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Evaluation Model Based on Artificial Neural Networks for the use and Appropriation of Information and Communication Technologies in Higher Education Teachers

Javier Vargas[1], María Consuelo Moreno[2] and Lauren Isaza[3]

[1] *Doctor of Education Sciences from the Metropolitan University of Education Science and Technology (UMECIT- Panama) Professor, Faculty of Engineering, Cooperative University of Colombia. Research Group "GIPIS"*

[2] *Professor Metropolitan University of Education Science and Technology (UMECIT- Panama) Vice-Rector of Institutional Projection, Cooperative University of Colombia*

[3] *Professor, Department of Basic Sciences and Engineering, University Corporation Minuto de Dios – Uniminuto, Research group Trabajo de Llano Villavicencio, Colombia.*

Abstract

The article summarizes the research results of the design and implementation of an assessment model based on artificial neural networks for the use of information technologies and the appropriation of information and communication technologies in higher education teachers. The mathematical modeling was carried out using as a structure the topology of an artificial multilayer neural network, where the characteristic equations of each of the nodes and layers were found. The proposed model was called the SMARTIC Model, derived from the acronym Information and Communication Technologies and intelligent. The SMARTIC model was applied to a population of 30 teachers where the level of ICT use and appropriation was diagnosed and the data were validated using the normal distribution, finding a linear relationship f(x)=x for each of the nodes.

Keywords: Assessment Model, ICT, Education, Teacher Evaluation, Artificial Neural Networks

INTRODUCCIÓN

The evaluation of the use and appropriation of information and communication technologies applied to higher education teachers should be carried out from a holistic perspective based on the missional and substantive functions of the university, therefore from this perspective several aspects should be considered in the measurement, such as the area of knowledge, the level of training (Degree and Postgraduate), complementary training and work experience. From the specific point of view of ICT, training in the use and appropriation of these technologies should be considered.[1][2]

The proposed evaluation model was called the SMARTIC EVALUATION MODEL. The name is composed by its acronym SMART that refers to the intelligence and ICT initials of Information and Communication Technologies, so the evaluation model is inspired by artificial intelligence techniques such as Artificial Neural Networks (ANN). For the particular case of the proposed model, it makes it possible to evaluate the use and appropriation of ICT by university professors. [3]

The evaluation criteria of the model in its hidden layer are called technological factor, didactic-pedagogical factor and research factor; these factors were selected based on the competences of the 21st century teacher. Each of these factors is fed according to the criteria of training area, level of training, work experience, training factor, use and appropriation of ICT.[4]

Artificial neural networks in decision-making in the education sector.

Today we live in a digital age, which in one way or another has brought about a profound change in all aspects of society. With regard to education, it is undeniable that teachers are at a turning point where a methodological change in their teaching and pedagogical techniques or models is needed. [5]; in [6] they present that nowadays a great number of software is generated and developed, it is difficult to find an educational software that fits the different needs of a specific education system, hence the variety of software in this area. Computers do work in more efficient ways than humans, however, in the educational field, it has not been possible to create software that improves the conditions of a good teacher [7][8]

Most of the educational software currently produced focuses on classifying files or documents, in order to make information more accessible and to achieve more efficient searches, to improve the calculation processes in information evaluation and selection activities. However, it is necessary to generate educational strategies that allow the use of software to be incorporated into academic processes in order to make the right decisions regarding evaluation and learning. [8][9][10]

Modernization poses new challenges and the generational gap between teachers and students must confront researchers to carry out various investigations that lead to the use of information technologies in education to obtain changes in the pedagogical area. [8][11]

Artificial neural networks and the whole subject of artificial intelligence systems in general have recently shown that they can be a strong ally in the development of educational tools. The aim is that, together with the learning techniques, tools can be developed to support the activities carried out by the students in the assimilation of all the new information they are given. Therefore, artificial networks of neurons allow the integration of a new field of study in pedagogy and the development of products that contribute to didactics. [12][13]

Currently in education, artificial neural networks are mainly used to generate systems that classify information in courses that contain a large volume of data and are very complex for the learner. Neural networks are being used in math courses to solve certain types of complex and advanced problems.

Based on the above, it delves into the artificial neural networks, because since time immemorial human beings are questioned about their human nature and differentiates them from other living species that inhabit our planet, hence the scientific name Homo Sapiens. This questioning has been widely linked to the fact that the human species can reason, be aware of its existence in the world, in other words man is intelligent. This has led to the raising of major questions that have in one way or another tried to explain human behavior and several of the phenomena that surround us. [14] [15]

In addition, with the advance of technology and science, problems are becoming more and more specialized, complex and difficult to solve. The human being has developed an endless number of computer technologies and techniques focused on carrying out all kinds of work, but he is always at the limit of the technology developed, which has given rise to different and alternative fields of study such as artificial intelligence. One of the areas of study of artificial intelligence is fuzzy logic, which focuses its operation on the way people make decisions and couple them by means of inference rules, for example an average person who drives his vehicle can intuit that he is going fast or slow but does not know exactly, this can be predicted with the help of instruments that indicate the speed of his movement and by means of inference rules make decisions regarding actions in the driving of the car. The other important issue that belongs to artificial intelligence is artificial neural networks that try to mimic the way biological neurons solve problems. [15]

Therefore, artificial neuron networks base their functioning on a human brain, where the basic unit of processing is a neuron, and although it is known how neurons work together in a very general way, all the mysteries and questions that involve the understanding of reasoning and the exact method in which a group of neurons gives rise to the generation of a result from abstract stimuli and symbolisms have not yet been revealed by neuroscience, a factor that hinders and limits the development of computer systems based on neural networks. When we talk about neural networks, we can observe a clear break between the classic line that divides the hardware from the software because, although there is hardware, the basic processing unit is the artificial neuron that is found inside the hardware. [16]

METHODOLOGY

The nature of the proposed research is quantitative in approach, therefore, a numerical processing is performed, where the collection of information is carried out by means of a survey type instrument with a Likert scale, which allows for an ascension procedure in which the target population assigns its persuasions to a specific numbering level or its qualitative analogy [17][18].

According to the study method used, the research is projective in nature. [19] states that the type of projective research seeks to provide a solution to a problem or a practical need through the design of plans, programmes or models. The methodological design is field, contemporary and transectional. This design is proposed because the data will be collected in a natural and non-artificial environment, for a current event and in a single moment.

Evaluation model - SMARTIC

The SMARTIC model contributes to educational innovation from the areas of educational administration and technology. It combines assessment models with artificial neural networks, allowing decisions to be made in search of educational quality.

The use of artificial neural networks as an artificial intelligence technique and bio-inspired systems is brought to the education sciences, articulating the areas of administration and engineering. For this research, the analysis of teacher-centred assessment models, self-assessment models, competency-based assessment models and training models was carried out, which, when combined in an artificial neural network, evaluated the use and appropriation of ICT by teachers and, in turn, generated a training path that guides them in their professional qualification in the area of ICT.

The SMARTIC assessment model is based on the topology of a multilayer artificial neural network (ANN). The input layer consists of six (6) nodes which receive the input information provided and related to the particular characteristics of each teacher. The second layer has three nodes (3), which receive the output information from layer one (1) for processing. Layer three (3), is the output layer that receives the information from layer 2 and provides a Z output, called ICT use and appropriation.

In such a way, layer one contains 6 nodes, each node receives information on particular teacher characteristics, these nodes process the information related to Training Area (FA), Level of training (NF), Work Experience (Exp), ICT Use Factor (Fμ), ICT Ownership Factor (Fα), ICT Training Factor (Fφ) and Training Route (RF). Layer two contains 3 nodes, which receive the information processed by layer one and determine outputs in the Technological Training -FTEC-, Didactic and Pedagogical Training -FDYP- and Research Training -FINV- nodes. This layer has a maximum saturation value called a threshold. This threshold value ensures that the node delivers a value greater than 6 equal to 100%.

Layer three is made up of a node called the use and learning of ICTs -UATIC-, whose final processing provides a Z output, which will allow the teacher training path in the use and appropriation of ICTs to be determined. Figure 1 presents the Assessment Model for Higher Education Teachers in the Use and Appropriation of ICTs. SMARTIC.

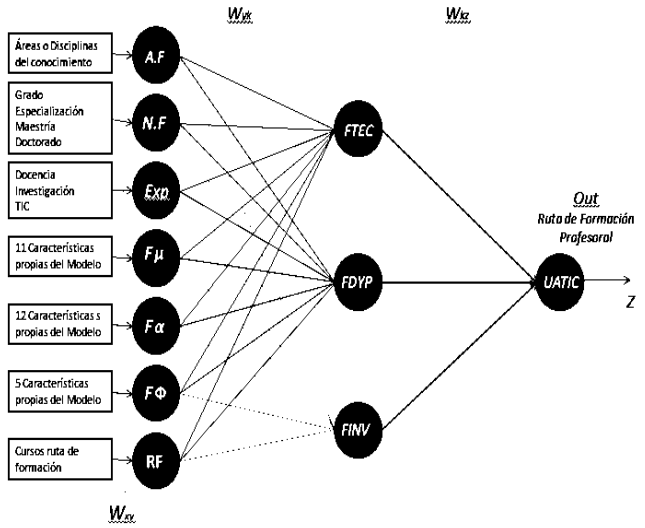


Figure 1. Assessment model for higher education teachers in the use and ownership of ICTs - SMARTIC

The model provides a quantitative assessment of 0 to 1 or 0 to 100% regarding the use and appropriation of ICT by the teacher being assessed. This value is delivered through the output node Z, called UATIC, use and appropriation of ICT. Equation 1 shows the mathematical modeling of the z node.

$$\boldsymbol{Z\ (UATIC)} = \left(\frac{(\boldsymbol{W_{kz}FTEC})}{\mathbf{30}}\right) + \left(\frac{(\boldsymbol{W_{kz}FDyP})}{\mathbf{30}}\right) + \left(\frac{\boldsymbol{W_{kz}FINV}}{\mathbf{30}}\right) \quad (1)$$

Where,

Z (UATIC): Use and appropriation of ICT, Maximum Value 1 or 100%.

FTEC: Output value of the Technological Factor node

FDyP: Output value of the node Didactic Factor and pedagogy

FINV: Output value of the Investigative Factor node

FTEC is a node of the hidden layer, which evaluates the technological factor. The calculation is made by adding the Wyk weights multiplied by the value of the nodes of the training area, training level, work experience, appropriation factor, use factor and training factor. Equation 2 presents the mathematical modeling found for the FTEC node.

$$\text{FTEC} = \text{W}_{\text{yk}}\text{AF} + \text{W}_{\text{yk}}\text{NF} + \text{W}_{\text{yk}}\text{EXP} + \text{W}_{\text{yk}}\text{F}\mu + \text{W}_{\text{yk}}\text{Fa} + \text{W}_{\text{yk}}\text{Ff} \quad (2)$$

Where,

FTEC (Technological Factor) , this factor is conditioned to a threshold value equivalent to 6 units, this means that for values greater than 6 they are assumed to be 100% on output or equivalent to 1.

AF: Output value of the Training Area Node

NF: Output value at training level node

EXP: Output value at work experience node

Fμ: Node output value ICT usage factor

Fa: Output value of the ICT appropriation factor node

Ff Output value of the ICT training factor node

FDyP is the name given to the didactic and pedagogical factor node, it is located in the hidden layer of the network and is calculated by multiplying the weightings w and the input nodes of the model. Equation 3 represents the mathematical modeling found for the FDYP node.

$$\text{FDyP} = \boldsymbol{W_{yk}}\text{AF} + \text{W}_{\text{yk}}\text{NF} + \text{W}_{\text{yk}}\text{EXP} + \text{W}_{\text{yk}}\text{F}\mu + \text{W}_{\text{yk}}\text{Fa} + \text{W}_{\text{yk}}\text{Ff} \quad (3)$$

Where,

FDyP: Didactic and pedagogical factor, this factor is conditioned to a threshold value equivalent to 6 units, this means that for values greater than 6 they are assumed as 100% on output or in their equivalent to 1.

AF: Output value of the Training Area Node

NF: Output value at training level node

EXP: Output value at work experience node

Fμ: Node output value ICT usage factor

Fa: Output value of the node appropriation factor of the TIC

Ff: Output value of the ICT training factor node

FINV, the research factor is called this factor gives a value where the dominance of ICT in scientific research is determined. Equation 4 for this is calculated from the values of the input nodes.

$$\text{FINV} = \text{W}_{\text{yk}}\text{AF} + \text{W}_{\text{yk}}\text{NF} + \text{W}_{\text{yk}}\text{EXP} + \text{W}_{\text{yk}}\text{F}\mu + \text{W}_{\text{yk}}\text{Fa} + \text{W}_{\text{yk}}\text{F}f \quad (4)$$

Where,

FINV: Investigative Factor, this factor is conditioned to a threshold value equivalent to 6 units, this means that for values greater than 6 they are assumed as 100% on their output or in their equivalent to 1.

AF: Output value of the Training Area Node

NF: Output value at training level node

EXP: Output value at work experience node

Fμ: Node output value ICT usage factor

Fa: Output value of the ICT appropriation factor node

Ff: Output value of the ICT training factor node

RESULTS AND DISCUSSION

Thirty teachers were evaluated using the SMARTIC model, in order to determine the level of ICT use and appropriation in the range of 0 to 100%. Where the values delivered by the SMARTIC Model for the Technological, Didactic and Pedagogical Factor and Research Factor nodes were found.

Table 1. Diagnosis of the use and appropriation of ICTs Using the SMARTIC Model

PROFESOR	FTEC	FDYP	FINV	Z
1	0,18	0,13	0,17	48%
2	0,22	0,10	0,17	49%
3	0,16	0,12	0,18	46%
4	0,15	0,13	0,15	43%
5	0,17	0,11	0,16	44%
6	0,18	0,10	0,20	48%
7	0,20	0,09	0,16	45%
8	0,19	0,12	0,17	48%
9	0,18	0,13	0,20	51%
10	0,18	0,14	0,20	52%
11	0,17	0,11	0,17	45%
12	0,15	0,12	0,18	45%
13	0,16	0,13	0,19	48%
14	0,18	0,14	0,18	50%
15	0,17	0,12	0,17	46%
16	0,14	0,11	0,17	42%
17	0,14	0,12	0,20	46%
18	0,13	0,13	0,19	45%
19	0,13	0,14	0,19	46%
20	0,13	0,09	0,18	40%
21	0,14	0,10	0,17	41%
22	0,15	0,10	0,18	43%
23	0,18	0,09	0,15	42%
24	0,18	0,12	0,11	41%
25	0,17	0,12	0,12	41%
26	0,17	0,11	0,11	39%
27	0,15	0,13	0,12	40%
28	0,15	0,15	0,14	44%
29	0,16	0,18	0,15	49%
30	0,16	0,17	0,14	47%

For the Technological Factor node, the range of values obtained is between 0.13 and 0.22. For the didactics and pedagogy node it varies between 0.9 and 0.18, finally, for the research factor it varies between 0.11 and 0.20.

With respect to the output named Z in the SMARTIC model, the range obtained with respect to the use and appropriation of

ICT by teachers was 39% for the lowest value and 52% for the highest value.

According to the international standards used in the model, it is determined that at the time of the evaluation, teachers should obtain a percentage of 50% of output equivalent to an up-to-date teacher in the use and appropriation of ICT.

The arithmetic average calculated for the output was 45.13%, this indicates that it is necessary for teachers to continue with the training path suggested by the model. In this way, those who did not reach 50% of the qualification will qualify and those who obtained more than 50% will keep their qualification up to date according to the international standards for higher education teachers in the 21st century.

Table 2. Statistical calculations of the application of the model

	N	Minimum	Maximum	Media	Standard Deviation
FTIC	30	,13	,22	,1640	,02143
FDYP	30	,09	,18	,1217	,02151
FINV	30	,11	,20	,1657	,02635
Z	30	39,00	52,00	45,133	3,46145
N válido (por lista)	30				

In table 2, the statistical calculations are shown. For the specific case of the Z output, it is observed that the standard deviation was 3.46, this indicates that the range is between 41.67% and 48.59% in normalized values.

Model consistency was performed using the normal probability technique and the normal probability graph.

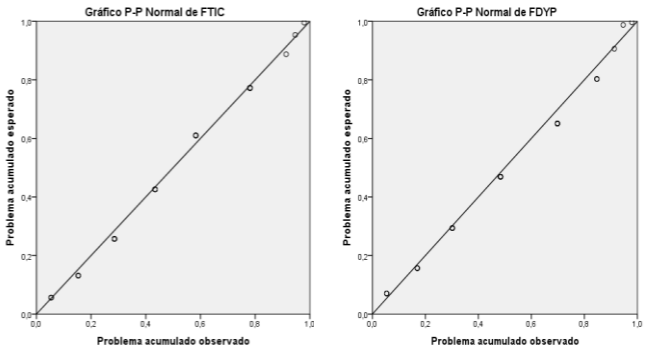
For the distribution parameters, presentan is provided in table 102, with values of 0.1640 for FTIC, 0.1217 for FDYP, 0.1657 for FINV and for Z a value of 45.13.

Table 3. Estimated distribution parameters of the applied model

		FTIC	FDYP	FINV	Z1
Distribución normal	Ubicación	,1640	,1217	,1657	45,1333
	Escala	,02143	,02151	,02635	3,46145

According to the normal distribution graph, the measured points of each variable are expected to be on the straight line f(x)=x, which represents the desired data. In the case of the application of the SMARTIC model, the consistency in the distribution of the data was determined by indicating that all the variables of the model presented a standardized distribution, this can be seen in figure 2.

Figure 2. Standardized distribution of the SMARTIC model application



CONCLUSIONS

A useful model was designed to evaluate the use and appropriation of ICT in higher education teachers, using the topology of artificial neural networks, with input layer, process layer and output layer. This topology was selected from the different network topologies that can be constructed, based on the topology of the multilayer perceptron. The assessment model integrates the models focused on the teacher's profile and self-assessment. The input variables are aimed at measuring the level of training, work experience in ICT, research and teaching, the factor of use, appropriation and training. These factors were determined by a self-assessment of the teacher on a numerical scale from zero to ten, finally the training path node that measures the training undertaken within the ICT standards for the current higher education teacher. The input variables are multiplied by the weights assigned by the expert criteria, the result enters the processing layer where the technology, research, didactics and pedagogy node is located. In the process of selecting the weighting methodology, it was determined that the Delphi ("multi-criteria") methodology allowed each factor to be weighted depending on the experience of professionals in the area, and in turn to use statistical techniques to find the central tendency of the weightings carried out. Mathematical modeling was based on linear combinations represented by a mathematically adequate structure.

With respect to the appropriation that teachers have of information and communication technologies, it was determined that with an average evaluation of 25.8% they are in a low degree of appropriation, the characteristics of low level are associated with ICT for scientific publications, development of video games, App, virtual laboratories and instructional design, this leads to the teaching processes lack incorporation of innovative, current and modern educational technology that are in accordance with current standards. In an intermediate grade with a 50% of qualification are the characteristics associated with the incorporation of ICT, EVA management, production of VPAs and EVAs, scientific or academic networks, ICT strategies and virtual worlds. The characterization regarding the appropriation of ICT by teachers indicates that it is necessary to establish action plans that lead to the improvement of the technological channels of ICT management, training and production applied to teaching processes.

Training in the use and appropriation of information and communication technologies is fundamental for the qualification of teachers with respect to ICT standards, therefore it is of vital importance to establish the training received and at what level it is. For this reason, a measurement was made of the training received by the teachers under study in the use and appropriation of ICTs, establishing that 70% of the teachers received training in the use and appropriation of ICTs, 55% in didactic and pedagogical training and 45% in training for scientific and technological activities and tools. From the foregoing, it can be seen that it is necessary to strengthen ICT training that allows teachers to qualify for the use and appropriation of the current technologies that they contribute to teaching processes.

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