Research Article

Neural Network for Vocational Guidance Based on The Applicant's Profile For Admission To A Study Program

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Abstract

The vocational orientation tests are currently oriented to established principles and methods, where the applicant identifies his competencies to choose his professional career, the model of university accreditation in its standard 18 reference on the admission to the program of studies and that must be in accordance with the profile of income raised by each program of studies. Artificial intelligence has become necessary through its techniques in the solution of some problems of human behavior simulated through electronic and digital media, so the objective of this research was to develop a neural network based on vocational guidance from the profile of income to ensure that the applicant knows his competencies towards a study program. For this case, it is considered the knowledge, skills and attitudes raised by the program of studies. This neural network considered in 3 incoming axons, 6 hidden layers and one outgoing axon, each nucleus considers sigmoidal activation functions while, for the backpropagation algorithm, functional derivatives of second level have been used, obtaining results with an accuracy of 0.996 correlation with respect to the real data and a constant variance between the tests of 0.01, guaranteeing its use to automate01, guaranteeing its use for automation. Data collection has been done through surveys based on a transversal non-experimental research design and using the applied correlational research level.

Key words: admission to the study program, conditions for admission, artificial intelligence, career guidance.

1. Introduction

The choice of a professional career is vital for a high school graduate who goes through a route of indecision due to the multiple internal and external influences they have, which eventually becomes complex and disastrous, generating a conflict. González (1999), quoted by Guerra Rubio and Quevedo Guerra (2007) states that "... fear of failure, of self and others' disappointment, are often common feelings of the young pre-university student, which then becomes a source of anxiety and stress" (p. 2): In relation to the question "What could I study? the answer is framed in the choice of a program of studies with personalized characteristics if the individual treats it individually. Maura (2001) for his part refers that the problem of the choice of a profession occurs worldwide and refers that "Many are the factors that influence the professional choice (...). The analysis and interpretation of how and why to choose a profession depends on the theoretical position (...) of vocation and vocational orientation" (Maura, 2001, p. 49).

Vocational orientation makes possible the approach between the student and the competences of the professional career through a specialist called a counselor, who besides placing him/her in a specific area, must train him/her to handle with the adequate instruments a changing and complex world in his/her professional life (León Mendoza & Rodríguez Martínez, 2008). On the other hand, Vidal Ledo and Fernández Oliva (2009) emphasize that

vocational guidance does not occur in a single moment but should accompany the student throughout his or her education "... so that he or she knows and makes decisions to build his or her own knowledge according to his or her vocation" (p. 1); complementing this, León Mendoza and Rodríguez Martínez (2008) as well as Orrantia and Silva (2014) identify that guidance should be given on the one hand for those who are entering and on the other hand, for those who are close to entering the labor market. In view of this panorama, it can be affirmed that vocational guidance is a complex and determining issue for academic training and that its misapplication and misinterpretation will be one of the causes of student desertion.

For some authors, student dropout is considered as a school failure, and one of the factors is that the student repeats one or more subjects, which lowers his self-esteem (Martínez-Pérez et al., 2020). In addition, the research of Martínez-Pérez et al. (2020) state that:

> … Among the determinants of university student dropout are vocational problems, the economic situation of their families, academic performance and some of the causes of the latter include: low motivation due to vocational problems; previous academic weaknesses, weaknesses in teaching and learning methodologies and dissatisfaction with the career, among others (p. 2).

Salas Moya et al. (2020) in his paper, the author mentions that the vocational guidance service is normally provided by psychologists, who must discover the innate competencies of the student and support in the decisions they will make. Therefore, it is identified that one of the causes for student dropout is the problem of vocational guidance. Most public and some private university institutions do not have the application of the service according to the above-mentioned authors. The consequence in time will be the lack of competitive professionals, affecting economic, social, technological and scientific development of the country.

The approach of the entry profile is currently important for the study programs, since the definition of their requirements is the result of the analysis of the graduate profile and the needs of the stakeholders, thus seeking to ensure their continuous improvement (Sineace, 2018).

One of the ways to address the above problems is to resort to artificial intelligence which, according to Badaró, Ibañez, Agüero (2013) cited by Ocaña-Fernández et al. (2019) simulates the capabilities and behaviors that the human brain develops. Also Ponce Cruz and Herrera (2010) talks about the simulation of the acting functionalities of the human being through artificial models, while Russell et al. (2011) classifies them through different definitions:

> *The ones at the top refer to mental processes and reasoning, while those at the bottom refer to behavior. The definitions on the left measure success in terms of fidelity in the way humans act, while those on the right refer to an ideal concept of intelligence, which we will call rationality. A system is rational if it does "the right thing", based on its knowledge* (p. 2).

Now, neuroscience is based on the study of the neurological system (brain) and is related to human thought; therefore, in view of the current problems reviewed, the research developed aims to develop a neural network for vocational guidance that bases its structure on the profile of the entrant to a study program in such a way that it can influence as one of the factors in the probabilistic decrease of desertion.

2. Materials and Methods

The development of the research applied a non-experimental transactional correlational design at the correlational level (Hernández-Sampieri & Torres, 2018) due to the treatment of the different vocational orientation tests and the analysis of the entrance profile with respect to them, so its treatment was given through the development of a neural network. The unit of analysis of study refers to a segment of applicants to the program of study of Systems Engineering that in its totality was 100 from the National University of Huancavelica year 2019.

i. Vocational Guidance.

According to Molina (2001) quoted by León Mendoza and Rodríguez Martínez (2008) defines it as a set of internal and external characteristics inherent to the capabilities of human beings that will influence their future León Mendoza and Rodríguez Martínez (2008), identified as an analytical system of student needs that will ultimately

define their career and the transition from student life to the world of work. It can also be said that vocational guidance is a "set of practices aimed at clarifying vocational problems. It is a preventive work whose objective is to provide the necessary elements to enable the best orientation for each student"(Salas Moya et al., 2020, p. 2). Likewise, Vidal Ledo and Fernández Oliva (2009) complement it by mentioning that it is a "process that assists in the choice of a profession, its preparation, access to the exercise of the same and subsequent evolution and progress" (p. 1). Most public universities in Peru do not implement this system despite the fact that the Ministry of Education (MINEDU) has established guidelines through a vocational orientation booklet on the subject of life projects, but without any application.

1. **Types of Vocational Orientation Tests.** Among them are:

- **Holland Theory.** Gottfredson (1999), cited by Vicente and Fernández (2006), mentions that this theory stems from Murray's formulations and that human behavior depends on the personality as well as the environment, vocational psychology has to do with the student's personality and work dimensions. Holland (1992, 1997) quoted by (Vicente & Fernández, 2006) formulates it as "... the pretension to organize knowledge about vocational behavior and to suggest new research methods, as well as to increase the body of knowledge on this subject" (p. 117); according to this theory people are categorized according to their vocational personality: "realistic (R), researcher (I), artistic (A), social (S), entrepreneurial (E) and conventional (C); which are represented in this order in a hexagonal model that indicates the relationships between these types" (p. 117); according to this theory people are categorized according to their vocational personality: "realistic (R), researcher (I), artistic (A), social (S), entrepreneurial (E) and conventional (C); which are represented in this order in a hexagonal model that indicates the relationships between these types" (p. 117) (Fernández-Nistal & Mora-Soto, 2020, p. 13), this description allows to talk about RIASEC.
- **Test de CHASIDE**. This test identifies the interests and aptitudes of people who want to know about their vocational and professional orientation Maura (2013) cited by Pereira (2019), obtaining the results of 98 questions is classified into professional areas C (Administrative and accounting), H (Humanistic, legal sciences and social sciences), A (Artistic), S (health sciences), I (Engineering, technical careers and computing), D (Defense and security) and E (Agricultural and nature sciences).

2. **Admission to the study program.** Standard 18 of the model of accreditation of university higher education study programs published by the National System of Evaluation, Accreditation and Certification of Educational Quality (SINEACE) refers that, within the admission process, it establishes criteria according to the entrance profile and which are manifested within the admission prospectus; its quality "... is considered as one of the aspects that influences student desertion" (p. 73). 73); the admission criteria are established by the study program and are oriented to the admission profile (competencies, qualities, values, etc.) which "... guides in the identification of the criteria that the program uses..." based on the evaluation of the graduate profile "... to define and implement the mechanisms for the selection of applicants" (p.74), thus making it easier for the entrant to face university life with a greater probability of success. (Sineace, 2018).

he admission profile is an input that should be empirical evidence of each study program, since it will allow the generation of strategies that strengthen the students' abilities and skills to avoid possible dropouts and improve their efficiency (Gámez et al., 2012).

Each study program of the National University of Huancavelica, within the admission prospectus, establishes the competencies necessary for the profile of the entrant, comprised of knowledge, skills and attitudes; Rodríguez et al. (2007) talks about the competencies and synthesizes them through knowledge, skills and values; their contents determine the knowledge, know-how and know-how of the human being.

ii. Artificial Intelligence

Rouhiainen (2018) defined as the ability acquired by computers to simulate the activities performed by human intelligence, also defined as the "... ability of machines to use algorithms, learn from data and use what they learn in making decisions just as a human being would" (p. 17).

1. **Artificial Neural Network**. It represents the nervous system of the human brain through mathematical algorithms capable of solving complex problems, (Haykin, 2009) cited by García et al. (2020) consider that an ANN is a "... mathematical model that tries to emulate the biological neuronal systems of the human being in the processing of information" (p. 443). See Figure 1.

Figure 1

Artificial biological and artificial network

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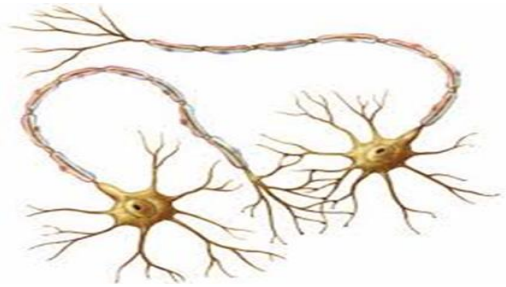
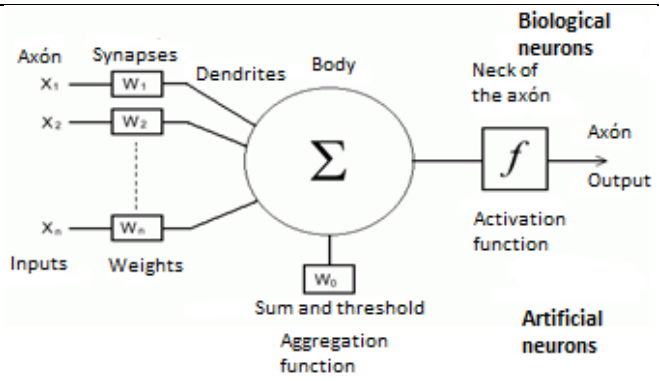
<td>  </td>
<td> 
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a. ***Standard Model of an Artificial Neuron***. According to the principles described by Rumelhart and McClelland (1986) as cited by Larranaga et al. (1997) a standard neuron consists of:

- An input set x_i and some synaptic weights w_{ij} , with $j = 1, \dots, n$.(p.3)
- A propagation rule hi defined from the set of inputs and the synaptic weights. $h_i(x_1, \dots, x_n, w_{i1}, \dots, w_{in})$. The most commonly used propagation rule consists of linearly combining the inputs and the synaptic weights, obtaining: $h_i(x_1, \dots, x_n, w_{i1}, \dots, w_{in}) = \sum_{i=1}^{n} w_{ij} x_j$. (p. 3)

  It is usually customary to add to the set of neuron weights an additional parameter θ_i, which is called threshold, which is customarily subtracted from the postsynaptic potential. That is: $h_i(x_1, \dots, x_n, w_{i1}, \dots, w_{in}) = \sum_{i=1}^{n} w_{ij} x_j - \theta_i$ (p. 3)
- ***Activation Functions***. Represents the output of a neuron and its activation state (if the data is within the parameters, the function is activated) $y_i = f_i(h_i) = f_i\left(\sum_{j=0}^{n} w_{ij} x_j\right)$.

  All-Nothing neurons: are called threshold devices, $f_i\left(\sum_{j=1}^{n} w_{ij} x_j - \theta_i\right)$ is a step function where the output is digital. (Larranaga et al., 1997):

$$y_i = \begin{cases} 1 & si \sum_{j=1}^{n} w_{ij}x_j \geq \theta_i \\ 0 & si \sum_{j=1}^{n} w_{ij}x_j < \theta_i \end{cases}$$

Continuous sigmoid neuron: is a nonlinear function ranging from 0 to 1, having an inflection point at x=0 (Peirotén López de Arbina, 2018), being its equation:

$y_i = \frac{1}{1+e^{-\left(\sum_{j=1}^{n} w_{ij}x_j - \theta_i\right)}}$, with $y_i \in [0,1]$, being applied to multilayer perceptrons.

iii. Application development

For the development of the research, the profile of the student was taken as a reference in the admission prospectus of the Universidad Nacional de Huancavelica (UNH), Systems Engineering program, which considers the following competencies shown in Table 1.

Table 1

Identified competencies for the entry profile to the Systems Engineering degree program

N°	Knowledge	N°	Skill	N°	Attitudes
1	Biology	1	Coherent reasoning	1	Tolerance
2	Ecology	2	Forming conceptual schemes	2	Openness
3	Physics	3	Solving problem situations	3	Willingness to change
4	Social Sciences	4	Interpersonal relationship management	4	Collaboration
5	Humanities	5	Team work	5	Dialogue
6	Computer Science and Informatics	6	Adaptation to work	6	Respect for life
7	Languages	**7**	**Send**	7	Respect for biodiversity
8	**Mathematics**	7.1	Ideas	8	Environment Conservation
8.1	Algebra	7.2	Judgments	9	Honesty
8.2	Arithmetic	7.3	Theories	10	Commitment
8.3	Trigonometry	**8**	**Information Skills**	11	Responsibility
8.4	Geometry	8.1	search for information		
8.5	Probability	8.2	ordering information		
8.6	Statistics	8.3	using information		
		9	**About reading**		
		9.1	Analysis		
		9.2	Synthesis		
		10	**About your expression**		
		10.1	In writing		
		10.2	Orally		

Note: taken from admission prospectus – UNH 2019

Table 1 shows the classification of the competencies considered for the profile of the entrant evaluated by the professional career according to the graduation profile, achievement of competencies and the labor market of their environment. The number of questions will depend on the competencies that each study program may consider. In this case, 40 questions with their respective scores and classified in groups of 3 were considered.

Table 2

Weights considered for each competition.

N°	**Competencies**	Questions	Scoring
1	Knowledge	13	50%
2	Skills	16	30%
3	Attitudes	11	20%
TOTAL		40	100%

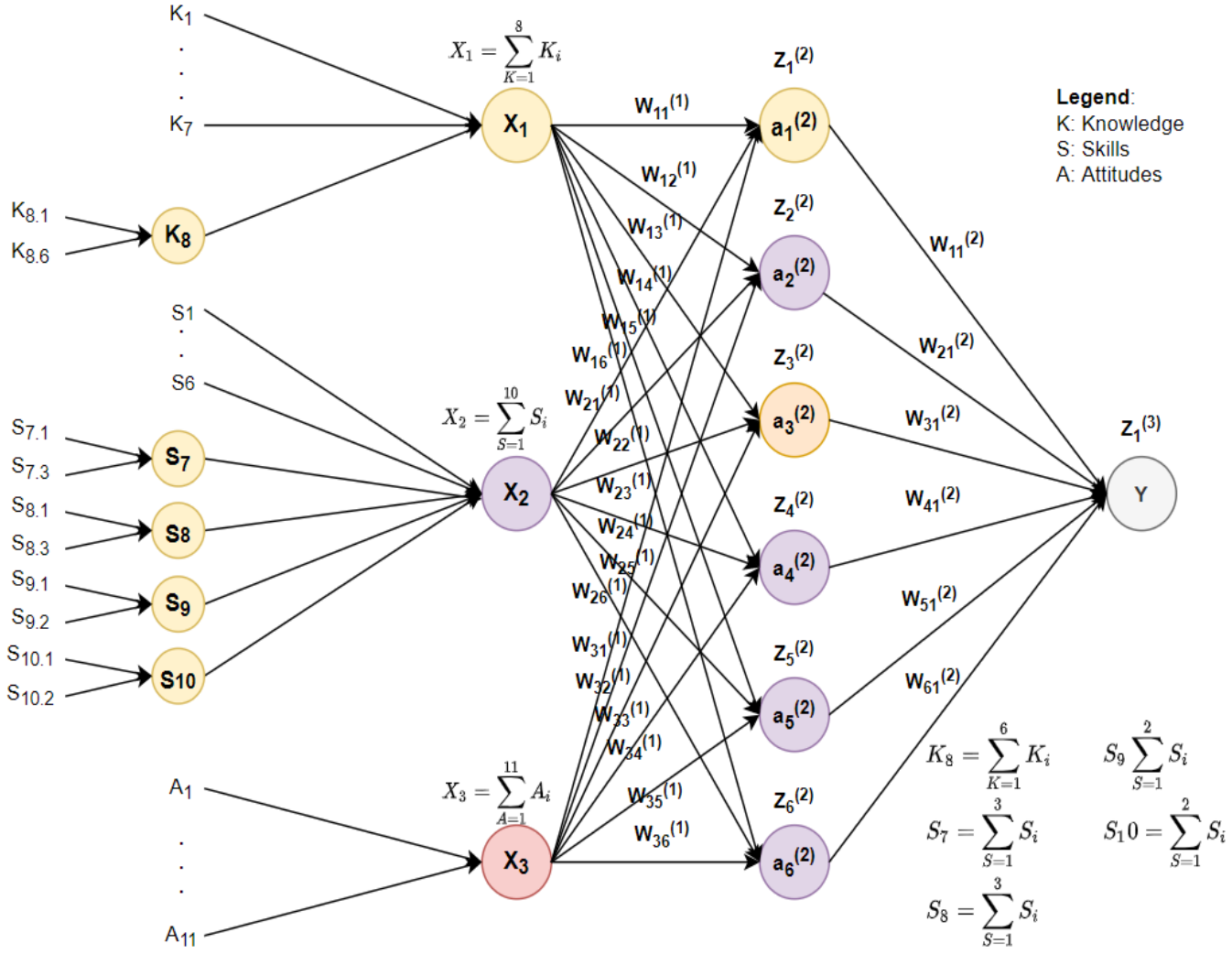
Note: taken from admission prospectus – UNH 2019

Table 2 shows the classification of the competencies and that have been taken from the applicant profile published in the prospectus, the number of questions differ for each competency that in this case the one with the highest score is the knowledge competency with 13 questions and a score of 50%, followed by the skills with 16 questions and a score of 30% and finally the attitudes that considers 11 questions with a score of 20%, these weights are also published in the admission prospectus.

The competencies considered in the applicant's profile have been analyzed and modeled through neural networks in order to represent the vocational orientation test related to the UNH systems engineering curriculum. See Figure 2.

Figure 2

Neural network schematic of entry profile test.



Note: own elaboration

Figure 2 shows the neural network constructed in which 40 data related to the competencies of the entry profile classified as follows 3 axón's (X_1, X_2, X_3), each incoming axon generated 18 synapses or weights ($W_{11}^{(1)}$, …, $W_{21}^{(1)}$, …, $W_{31}^{(1)}$, …, $W_{36}^{(1)}$), both are calculated by means of the aggregation function ($Z_1^{(2)}$, $Z_2^{(2)}$, $Z_3^{(2)}$, $Z_4^{(2)}$, $Z_5^{(2)}$, $Z_6^{(2)}$) complying with: $Z^{(2)} = X*W^{(1)}$ and the construction of the activation function $a^{(2)} = f(Z^{(2)})$ represented by the sigmoid function for the hidden layer; the protruding axon represented by "y" is the operation between the activation functions ($a_1^{(2)}$, $a_2^{(2)}$, $a_3^{(2)}$, $a_4^{(2)}$, $a_5^{(2)}$, $a_6^{(2)}$) and their respective weights ($W_{11}^{(2)}$, $W_{21}^{(2)}$, $W_{31}^{(2)}$, $W_{41}^{(2)}$, $W_{51}^{(2)}$, $W_{61}^{(2)}$) constructing the function $Z^{(3)} = a^{(2)}*W^{(2)}$ and activation function $y = f(Z^{(3)})$ the function used is the sigmoid. The results found are not completely reliable since the percentage of reliability is not high, so we have resorted to identifying the cost function with the mean squared error $J = ½*e^2$ and the gradient descent algorithm with the derivative of the function and to ensure high reliability the second derivative of the function was used (LeCun et al., 2012).

3. Results (Tests Performed)

For the training of the neural network, information was collected from 100 applicants about the competencies they have in relation to the entry profile, the data entry was done through a spreadsheet where they responded to direct questions with dichotomous answers (Yes = 1 and No = 0) that were posed based on the competencies selected by the study program, the results of the survey can be seen in Table 3.

Table 3. Consolidated surveys carried out in 2019.

CONOCIMIENTOS													HABILIDADES												ACTITUDES										
50%													30%												20%										
1	2	3	4	5	6	7	8						1	2	3	4	5	6	7			8			9		10		1	2	3	4	5	6	7	8	9	10	11
							8.1	8.2	8.3	8.4	8.5	8.6							7.1	7.2	7.3	8.1	8.2	8.3	9.1	9.2	10.1	10.2										
6.25%	6.25%	6.25%	6.25%	6.25%	6.25%	6.25%	1.04%	1.04%	1.04%	1.04%	1.04%	1.04%	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.00%	1.50%	1.50%	1.50%	1.50%	1.82%	1.82%	1.82%	1.82%	1.82%	1.82%	1.82%	1.82%	1.82%	1.82%	1.82%
1	1	1	1	1	0	1	1	1	0	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
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1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

comply with 1.56%, being the average of 4.35% and, compared to the maximum value, most of them comply with this competency; for the skill competency, of the maximum value (3%), 1.20% is the minimum value of compliance, its average tends to 2.64%, so most of them comply with this competency. Finally, for the attitude competency, of the maximum value (2%), the minimum is 0.73% of compliance with the competencies and, like the previous ones, the average is 1.79%, this value being close to the maximum for this competency.

A real result was obtained from the surveys carried out; the data, product of the competencies, has been used to enter the neural network database, to be processed in different tests (4 tests) and completed in Table 4.

Table 4. Result of the neural network model application.

N°	Consolidated Knowledge	Consolidated Skills	Consolidated Attitudes	Actual Result	Result RN Test 1	Result RN Test 2	Result RN Test 3	Result RN Test 4
1	0.427	0.270	0.200	0.8971	0.9019	0.9000	0.9042	0.9029
2	0.479	0.270	0.182	0.9310	0.9363	0.9381	0.9337	0.9375
3	0.500	0.300	0.200	1.0000	0.9723	0.9730	0.9692	0.9709
4	0.500	0.265	0.127	0.8923	0.8927	0.9030	0.9096	0.9017
5	0.500	0.285	0.200	0.9850	0.9665	0.9670	0.9630	0.9666
6	0.500	0.280	0.200	0.9800	0.9643	0.9648	0.9608	0.9647
7	0.313	0.190	0.109	0.6116	0.5932	0.6037	0.5874	0.6065
8	0.500	0.300	0.182	0.9818	0.9648	0.9648	0.9624	0.9641
9	0.354	0.190	0.200	0.7442	0.7374	0.7526	0.7236	0.7205
10	0.500	0.300	0.182	0.9818	0.9648	0.9648	0.9624	0.9641
11	0.438	0.300	0.200	0.9375	0.9333	0.9369	0.9355	0.9307
28	0.438	0.280	0.200	0.9175	0.9207	0.9208	0.9217	0.9206
29	0.438	0.230	0.164	0.8311	0.8410	0.8409	0.8444	0.8431
30	0.438	0.290	0.200	0.9275	0.9273	0.9292	0.9288	0.9258
31	0.500	0.300	0.164	0.9636	0.9529	0.9521	0.9546	0.9559
32	0.500	0.280	0.182	0.9618	0.9543	0.9561	0.9527	0.9559
33	0.438	0.275	0.164	0.8761	0.8919	0.8912	0.8900	0.8892
57	0.500	0.240	0.200	0.9400	0.9415	0.9411	0.9379	0.9394
58	0.438	0.265	0.200	0.9025	0.9095	0.9068	0.9099	0.9119
59	0.490	0.275	0.182	0.9464	0.9463	0.9481	0.9441	0.9477
60	0.500	0.260	0.200	0.9600	0.9541	0.9541	0.9504	0.9548
61	0.500	0.300	0.200	1.0000	0.9723	0.9730	0.9692	0.9709
62	0.281	0.120	0.091	0.4922	0.5027	0.4934	0.5045	0.4901
63	0.500	0.300	0.182	0.9818	0.9648	0.9648	0.9624	0.9641
64	0.438	0.285	0.182	0.9043	0.9163	0.9162	0.9126	0.9113
65	0.427	0.300	0.200	0.9271	0.9228	0.9276	0.9272	0.9214
66	0.500	0.300	0.182	0.9818	0.9648	0.9648	0.9624	0.9641
67	0.438	0.285	0.164	0.8861	0.9019	0.8997	0.8988	0.8978
78	0.500	0.240	0.182	0.9218	0.9263	0.9303	0.9271	0.9247
79	0.229	0.145	0.091	0.4651	0.4837	0.4833	0.4775	0.4808
80	0.500	0.300	0.200	1.0000	0.9723	0.9730	0.9692	0.9709
81	0.500	0.265	0.182	0.9468	0.9449	0.9478	0.9442	0.9470
82	0.406	0.285	0.182	0.8731	0.8824	0.8820	0.8816	0.8786
83	0.500	0.300	0.164	0.9636	0.9529	0.9521	0.9546	0.9559
84	0.354	0.210	0.091	0.6551	0.6625	0.6499	0.6404	0.6369

85	0.406	0.290	0.200	0.8963	0.8933	0.8978	0.9013	0.8950
97	0.438	0.290	0.200	0.9275	0.9273	0.9292	0.9288	0.9258
98	0.490	0.285	0.182	0.9564	0.9525	0.9536	0.9499	0.9528
99	0.427	0.285	0.182	0.8939	0.9056	0.9055	0.9027	0.9002
100	0.490	0.300	0.164	0.9532	0.9487	0.9472	0.9490	0.9501

Note: own elaboration.

The difference of the data (real result and the 4 neural network results) is almost similar between real and artificial. See Table 4

Table 5. Result of the differences between the actual result with respect to the tests

Description	Test 1	Test 2	Test 3	Test 4	Average
Maximum value	0.0296	0.0270	0.0308	0.0291	0.0291
Minimum value	-0.0186	-0.0182	-0.0173	-0.0157	-0.0175
Variance value	0.0139	0.0140	0.0139	0.0138	

Note: Own elaboration.

Table 5 shows the comparative results between the real result and the different tests applied to the neural network model, the average of the maximum difference is 0.029, also when analyzing the average of the minimum difference which is -0.0175 and we can affirm that the differences are minimal, the values found in the variance with respect to each test vary between a range of 0.001.

The coincidence between the real data and the neural network can be observed through the intersecting points in the Cartesian plane. See Figure 3.

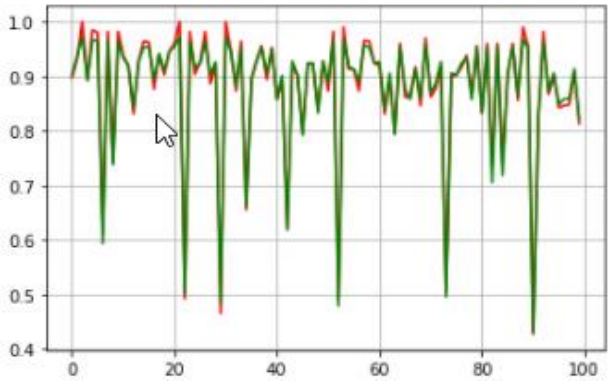

Figure 3. Comparison between the data results of the real result and the neural network result.
Note: own elaboration; Source: Jupiter, 2021.

Figure 3 shows the representative points through lines, whose amount of interaction was given by 600, its evaluation function and gradient is 685 and the method used for the minimum cost function is the BFGS, finally the value of the function for this run is 0.006291.

The validation of the consistency of the results in Table 4 was done through statistical software which through data correlation yielded the following results. See Table 5:

Table 6. Validation of the neural network results and real data.

	Media	Dev. Deviation	Dev. Error average	Correlation
Real Result	,8791	,1193	,0119	,996
Result_RN_1	,8777	,1172	,0117	
Result_RN_2	,8778	,1174	,0117	,996
Result_RN_3	,8775	,1168	,0116	,995
Result_RN_4	,8779	,1165	,0116	,996

Note: own elaboration, results of the program SPSS.

Table 6 shows the values necessary to support that the results of the neural network have a strong correlation with respect to the real data, which is 0.996.

4. Discussion

Through the process of the types of vocational orientation tests proposed by Holland (CHASIDE and RIASEC tests), the procedures for the choice of different study programs have been taken as a basis, as well as other articles raise different connotations about vocational orientation, but it has not been seen that any of them base their studies on the construction of a neural network to represent and analyze the competencies that the applicant should have and that are considered in the profile of the entrant, which in this case considers the knowledge, skills and attitudes that applicants to the study program should have, and also serves as a general pattern for the entrance to the study program.

This research work will note the importance of the entry profile of the study programs, so that the study programs must give importance in establishing the competencies that the applicants must have, in this way to know if they are oriented to the desired professional career.

5. Conclusions

The result of the neural network data maintains a strong relationship with the real data produced by the surveys applied to the applicants of the Systems Engineering program.

It has been observed that, according to the results of the neural network, these have a high degree of assertiveness with respect to the real data of the survey, correlation of 0.996 and constant variability with respect to the tests 0.013.

In order to increase the degree of reliability of the neural network, it was necessary to apply the second derivative to the activation functions of the neural network and increase the number of hidden layers by 6.

The competencies that the applicants must have, must be related to the needs of the profile of the entrant of each study program, it is important that each one of them becomes aware of identifying these competencies for the achievement of academic success and to avoid desertion.

The needs reflected in the applicant profile that each career mentioned in the admissions prospectus can be considered as fundamental vocational orientations so that the student can measure his or her competencies with respect to the study program.

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