AC 2003-1255: MODELING THE PERFORMANCE OF AN OUTCOME-BASED EDUCATIONAL FRAMEWORK

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Modeling the Performance of an Outcome Based Educational Framework

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Abstract

In this paper, we introduce an Outcomes Based Educational model that has been adopted by Zayed University, a newly established institution in the United Arab Emirates. We provide an overview of the learning outcomes assessment courses used to support and assist students in their development of the university learning outcomes. We introduce the assessment process and the e-portfolio. The academic program model is a new concept that uses the outcome-based approach and the grade point average technique. This hybrid model is complex and includes many unsolved issues. In order to understand and clarify some of these issues, we propose to use neural networks that provide a mathematical model. To simplify the complexities of the academic model, we use a reduced map of the relationships between students' activities and the learning outcomes to be used in the assessment process. The model is tested using students' works. The neural networks based model is used to help decision makers improve the educational model.

1. Introduction

The educational model adopted by Zayed University (ZU), a new institution in the UAE, is based on an Outcome-Based Educational (OBE) learning approach[1]. This new educational concept in the Gulf region responds to the new demands of a modern society while continuously providing improvement to succeed in this rapidly changing world[2]. It also shifts the educational paradigm from what the teacher should teach to what the student should learn. In the OBE learning approach, the Learning Outcomes (LOs) are the kernel of the courses and the curriculum. All courses in an Outcome-Based Educational model are designed to clearly show the experiences that students may draw upon to achieve a learning outcome[3].

The Zayed University OBE learning model[1] is framed by three sets of Learning Outcomes two of which are course embedded. In this paper, the focus is on the higher intellectual outcomes that are not course embedded. They are called Zayed University Learning Outcomes (ZULOs). To fulfill their ZULO requirements, students compile evidence of their achievement in an electronic portfolio (e-portfolio), which is assessed by a faculty panel. A number of issues that are linked to the use of the Outcome-Based Educational approach have been identified. They include the correlation between the selection of the evidence and the achievement of a specific learning outcome, the students' reflection on their learning experiences, and the subjectivity and consistency in the assessment of student portfolio.

In this paper, we give an overview of the Zayed University OBE model with a focus on the ZULOs component. We provide an overview of the learning outcomes assessment courses used to assist students in their development of their work. We introduce the assessment process and the e-portfolio. Then, we propose a way of reducing the complexities of relationship between students' activities and the Learning Outcomes. We propose to use Neural Networks (NN) for modeling the ZU OBE framework. The model is tested on existing student works. We show how the testing results contribute to the shaping of the six Zayed University Learning Outcomes. Furthermore, the Neural Networks can be used to enhance the Zayed University OBE framework. The rest of this paper is organized as follows. Section 2 gives an overview of outcome-based education. Section 3 introduces the learning outcomes assessment courses. Section 4 presents the assessment process and the e-portfolio. Section 5 shows how assessment is performed using neural networks. Finally, Section 6 provides conclusions and future perspectives.

2. Overview of Zayed University APM and the Learning Outcomes

The Zayed University OBE model has been designed to ensure that all students acquire quality education and skills required for success in modern information driven society. It was developed to address challenges that face rapidly changing societies such as the UAE. The Zayed University academic program model is a hybrid approach that uses the grade point average system to evaluate student academic achievement and also includes Learning Outcomes embedded at all levels of the curricula[1]. It is designed to serve as the underlying structure that guide faculty and students in the development of all Zayed University programs. Figure 1 shows the components of the Zayed University educational model.

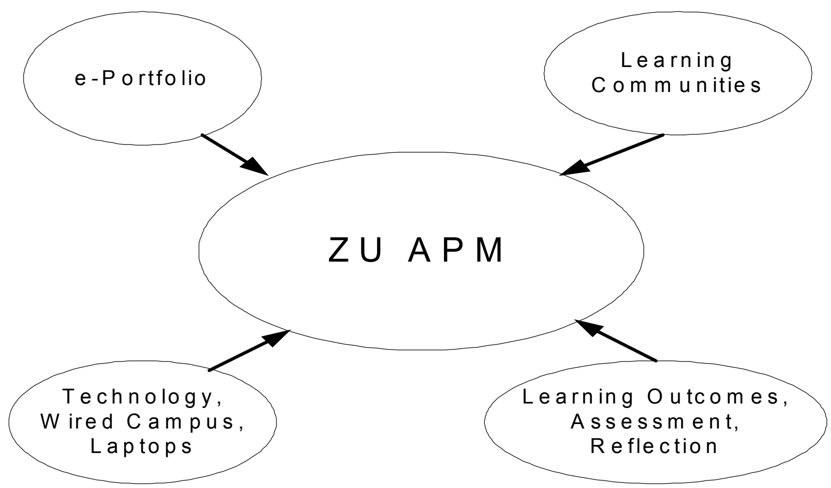

Fig.1. Components of the Zayed University Academic Program Model

The Zayed University academic model includes Learning Outcomes at all stages in the student's academic life. Students with the assistance of their advisors develop an individual learning plan. The Learning Outcomes emphasize planning, decision-making and application skills, and students are assessed for their ability to demonstrate applied synthesis and integration of knowledge and skills. There are six key Zayed University Learning Outcomes that form the basis of the ZU APM model. All students must demonstrate accomplishments in the six ZULOs before they graduate. They are defined as follows:

- *Information Literacy and Communication*: ZU graduates will be able to recognize information needs, access and evaluate appropriate information to answer those needs, and communicate effectively to a variety of audiences in both English and Arabic.

- *Information Technology*: ZU graduates will be critically aware of the implications of information technology on the individual and on society, and be able to use IT to communicate and solve problems in an ethical way
- *Critical Thinking and Reasoning*: ZU graduates will be able to use information, reasoning, and creative processes to achieve goals and make responsible decisions
- *Global Awareness*: ZU graduates will be able to relate to communities beyond the local, perceive and react to differences from an informed and reasoned point of view, and be critically aware of the implications and benefits of cultural interaction.
- *Teamwork*: ZU graduates will be able to work efficiently and effectively in a group.
- *Leadership*: ZU graduates will be able to assume leadership roles and responsibilities in a variety of life situations and accept accountability for the results.

3. Overview of Learning Outcomes Assessment Courses

Zayed University Students are expected to track and provide evidence of their significant learning experiences. To facilitate this process, students take special courses to learn how to collect pieces of evidence selected from classroom project and out of class activities. Students provide evidence of their achievement by creating an electronic portfolio (*e-portfolio*) reflecting their learning experiences. The e-portfolio is a collection of students' work that allows them to demonstrate academic achievement and personal growth, and also record their progress over time. Moreover, the e-portfolio allows students to see the relationships between the educational experiences, curricular and extracurricular, and represents some of the best samples of their work. It also provides an explanation of how those samples demonstrate students' achievement of the university's learning expectations.

Furthermore, ZU students are required to write an *essay* to reflect on their learning experiences, in which they explain how they substantiate the level of achievement of a particular learning outcome. Students are required to present an oral defense of their abilities in the Zayed University Learning Outcomes to an *assessment panel*. This assessment requires students to discuss three areas of their development in the ZULOs: a piece of evidence which represents their best work, a reflection on the outcome achievements, and a statement of how they have satisfied the college requirements for the ZULOs for their major. The assessment panel provides oral and written feedback to students regarding their developmental level in each ZULO and will produce a narrative *report*. The report will become part of the student's record and is forwarded to colleges. The colleges can then decide on how they wish to use this feedback in decisions regarding entry to internship.

During their final baccalaureate year, Zayed University students must successfully complete an *internship* and develop a *capstone* project. The capstone project serves as a culminating focal point, encouraging students to tie together the knowledge, skills and abilities they have developed during their learning experience at the university. Students' abilities in the ZU Learning Outcome areas are assessed in connection with both the internship and capstone. In their internship, students must satisfy the employer's as well as faculty supervisor's requirements. In their capstone project, they must take responsibility for completing a major project in their chosen field to the satisfaction of their major program faculty. At the end of their internship, students make a final report in which they perform a reflection on their achievement of the learning outcomes and a critical review of their experience. This exercise may help students make better career decisions upon graduation.

It is difficult to keep up in today's fast –paced world. One of the major purposes of the capstone project is to develop students' awareness of the vital importance of lifelong learning. Throughout the university's programs, students develop skills they will need in order to continue learning and to make good use of their knowledge, whatever future circumstance they may face. They are expected to reflect on their work, objectively assess their accomplishments, and continuously improve their performance. Equipped with intellectual skills learned and experimented with during the capstone experience and which go far beyond the course-credit approach, Zayed University graduates are ready to envision the possibilities and seize the opportunities that will shape their future and the future of their nation.

4. Complexities of the model and unsolved issues

The Academic Program Model is a new concept to the institution and therefore its successful adoption and implementation by faculties and students is conditional upon a number of points. First of all, the faculty as a body should believe and embrace the OBE model. This should be reflected by the inclusion and implementation of the outcomes in the faculty' coursework. In fact, the university requires that all faculty members submit course syllabi with a common format that clearly shows where and how the outcomes are implemented in the course. Faculty begins by clearly stating all the learning outcomes in his/her course syllabus including a centerpiece in the list of class activities that embed the outcomes. However, the course syllabus provided by the faculty does not necessarily mean that he/she will implement the outcomes in the classroom. The degree of implementation of the OBE by the faculty will impact the success of the APM.

Students in the university are exposed to the OBE approach since they join the institution. They take specially designed courses that introduce them to the learning outcomes. They are taught on how they look for evidence and how they reflect on their learning experiences. However, often times the piece of evidence that the students provide to show that they have satisfied a given ZULO, does not support the indicators that satisfy the outcomes. Therefore, they need to write a reflection piece to clearly show how the evidence supports the outcomes. Moreover, this problem is aggravated by the fact that English is not the students' native language.

The above and other issues such as the definitions of the outcomes and indicators, the number of indicators per outcome, and the redundancy in the indicators challenge the implementation of the APM and impact its performance. We simulated the APM to test its performance, and to better understand the strengths and weaknesses of the outcomes[4].

5. Neural Networks based modeling and assessment

A mathematical model is developed to capture the dynamics of the Academic Program Model. The inputs are the activities developed by students and the outputs are the achieved outcomes. However, the activities should satisfy the indicators in order for the outcomes to be achieved. Because the activities/indicators relationships are multidimensional and could be interpreted differently in some cases, it is natural to use a modeling approach that takes into account these complexities. Therefore, we chose to use the highly efficient Artificial Neural Networks (Ann's) as a modeling and analysis tool[5]. Ann's are universal approximators[6, 7] that when appropriately trained can learn any input-output map. The indicators/outcomes map is more clearly defined. Neural networks or if-then type of rules can model it. However, due to the redundancy in the definition of some indicators, we chose another neural network to perform the map function as shown in Figure 2.

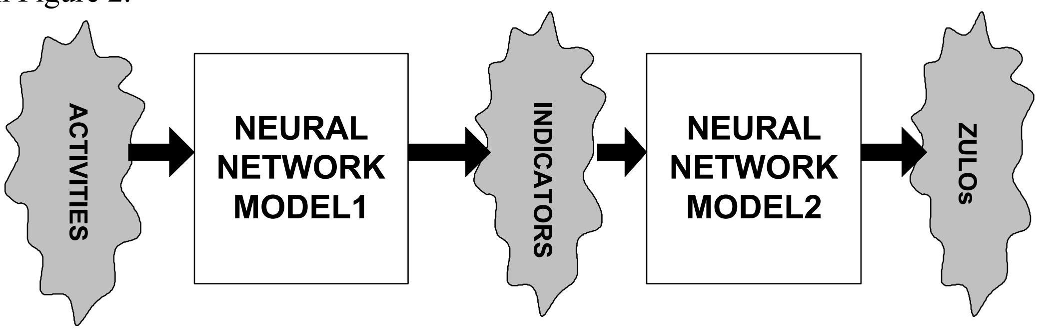

Fig.2. Activities-Indicators-ZULOs model

Table 1 gives a list of activities, curricular and extra curricular, and how they map into the indicators and the outcomes.

Table 1. Example of ZULO-Indicator-Activity map

ZULO	Indicators	Example of Activities
1. Information Literacy and Communication	1. Determine the nature and extent of information needs 2. Access information 3. Evaluate information and its sources critically 4. Use information effectively to varied audiences in multiple contexts 5. Adhere to ethical practices in use of information	Use of Internet, Search for information, Use of Internet, WWW, on-line databases Class Projects Presentation
2. Information Technology	1. Use information technology tools for productivity, communication, research, problem solving and decision making to a professional standard 2. Identify the wider implications and ethical issues of the use of information technology, and recognize its impacts on society and the individual	Use of computers, Use of application software, Use of Internet, WWW technologies
3. Critical Thinking and Reasoning	1. Analyze, synthesize, and evaluate information from differing perspectives 2. Develop and defend a reasoned argument 3. Use cognitive abilities and strategies for decision making 4. Reflect on and evaluate own thinking processes and reasoning	Class projects Seminars Writing a paper Debate society Discussion Internship Capstone

4. Global Awareness	1. Provide an informed response to a global concept or issue 2. Examine global issues within the local context 3. Propose or plan action to address an international issue in the local context in a way that demonstrates social responsibility 4. Acknowledge other cultures	Class projects Athena society Clubs, Organizing special events, Attending conferences, Internship, Capstone
5. Teamwork	1. Negotiate and compromise for shared decisions while maintaining one's own integrity 2. Cooperate with group members while assuming responsibility for self and group outcomes 3. Use recognized theories of group dynamics and apply personal experience to facilitate group process 4. Offer creative and constructive input to the group and accept similar feedback 5. Recognize and acknowledge each group member's contribution and those of others	Student council Athena society Clubs, Organizing special events, Giving outside class presentation, Leading a class project, Internship Capstone
6. Leadership	1. Identify and evaluate qualities of leadership in others 2. Construct a personal philosophy of leadership 3. Consider multiple perspectives of other prior to pursuing a stated goal 4. Implement a personal philosophy using innovative approaches to achieve constructive outcomes	Student council, Athena society, Clubs, Organizing events, Presentation, Leading a class project, Internship

The model in Figure 2 could even be made simpler by mapping the activities directly to the outcomes. This reduces the complexity while providing an approximate solution to the problem. Hence, we propose the model shown in Figure 3.

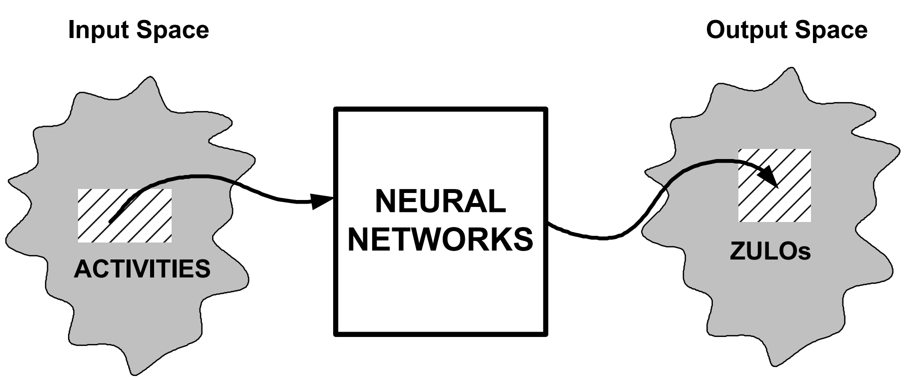

Fig.3. Activities-Outcomes model.

Although, there are many different kinds of neural network architectures and learning algorithms, we chose to use multilayer feed forward neural networks, as shown in Figure 4, trained with the back propagation learning algorithm[8].

The inputs to the NN are the combination of the activities and students reflection. If students select an activity and supports it with the correct reflection then the outcome is achieved. However, in case students select an activity that does not support an outcome or the student reflection is not consist with the selected activity, then the outcome is not achieved. We use the logic function AND to aggregate the activities to the reflection at the inputs. For the outputs, a sigmoid type of transfer function is used. The sigmoid function can either be extended or

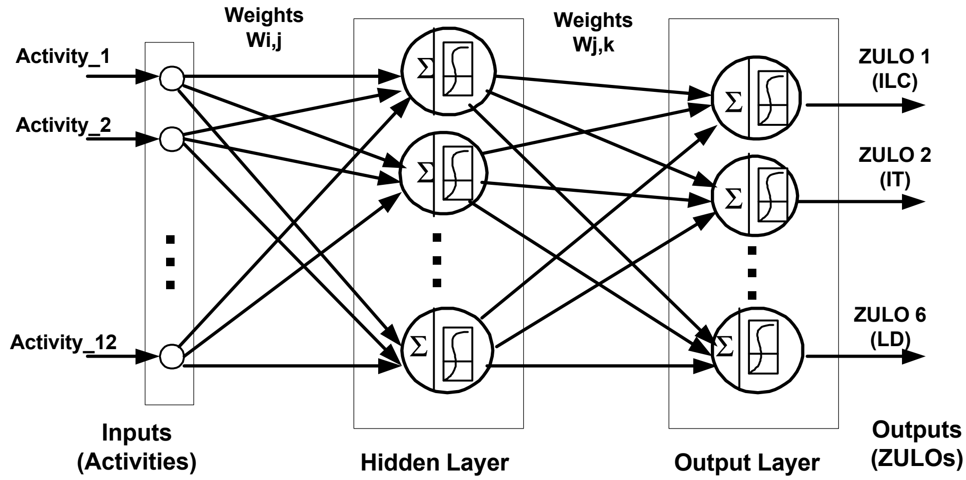

Fig.4. Feedforward neural networks model

contracted depending on our requirements for success. If it is close to a step function, then the requirements for pass/fail are stringent. On the other hand, when the sigmoid is close to a linear function, the requirements for success are lenient.

We performed a number of simulations based on the input-output data of Table 2. This table shows twelve different groups of activities. They have been formulated based on the indicators of Table 1. For example, Activity 1 and 2 are related to the Information Literacy and Communication outcome.

Table 2. Activities-ZULOs map

	Activities where students	Reflection	Information Literacy & Com.	Information Technology	Critical Thinking & Reasoning	Global Awareness	Team Work	Leadership
1	Determine the nature and extent of information needs, access and evaluates information	X	1.0	0.0	0.0	0.0	0.0	0.0
2	Use information to communicate effectively, and understands ethical practice	X	1.0	0.0	0.0	0.0	0.0	0.0
3	Use technology for productivity, communication, research, problem solving and decision making	X	0.0	1.0	0.0	0.0	0.0	0.0
4	Identify implications and ethical issues of the use of technology, and recognize its impacts on society and individual	X	0.0	1.0	0.0	0.0	0.0	0.0
5	Use cognitive strategies to define a goal, make a decision, or solve a problem	X	0.0	0.0	1.0	0.0	0.0	0.0

6	Reflect and evaluate own thinking processes and reasoning	X	0.0	0.0	1.0	0.0	0.0	0.0
7	Provide an informed response (examine) to a global concept or issue	X	0.0	0.0	0.0	1.0	0.0	0.0
8	Address international issues in a responsible way and acknowledge values of other cultures	X	0.0	0.0	0.0	1.0	0.0	0.0
9	Cooperate with group members, negotiate and compromise for shared decisions	X	0.0	0.0	0.0	0.0	1.0	0.0
10	Use recognized theories of group dynamics, offer creative and constructive input, and assumes responsibility	X	0.0	0.0	0.0	0.0	1.0	0.0
11	Identify and evaluate qualities of leadership and construct their own philosophy	X	0.0	0.0	0.0	0.0	0.0	1.0
12	Consider multiple perspectives of others and implement their own innovative philosophy	X	0.0	0.0	0.0	0.0	0.0	1.0

The OBE model has been tested using Neural Networks Toolbox on MATLAB Simulation package. We use 22 neurons of Tan-Sigmoid transfer functions at the middle layer and six Log-Sigmoid transfer functions to generate the ZULO outputs at the output layer. Tan-Sigmoid generates output between –1 and 1 and helps speed up the process of learning of the NN. Log-Sigmoid function generates continuous output in the range 0 and 1. The maximum number of 1 represents the case of student providing evidence and an appropriate reflection on the activity. We used the gradient descent-training algorithm with momentum where the learning rate is set to 0.05 and the momentum factor is set to 0.9. We chose a learning goal of 1e-5 and a training epoch of 50000. Figure 5 shows the sum-squared error while training is performed. Though the network did not reach the error goal we set at the maximum number of epochs, the error value of 0.000483988 was small enough to be considered a good performance.

We tested the obtained network using a matrix of inputs showing a maximum evaluation of 1.0 for each group of activity. The results of testing are shown in Figure 6, which confirms the performance of the network. Then, we selected a student work and its assessment and conducted the simulation (Activity 1 to 70% and Activity 12 to 80% success). Here also, the network outputs the right answers (right-hand side of Figure 6).

There is a need to carefully address the issues listed in section 4 for successful and efficient implementation of the Zayed University hybrid APM model. These issues include the assessment of the student's work, the efficient selection of activities that lead to achieving a given Zayed University Learning Outcome (ZULO), courses design that are based on general education and majors learning outcomes, and the assessment of the performance of students in their understanding of the learning outcomes concept. The academic model has to be assessed and refined to best address the above-mentioned issues. For that purpose, an analysis tool can be devised to track and monitor the performance of the APM model. This process can be done by using a traditional method, such as collecting data from the university's registrar office and performing basic statistical analysis on a yearly basis. However, this method will generate information that may be difficult to assess and interpret.

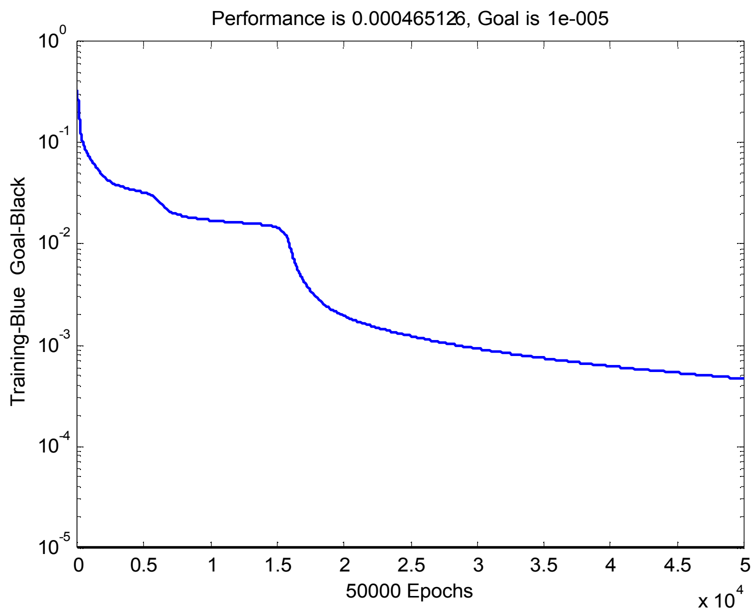

Fig.5. Sum-squared error of the neural networks

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» A=sim(net,P)

A =

 Columns 1 through 7

  0.9665  0.9695  0.0272  0.0149  0.0242  0.0037  0.0129
  0.0202  0.0060  0.9715  0.9599  0.0096  0.0233  0.0016
  0.0242  0.0146  0.0214  0.0102  0.9641  0.9567  0.0153
  0.0030  0.0273  0.0201  0.0103  0.0235  0.0054  0.9668
  0.0041  0.0236  0.0141  0.0118  0.0223  0.0055  0.0010
  0.0067  0.0001  0.0172  0.0336  0.0006  0.0189  0.0268

 Columns 8 through 12

  0.0255  0.0122  0.0031  0.0201  0.0000
  0.0282  0.0051  0.0242  0.0048  0.0230
  0.0270  0.0065  0.0291  0.0136  0.0255
  0.9639  0.0100  0.0019  0.0214  0.0285
  0.0002  0.9714  0.9680  0.0070  0.0284
  0.0030  0.0264  0.0130  0.9699  0.9583
```

```
» B1=sim(net,B)

B1 =

 Columns 1 through 7

  0.8861  0.0492  0.0492  0.0492  0.0492  0.0492  0.0492
  0.0101  0.0059  0.0059  0.0059  0.0059  0.0059  0.0059
  0.0164  0.0173  0.0173  0.0173  0.0173  0.0173  0.0173
  0.0032  0.0094  0.0094  0.0094  0.0094  0.0094  0.0094
  0.0040  0.0156  0.0156  0.0156  0.0156  0.0156  0.0156
  0.0064  0.0188  0.0188  0.0188  0.0188  0.0188  0.0188

 Columns 8 through 12

  0.0492  0.0492  0.0492  0.0492  0.0001
  0.0059  0.0059  0.0059  0.0059  0.0158
  0.0173  0.0173  0.0173  0.0173  0.0221
  0.0094  0.0094  0.0094  0.0094  0.0222
  0.0156  0.0156  0.0156  0.0156  0.0258
  0.0188  0.0188  0.0188  0.0188  0.9013
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Fig.6. Testing the Neural Network

6. Conclusions

In this paper, we proposed a learning assessment process for an OBE educational model that can support and assist students in their development of the university's learning outcomes. Students provide evidence and reflections on their achievements of the understanding of the outcomes and their progress by developing electronic portfolios. Assessment panels review the student work and provide feedback. We have shown that reduced set of activities can help reduce the complexities in the assessment process formulation. We proposed to use neural networks to model the activities and learning outcomes relationships. The mathematical model was used to look for the student activities that best support indicators for achieving a particular learning outcome. We showed how the model could look for weaknesses in the learning outcomes by statistically tracking student's achievements. The results can be used to revise the university's curriculum and address the challenges that face rapidly changing societies such as the UAE. The proposed neural network based assessment model provides educators and administrators with some insight on how the learning model will perform under various conditions.

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