

The Use of ICTs in the Digital Culture for Virtual Learning of University Students Applying an Artificial Neural Network Model

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Abstract—Artificial neural networks are mathematical models of artificial intelligence that intend to reproduce the behavior of the human brain and whose main objective is the construction of systems that are capable of demonstrating certain intelligent behavior. The purpose of the investigation is to determine the influence of the use of Information and Communication Technologies (ICTs) in the digital culture in the learning process of university students in Peru and Bolivia in the context of the Coronavirus – COVID 19 sanitary emergency, through the application of artificial neural network models. The investigation has a quantitative focus, the applied type, with a correlational level and a non-experimental design. Data was recollected by means of a digital questionnaire, applied to students of two universities. The population is composed of 3980 students of the Universidad Privada Domingo Savio (UPDS, Tarija, Bolivia) and 1506 of the Universidad Nacional de Moquegua (UNAM, Moquegua, Peru). The sample consists of 496 students. The hypothetical-deductive and the artificial intelligence methods were used. It was determined that the ability to install software and data protection programs, the use of mobile devices for academic purposes and the command of specialized software are the most influential factors in the digital culture of the students at UNAM and UPDS.

Keywords—Artificial neural network; digital culture; ICT; virtual learning; COVID 19

I. INTRODUCTION

In [1], the complexity of the human brain is amazing, consisting of hundreds of billions of neurons with billions of connections that make the neural function of the brain very complex. In [2], the artificial neural networks are systems that simulate the properties that are observed in the biological diversity through mathematical models that are recreated by artificial mechanisms. Artificial neural networks are information processing systems that are inspired by the behavior of biological neural networks [3], [4], [5]. The artificial neural networks are mathematical models that are inspired by the biological neural systems, like the human brain, and can be considered as a data processing technique that maps, or relates, a certain type of entry information flow with an exit processing flow. There are variations of artificial neural networks to perform classification tasks, pattern

recognition and prediction [6]. Artificial neural networks stand out as an automatic learning technique, due to their ease of use and comprehension compared to statistical methods, and their good performance in different automatic learning tasks [7][8].

ICTs include any communication device, such as computers, telephones, television, radio, etc., as well as services and software that work with devices, such as e-mail, software used for management, learning, videoconferencing, and so on [9]. The use of ICTs enhances student protagonism [10], keeping them up to date with technological development to maintain their sustainability in time [11].

Digital culture is the influence of technology on the behavior of people [12]. In [13], digital culture can be identified as a component of the actual digital transformation and as an epistemological obstacle in the sociological analysis of the same phenomenon. Digital culture are the abilities, knowledge, creativity and attitudes necessary to use in digital media in order to learn and comprehend in a knowledge society [14].

This article demonstrates the application of a model of an artificial neural network to explain the use of ICTs in the digital culture of students at two universities in Peru and Bolivia. The artificial neural networks that were used have an input layer of 11 units, a hidden layer of 5 units and an output layer of 1 unit, as well as training and test or validation data of the neural models. The artificial neural networks demonstrate that the dimensions that have the greatest influence in the digital culture are the ability to install software and data protection software, the command of mobile devices for academic purposes and the command of specialized software, according to the models of UNAM and UPDS.

The content of the article is organized as follows: Section II gives a short review of the state of the art in ICT, digital culture and artificial neural networks; Section III describes the methodology used in the investigation; Section IV describes and analyses the results that were obtained; Section V discusses the results; Section VI describes the final conclusions of the investigation; finally, the description of the future work that could be implemented to improve the obtained results.

II. RELATED WORK

In [14] aspects of the digital culture of student in the Faculty of Humanities and Pedagogy are described; general characteristics like cyber culture, the level of use of software, the use of technological devices and their digital abilities. [15], revises and synthesizes the expectations of employers in terms of digital abilities of graduates, the steps and measures taken by institutions of higher education to prepare students and to take advantage of their motivation to be more competitive and satisfy the needs of employability in the Fourth Industrial Revolution, supplying information about the digital alphabetization abilities that are required of young graduates, their expectations, and how digital alphabetization can be developed in institutions.

For [16], the ICTs have become a part of everyday life of people in business, entertainment, education and many other areas of human activity. Students have just begun to learn and accept new ideas, show a mature creativity, develop critical thinking and the ability to make decisions. In education, the successful integration of ICTs in learning and teaching depends on the attitudes of the teachers and their capacity to use the technology of communication not only competently but also with ability and imagination. According to [17], the access of ICTs in the world has increased, but there is still a gap between the necessity of ICT infrastructure and its availability.

According to [18], the objective of the investigation was to connect the ICTs with the distribution processes and the use of knowledge in the institutions of higher education. There was evidence that the profiles of the universities to implement knowledge management are focused on two components: the distribution and the use of knowledge. Among the more relevant results, it can be highlighted those two main profiles were found that characterize the process of knowledge management using ICTs. The strength of the first group lies in the component of investigation, which means it manages the promotion and diffusion of investigation in academic spaces. On the other hand, the second group's major strength lies in ICTs for the use of knowledge, which indicates that the universities in the second group focus their efforts on the management of ICTs as a means of knowledge management.

In the last decades, [19] artificial neural networks have gained significant attention in a part of the scientific community, as a technique that creates and combines multiple models of automatic learning to produce an optimal model that obtains the best results.

The use of neural networks is an area of growing interest, especially due to the availability of large quantities of information from multiple sources [20]. The algorithms of Artificial Intelligence (AI) have been used frequently to model complex functions for which the traditional mathematical methods no longer suffice. The artificial neural networks are one of the artificial intelligence methods that have the capacity to perform highly accurate simulations with potent learning algorithms and training capacities [21]. For [22], the neural network is an automatic learning algorithm. Neural networks help to simulate the functioning of the human brain [5].

III. METHODOLOGY

The investigation has a quantitative focus, the applied type, with a correlational level and a non-experimental design. The data were recollected through a digital questionnaire, implemented by means of the Google Forms tool, sent to students of two universities, one in Peru and the other in Bolivia. The population consisted of 3980 students of the Universidad Privada Domingo Savio in Bolivia and 1506 students of the Universidad Nacional de Moquegua in Peru. The sample consisted of 496 students (306 of the UPDS and 190 of the UNAM), for which the Stratified Random Sampling method was used. For the variables use of ICT and digital culture, questionnaires were used as the technique and a digital questionnaire as the instrument. The hypothetical-deductive method and artificial intelligence were applied.

The variables used in the investigation are the following:

- 1) Access to ICTs.
 - a) Computer and communication resources.
 - b) Command of Microsoft Office applications.
 - c) Command of specialized software.
 - d) Use of mobile devices for academic purposes.
 - e) Use of computer accessories.
 - f) Ability to install software and data protection programs.
- 2) Digital culture.
 - a) Study habits in a virtual environment.
 - b) Use of computer and communication resources in the learning process.
 - c) Use of digital resources in the learning process.
 - d) Command of video conferencing software.
 - e) Frequency of use of computers and devices for academic and investigation purposes.
 - f) Frequency of consulting virtual libraries and internet search engines.
 - g) Frequency of use of social networks for academic purposes.

IV. RESULTS

A. Modeling, using an Neural Network

These are the processing results of the artificial neural networks for the Universidad Nacional de Moquegua and Universidad Privada Domingo Savio students.

The results of Table I demonstrate that the artificial neural networks used 11 units in the input layer, 5 in the hidden layer and 1 unit in the output layer. The standardized method was used as the rescaling method for the scale dependents to improve the training of the neural network. The hyperbolic tangent was used as the activation function of the hidden layers. Identity was used as the activation function of the unit of the output layer.

Fig. 1 shows the model of the artificial neural network for UNAM. The blue lines are the negative synaptic weights, and the gray lines are synaptic weights with positive values.

TABLE I. NETWORK INFORMATION

Input Layer	Factors	1	Gender
		2	Marital status
	Variates	1	Computer and communication resources
		2	Command of Microsoft Office applications
		3	Command of specialized software
		4	Use of mobile devices for academic purposes
	5	Use of computer accessories	
6	Ability to install software and data protection programs		
Number of Units ^a		11	
Rescaling Method for Variates		Standardized	
Hidden Layer(s)	Number of Hidden Layers		1
	Number of Units in Hidden Layer 1 ^a		5
	Activation Function		Hyperbolic tangent
Output Layer	Dependent Variables	1	Digital Culture
	Number of Units		1
	Rescaling Method for Scale Dependents		Standardized
	Activation Function		Identity
Error Function		Sum of Squares	

a. Excluding the bias unit.

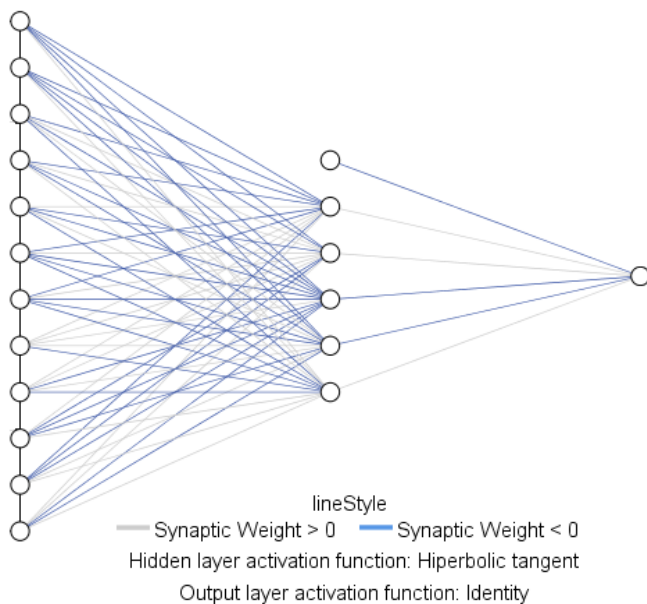


Fig. 1. Artificial Neural Network of UNAM.

Fig. 2 shows the Artificial Neural Network model for UPDS. The blue lines are the negative synaptic weights, and the grey lines are synaptic weights with positive values.

In Table II, it is observed that the neural network model for UNAM considers 66.3% of the data for training and 33.7% for testing or validation of the model.

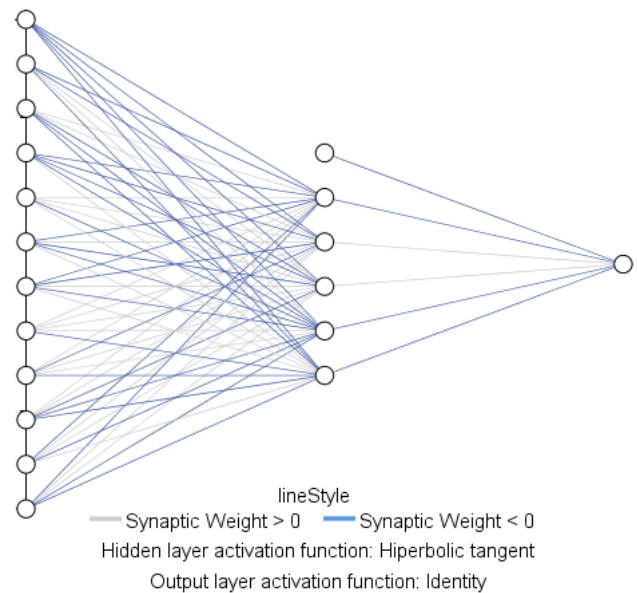


Fig. 2. Artificial Neural Network of UPDS.

TABLE II. CASE PROCESSING SUMMARY - UNAM

Case Processing Summary			
		N	Percent
Sample	Training	126	66.3%
	Testing	64	33.7%
Valid		190	100.0%
Excluded		0	
Total		190	

In Table III, the neural network model for UPDS considered 70.9% of the data for training and 29.1% for testing and validation of the model.

TABLE III. CASE PROCESSING SUMMARY - UPDS

Case Processing Summary			
		N	Percent
Sample	Training	217	70.9%
	Testing	89	29.1%
Valid		306	100.0%
Excluded		0	
Total		306	

Table IV represents the results of the training and testing process of the artificial neural network of the Universidad Nacional de Moquegua in Peru.

TABLE IV. MODEL SUMMARY - UNAM

Training	Sum of Squares Error	14.533
	Relative Error	0.233
Testing	Sum of Squares Error	7.720
	Relative Error	0.271

Dependent Variable: Digital Culture

a. Error computations are based on the testing sample.

Table V shows the results of the training and testing process of the artificial neural network of the Universidad Privada Domingo Savio in Bolivia.

TABLE V. MODEL SUMMARY - UPDS

Training	Sum of Squares Error	18.476
	Relative Error	0.171
Testing	Sum of Squares Error	10.615
	Relative Error	0.234

Dependent Variable: Digital Culture
a. Error computations are based on the testing sample.

Table VI shows, the importance of the independent variates is observed. This measurement indicates the size of the variation of the value that is predicted by the network for

different values of the independent variates. The variates are ordered by importance, from major to minor, with the variates of Ability to install software and data protection programs, use of mobile devices for academic purposes and command of specialized software as the most important ones for the network to predict the digital culture for the UNAM and UPDS models.

A comparative table (Table VII) is presented to know the realities about the use of information and communication technologies in higher level educational entities, referenced with results in other research works: Universidad Católica Andrés Bello - Venezuela, Universidad de Extremadura-España, Universidad Privada Domingo Savio - Bolivia, Universidad Nacional de Moquegua-Peru and Universidad Nacional de Cordova - Argentina [23].

TABLE VI. IMPORTANCE OF INDEPENDENT VARIABLES IN DIGITAL CULTURE

Independent variates	UNAM		UPDS	
	Importance	Normalized Importance	Importance	Normalized Importance
E2: Gender	0.025	8.0%	0.023	6.9%
E6: Marital status	0.050	15.8%	0.041	12.6%
D1: Computer and communication resources	0.071	22.2%	0.086	26.5%
D2: Command of Microsoft Office applications	0.039	12.4%	0.055	16.8%
D3: Command of specialized software	0.169	53.3%	0.103	31.6%
D4: Use of mobile devices for academic purposes	0.259	81.7%	0.287	88.2%
D5: Use of computer accessories	0.069	21.7%	0.080	24.6%
D6: Ability to install software and data protection programs	0.317	100.0%	0.325	100.0%

TABLE VII. COMPARATIVE ANALYSIS

Comparison of results in the use of ICTs	Universidad Católica Andrés Bello - Venezuela	Universidad de Extremadura-España	Universidad Privada Domingo Savio- Bolivia	Universidad Nacional de Moquegua-Peru	Universidad Nacional de Cordova-Argentina
Computer resources - Technological infrastructure - They have a computer		100.0%	26.5%	22.2%	100.0%
Mastery of Microsoft office applications - digital content	57.4%	50.5%	16.8%	12.4%	
Mastery of specialized software	81.2%		31.6%	53.3%	
Mastery of mobile devices for academic purposes	85.9%	77.2%	88.2%	81.7%	89.2%
Ability to install software and data protection programs - users of information technology	43.5%		100.0%	100.0%	
Internet connection at home		69.3%			89.2%
Use of virtual platform	56.2%	68.3%			98.0%
Virtual platform	Moodle	Moodle con H5P	Moodle	Plataforma SIGEUN	Classroom y Moodle
Videoconferences	Modulo 7	Zoom -Teams	Plataforma Office 365	Zoom Office 365	Zoom o Google Meet

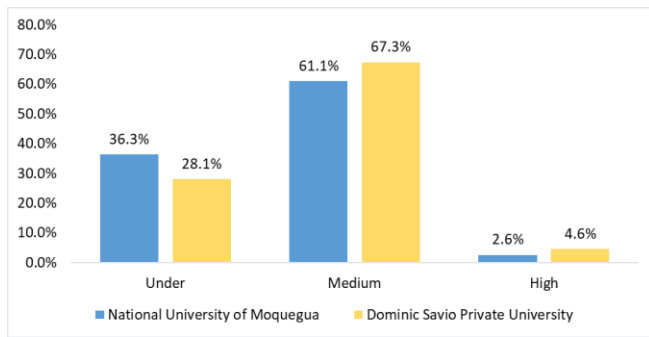


Fig. 3. Access to ICT.

Fig. 3 shows that 36.3% of the Universidad Nacional de Moquegua students have a low level of access to ICTs, compared to 28.1% of the Universidad Privada Domingo Savio students. 67.3% of the Universidad Privada Domingo Savio students have medium access to ICTs, versus 61.1% of the Universidad Nacional de Moquegua students. 4.6% of the Universidad Privada Domingo Savio students have a high level of access to ICT, compared to 2.6% of the Universidad Nacional de Moquegua students.

Fig. 4 shows that 5.3% of the Universidad Nacional de Moquegua students have a low level of digital culture, vs 7.2% of the Universidad Privada Domingo Savio students. 80% of the Universidad Nacional de Moquegua students show a medium level of digital culture vs 68.6% of the Universidad Privada Domingo Savio students. 24.2% of the Universidad Privada Domingo Savio students have a high level of digital culture vs 14.7% of the Universidad Nacional de Moquegua students.

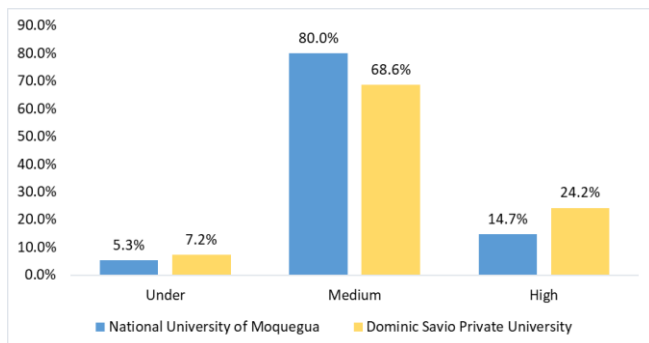


Fig. 4. Digital Culture.

V. DISCUSSION

The main characteristic of the study was to perform a comparative analysis of the use of ICTs and its implication on the digital culture of the students in two countries with similar social and economic realities in order to analyze the behavioral pattern of the Universidad Privada Domingo Savio students in Bolivia and Universidad Nacional de Moquegua in Peru.

The advantage of the methodology that was applied is that an artificial neural network can obtain reliable results due to its tolerance to errors and because it is permissive to the intervention of all neurons; even when a part of the system is damaged, the total functioning is not affected as it learned

from the experience of the representative sample or from the training data. In this investigation, 11 units were identified at the entry level, 5 in the hidden layer and 1 in the output layer. They required previous training through the weight adjustment of the connections in order to find an effective solution to the problems of the weight values and elements of the input variates and output variates with numeric values.

The quality of the training data represented in Tables I, II, III, IV and V warrant the model of the adaptive learning pattern, considering that the test data suffice to generate meaningful results in the time applied to adjust the weights of the entry layers of all neurons and to validate the application of the neural networks.

The variates of ability to install software and data protection programs, use of mobile devices for academic purposes and command of specialized software predict the digital culture in each of the universities involved in the investigation, which are assumed to be a product of the digital disruption due to the use of digital platforms, advanced generations of mobile networks, the Internet of Things, cloud computing, artificial intelligence and even the digital economy, that have an effect on the teaching learning processes, which requires the construction of new models of ecosystems of education and ICTs, reason why the university authorities have to anticipate this context.

The low levels of access to ICTs in both universities, 36.3% at the Universidad Nacional de Moquegua and 28.1% at the Universidad Privada Domingo Savio are determined by the social and economic conditions of the students, on top of limited connectivity. The minimal level of intermediate access to ICT of 4.6% at the Universidad Privada Domingo Savio and 2.6% at the Universidad Nacional de Moquegua are a warning signal that an intervention of the state authorities is required to focus on the necessities and inequalities in order to diminish the vulnerability of the students and to educate and promote national development through educational policies that tend to achieve equality of opportunities.

Even if the medium level of digital culture of students at 80% and 68.6% for the Universidad Nacional de Moquegua and the Universidad Privada Domingo Savio respectively is favorable, a bigger investigation is needed to determine the positive or negative incidence in academic performance, as it can be observed that in the majority of cases, students access low quality information, or that social networks are used as a source of distraction or even tend to stimulate social isolation.

A consistency is found with [14] which describes aspects of the digital culture, cyber culture, the level of use of software, the use of technological devices and their digital abilities. In [15] the expectations of employers towards digital abilities of graduates are revised and synthesized, an aspect that is not addressed in this investigation, but which has implications when it is necessary to determine the levels of employability and to project the new competencies of graduates for labor insertion, which demands a change in the curricular structure, the study plans and the need to project tendency analysis, scenarios and prospects of university education, parallel to the digital transformation of companies and the automation processes.

In [16] the successful integration of ICTs in the learning and teaching process is assumed, which leads us to believe that if new teaching tools are introduced, the teacher must also find new methods of teaching, creating and editing new contents in order to achieve active participation, even more when working with interactive young digital natives with access to an abundance of information.

The investigation is also in agreement with [17] in terms of the existence of a vast breach between the necessity of ICT infrastructure and its availability, which depends on factors in the economic, social and technological environment.

Finally, there is consistency with [18] in terms of knowledge management in universities that are focused on the distribution and use of knowledge through the application of ICT by means of promoting and diffusing investigation or the adequate management of ICTs as a means to manage knowledge. In both cases the environment determines the acquisition of knowledge, abilities and digital attitudes of the teacher and how the student assumes a critical attitude towards the use of ICT, through the selective use of information that is assessed on its quality. Only this way it is possible to achieve an efficient interrelation between the ICTs and the digital culture in the university system.

VI. CONCLUSION

The artificial neural networks made it possible to discover in an automatic way the relation between the variates Use of ICT and Digital Culture in function of the empirical data that were applied to the students of the Universidad Nacional de Moquegua - Peru and the Universidad Privada Domingo Savio - Bolivia, which information will allow for problem solving and better academic decision taking in each of the universities that were subject to the investigation.

The dimensions that have the greatest influence on digital culture as predicted by the artificial neural networks are the following: the ability to install software and data protection programs, the command of mobile devices for academic use and the command of specialized software in accordance with the models of the Universidad Nacional de Moquegua and the Universidad Privada Domingo Savio.

VII. FUTURE WORK

Future work will be related to the application of artificial intelligence algorithms to solve public management problems.

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