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Conceptual Evaluation of Massive Open Online Courses through Pathfinder Associative Networks

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Abstract: In this research, a new methodology for the conceptual evaluation of students of a Massive Open Online Course (MOOC) is addressed. The electronic circuits MOOC course "Bases de Circuitos y Electrónica Práctica" (Fundamentals of Circuits and Practical Electronics) was used as a model. The conceptual evaluation of the course was measured by the semantic proximity between ten relevant concepts of the course. This semantic structure involves conversion and reduction processes through Pathfinder associative networks and the minimum spanning tree. The gain between the start and the end of the course is calculated by statistical tests considering the similarities between the students' networks and the teacher's network, as a reference network. The results show significant gains, particularly when evaluating courses with badges. We propose this evaluative model as a recommended generic model that can be integrated into MOOCs due to its immediate and online response.

Keywords: Evaluation, MOOCs, Cognitive models, PFNET, Minimum spanning trees, Minkowski distance, R language
Categories: L.0.0, L.1.1, L.3.0, L.3.5, L.6.0

1 Introduction

In a knowledge society, education needs to be re-thought in depth in order to adapt to the genuinely student-centred learning pattern rather than its fixed traditional learning counterpart. In student-centred learning, the responsibility is shifted from teachers to students; students are expected to maximize their learning outcomes using relevant technologies and their own competencies. This learning pattern was announced as one of the principle commitments of the bologna process, for the progress of the European Higher Education Area (EHEA) [EHEA 15], in its last ministerial conference in Bucharest in April 2012 – stressing as well on other factors such as learning outcomes, quality assurance, mobility, and evaluation frameworks. The purpose is to create graduates who can evolve seamlessly into a mode of lifelong learning, continuing education, or even vocational education to cope with such knowledge society [Bourne, Harris and Mayadas 05]. Learning or knowledge acquiring is no longer confined to certain age, place, or time. Instead, it can be seen as something voluntary and self-motivated that takes place throughout life and on an on-going basis from our daily interactions with others and with the world around us.

In 1969, the world's first successful open university, The Open University (OU), was established in United Kingdom, followed by many successful initiatives around the globe that offer higher education on a part-time and/or distance learning basis – including people with health disabilities – such as Spanish University for Distance Education (UNED) in Spain and Latin America, Open Universities Australia (OUA) in Australia, Indira Gandhi National Open University in India, and Arab Open University (AOU) in Middle East and Africa. However, full-distance education programs were not likely until the evolution of Information and Communication Technologies (ICT) and their application in education, what is now known as E-learning.

In 2002, Massachusetts Institute of Technology (MIT) have sparked the global Open Educational Resources (OER) movement by its MIT OpenCourseWare (OCW) [OCW 02] initiative and after announcing that it was going to putting its entire course catalog online in order to enhance human learning worldwide by the availability of a Web of knowledge. As of November 2011, over 2080 courses were available online. MIT was then quickly followed by the creation of the OCW Consortium [OCWConsortium 11] which now unites over 300 institutions, corporates, organizations and consortia from over 40 countries around the world with materials from thousands of courses accessible. Extending the concepts of OCW, Massive Open Online Courses (MOOCs) was originated in 2008 within the OER movement. MOOCs are open online courses that are more structured formal and aiming at large-scale interactive participation. Only a few percent of the tens of thousands of students who may sign up complete the course. Typically they do not offer academic credit or charge tuition fees but in some cases they offer the possibility of earning academic credit or certificates based on supervised examinations. Over the time, the adoption of E-learning in academia and work place are getting more common thanks to the rapid pace of evolution of ICT. The adoption of E-learning is rapidly evolving and the process is irreversible. According to "The 2011 Survey of Online Learning" of the Sloan Consortium [Allen and Seaman 11], 31% of higher education students now take at least one course online and 65% of higher education institutions now say that online learning is a critical part of their long-term strategy.

1.1 Motivation

The prevalence of online courses, as occurred within many fields, will evolve in line with the academic and professional demands. This research deals with the structure and the approach that MOOCs actually adopt and in particular the way they are assessed, trying to shed light on the process of building knowledge acquired by the student during the course, so that the information obtained by the teacher about the quality of learning of the students is increased, in a noninvasive way to students.

The current design of the MOOCs permits the participation of a large number of people. Nowadays, many students are subscribed to this wide range of courses, and the number is continuing to rise exponentially. The current evaluation design of MOOCS allows the teacher to know the progress of each student, but only contemplating the number of completed tasks or modules. By applying quizzes or other tools, either at the beginning or at the end of the course, we could evaluate what students have learned in each module. On the other hand, many online courses offer the possibility of a traditional exam once they are finished, an optional step for those who would like to obtain an official accreditation of the knowledge acquired.

The principle raised question is: how to automate the evaluation process in an intelligent way? In other words, without restricting ourselves to mere tests or practical exercises, Could there be an alternative evaluation design that could measure the knowledge acquired as if it was a guide or learning map? In response to these needs, in this paper we examine whether the use of associative networks can describe the knowledge acquired by students participating in a MOOC in an automated way, and the advantages that may result from their use as opposed to the traditional and the prevalent exercises or test of thematic assessment.

1.2 Objectives

As a research objective we proposed the evaluation of the learning performance of a set of students of a MOOC [Guàrdia, Maina and Sangrà 13] on "practical electronics" by assessing the difference between the baseline semantic structure (baseline network) and the cognitive structure of students. This procedure would provide a holistic evaluation criteria for student learning rather than the traditional evaluation method of MOOCs, which focuses on the evaluation by tasks.

1.3 Document Structure

This paper is structured as follows: [Section 2] provides a review on few important concepts that will be adopted in the research process. [Section 3] describes the sample of students participating in the research and the resources used for collecting the information. [Section 4] describes the proposed evaluation pattern in detail. [Section 5] presents the obtained results of the research. Finally, a conclusion is drawn and presented in [Section 6].

2 Review of Concepts

A good teacher [Downes 10] often has the goal of inquiring about the phenomena occurring in the students' minds and about how to carry out the representation, description, and study of such phenomena. By learning more about the students' mental processes and how they function. Appropriate teaching and learning techniques and procedures can be developed for achieving an optimum process for conveying information to students, which would produce beneficial results for the students, and consequently, for the educational system.

In the classic teacher-student model of information transfer within MOOCS, the educator is a mediator in order for students to acquire the necessary knowledge. In this research, Cognitive Science (CS) [CCNBook 14] is the reference framework upon which this conceptual evaluation model is developed.

The CS is founded mainly on two solid pillars: Biology and Artificial Intelligence. The former is important for providing the knowledge required to understand the physiological, neuronal, and nervous structures, which support mental processes. The latter deals with processes of reproducing human thought and the solution of problems with computer systems, using systems of neuronal networks, expert systems, and fuzzy logic, among other procedures.

Previous studies were carried out, among others, by [Casas and Luengo 99, 00] which considered how the use of Artificial Intelligence techniques could help to describe, represent, and study the mental processes in terms of the acquisition of a concept or the comprehension of a certain topic. These mental processes are symbolized by a network model (connectionist), by which it is assumed that the information is organized in structures with semantic content. This information is composed of concepts – also called nodes – and these are linked by connections (arcs). Thus, in order to determine the significance of a stimulus, we start from the connections that exist between the different concepts, such as the strength of relationship that exists between the different arcs or the weight of association between the different concepts [Schvaneveldt, Durso and Dearholt 89]. In this regard, we suggest the use of Pathfinder associative networks with the purpose of discovering the connections between concepts with regard to the electronic circuits practices carried out using the remote laboratory platform, Virtual Instrument Systems in Reality (VISIR). VISIR is a remote laboratory, integrated and accessed within the electronic circuits MOOC course offered by UNED, with the objective of performing a conceptual evaluation of the knowledge acquired in the course.

2.1 **Pathfinder Associative Networks**

Understanding requires thinking. Understanding is actively constructed from the inside by establishing relationships between new information and what they already know or between pieces of known information, but previously isolated. This learning has been attributed meaningful learning.

Meaningful learning involves assimilating and integrating information. The meaningful learning of concepts is rarely based on isolation. Each new incoming knowledge is intended to be built in the cognitive structure of the individual. The learning process is realized by matching related knowledge with the new. Eventually, a network is formed efficiently, meaning that maximum connection is achieved with next concepts with minimum number of nodes or concepts to control a topic. Such networks can be represented by cognitive maps or by pathfinder networks.

Pathfinder associative networks [Schvaneveldt 90] are representations in which concepts are identified by nodes and their relationships by arcs which are longer or shorter depending on the weight or strength of their semantic proximity. These methods assume that a spatial representation between the concepts can be used to describe the pattern of relationships between them in the memory [Casas and Luengo 04].

Associative networks have certain characteristics which are desirable in a research tool, making them ideal for evaluating the relationship between concepts, such as:

- Capacity to carry out studies with as much detail as desired.
- Presentation of data in a graphical form, which is very useful for facilitating the comprehension of information.
- They are simple to apply and do not require profound knowledge of the topic.

These characteristics, among others, make them interesting as a tool for obtaining the cognitive structure of students faced with a task.

Pathfinder associative networks have applications mainly in three fields: basic research, teaching, and designing interfaces in hypermedia products. In the field of teaching, there are studies on differences between experts and apprentices, or the prediction of student achievement from the similarities between teachers and learners [Sanders 08].

2.2 Conceptual Evaluation

Another important issue in education, besides the construction of knowledge, is the role of monitoring done by the evaluation.

In the evaluation process, following [Rowntree 86], we must ask the following questions: Why we evaluate? What should be evaluated? How to evaluate it? And what to do with the results of the evaluation?

In MOOCs, such questions could be addressed as follows:

1. It is evaluated to: motivate students by providing feedback to them and to the teachers as well; prepare students for real life workplace; or improve students' ability.
2. It should assess knowledge through understanding and connecting.
3. With regard to assessment, it is important to determine when and with which procedures. In the classical model of evaluation, MOOCs are evaluated at the end of each topic or each module. In the proposed model, evaluation can be continuous or summative, although the experiment focuses on the latter. As procedures, the classical model calls for objective tests, questionnaires, or brief exercises or problems. In return, we propose a model focused on general concepts.
4. Finally, regarding what to do with the evaluation results, in the student-centered MOOCs, responses varied according to the motivations of the students.

On the other hand, the nature and purpose of the evaluation [Novak and Gowin 84] influence the specific cognitive activity of the student. The vast majority of students focus their attention on learning what will be evaluated [Clariana and Wallace 02]. Students direct their activity to rote learning if it is evaluated with a multiple-choice test or to a procedural learning if exercises must be done, but teachers should have a more holistic vision of learning and should be interested in learning their cognitive structure when teaching a particular topic.

The research proposed presents a new method for evaluating learning, since this is always approached with tests which partially control the set of concepts learned by the student, but do not give an idea of the cognitive domain of them. This research can provide MOOCs a tool for evaluating the conceptual learning of the main topic, the whole set of its concepts, or of a particular topic. Furthermore, this tool can be perfectly integrated into the online development of the course.

3 Sample and Material Used

3.1 Participants

The study was carried out on the concepts taught in the MOOC: “Bases de circuitos y electrónica práctica” (Fundamentals of Circuits and Practical Electronics). There were 3,315 students registered for this course, although only 2,419 were active (carrying out some type of activity, such as participating in forums, viewing videos, answering questions, etc.). Only 80 students achieved the badge by exceeding the objectives set for the course: 39% of the videos were viewed and 61% of the questions were answered correctly.

At the beginning of the course, the students were informed with the research to be carried out and were asked for their voluntary collaboration. Data from 144 students was collected at the start of the course, which represents a sample error of 8% in the worst case scenarios of the sampling ($p = q = 0.5$). Upon the completion of the course, the data was collected again as indicated below, with 52 students participating, of which 46 coincided with students evaluated at the start and therefore usable for comparison in the evaluation of the conceptual gain of the topics acquired during the course.

3.2 Resources

The following data from each student was needed for the following research objectives: a) identification, in order to find out the conceptual gain during the teaching process, and b) the matrix of semantic distance between the relevant concepts of the course. Moreover, the evaluation must provide the baseline semantic distance matrix of the relevant concepts.

The material used in the research to gather the data required of each student in one file was the free software program “jRateDrag.” This program simplifies the creation of networks to obtain a distance matrix. Through a graphic interface, it presents the terms so that the student can move them with the mouse in order to indicate the semantic proximity between them. This program has advantages over other free software, such as JRate.jar and JTarget.jar, as discussed by Schvaneveldt in [Interlink 14]. It presents all the terms that are to be connected on one screen, thus facilitating the data collection work. Instead JRate.jar presents the binary relationships between terms for evaluation; and JTarget.jar presents the relationship between each term and the rest although with a graphical interface, thus requiring *n-1* screens for gathering the relationship between all the terms. These advantages in comparison to its competitors lead us to select this program for data collection.

The program “jRateDrag” generates two files, one with a “jpg” extension and the other with a “prx” extension. For the purpose of research, we are only interested in the latter, whose format contains the identification data of the students and the relationship between terms [see Tab. 1].

In the table, the (DATA) row shows us the student’s identification (DNI – national identity number) followed by the letter “a” to indicate the moment of data collection, in this case, at the start of the course. To indicate the end of the course, the student’s national identity number will be followed by the letter “b.” Then there is a set of data which the program generates and finally the matrix of semantic distance between the ten concepts are considered essential for comprehension of the MOOC [Martin 12] on "circuits and practical electronics."

```
DATA:     09303486a.prx           DATE:     22/11/13  1:44
ELTIME(MilliSecs):  600593
dissimilarities
10 items
0 decimals
0 min
1000 max
lower triangle:
  23
 253  168
 369  149 145
 493  255 263 124
  48  246 261 360  387
 249   31 139 144  162 230
 128  155 136 241  270 125 130
 236  145  26 145  181 240 115 115
 241   71  97 130  157 230  42 114  86
```

Table 1: Example of data file with the answers of a student

The data of the baseline matrix was saved in a reference file. The concepts of this baseline semantic matrix were selected by the teacher of the course. For the elaboration of this reference file, the guidelines followed were those used in the previous research [Hidalgo 07, Arias 08], which are of proven validity for the purposes of this research. The guidelines are as follows:

- First, each one of the concepts that make up the network was defined: these definitions were the product of a literature review as well as consultations and discussions with colleagues.
- Afterwards, the degree of relationship that each one of the concepts had was determined by a relationship matrix with the following criteria:
  a. If concept C1, in its definition, contains concept C2, then the relationship must be maximum, and therefore its proximity or distance is minimum (d_{min}).
  b. If concept C1, in its definition, contains concept C2, which in turn contains concept C3, that is, a second order relationship, then the relationship between C1 and C2 has a greater distance than d_{min}.
  c. Following the same guideline, a third order relationship was assigned a distance value greater than point *b*.
  d. A fourth order relationship or greater was assigned the most distant proximity value, near the maximum of the scale of distances, in this case 1000.

As mentioned previously, the students' data was collected on two occasions, at the start and at the end of the course, and were always compared to the baseline matrix.

The entire procedure of information processing was carried out by programs prepared (ad hoc) in R language, which is an integrated option of free software for processing Pathfinder associative networks. Three applications were prepared: a) one application which transformed the students' data into Pathfinder associative networks; b) another application for comparing the students' networks with the baseline network, giving individual values of similarity; and c) a third to fuse into one file the similarities according to the baseline network and the students who coincided at the start and the end of the course-the students who finished the course successfully. Furthermore, in order to assess the significance of the differences observed at the two occasions, statistical tests for related samples were applied to these variations.

From the point of view of the student, the exercise of creating the network is quite intuitive, the "jRateDrag" program shows a graphical interface where a number of concepts or terms are presented-in our case ten. The exercise done by the student will determine the degree of relationship among them. To determine this relationship simply move the terms on the screen moving away or towards, further terms can be grouped into different groups according to the relationship that the student believes. Finally, the program will translate these relationships in proximity distances, establishing a weight more or less according to the proximity of terms.

All this is achieved simply with a mouse, by clicking and dragging the terms. The [Fig. 1] shows a screenshot of the graphic interface used by the students.

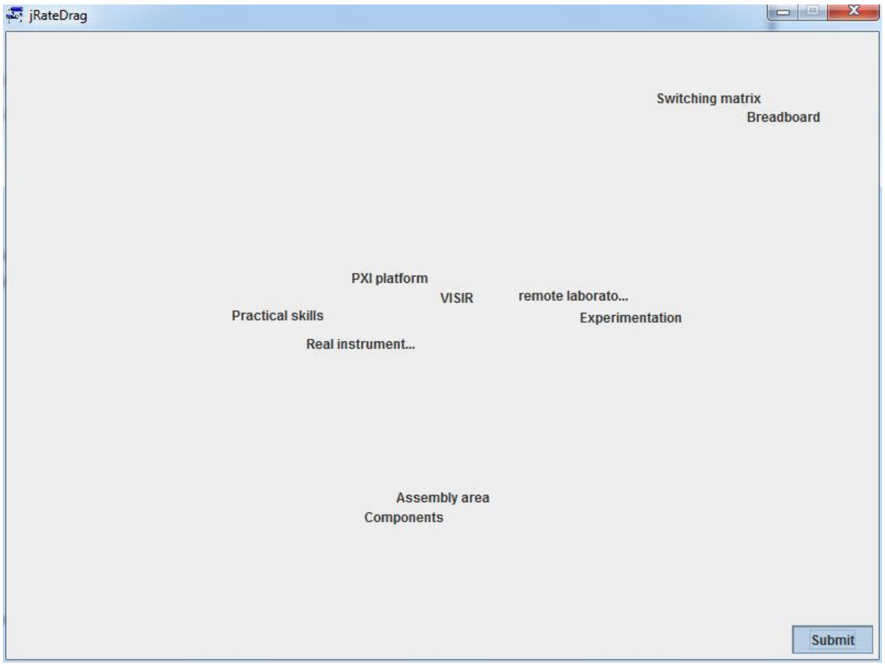

Figure 1: Graphic interface where students must relate terms

4 Procedure

The research was carried out in the following steps, which are outlined in [Fig. 2]:

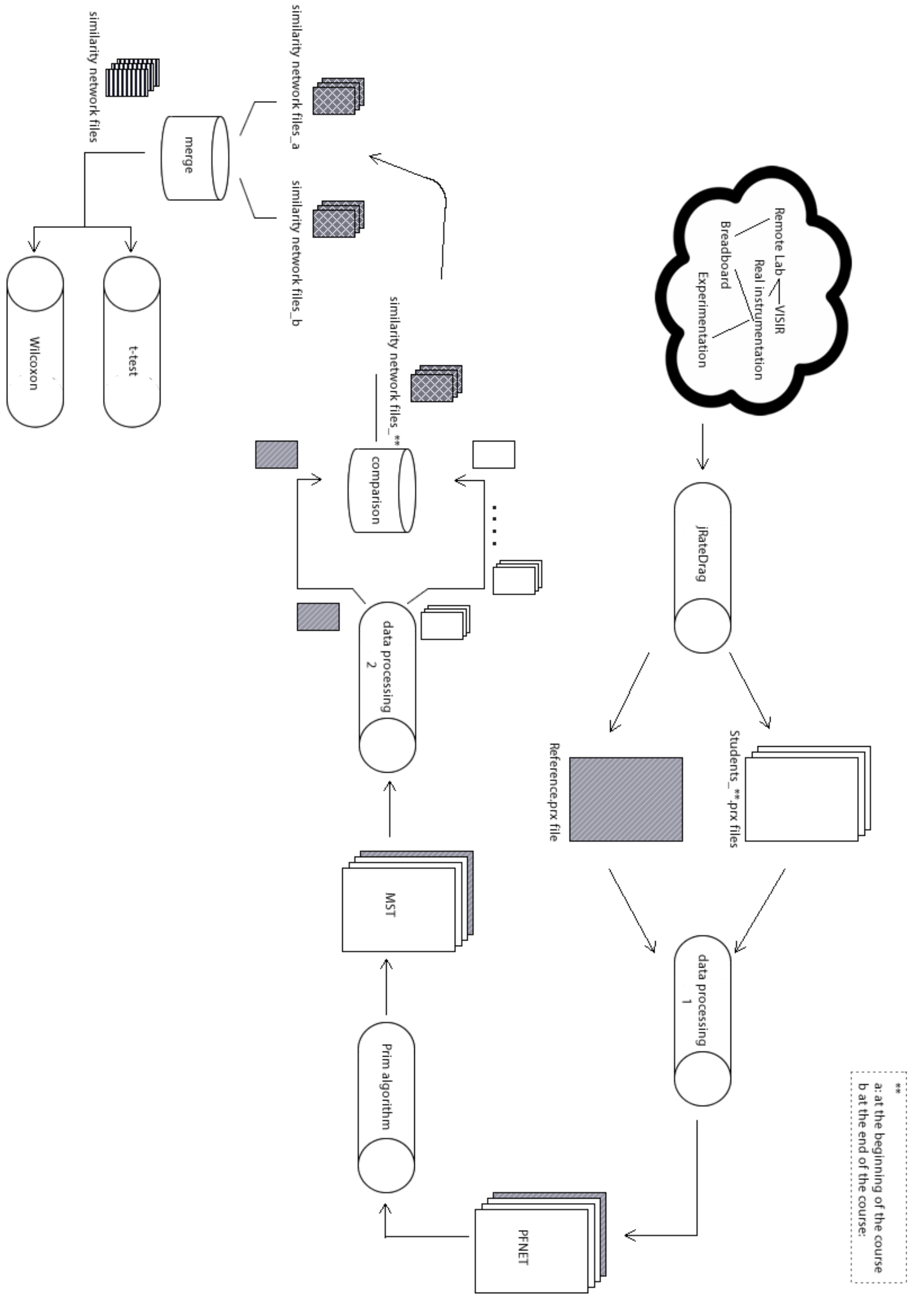

Figure 2: Block diagram of data processing

1. Reading of the students' responses (.prx files generated by the jRateDrag program) (as shown in the example of the table [see Tab. 1]) and the reference file. The values of the data matrix represent the semantic distances [Schvaneveldt, Durso and Mukherji 82] between the concepts in a 0-1000 scale.
2. To process the .prx files, they were transferred to a data frame with the typical format of a graph: origin, destination, and weight (distance).
3. The similarity was transferred to a 0-1 scale to compare the students among themselves and make the degree of relationship between the nodes comprehensible.
4. For each student, the initial graph has all the binary relationships between the *n* nodes (concepts), but this construction is not operative when highlighting the relevant nodes and their distance with other nodes [Chen, Houston, Sewell and Schatz 98]. To simplify the network, the Pathfinder algorithm (PFNET(*p,q*)) was used, which considers that each link or arc e_{ij} is included in the Pathfinder associative network with parameters (*p,q*), if and only if e_{ij} provides a path from node N_i to node N_j with a weight at least as small as the weight of any other path which has no more than *q* links, that is, a link is removed if there is a path with a lower weight, as long as that path has no more than *q* links, using the metric *p* to calculate the weights of paths with multiple links.
   Consequently, from the initial graph of each student, the Minkowski distance was calculated with $p = \infty$, as it is the metric used to measure proximity of variables measured in a scale that is not a ratio scale [Chen 98]. Next, the network was reduced, through the construction of Pathfinder associative networks (PFNET) using *q* links or arcs, with $q = n - 1$. The *q* arcs represent the maximum simplification of the network, PFNET(*p,q*) networks were constructed in symbols.

$$\lim_{p\to\infty}\left(\sum_{i=1}^{n}|x_i - y_i|^p\right)^{1/p} = max_i^n|x_{in} - y_{in}|$$

Minkowski Distance

5. Once the network was simplified, the objective was to find a subset of links that could make up a tree. The vertexes of the tree are the concepts and the total weight of all the links in the tree is the least possible, obviously including all the concepts. This tree, called minimum spanning tree (MST) [Serrano, Quirin, Botia and Cordón 10], was obtained through Prim's algorithm as the graph is weighted and implemented in R, which requires the object of processing to be a graph. Therefore it was necessary to transfer from network format to graph format.
6. Once the minimum spanning tree was constructed, the graph format was transferred to the data frame format (origin, destination, and weight of the relationship) in order to carry out the statistical processing of the results.
7. Once the network of each student was simplified, the same was done with the teacher's baseline network and the comparison of each student's network with the baseline network was performed. The degree of relationship was

measured by the similarity between two networks: (number of links in common) / (number of links in the two networks, minus the ones in common), a measurement which has been used in different papers [Arias 08].

8. Finally, to evaluate if there were significant differences between the distance with the baseline before taking the course and with the baseline after finishing it, that is, if there is a gain by nearing the baseline cognitive structure, related samples t-test and Wilcoxon statistical tests were used.

In short, the process takes all student responses, from each response a matrix data is extracted. This data matrix represents the semantic distances between the ten concepts. To obtain the simplified network, which has only the most relevant relationships between nodes (concepts), the pathfinder algorithm is used. The associative pathfinder networks removes the relationships with partnership that have lesser grade of similarity.

With this simplified network, in order to compare it with the reference network, both networks are converted to a structure of subset of links leading to a tree. This tree is called minimum spanning tree (MST). From both trees and each student answer, we can see the student gain to the cognitive reference structure. To contrast the profit before and after completing the course, the statistical tests of t-test and Wilcoxon are used inasmuch as the same students sample is used as a control factor or validity of the test.

5 Results

The research process, discussed in the previous sections, starts from initial networks, whose data, as an example, were shown in [Tab. 1]. After carrying out the Pathfinder algorithm and the minimum spanning tree, this network can now be interpretable to emphasize its relevant elements. Through the Kamada-Kawai representation [Vargas and Moya 07] the example network has the form shown in [Fig. 3]. It should be noticed that the values of [Fig. 3] shows relationships of terms from [Tab. 1] in the range [0, 1], that is, divided by 1000 in this case.

As shown for this particular student, the concept of “real instruments” is relevant, relating to “components,” “practical skills”, and “VISIR,” but at this starting point (at the start of the course), it is far from the baseline network [see Fig. 4].

Upon the completion of the course, a student modified his or her cognitive structure and approaches the baseline network as shown in [Fig. 5].

If the comparison is made with the baseline network, as indicated in point 7 of the research process [see Section 4], the similarity measurement for the given student will go from 0.125 to 0.385. Tripling its similarity measurement, indicating a greater assimilation of the course concepts.

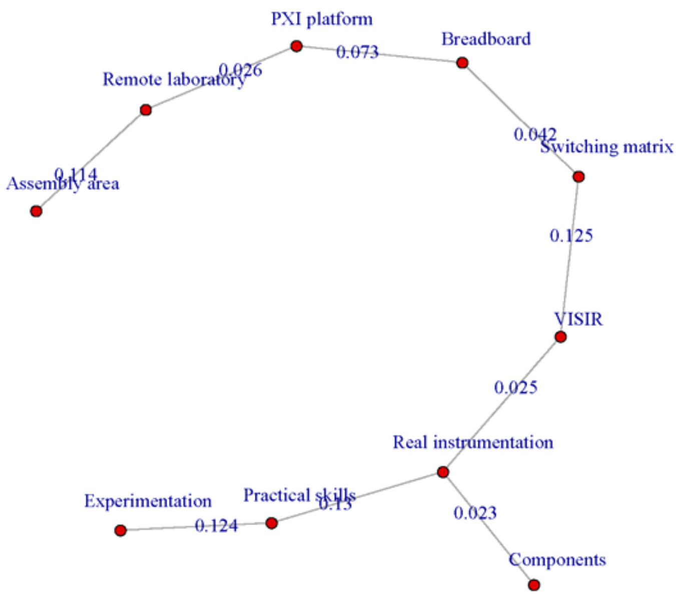

Figure 3: Example network (starting point)

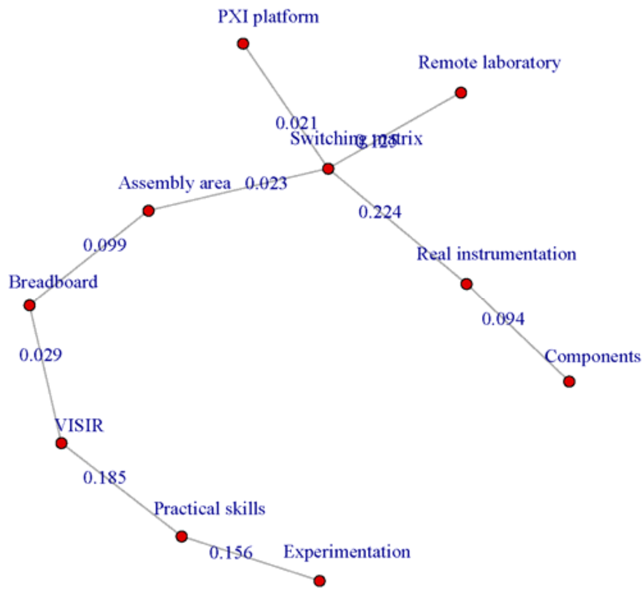

Figure 4: Baseline network

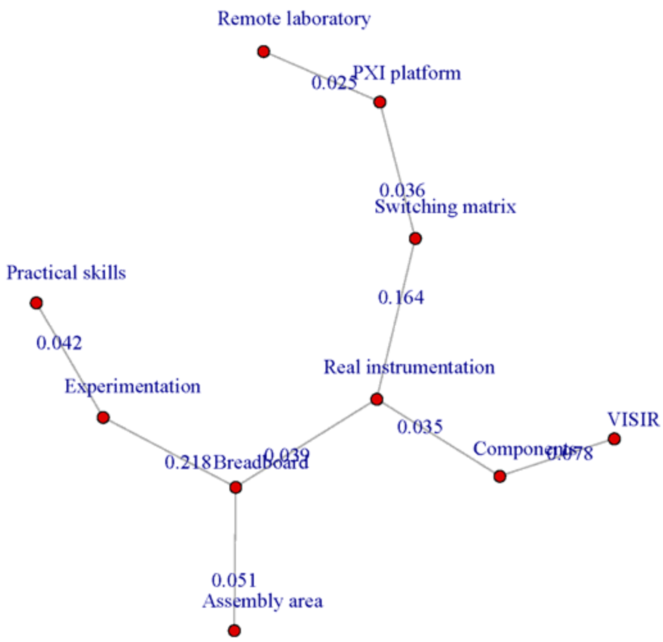

Figure 5: Example network (ending point)

Now if the evaluation is carried out globally on the 46 students who completed the course and also participated in the research, according to point 8 of the process [Section 4], the results would be shown in [Tab. 2] and [Tab. 3]. These tables show the values t-test and Wilcoxon and its significance.

```
        Paired t-test

data:  d$Vb and d$Va
t = 2.0099, df = 45, p-value = 0.02523
alternative hypothesis: true difference in means is greater
than 0
95 percent confidence interval:
 0.006470081         Inf
sample estimates:
mean of the differences
             0.03934783
```

Table 2: Related samples t-test

```
        Wilcoxon signed rank test with continuity correction

data:  d$Vb - d$Va
V = 441, p-value = 0.01967
alternative hypothesis: true location is greater than 0
```

Table 3: Related samples Wilcoxon test

First, we should emphasize that a parametric test and a nonparametric test were carried out to evaluate results since the sample was small. Globally, the results for the t-test as well as for the Wilcoxon test show a significant difference (p-value = 0.02523 or p-value = 0.01) with a positive gain between the starting point and ending point of the course, evidenced by the positive values of the t-test (t = 2.0099) or Wilcoxon (V = 441). These results, although significant, have low similarity values with the baseline network, which coincides with the small number of students who achieved the badges. In other words, the course generally has a high degree of difficulty.

[Fig. 6] shows the differences obtained, as described in point 7 of the process [see Section 4], for the starting and ending points of the course. In general, there are higher values at the end, which is confirmed statistically with these differences being significant. All the values of the differences are less than 0.5, but the variations of the differences at the end of the course are greater than at the start.

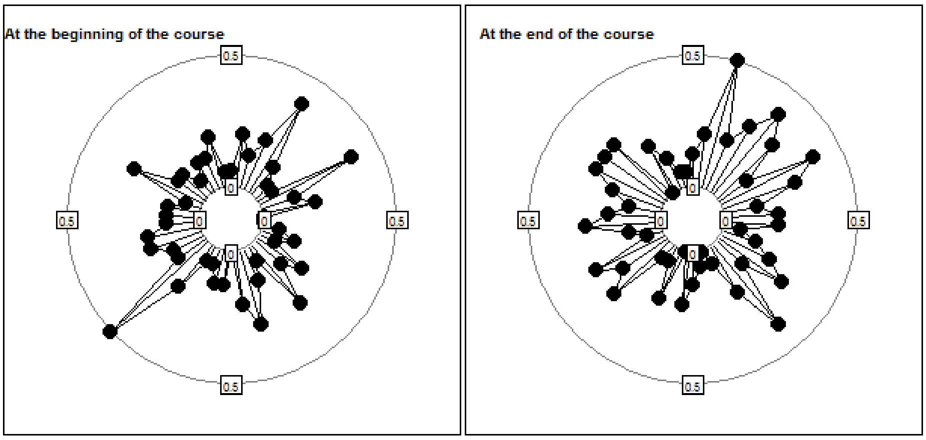

Figure 6: Values of the differences with the baseline network

So this evaluation model allows to see graphically the variations of students, showing the outstanding students and the average of them. Also, a perception of the knowledge acquired is obtained by this method without the consent of the student. In addition, this method has the advantage of summative evaluating as opposed to the traditional evaluation with its assessment by topics. This evaluation model also provides more information than the traditional in terms of presenting the overall results of course, the variation of skills of students during the course, and the levels reached by them.

6 Conclusions

This research has allowed us to emphasize the relevance of the evaluation of the students' cognitive processes with a non-invasive instrument, with which they can freely express themselves without the constraints of nervousness and stress present in a conventional test. Moreover, this form of evaluation holistically approaches the evaluation of the mental comprehension that students have of a certain topic.

This evaluative model of MOOCs facilitates also the incorporation of the tools developed into the course itself in an integrated and homogeneous way, providing an individual and immediate evaluative model of the student's knowledge at a particular time and jointly with the comprehension of the course content.

The results of the research produce positive values. Although the participation in the experiment was voluntary, the degree of involvement was reduced, the results of this course could be extrapolated to any other provided MOOC.

It should be noticed that this network model is also useful in the planning phase of the course because it allows the selection of knowledge, the sequencing of them, and the evaluation of these the above mentioned concepts.

Thinking in the context of MOOCs, the evaluation by this method has certain limitations: 1) there must be a consensus among different experts or professors in terms of the contents of the course and its most relevant concepts; and 2) there must be a consensus among experts on the grade of relationship between concepts of the course. Even with these limitations, which can be added as a temporary component of such consensuses, are issues inherent to science itself. This evaluation method has significant advantages: it is integrated in the course itself; its holistic nature; and it avoids unnecessary tensions that could be raised by the student since the evaluation is not an exam or test, in the classic sense of it.

In the evaluation of students, another issue of debate is whether the similarity of the student network with the teacher network should always be considered as a positive aspect. The positions can be found, but it is the "rules of the game" that are imposed in the education process. Even in the classic evaluation model, there is always a confrontation between the thought of the teacher and the outcomes of students. The teacher evaluation meets the expectations demanded by his or her students, though, it should not be reluctant to a different perspective that brings originality. Similarly, in the evaluation by pathfinder, networks should be evaluated carefully networks that "amazing" results.

In this research, the participation was voluntary, we obtained some parallel achievements of the students, but even the obtained results, are in line with those achieved by the pathfinder networks.

References

[Allen and Seaman 11] Allen, I.E. and Seaman, J.: "The ninth annual survey of Sloan-C: Going the Distance: Online Education in the United States, 2011"; The Sloan Consortium, Newburyport, USA (2011)

[Arias 08] Arias, J.: "Evaluación de la calidad de cursos virtuales: Indicadores de calidad y construcción de un cuestionario de medida. Aplicación al ámbito de asignaturas de Ingeniería Telemática"; Doctoral Thesis, Extremadura University, Spain (2008)

[Bourne, Harris and Mayadas 05] Bourne, J., Harris, D. and Mayadas, F.: "Online Engineering Education: Learning Anywhere, Anytime"; Journal of Engineering Education, 94, 1 (2005), 16.

[Casas and Luengo 99] Casas L. and Luengo, R.: "La exploración de la estructura conceptual en los alumnos. Un método empírico: las Redes Asociativas Pathfinder"; Campo Abierto, 16 (1999), 11-34.

[Casas and Luengo 00] Casas, L. and Luengo, R.: "Aproximación al concepto de ángulo a través de redes asociativas Pathfinder en alumnos de educación primaria y secundaria obligatoria"; Campo Abierto, 17 (2000), 39-60.

[Casas and Luengo 04] Casas, L. and Luengo, R.: "Representación del conocimiento y aprendizaje. Teoría de los conceptos nucleares"; Revista española de pedagogía, 62, 227 (2004), 59-84.

[CCNBook 14] CCNBook. Computational Cognitive Neuroscience. University of Colorado (2014). Retrieved on December, 19th 2014, from https://grey.colorado.edu/CompCogNeuro/index.php?title=CCNBook/Main

[Chen 98] Chen, C.: "Generalised similarity analysis and pathfinder network scaling"; Interacting with Computers 10 (1998), 107-128.

[Chen, Houston, Sewell and Schatz 98] Chen, H., Houston, A. L., Sewell, R. R. and Schatz, B. R.: "Internet browsing and searching: User evaluations of category map and concept space techniques"; Journal of the American Society for Information science, 49, 7 (1998), 582-608.

[Clariana and Wallace 02] Clariana, R. B. and Wallace, P. E.: "Paper-based versus computer-based assessment: Key factors associated with the test mode effect"; British Journal of Educational Technology, 33, 5 (2002), 595-604.

[Downes 10] Downes, S.: "The Role of the Educator"; Huffington Post Education (2010). Retrieved on December, 19th 2014, from http://huffingtonpost.com/stephen-downes/the-role-of-theeducator_ b_790937.html

[EHEA 15] European Higher Education Area (EHEA) (2015). Retrieved on May, 22th 2015, from www.ehea.info

[Guàrdia, Maina and Sangrà 13] Guàrdia, L., Maina, M., Sangrà, A.: "MOOC Design Principles. A Pedagogical Approach from the Learner's Perspective"; Open Education Europa (2013). Retrieved on December, 19th 2014, from http://www.openeducationeuropa.eu/en/article/MOOC-Design-Principles.-A-Pedagogical-Approach-from-the-Learner%E2%80%99s-Perspective

[Hidalgo 07] Hidalgo, V.: "Aproximación a la medida del aprendizaje a través de Redes Asociativas Pathfinder"; Master's Degree Dissertation, Extremadura University, Spain (2007)

[Interlink 14] Interlink. Tools for Pathfinder Network Analysis. Retrieved on December, 12th 2014, from http://interlinkinc.net/

[Martin 12] Martin, F.G.: "Will Massive Open Online Courses Change How We Teach?" Communications of the ACM, 55, 8 (2012), 26-28.

[OCW 02] MIT OpenCourseWare (OCW). Retrieved on May, 22th 2015, from www.ocw.mit.edu

[OCWConsortium 11] OCW Consortium. Retrieved on May, 22th 2015, from www.ocwconsortium.org

[Novak and Gowin 84] Novak, J. and Gowin, D.: "Learning How to Learn"; Cambridge University Press / New York (1984)

[Rowntree 86] Rowntree, C.: "Preparación de cursos para estudiantes"; Herder, Barcelona (1986)

[Sanders 08] Sanders, I.: "Evaluación cognitiva de estructuras de conocimiento y del cambio conceptual producido por la instrucción presencial y semipresencial"; Doctoral Thesis, Universidad Autónoma Nuevo León, Mexico (2008)

[Schvaneveldt 90] Schvaneveldt, R.W.: "Pathfinder Associative Networks: Studies in Knowledge Organization"; Ablex Publishing Corp / Norwood, N.J. (1990)

[Schvaneveldt, Durso and Dearholt 89] Schvaneveldt, R. W., Durso, F. T., and Dearholt, D. W.: "Network structures in proximity data"; The psychology of learning and motivation: Advances in research and theory, 24 (1989), 249-289.

[Schvaneveldt, Durso and Mukherji 82] Schvaneveldt, R. W., Durso, F. T. and Mukherji, B. R.: "Semantic distance effects in categorization tasks"; Journal of Experimental Psychology: Learning, Memory, and Cognition, 8, 1 (1982), 1-15.

[Serrano, Quirin, Botia and Cordón 10] Serrano, E., Quirin, A., Botia, J. and Cordón, O.: "Debugging complex software systems by means of pathfinder networks"; Information Sciences, 180, 5 (2010), 561-583.

[Vargas and Moya 07] Vargas, B. and Moya, F.: "Visualizing the Structure of Science"; Springer / Berlin (2007)