PERSONALIZATION OF TEACHING IN E-LEARNING SYSTEMS

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Critical Review

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Abstract: Personalized teaching offers students the opportunity to study independently, with a focus towards fostering and developing their research traits, to intensively develop students' abilities and competencies. Traditional teaching is a common mode of education through which tutors use the same teaching method, regardless of the differences and complex personalities of students in a single class or group. Such an approach to teaching has the effect of slowing down the progression of talented students on one hand while making it harder for less successful students to follow classes on the other. The consequences of this approach to teaching are a rapid loss of learning motivation and perception of classes and learning as unpleasant obligations.

Contemporary e-learning systems offer personalized learning, by tailoring it to the needs and unique traits of each student. Usage of neural networks in data processing for personalized learning will ensure the formation of adequate classes, full understanding, and adoption of the material prescribed by the curriculum, compliance with the general curriculum, and constant insight into the students' progress.

Keywords: personalized learning, e-learning, neural network.

INTRODUCTION

Different types of intelligence described by the Theory of Multiple Intelligences are the basic factors to be considered in correlation with the personalization and individualization of teaching methods in general [3, 4, 6, 7].

Each person is an individual, characterized by specific traits and abilities that are different by their nature. Students differ in their ability to perceive, organize, conceptualize, recollect memories, and use information (holistic/analytical type, dependent/independent type, socially sensitive/insensitive type, etc.). Also, personality factors influence the development of the traits of an individual (extrovert/introvert type, social skills, inhibitions, and more) [8].

Numerous studies have been devoted to teaching/learning styles such as visual, auditory, kinesthetic, as well as the strategies of teaching/learning such as cognitive, meta-cognitive, or social-affective [2].

In their research, Felder and Henriques concluded that students can learn in many different ways, by looking and listening, thinking, and acting, through logical reasoning or intuitively, memorizing, or visualizing. The teaching methods can also differ. Some tutors teach orally, others demonstrate or discuss. Some formally focus on rules, others on examples, some emphasize memorization, and so on. How much an individual student will learn in class depends in part on their innate ability and preparedness, but also on the compatibility of his or her approach to learning, and the tutor's approach to teaching [9].

The goal of personalizing teaching is to help students become aware of their learning strategies, analyze them, and identify which ones benefit them the most in different situations, as well as to develop new or to refine existing strategies. Developing awareness of such strategies would help students in becoming more effective learners and learn continually through their lives [13].

Usage of neural networks in data processing for personalized learning will provide the conditions for the adequate formation of classes, by respecting all the diversity of students, full understanding

and adoption of the material prescribed by the curriculum, consistency with the general curriculum and the constant insight into the progress of student achievement. This paper will use artificial neural networks as a method of processing and displaying data.

Method

Predicting student success is important for defining one's career, counseling, and guidance towards major choices. The development of predictive models is needed to become more aware of factors that could negatively affect student success (for instance, poor previous school experience, poor grades in an individual subject, etc.). Artificial neural networks that were previously researched to manage academic data, which was used to predict students' success. Emphasizing students' basic characteristics is one of the most important items in predictive modeling, as well as analyzing the studies addressing different classification methods.

Artificial neural networks are systems of interconnected neurons, which relay messages between themselves. The connections between these neurons have numerical weights that may be subject to change depending on experience, which makes the neural networks adaptive and capable of learning [15].

The structure of artificial neural networks consists of an input layer, output layer, and at least one hidden layer [17]. The data that is presented to the output layer are the desired values of the output variables. Before learning itself, it is necessary to define the model (input and output variables) and collect data from the school/student service and e-learning system on which the network will be applied.

Data should be divided into three samples: for training, cross-validation, and testing. There are no rules for the creation of this division, but it is recommended that most of the data points should be used for training of the network, while a smaller segment of data should be aimed at the testing and validation process.

A classification of data is defined to enhance the student's success. Such classification is determined by the minimum and maximum values related to student achievement during schooling. Its accuracy is increased during teaching by introducing variables such as records on student status, the average grade of students by current and past school years, number of subjects, the average grade of students by subjects.

In the network of artificial neurons that we are presenting, a simple model of what a neuron does is used. The neuron is modeled as a logical unit [10]. Xt (Figure 1) symbolizes the body of the neuron, while the input branches represent dendrites. Also, there is one output branch that represents the axon. In professional literature, such a unit is called a "perceptron".

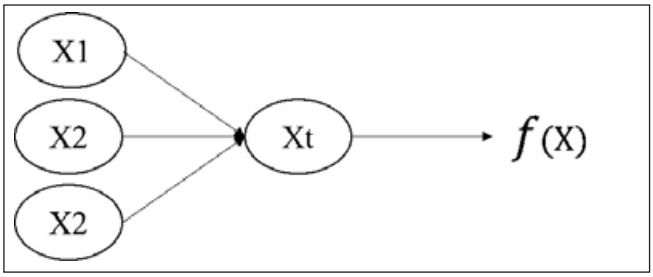

Figure 1: *Model of a neuron*

A neural network with forwarding propagation was used in this paper. In such a network, information flows one way; from the input units, data passes through hidden units, all the way to the output units. There are no cycles in the network, in contrast with recurrent neural networks [5].

The activation function used in the neural network is a sigmoid function:

$$h_\theta = \frac{1}{1+e^{-\theta^T x}} \quad (1)$$

where "x" represents the input, "θ" weighting factors, and "T" a transposition function. The activation function is also referred to in the literature as a hypothesis or a model, which is a generic term referring to a solution to a problem of a certain data exploration algorithm. The general form of a sigmoid function is:

$$g_z = \frac{1}{1+e^{-z}} \quad (2)$$

and its graph is shown in Figure 2. In addition to the sigmoid function, the unit step function, part by part linear, Gaussian function ie. normal distribution, as well as many others [1, 12, 16, 18].

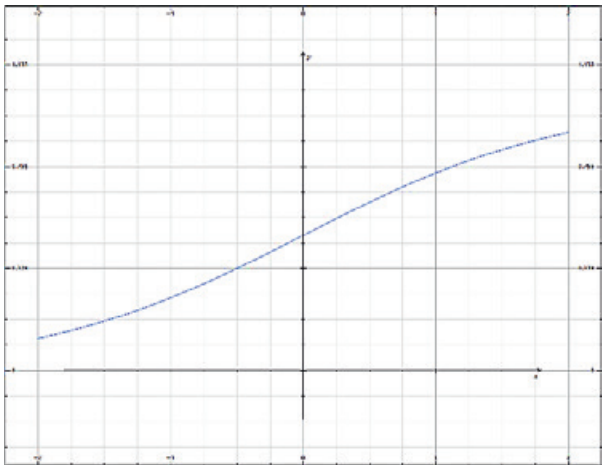

Figure 2: *Graph of a sigmoid function*

To develop the neural network model, a database with variables was created containing: records of student status, the average grade of students during current and past school years, number of subjects, the average grade of students per academic subjects.

The database with said variables includes processed results for 101 students of elementary school "Vojvoda Radomir Putnik", Dedinje, Belgrade, Republic of Serbia.

Input attributes were:

1. student status records
2. grading,
3. tests,
4. average grade of students per current year,
5. success in past school years and
6. mathematics assignments.

The output or target variable was:

7. result - the level of achievement - satisfactory

After arranging the data and transcribing it into CSV (comma-separated values) format, the data was compiled with the Neuro designer software application. Figure 3 shows the input variables and the output or target variable.

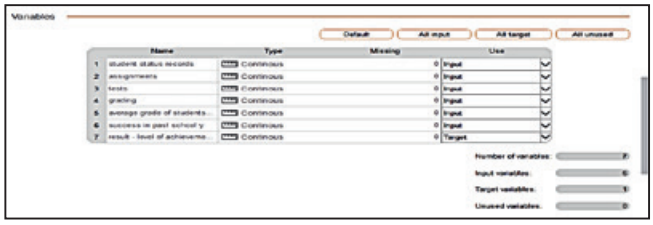

Figure 3: *Input variables and output or target variables*

Furthermore, the data for training and testing were determined in such a way that 60.8% of the total data points were determined for training and 19.6% of the data points were determined for testing. Figure 4 shows the historical error data for the applied Quasi-Newton optimization method by epochs.

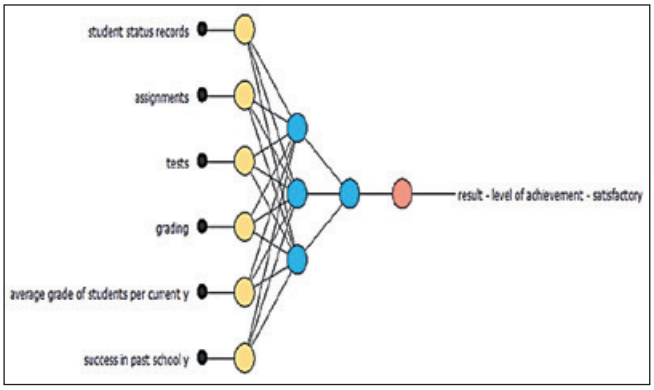

Figure 4: *Graphical representation of the Quasi-Newton optimization method*

The artificial neural network formed in this way has an input layer, three hidden layers, and an output layer as shown in Figure 5.

The value of the target variable "result - level of achievement - satisfactory" is determined by the values (0 and 1). The value of the target variable "0" is a value that indicates that in dealing with students it is necessary to take corrective measures, related to the individual characteristics and needs of the students. The corrective measures that need to be applied relate primarily to the revision of teaching methods, ie. the adaptation of activities to the needs of the individual student, reflected in other learning styles.

Numerous studies are devoted to learning styles such as: visual, auditory, kinesthetic (abbreviation: VAK), and learning strategies such as: cognitive, meta-cognitive, or social-affective. VAK concepts were originally developed by psychologists and teachers such as Fernald, Keller, Orton, Gillingham, Stillman, and Montessori, beginning in the 1920s. The VAK principles and theories today extend to all types of learning and developmental methods, well beyond its original fields of application. The VAK model provides a different perspective for understanding and the explanation of the preferred or dominant way of thinking and learning [14, 19].

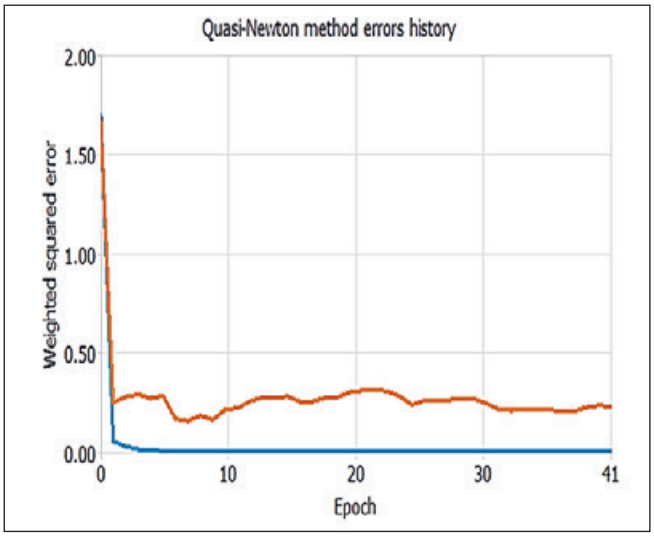

Figure 5: *View of the neural network*

To model an e-learning system that focuses on personalized learning, we have used the results obtained using artificial neural networks.

Results

The results of the classification accuracy of artificial neural network models represent the rate of correct classification on the training and testing samples [11]. The classification rate by output category applies to each grade separately. The average classification rate, in this case, is the rate of correctly classified students relative to the test sample. The average classification rate is 69.3%. As a model, we have used a multilevel perceptron with a forward propagation algorithm, containing three hidden layers, four neurons in hidden layers, a sigmoid activation function, and a forward propagation algorithm.

The obtained results show that in the test sample 69.3% of cases were correctly classified, while 30.7% of cases were wrongly classified. This network represents the classification rate for the output variable - "student mathematical achievements".

Based on the research, we have learned that students will be 85% more likely to receive a grade of three or more in the subject of mathematics, depending on the number of access to the eLearning system, and with the active guidance of teachers, which primarily refers to the proper identification of an adequate learning style.

To determine the results related to the value of the output variable "result - level of achievement - satisfactory" in the "NeuroDesigner" software application, testing was conducted to find the extreme values for the obtained grades, in case no corrective measures related to learning styles were applied. Figure 6 shows the values of grades at the lowest level of achievement which is "1", while the cumulative value is expressed in percentages indicating the probability that a student will meet a satisfactory level of achievement, and is 0.008%.

	Value
student status records	1
assignments	1
tests	1
grading	1
average grade of students per current y	1
success in past school y	1
result - level of achievement - satisfactory	0.00829400187

Figure 6: *Value of grades at the lowest achievement level*

Contrary to the case above, when corrective measures are applied to learning styles and when the grades are in the highest achievement level of "5", the cumulative value is expressed as a percentage indicating that the student is likely to meet a satisfactory level of achievement is at 0.987%. Figure 7 shows the values of the grades at the highest level of achievement which is "5".

	Value
student status records	5
assignments	5
tests	5
grading	5
average grade of students per current y	5
success in past school y	5
result - level of achievement - satisfactory	0.98732141

Figure 7: *Values of grades at the highest level of achievement*

The research presented in this paper indicates that the implementation of the proposed neural network model in the system of integrated e-learning platform can improve the rate of students' academic success and properly orient them towards the implementation of corrective measures, related to the identification and the utilization of adequate learning methods.

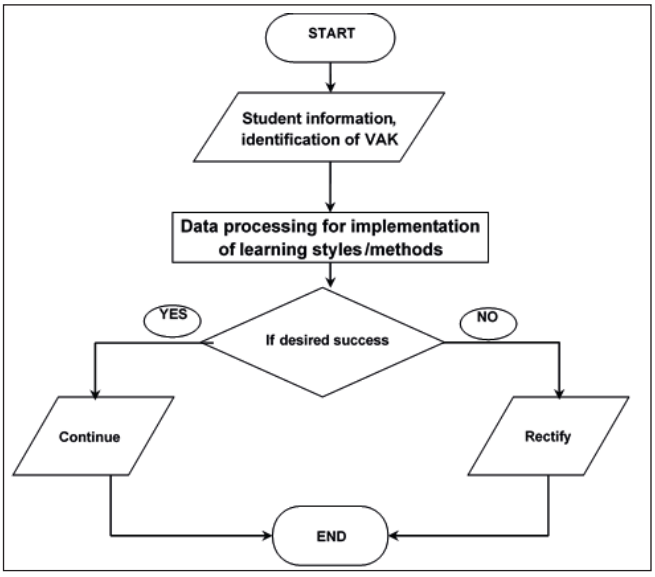

Figure 8: *Shows the functionality algorithm for applying artificial neural network results in the personalization of learning through e-learning systems.*

DISCUSSION

The basic contribution of this paper is reflected in several aspects. Firstly, the developed models of artificial neural networks can indicate to the teaching staff the success rate of the students.

Models for predicting student achievements can indicate to students which classroom activities they need to improve. This primarily refers to certain activities in an adequate e-learning system, such as homework, tests, quizzes, etc., where the algorithms developed specifically for this task may indicate certain activities that need to be stepped up to increase the academic achievements among students. Secondly, models can also be used by students themselves, to assess their future development during schooling, based on existing learning and grading habits or patterns, assessing the time needed to organize themselves, or the amount of additional effort needed for achieving their desired success.

CONCLUSION

In terms of the achieved scientific goal of our paper, we can conclude that a good basis has been created for the improvement of the teaching/learning process, in accordance with the student traits obtained, by developing and analyzing models based on artificial intelligence and neural networks.

The recommendation is based on the results of models that achieve predictive validity greater than 70% for average grades, grades for individual school subjects, as well as the identified factors and variables that are of great importance for the success of the learning process. The paper concludes that neural network models provide the highest accuracy in predicting student success.

The research findings presented in this paper will help identify the requirements that prospective students are facing, as well as the ways they can achieve the best possible outcomes during school years. The results of this research may be used by other educational institutions.

REFERENCES:

[1] Afzaal, H., Farooque, A. A., Abbas, F., Acharya, B., & Esau, T. (2020). Groundwater Estimation from Major Physical Hydrology Components Using Artificial Neural Networks and Deep Learning. Water, 12(1), 5.

[2] Anderson, Neil J. (1991). Individual Differences in Strategy Use in Second Language Reading and Testing. The Modern Language Journal, Vol. 75, No. 4: 460-472.

[3] Berman, Michael (1998). A Multiple Intelligences Road to an ELT Classroom. Carmarthen: Crown House Publishing.

[4] Berman, Michael (2001). ELT Through Multiple Intelligences. London: NetLearn Publications. Retrieved, Nov. 2006 from http://www.netlearnpublications.com

[5] Ke-Lin Du, M. N. S. Swamy, 2014. Neural Networks and Statistical Learning, Springer-Verlag, London.

[6] Gardner, Howard. (1983). Frames of Mind. The Theory of Multiple Intelligences. New York: Basic Books.

[7] Gardner, Howard. (1999). Intelligence Reframed. Multiple Intelligences for the 21st Century. New York: Basic Books.

[8] Ellis, R. (1986). Understanding Second Langauge Acquisition. Oxford: OUP.

[9] Felder, Richard M., and Eunice R. Henriques. (1995). Learning and Teaching Styles In Foreign and Second Language Education. Foreign Language Annals 28 (1): 21–31

[10] Alexander I. Galushkin, 2007. Neural Networks Theory, Springer-Verlag Berlin Heidelberg.

[11] Herbert Jaeger; Using Conceptors to Manage Neural Long-Term Memories for Temporal Patterns 18(13):1–43, 2017

[12] Jagtap, A. D., Kawaguchi, K., & Karniadakis, G. E. (2020). Adaptive Activation Functions Accelerate Convergence in Deep and Physics-informed Neural Networks. Journal of Computational Physics, 404, 109136.

[13] Jakobs, George M., and Thomas S. C. Farrell. (2001). Paradigm Shift: Understanding and Implementing Change in Second Language Education. TESL-EJ, Vol. 5. No. 1 A-1 April 2001. http://www.cc.kyoto-su.ac.jp/information/tesl-ej/ej17/a1.html

[14] S. Milinković, M. Maksimović, 2013. Case study: Using Decision Tree Classifier for Analyzing Students' Activities, Volume 3 Number 2 (pp. 87-95). Journal of Information Technology and Applications, Pan-European University Apeiron, Banja Luka, Republic of Srpska, BiH.

[15] Mišković V., Primena metoda mašinskog učenja u procesu razvoja informacionih sistema, Univerzitet Singidu-

num, Departman za informatiku i računarstvo, Beograd, Naučni skup sa međunarodnim učešćem, Sinergija 2010, br.str.185-191 ISBN: 978-99955-26-20-7.
[16] Ozgur, N., Taş, N., & Peters, J. F. (2020). New Complex-valued Activation Functions. An International Journal of Optimization and Control: Theories & Applications (IJOCTA), 10(1), 66-72.
[17] Maziar Raissi; 19(25):1–24, 2018 Deep Learning of Nonlinear Partial Differential Equations, Journal of Machine Learning Research Deep Hidden Physics Models: http://www.jmlr.org/
[18] Socha, J., Netzel, P., & Cywicka, D. (2020). Stem Taper Approximation by Artificial Neural Network and a Regression Set Models. Forests, 11(1), 79.
[19] Wickramsinghe, Samanthi & Hettiarachchi, Sunesh. (2017). Relationship Among Students' Learning Styles, Assessment Methods and Students' Performances, 3rd International Conference on Education and Distance Learning, At Sri Lanka, Volume: International Journal of Education and Distance Learning (Online: ISSN 2424-6514, Print: ISSN 2424-6506).

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