



## DEVELOPMENT OF THE COMPETENCE OF “ELEMENTARY SKILLS ON INFORMATICS”, BY USING INFORMATION AND COMMUNICATION TECHNOLOGIES IN THE TEACHING-LEARNING PROCESS OF THE NUMERICAL METHODS

S. PÉREZ-CÁCERES, M. GONZÁLEZ-LEE, E. MORALES-MENDOZA, L. J. MORALES-MENDOZA, C. RODRÍGUEZ-FLORES, R. VÁZQUEZ-BAUTISTA AND R. VARGUEZ-FERNÁNDEZ

Facultad de Ingeniería en Electrónica y Comunicaciones, Universidad Veracruzana, Poza Rica, Veracruz, México  
{sperez, mgonzalez01, efmorales, javmorales, carodriguez, favazquez, rvarguez}@uv.mx

### ABSTRACT

*In this work, results of a qualitative research based upon action research method are presented; Information and Communication Technologies were used during the teaching-learning process of the numerical methods. Using WebQuest as a tool for development competences this research, three student sets were considered as the main study corpus, during three different periods. Results show favorable outcomes from student's perspective; they perceived a better learning experience and development of competences. Regarding of the development of competence of "Elementary Skills on Informatics", the students agreed to say that their competence developed between "enough" and "much", whilst the teacher researcher and the expert group argued that the development of the competence was slightly below "enough"*

**Keywords:** *Information and Communication Technologies, WebQuest, development of competences, teaching-learning process, evaluation matrix, numerical methods.*

### 1 INTRODUCTION

Nowadays, a new social model known as the Knowledge Society has been driven by inequality when it comes to the fair use of Information and Communication Technologies (ICTs), even when it has made possible to establish an unprecedented inter relationship among individuals with political, social economical impact extending its influence to the education field [2]. As a consequence, all national and international scenarios have established politics for ICTs usage in educational processes.

It is known that teaching practice has to be transformed in an ICTs based teaching-learning strategy. The planning and execution processes has to be adapted accordingly and incorporate institution wide, also, the techniques application shall be evaluated so feedback effectively leads to improvement.

#### 1.1 National and International Use of ICTs Framework

In a document produced at the World Conference on Higher Education attended in 1998 in the UNESCO headquackers in Paris [24] established one of the most influential references on ICTs use. Specifically, article 12 establish that ICTs will influence the way of generating, acquiring and teaching, at the same time, allowing the possibility of course and pedagogic method reformulation and the opportunities for higher education as well. Taking into account that the teacher is a key element in this process, yet his participation has to evolve in order to ensure that the information translates into knowledge and the comprehension is achieved.

Also, the higher education centers shall take advantage of the power of the ICTs by maintaining



high standers for practice and overall results, keeping in mind an open mind equity, and cooperation with other countries.

On the other side, there are many proposals related to competency based such as the ones developed for Latin American Tuning [4] and 6x4 UEALC [1]. The former is about building languages and techniques for mutual comprehension in high education that will make easier the transnational and trans regional acknowledgement processes. In this subject, four main boards of experts worked on eight lines of interest, teaching, learning and evaluation of general competences were considered. In addition, four boards of experts working in eight lines of interest related to engineering, representatives of 21 universes and 18 institutes integrated those boards. The main product of those works is 27 generic competences suited for Latin America.

A second project, 6x4 UEALC (including six careers, considering four axis and a discussion of colleagues) established as an objective to “Establish operating conditions that allow better compatibility and convergence of high education in Latin America and Caribbean, their comparison and pairing to the ones in the European Union using dialog and collaborative work among institutions and high education societies in both geographical regions. Such collaboration shall be focused in practices and education wise of specific topics, this would allow to build frameworks towards changing and increasing its pertinence” . In order to accomplish this goal, six careers were considered: Management, Health sciences, History studies, Chemistry, Mathematics and Electrical Engineering. Four topics were covered: Academic Competences, Curricular Credits, Quality Certification and Research and innovation. The competences of an engineer are of special interest for this work similarly to the work presented in final draft of 6x4 project.

In the case of Mexico, a Government program from 2007 to 2012 [20] related to education and developed by the Secretariat of Public Education has two objectives related to ICTs and competences development with direct relationship with this work; objective 3 that establish that ICTs should be incorporated to the education system in order to strength the learning, increase their competences for life and to favor their insertion in the knowledge society. Objective 4 establish an integral offer of

education that balances citizen values, competences development and knowledge acquisition supported on regular activities in classroom, teaching practice and institutional environment for strengthen interaction based on democracy and intercultural interaction

## 1.2 WebQuest as a Pedagogic Strategy

Bernie Dodge developed WebQuest in 1995 [9]; he defined WebQuest is an inquiry-oriented activity in which learners interact with resources on the Internet.

WebQuest is designed for making the best of the time the student have, so he can focus on the information instead of the search of information itself. This allows to coach students in analysis, synthesis and evaluation of the information. It is a didactic resource that uses the World Wide Web. Alumni are introduced to a scenario and a task, usually a problem or even a project that they have to solve.

A WebQuest is a guided learning experience that uses links to essential resources available in the Web and a real life task that encourages the student to investigate the answer a main question with open answer and at the end, a whole group participates with the sole propose of changing recently acquired information into a refined knowledge. The best WebQuest encourage alumni to find out the rich relationship among concepts making easier the real-life contribution of knowledge and the student meditates about their own metacognitive process [16]. According to Dodge and March, a WebQuest is made of six key elements: Introduction, Tasks, Processes, Resources, Evaluation and Conclusion

## 1.3 The Universidad Veracruzana and ICTs Use in its Classrooms

At the Universidad Veracruzana (UV), the use of ICTs in classroom is established in the General Plan for Development 2025 [22], this plan considers as one of the strategically axis the innovation in education, it considers the incorporation of informatics and telecommunication technologies in all levels and modalities. On the other hand, as a strategy to consolidate the Flexible and Integral Educative Model (MEIF) [3], the UV starts “Project Classroom”[23] which objective is “to create networks of teachers aimed to innovation in teaching



practice, focused in learning of student and in the collective knowledge construction”, using ICTs in planning and institutional design.

Under this framework, in August 2004, the Facultad de Ingeniería en Electrónica y Comunicaciones (FIEC) of the UV updated the program of Ingeniería en Electrónica y Comunicaciones (IEC) according to the guidelines of MEIF, using a competence-based approach.

With the propose of finding out details on the implementation of course planning in IEC approved in 2004, a diagnose exploration was made in 2009, results of the survey on the faculty teachers confirmed that the objective of developing competences was not achieved, furthermore, no evidences of the use of methods for acquiring specific competences during the construction process. Besides, this survey also shows that the use of ICTs is not enough. This situation motivates the research presented in this paper, which uses the WebQuest methodology [5], which is considered as a strategy that propitiates competences development, and also, it is a good starting point for teachers who are novice to using Internet as teaching aid [14].

The didactic strategy is based on results of a faculty teacher board and the main conclusion is that the WebQuest are useful for the competence development for engineering alumni [18].

#### 1.4 Numerical Methods Learning Experience.

Numerical methods are techniques for proper arithmetical formulation of mathematical problems [6]. Numerical methods learning experience as taught at FIEC is 4 hours a week using two hours for theoretical discussions and two more hours for practical implementation that give six course credits. A board of experts who established the minimum topics that a student should study developed current available courses. Also, those subjects are considered necessary by the organizations that certify the quality of engineering teaching practices. So, this is a possibility for future application of this research.

Given those arguments, the following research question arises: How to encourage and evaluate a development of competences on informatics for the engineering students by using ICTs during the teaching-learning process of numerical methods? In

order to lead this research, the following objective is set: to implement and evaluate a strategy based on the use of ICTs that develop competences on informatics for the students of numerical methods in the students of Electronics and Communications Engineering at the UV.

## 2 METHODOLOGY

This research has been thought with a qualitative paradigm taking into account its more important characteristics [12]: Defines research questions [11], no hypothesis has to be proven, feedback is achieved by collecting the point of view of the participants. The method is based on action research, according to Cresswell [8].

In order to unbiased results so a more realistic conclusion will be achieved, the sources triangle technique was applied [19], expected results were compared to the feedback from alumni and also compared to the opinion of the expert group about competence development; in this paper, the process and results related to the use and valuation of the WebQuest strategy are discussed, also, development of competence on elementary skills on informatics from self-evaluation of students, the perception of the teacher researcher and the expert group evaluation.

### 2.1 Alumni Sample

In order to select properly a sample accordingly the qualitative paradigm, sampling was biased [15] by selecting alumni who attended the numerical method course at the FIEC of three different periods and three different classes. Group 1 consisted of 28 students, group 2 was 31 students and group 3 of 23 students; each group roughly represents 25% of junior students of each class.

### 2.2 Instructional Design

Observation process is based in the same stages of Instructional Design as explained next:

*1) Analysis:* From diagnostic of curricula approved in 2004 for IEC, a review on the theory of use of ICTs and the methodology for WebQuest. Finally, the discussion held for Project Classroom about development of competences, complex thought and the use of ICTs were recalled.

2) **Design:** proper scenario was established for numerical method learning experience, re-defining its contents considering the eight competences defined in curricular plan for IEC approved in 2004 and the eight generic competences stated by Project Tuning, as a result 13 competences were chosen:

- a) Analysis and Synthesis skills.
- b) Knowledge application skills
- c) General knowledge on the field
- d) Ability for information digest.
- e) Relationship skills
- f) Autonomous work skills.
- g) **Elementary skills on informatics**
- h) Researching skills
- i) Implementation skills
- j) Planning skills
- k) Designing skills
- l) Evaluating skills
- m) Management skills

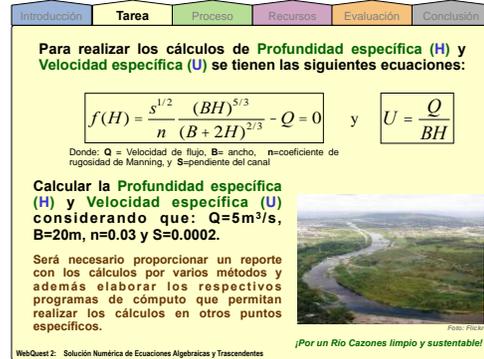
These competences were named according Project Tuning Latin America and curricular plan 2004.

At this stage, four WebQuest were designed and a web was chosen as a resource for online courses such as Moodle [17], Claroline [7] and Eminus [21], Eminus was chosen since it meet requirements for course implementation, besides, it is a requirement for Project Classroom in this way, it complemented course activities with cloud storage resources, specifically, Google Drive [10]. An example of WebQuest designed for this research is shown in Fig. 1.



The screenshot shows a web page titled 'WebQuest 2: Solución Numérica de Ecuaciones Algebraicas y Trascendentes'. It features a navigation bar with tabs for 'Introducción', 'Tarea', 'Proceso', 'Recursos', 'Evaluación', and 'Conclusión'. The main content area includes a paragraph about water pollution in Poza Rica, a photograph of a river, and a call to action for a project. The text reads: 'Como debes saber, el desarrollo de Poza Rica y ciudades vecinas depende del Río Cazones. Pero lo hemos contaminado demasiado y esto ocasiona muchos problemas como el abastecimiento de agua potable y las inundaciones que todos conocemos. Para contrarrestar estos efectos el H. Ayuntamiento de Poza Rica ha iniciado un Proyecto y ha solicitado a la Fac. de Ingeniería realizar los cálculos de Profundidad y Velocidad en puntos específicos. ¿Te gustaría participar en este Proyecto?'.

a)



The screenshot shows the 'Tarea' and 'Proceso' sections of the WebQuest. It contains mathematical formulas for calculating specific depth and velocity:  $f(H) = \frac{s^{1/2}}{n} \frac{(BH)^{5/3}}{(B+2H)^{2/3}} - Q = 0$  and  $U = \frac{Q}{BH}$ . It also lists given values:  $Q=5m^3/s$ ,  $B=20m$ ,  $n=0.03$ , and  $S=0.0002$ . A photograph of a river is included with the caption '¡Por un Río Cazones limpio y sustentable!'.

b)

Fig. 1. Designed WebQuest, showing introduction and task sections.

3) **Development:** all designed resources were used in the teaching-learning process of numerical methods, also evaluation criteria for this strategy, which will be discussed later in this paper, including discussions on the results.

4) **Implementation:** our proposal was applied in the learning experience of numerical methods taught during three different periods of time, to groups 1, 2 and 3. All WebQuest and supporting materials were uploaded to Eminus web portal; Google drive was used for sharing documents for the task assigned to the groups.

5) **Evaluation:** Evaluation matrices were used for evaluating results, in this paper, results related to the use of ICTs and the competence of “Elementary Skills on Informatics” are presented.

### 2.3 Evaluation Instruments

During this research, instruments that were used are described ahead; the first one was for students and the second one for students, teacher researcher and the expert group with minor changes, mainly in edition. These instruments are:

*Evaluation Matrix for subjects of use and validation of strategies and resources.* This matrix contains information about the use of informatics resources. Grades considered are “Not Acceptable” (0 occurrences), “Acceptable” (1 to 4 occurrences), “Good” (5-8 occurrences) and “Excellent” (9 or more occurrences). Also, the grade of the WebQuest in development of competences and learning of numerical methods; considering achievement graded as: “nothing”, “little bit”, “enough” and “much”.



*Evaluation Matrix for Self-Evaluation on Development of Competences by Using WebQuest.* This matrix was adapted from Bernabé; it is based on criteria and evaluation results of improvement for the eight competences that are in the set of items to grade for each evaluation matrix. Adaptation of the matrices are as follows: Changing the item “fair good” for “enough”, also, they were edited to match regional jargon and changing some items so five competences in curricular plan 2004 for IEC are incorporated (Implementation, Planning, Design, Evaluation and Management), that are a concern for this research by the way. Table 1 shows a sample of the 17 items to be graded in order to evaluate the competence “Elementary skills on informatics”:

**Table 1.** Sample of the items used for evaluating the competence “Elementary skills on informatics”.

Elementary skills on informatics	nothing	little bit	enough	much
- Have you ever used email services?	o	o	o	o
- Have you ever made a Web search?	o	o	o	o
- Have you ever used Eminus for course management?	o	o	o	o
- Have you learnt strategies for using technology in the field of study of the WebQuest?	o	o	o	o

### 3 RESULTS

Evaluation instruments were uploaded as a "Form" to Google Drive and the students answered them online, then, all surveys were analyzed.

In order to analyze data from the matrices, they were coded using ordinal numbers. All of the options for answering were mapped in the set {0,1,2,3}. For the case of use of strategies and resources, the code was “Not Acceptable” (0), “Acceptable” (1), “Good” (2), “Excellent” (3) and for the evaluation of competences as “nothing” (0), “little bit” (1), “enough” (2), “much” (3).

The evaluation matrix for skills development was also adapted in order to grade the overall strategy from the teacher researcher point of view, this was accomplished before the grading performed by the students was known, in addition, this matrix was used also for the expert group, this group was formed by four teacher with ten and above years in teaching, regularly those teachers either taught the numerical method learning experience or had used WebQuest as an aid in one or more courses. When the first stage was completed, teacher researcher discussed results with the expert group, providing all the material used during the course and they gave an exposition all details of the implementation, then, the grading of this activity from the competences development point of view. Given that no relationship among process variables was intended nor compression among the sample groups, a descriptive analysis was carried out and its results are discussed in next section.

#### 3.1 Results of use and evaluation of strategies and resources

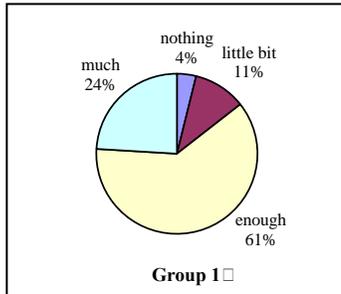
Eminus was used for accessing course information, even when alumni had never worked with a virtual learning environment [13]. All results were good since the web-based approach have all needed resources. Results for the evaluation matrix graded at the end of the third stage of the method (applied to group 3), as it is shown in Table 2, 91.30% of students' usage of computers is considered from Acceptable to Excellent.

**Table 2.** Use of ICTs percentage as done by group 3.

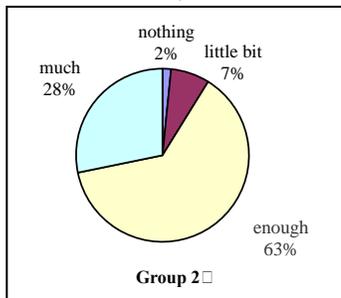
Software Resource	Not Acceptable %	Acceptable %	Good %	Excellent %
Word processor	0.00	30.43	26.09	43.48
The making of slides and diagrams	8.70	34.78	26.09	30.43
Web Browser	0.00	34.78	13.04	52.17
Eminus	0.00	13.04	39.13	47.83
email	0.00	26.09	26.09	47.83
Shared documents	0.00	17.39	34.78	47.83
Spread sheet	0.00	34.78	43.48	21.74
C++ lenguaje	8.70	30.43	47.83	13.04

Information organization was made using WebQuest, four WebQuest were designed for each Task assigned for this course. Figure 2 shows results

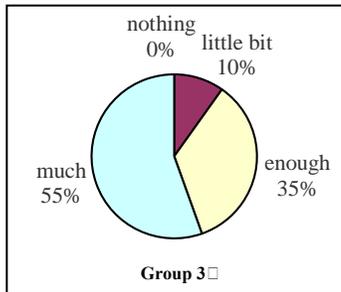
of the contribution of the overall strategy to development of competences:



a)



b)



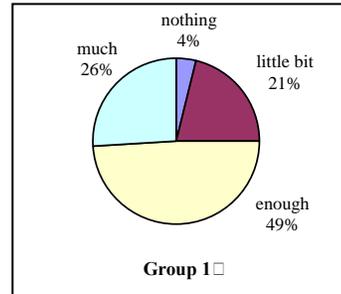
c)

**Fig. 2.** Contribution of WebQuest to development of competences.

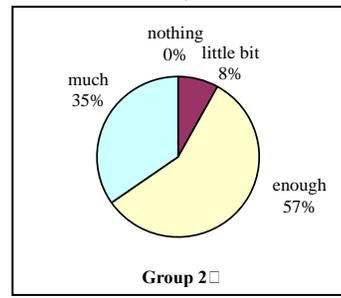
Each of the three times the strategy was used, alumni reported an improvement of 96%, this exhibits an important improvement as a result of the second and third application, in the latter, a 100% considered that competence development was achieved since a bigger percentage of “much” (55%) was reached.

During the surveys, almost all students agreed that WebQuest contributed to a better learning experience (96% of them), as shown in Fig. 3; also, it was observed a growing in the grade level as the

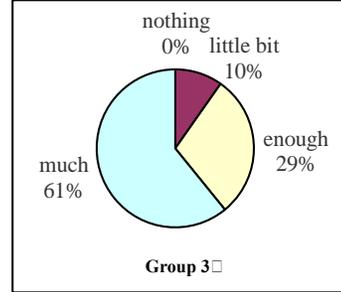
strategy described here was applied, a 61% increment for the item “much” at the end of the third round.



a)



b)



c)

**Fig. 3.** Contribution of WebQuest to the numerical method learning.

### 3.2 Development of Competence of “Elementary skills on informatics” as a result of the use of WebQuest

Even when evaluation instruments considered 13 competences to be developed as established early in the research, only results for “Elementary skills on informatics” are discussed. A number of 17 items were used for grading this competence. Figure 4 shows average values, according alumni, competence development at the end of the three rounds was considered between “enough” and “much”; opposed to the evaluation carried out by the expert group and

the expectation of the teacher research who considered that the competence development achieved nearly “enough”.

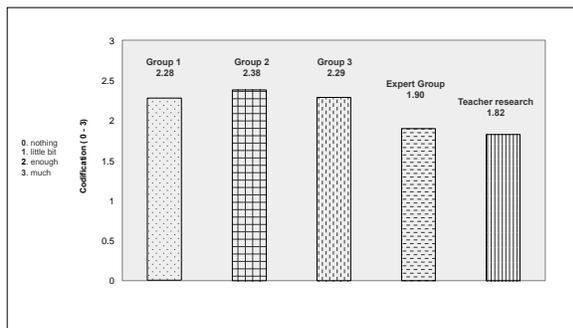


Fig. 4. Results for “Elementary skills on informatics” competence supported by WebQuest.

#### 4 CONCLUSIONS

The question that motivated this research: How to encourage and evaluate competence development on informatics for alumni of engineering by using ICTs during the teaching-learning process? Is answered at first with the implementation of the proposal discussed in this work. Once this implementation was finished and since results are good when it comes to development of competences, given that evaluation results show that competence “Elementary skills on informatics” was considered between “enough” and “much” due the use of WebQuest during the three rounds, this results surpassed the evaluation carried out by the expert group and the teacher research expectation.

Evaluation results for development of competences on the alumni, evaluation matrices of the use and evaluation of strategies such as the self-evaluation of development of competence lead to a way for evaluating the WebQuest based approach. Finally, by sticking to this strategy, the use of ICTs was encouraged, teachers and students used it as well, making a change in the way the teaching-learning process, and so the main objective of the action research was meet.

In addition, the process carried out for implementing a strategy based on WebQuest approach is a method that can be applied to other topics and evaluation of course resources based on ICTs.

#### 5 REFERENCES

1. ACET. (2008). *Propuestas y Acciones Universitarias para la Transformación de la Educación Superior en América Latina. Informe Final del Proyecto 6x4 UEALC*. Aseguramiento de la Calidad en la Educación y en el Trabajo. Bogotá: ASCUN.
2. Andrade-Castro, J., & Campo-Redondo, M. (2008). Tecnologías de Información. Inclusión en la educación basada en lo digital. *Revista Mexicana de Investigación Educativa*, 13 (36), 223-248.
3. Beltrán, J. (2005). El Modelo Educativo Integral y Flexible de la Universidad Veracruzana. *CPU-e, Revista de Investigación Educativa*, 1, 1-10.
4. Beneitone, P., Esquetini, C., González, J., Maletá, M. M., Siufi, G., & Wagenaar, R. (2007). *Final Report ALFA Tuning America Latina Project 2004-2007: Reflections on and outlook for Higher Education in Latin America*. Spain: University of Deusto.
5. Bernabé, I. (2008). *Las WebQuests en el Espacio Europeo de Educación Superior (EEES). Desarrollo y evaluación de competencias con Tecnologías de la Información y la Comunicación (TICs) en la Universidad*. Castelló de la Plana, España: Universitat Jaume I.
6. Chapra, S., & Canalé, S. (2007). *Numerical Methods for Engineers* (5th ed.). University of Michigan, USA: McGraw-Hill.
7. Claroline. (2001). *Claroline collaboration platform*. Retrieved February 12, 2011, from <http://www.claroline.net/>
8. Cresswell, J. (2005). *Educational research: Planning, conducting, and evaluating quantitative and qualitative Research* (2th ed.). Upper Saddle River, New Jersey, USA: Pearson Education Inc.
9. Dodge, B. (1995). WebQuests: a technique for Internet-based learning. *Distance Educator*, 1 (2), 10-13.
10. Google. (24 de April de 2012). *Google Drive documents sharing*. Retrieved May 16, 2012, from <https://drive.google.com>
11. Grinnell, R. M. (1997). *Social word research & evaluation: Quantitative and qualitative approaches* (5th ed.). Ithaca, New York, USA: E. Peacock Publishers.



12. Hernández, R., Fernández, C., & Baptista, P. (2006). *Metodología de la Investigación* (4a ed.). México, D.F.: McGraw-Hill.
13. JISC. (2000). *Final Report JISC 2000*. JISC.
14. Jonassen, D., Howland, J., Moore, J., & Marra, R. (2003). *Learning to Solve Problems with Technology: A Constructivist Perspective*. New Jersey, USA: Pearson Education, Inc.
15. McMillan, J. H., & Schumacher, S. (2005). *Investigación educativa* (5a ed.). Madrid, España: Pearson Education.
16. March, T. (2003). The learning power of WebQuest. *Educational Leadership*, 61 (4), 42-47.
17. Moodle. (2001). *Moodle is a learning platform*. Retrieve February 12, 2011, from: <https://moodle.org>
18. Pérez-Cáceres, S., Cristóbal-Salas, A., Morales-Mendoza, E., & Varguez-Fernández, R. (2011). Las WebQuest, una Propuesta de Formación Docente para Propiciar el Desarrollo de Competencias en los Alumnos de Ingeniería. *Formación universitaria*, 4 (3), 13-22.
19. Ruiz, J. I. (2007). *Metodología de la Investigación cualitativa* (4a ed.). Bilbao, España: Universidad de Deusto.
20. S.E.P. (2007). *Programa Sectorial de Educación 2007-2012*. México: S.E.P.
21. U.V. (2004). *Eminus. Sistema de educación distribuida*. Retrieved February 12, 2011, from <https://eminus.uv.mx/eminus/default.aspx>
22. U.V. (2008). *Plan General de Desarrollo 2025 de la Universidad Veracruzana*. Xalapa: U.V.
23. U.V. (2011). *Proyecto Aula de la Universidad Veracruzana*. Xalapa: U.V.
24. UNESCO. (1998). *World Declaration on Higher Education for the Twenty-First Century: Vision and Action*. París: UNESCO.