of the factor loads of the learning environment model those correspond to the availability of components in their learning environments (Group 2)

Features	Components			
	1	2	3	4
The level of students' digital competency	0.832	0.267	0.195	0.079
Experience utilizing digital competencies in scientific work	0.814	0.26	0.286	0.097

Training courses on boosting digital competencies for teachers	0.8	0.317	0.183	-0.041
Presentation of the teachers’ achievements (e-portfolio)	0.795	0.163	0.18	0.292
Self-estimate of the digital competence	0.793	0.18	0.248	0.196
The level of teachers’ digital competency	0.789	0.074	0.2	0.188
The research results approbation	0.788	0.307	0.196	0.126
Publishing the results of scientific researches	0.781	0.229	0.209	0.249
Training courses on boosting digital competencies for students	0.769	0.31	0.226	0.132
Recognition of results in the scientific community: personal profiles in scientometric databases, certificates, patents, etc.	0.753	0.12	0.157	0.261
Support from the IT-departments	0.728	0.289	0.291	0.115
Presentation of the students’ achievements (e-portfolio)	0.718	0.455	0.207	-0.017
Distant learning	0.676	0.128	0.213	0.278

We defined the variables that have high load values on the same factor. Then, we analyzed this factor considering the mentioned variables. We also interpreted the variables’ graphics, those coordinates the factor loads (Figure 1.).



Group 1 Group 2

Fig. 1. The graph of the contribution of characteristic values to the main components: groups 1, 2 (Source: Own work)

As a result, we received a confirmation for the university digital learning environment theoretical model we built, as with small deviations we managed to combine and group features into four components.

Here we suggest a data interpretation of receive four-factor model for the 1st and 2nd groups. We found a common factor that corresponds to the competency-based component that we defined both rot 1s and 2nd groups. To the 2nd group got an additional element "distant learning" (see Table 6), that we can explain as the readiness of teachers and students for self-education and online study mode. Today, (group 1) the face-to-face courses are used mostly for improving the level of competencies in the universities. The other factors for the 1st and 2nd groups differ.

The second factor (group 1) has high factor loads connected by technological and space-semantic component. The respondents in the available environment do not distinguish the space-semantic component, yet consider the technological component as an optimal combination of infrastructure, resources topology and educational technologies. The third factor (group 1) corresponds to the communicative component that has features of scientific communication by means of digital technologies (Table 5). This component also included the variables connected to the returns automation and systematic academic and scientific journals declaration, and students and teachers mobility (technological component). Thus we can make an assumption on the availability of communication management from the university. The fourth factor (group 1) we would explain as collaborative and research component, as it contains the variables of monitoring and correcting the process of environment usage for self-guided work, formatting the messages of education according to the student's requests, learning in cooperation, applying inquiry-based learning, using e-library, wiki-portal, and availability of internet traffic. Thus, we can argue defining a component that combines separate features of space-semantic, technological, and communicative components and corresponds to trends in education.

Among the factors of university digital environment development (group 2) space-semantic component corresponds a lot to the theoretical model. The respondents assume that building a modern infrastructure and resources topology is a basis to build the university digital environment. The third factor included the variables connected to the educational and scientific communication (communicative component) and organization of the process of education (technological component). In the improved environment (group 2), the respondents consider communication resources and pedagogic strategies to be a part of the technological process. For example, preparation, organization, and participation in the conferences must be conducted in terms of learning (self-conducted work), researching, and leveraging training projects. The fourth factor, that we can call communicative and dissemination, has such features are participating scientific societies, using the social services, wiki portals, creating and supporting websites of departments, participating research projects, etc. Thus, we can assume this component to mostly correspond to the communicative component. Though, at the same time, it includes some features of the competency-based component, connected to the presentation of the achievements and reports automatization.

4.3 Development Analysis of the Ukrainian Universities Digital Learning Environment

Comparing to the environmental expertise of 2013 [15] we can claim the results repeatability. The model of the university digital learning environment that we received by leveraging the factor analysis corresponds to the theoretical model of the information and educational environment both for 1st and 2nd-factor groups. However, we observe the development that corresponds to modern requirements [3].

3. The research of 2013 didn't highlight the *competency-based component*. Though in the available environment (group 1) and in the improved environment (group 2) this component corresponds to the theoretical model. Therefore, it is possible to express assumptions regarding the strengthening of the competence potential of the digital learning environment. This doesn't only support improving digital literacy but also advancing digital equity.
4. In 2013, 2 factors corresponded to the *space-semantic component* of the theoretical model. The respondents told off the topology of resources and It infrastructure, that can tell us about a probable lack of resources in the universities. Today, students and teachers do not tell off the space-semantic component, and its features are generally considered together with the technological component. This can mean that the infrastructure, communication, and information support are sufficient, but the students are not involved enough. The teaching practices in the digital environment are generally created by teachers and oriented for the traditional process of education. In the improved environment (group 2) the space-semantic component corresponds to the theoretical model, and the respondents have clear requirements to the equipment and resources. This fact can be a basis to implement a course of individual studying and to start changes in the field of teaching considering the request and authentic learning experiences.
5. The *technological component* was defined in all groups, though its interpretation differs. In 2013 organization of the educational process depended on the teachers' digital competencies. In the 1st group environment it's the optimal combination of the infrastructure, resources topology and educational technologies. The improved 2nd group environment considers a scientific and educational communication as an educational technology. We can explain it with readiness to use digital environment in cooperation, in network communities, to develop it with personal experience to be up-to-date and correspond with trends in education, such as interdisciplinary studies i cross-institution and cross-sector collaboration.
6. The *communicative component* is also defined in all groups. In 2013, in the 1st group, these components corresponded to the theoretical model, while in the improved environment (2nd group) it's more about the outer communication that allows to making new connections, finding partners, experts, etc. The latest corresponds to the needs of cross-institution & cross-sector collaboration and adapting organizational designs to the future of work in the condition of digitalization. We should mention that distinguishing a component of collaboration and research in the 1st group environment can be a transition to the development of the communicative and dissemination component of the 2nd group.

5 Conclusions

We used factor analysis to confirm the theoretical model. We used it to find 4 main components that group all the factors of the digital educational environment into such areas of focus as IT infrastructure and resources' provision, students' and teachers' digital competencies, scientific and educational communication between the students, teachers, and stakeholders, and educational process organization.

Comparing to the results of similar researches, even if we take into consideration the global development of the distance learning, online courses, open electronic resources, and redesigning learning spaces, we observed no significant changes on the main factors during the 2013-2018. However, messages, contents, and scopes change.

Both students and teachers claim that enabling digital learning environment as an improvement of the existing learning environment correlates to the mid- and long-term key trends accelerating higher education technology adoption: proliferation of open educational resources, the rise of new forms of interdisciplinary studies; advancing cultures of innovation, cross-institution & cross-sector collaboration. Effective implementation of the digital learning environment, both at the stage of designing and applying its methods, helps to overcome significant challenges impeding higher education technology adoption. Thus it empowers implementation of authentic learning experiences and improving digital literacy (solvable); adapting organizational designs to the future of work, advancing digital equity (difficult). However, having good enough IT-infrastructure, equipment, and level of digital competencies of the educational process participants, the solution of the problem depends more on the rethinking the roles of educators in the digital learning environment.

We consider the pedagogic design of the educational and scientific cooperation in the digital learning environment to be a prospective field for further research. We need to find out what factors influence the competencies of the digital environment participants most of all.

Repeating the digital learning environment expertise after a period of time for more respondents, and engaging participants (universities) from different countries will allow us to find out if the universities are ready for transformation to confirm the demands of the modern digital society.

References

1. World Economic Forum World Economic Forum http://www3.weforum.org/docs/GCR2018/05FullReport/TheGlobalCompetitivenessReport2018.pdf, last accessed 2019/10/03.
2. The Digital Enterprise: moving from experimentation to transformation http://www3.weforum.org/docs/Media/47538_Digital%20Enterprise_Moving_Experimentation_Transformation_report_2018%20-%20final%20(2).pdf, last accessed 2019/10/03.
3. Becker, S., Brown, M., Dahlstrom, E., Davis, A., DePaul, K., Diaz, V. and Pomerantz, J.: NMC Horizon Report 2018: Higher Education Edition. Louisville, CO: EDUCAUSE, 2018, https://library.educause.edu/~/media/files/library/2018/8/2018horizonreport.pdf, last accessed 2019/10/03.
4. Morze, N., Kuzminska, O., Protsenko, G.: Public Information Environment of a Modern University: ICT in Education, Research and Industrial Applications: Integration, Harmonization and Knowledge Transfer. CEUR Workshop Proceedings, pp. 264–272, http://ceur-ws.org/Vol-1000/ICTERI-2013-p-264-272.pdf (2013).

5. Bryson, C., & Hand, L.: The role of engagement in inspiring teaching and learning. Innovations in Education & Teaching International, 44(4), 349-362 (2007).
6. Kuzminska, O., Morze, N., Smyrnova-Trybulska, E.: Flipped learning model: Tools and experience of its implementation in higher education, The New Educational Review Vol. 49, No. 3, pp. 189-200. DOI: 10.15804/tner.2017.49.3 (2017).
7. Smyrnova-Trybulska, E., Noskova, T., Pavlova, T., Yakovleva, O. and Morze, N.: New educational strategies in the contemporary digital environment, International Journal of Continuing Engineering Education and Life-Long Learning, Vol.26 No.1, pp.6 – 24, DOI: 10.1504/IJCEELL.2016.075036 (2016).
8. Wheeler, S.: E-Learning and digital learning. In N. M. Seel (Ed.), Encyclopedia of the sciences of learning, pp. 1109–1111, New York: Springer (2012).
9. Smyrnova-Trybulska, E., Morze, N., Glazunova, O.: Design of a University Learning Environment for SMART Education, Smart Technology Applications in Business Environments, DOI: 10.4018/978-1-5225-2492-2.ch011 (2017).
10. Digital Learning Environment Manifesto, http://manifesto.edutainme.ru/en, last accessed 2019/10/03.
11. Drlík, M., Švec, P., Kapusta, J., Munk, M., Noskova, T., Pavlova, T., Yakovleva, O., Morze, N., Smyrnova-Trybulska, E.: Identification of Differences in University E-environment between Selected EU and Non-EU Countries Using Knowledge Mining Methods: Project IRNet Case Study, International Journal of Web Based Communities (IJWBC), Vol. 13, No. 2, DOI: 10.1504/IJWBC.2017.10004116 (2017).
12. Center for Studies in Higher Education. The University of California, Berkeley, 2009, https://cshe.berkeley.edu/seru, last accessed 2019/10/03.
13. Quality management principles, https://www.iso.org/files/live/sites/isoorg/files/archive/pdf/en/pub100080.pdf, last accessed 2019/10/03.
14. Witl, M., Dompseler, H.: How to create a digital learning environment consisting of various components and acting as a whole?, http://www.eunis.org/download/2017/EUNIS_2017_paper_16.pdf, last accessed 2019/10/03.
15. Panchenko, L.: Modeling the Informational Educational Environment of University with Factor Analysis, Bulletin of the University of Luhansk, № 10 (269), P. III, pp. 6-17, http://nbuv.gov.ua/UJRN/vluf_2013_10(3)__3 (2013) (in Ukrainian).
16. Reproducibility gold standard, https://www.coursera.org/learn/data-results/lecture/KOraT/reproducibility-gold-standard, last accessed 2019/10/03.
17. Kuzminska, O., Mazorchuk, M., Morze, N., Pavlenko, V., & Prokhorov, A.: Digital Competency of the Students and Teachers in Ukraine: Measurement, Analysis, Development Prospects. In: Information and Communication Technologies in Education, Research, and Industrial Applications, Communications in Computer and Information Science, vol. 2104, p. 366-379 (2018).
18. Levesque, R.: SPSS Programming and Data Management, 2nd Edition A Guide for SPSS and SAS Users. Chicago: SPSS Inc. (2005).
19. Carmines, E., Zeller, R.: Reliability and validity assessment. London, Sage Publications, Quantitative applications in the social sciences series no. 17 (1979).
20. Kutner, M., Nachtsheim, C., Neter, J., and Li, W.: Applied Linear Statistical Models, McGraw-Hill/Irwin, Homewood, IL. (2004).
21. Jolliffe, I.: Principal Component Analysis, 2nd Edition. Springer-Verlag New York, Secaucus, NJ. (2002).

The Blended Methodology of Learning Computer Networks: Cloud-based Approach

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Abstract. The article considers the use of blended learning as an effective methodology of encouraging students' cooperation in the process of solving practical problems and as a means of developing their essential professional skills. The following pedagogical approaches and techniques of blended learning are discussed: combination of face-to-face and distance learning, group members' partnership, development of group work skills, heterogeneous grouping, combined use of individual and peer assessment, teacher's monitoring of the students' work, task-oriented approach, chance for every member to be a leader, essential feedback. The authors suggest using private and public cloud technologies in an integrated academic cloud to support the implementation of group methodology in the teaching process. The analyzed academic cloud includes Apache CloudStack and EVE-NG Community platforms. This cloud environment was deployed at Physics and Mathematics Department of Volodymyr Hnatiuk National Pedagogical University of Ternopil (Ukraine). The developed methodology is used in course "Computer Networks". It has been verified experimentally by using appropriate statistical methods.

Keywords: blended learning, ICT-competence, cloud-based environment, Apache CloudStack, EVE-NG Community, computer science trainee teachers.

1 Introduction

Development of cloud technologies visibly affects both the aims and the content of ICT education. In view of this, researchers are currently looking for new and improving the existing forms and methods to combine the benefits of face-to-face and online learning.