# TEACHING AND LEARNING METHODOLOGIES SUPPORTED BY ICT APPLIED IN COMPUTER SCIENCE

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## ABSTRACT

The main objective of this paper is to show a set of new methodologies applied in the teaching of Computer Science using ICT. The methodologies are framed in the conceptual basis of the following sciences: Psychology, Education and Computer Science. The theoretical framework of the research is supported by Behavioral Theory, Gestalt Theory. Genetic-Cognitive Psychology Theory and Dialectics Psychology. Based on the theoretical framework the following methodologies were developed: Game Theory, Constructivist Approach, Personalized Teaching, Problem Solving, Cooperative Collaborative learning, Learning projects using ICT. These methodologies were applied to the teaching learning process during the Algorithms and Complexity – A&C course, which belongs to the area of Computer Science. The course develops the concepts of Computers, Complexity and Intractability, Recurrence Equations, Divide and Conquer, Greedy Algorithms, Dynamic Programming, Shortest Path Problem and Graph Theory. The main value of the research is the theoretical support of the methodologies and their application supported by ICT using learning objects. The course aforementioned was built on the Blackboard platform evaluating the operation of methodologies. The results of the evaluation are presented for each of them, showing the learning outcomes achieved by students, which verifies that methodologies are functional.

**Keywords:** Methodologies for virtual learning, virtual education, ICTs, virtual learning platforms, virtual assessment.

## INTRODUCTION

The theoretical development of the research in relation to the teaching methodologies supported by ICT has the following phases: (i) Foundations of the behaviorist theory; (ii) Gestalt theory; (iii) Foundations of Genetic- Cognitive Psychology; iv) Bases of the Dialectical Psychology; and v) Bases of Computer Science.

The research integrates theoretical part with the practice, as represented by the construction of the virtual course under the Blackboard platform. Finally, the research uses teaching methodologies, through the platform, based on the above-mentioned theories, in order to ensure students' learning in virtual spaces supported ICTs.

## THEORETICAL BASIS OF THE METHODOLOGIES

Pavlolv and Skinner are the main representatives of the behaviorist or associating approach regarding to classical and instrumental conditioning respectively. In behaviorism, human behavior receives the influences of the external world, which act as enhancers of it. Education becomes a technology represented by a sequence of actions consisting of mechanical stimulus- response - reinforcements, aimed at achieving the conditioning of the

**conduct of the subject. This conception is based on the principle "man is the product of the environmental reinforcing contingencies" (Perez, A., 1995, p. 37).**

**The conditioning involves a sequence of mechanical stimulation (S) presented to the subject, waiting for a response (R) and giving a reinforcement (E), generating a repetitive cycle of sequences S/R/E/ . . . S/R/E. The relationship of this cycle to a space of virtual training is represented by tutorial-type learning environments of virtual training, exercising and practice, or conditioning software, among others. The above mentioned environments are represented by learning objects, which integrate theoretical concepts with practice making the students learn about real world concepts. These learning objects can be built into the platform through games. Real and complex world cases in virtual spaces such as: "Design and implementation for location-based learning games" (Melero Gallardo, 2014); "The use of virtual worlds, with text-based, voice-based and a feeling of 'presence' naturally is allowing for more complex social interactions and designed learning experiences and role plays, as well as encouraging learner empowerment through increased interactivity" (De Freitas, Rebolledo-Mendez, Liarokapis, Magoulas, & Poulovassilis, 2010); or "Pervasive augmented reality games to experience tourism destinations" (Linaza, Gutierrez, & García, 2013).**

**The Gestalt theory is interpreted as the figure and ground to give meaning to the student's learning, assessed via an observable behavior (a final exam). The Gestalt approach views the conduct as an organized whole (Perez, A., 1995, p. 41). Then, a platform supported by ICTs, in order to comply with processes of virtual training, is a system with hardware and software components, comware (communications) to which it is necessary to add the orgware (human talent) or the organization of the entire system of virtual training; if one of the parties fails, the system does not work. Considering the virtual space as a whole, the problem-solving teaching methodology supports the more complex learning; this is confirmed by the fact that: "An important educational application of Gestalt theory is in the area of productive thinking (problem solving) ". (Duncker, 1945; Luchins, 1942; Wertheimer, 1945 cited by Schunk, D., 1997, p. 57) .Thus, in a holistic sense, the virtual spaces of training through the teaching methodologies set out; allow the development of higher learning in the subject.**

**In cognitive genetic psychology the two basic functional invariant of the intellectual functioning of the subject are the organization and adaptation. Assimilation and accommodation are the bases of the adaptation. The constant operation of these allow the formation of units of knowledge calls diagrams, whose development in the time form systems of knowledge and allow the subject to pass from a concrete thought to a formal one, in its biological-intellectual development . One of the support to better understand Piaget's theory has its basis on the Psychoanalytic theory of transference "…by regarding transferences as schemas in which assimilation predominates over accommodation" (Wachtel, 1980). The student in the learning process initially has some specific structures of knowledge. The student interacts with the platform supported by ICT and if she/he understands the structures of knowledge presented in the virtual course, then these diagrams are assimilated into her/his mind. This brings about the change of concrete cognitive structures to formal ones which corresponds to the stages of development of the subject (Hipsky, 2008), and the virtual learning of the student. Based on Piaget's postulates, the course of A&C uses the personalized learning supported by ICT (Keane, Keane, & Blicblau, 2014; Lyashenko & Frolova, 2014) in order to evaluate the change of the cognitive structures of the student when interacting with the virtual course.**

**For the Dialectical Psychology based on the materialist philosophy the concept of psyche is "(a) The psyche is a function … (b) the psyche of man is social," (Montealegre, R., 1992, p. 11). Then, if the psyche of man is social, then the subject learns through the culture and the interaction with the other (Anh & Marginson, 2013). The culture is present in the form of signs through the digital network. These signs are stimuli-means for the subject, within which is the human language and accordingly the language contained in the virtual course.**

**It is important to mention that the language in the ICT impacts the cognitive domains of the subject's audio, vision, touch, and smell. Therefore, "the main factor in the formation of concepts, and its generative cause, is a specific use of words as functional instruments". (Vygostky, L. 1995, new edition of the book Thought and Language in charge of Alex Kozulin p. 125). The signs or functional tools of language in the network supported by ICT allow the student to activate the Zone of Proximal Development - ZPD. The interrelationship of the ZPD with the ICTs is based on the fact that the cognitive functional structures of the brain are built in the ZPD or area of knowledge construction; and this area is influenced by the virtual learning space, generating in this way the student's learning influenced by the virtual course. The application of the learning in the interaction with the other strategy based on Vigostky's postulates is performed in the course of A&C using the methodology of learning by projects. The projects are constructed based on the contents of the virtual course, the information of the Internet macro network, and the interaction between the students and the lecturer in charge. (Mukama, 2014).**

**Constructivism is based on the Cognitive genetic psychology (Piaget), and on the dialectic psychology (Vigostky). In constructivism, learning is achieved by establishing relations between the new knowledge and knowledge structures already existing in the mind of the subject. In this sense, the design of the learning environment should allow the learners explore their preconceptions and interact with the virtual space supported by ICT; besides, it should generate new knowledge in the student, and finally, validate the new knowledge generated by the student through the network, with the teacher's guide, or with their peers, using learning communities. (S. Sergis, Zervas, & Sampson, 2014).**

**In the virtual teaching-learning process, Constructivism must be understood not only as a philosophy but also as pedagogy. Then, it is necessary to associate constructivist teaching that comply with the process of social learning to virtual level. Thus, constructivist learning involves that the student must commit themselves to the social discourse using the network, and validate the status of truth of the concepts presented in the virtual course, for the students will generate their own concepts and their contribution to the construction of knowledge. The social discourse in the network makes it possible for the apprentice: understand other approaches in the resolution of problems, argue their solution, to negotiate their ideas, expand or decrease the complexity of the problems, validate the solution of problems in terms of effectiveness and efficiency, project new learning experiences and research of constructivist nature (virtual worlds) (Shieh, 2012; Kotsilieris & Dimopoulou, 2014).**

**Collaborative learning is based on Vigostky's Social and Cultural theory. The virtual course is a communication bridge between the student and the world, through the Internet. This network enables the communication of the pupil in the virtual course and with other virtual courses, providing opportunities to the student to interact with social and cultural contexts different from which they belong to (Dabbagh & Kitsantas, 2012). In this sense students' learning is not only influenced by their preconceptions but by the culture in which they have been trained before applying to the virtual course. Based on the apprenticepreconceptions, the collaborative learning is achieved through social interaction (Dalgarno & Lee, 2010) that is presented in the learning process of the subject in their relationship with the other through the communication media, in this case the virtual course supported by ICT. The construction of knowledge in the subject has aspects both individual and social, allowing an active participation of the student and a more constructive role in the learning process. Therefore, the collaborative learning is an approach that allows the subject be aware of the process of acquiring their cognitive structures. As an active students, they must observe, compare and contrast their learning with that of their colleagues, through the socialization of the work as a team to achieve both their personal understanding as their sense of identity through social interaction (Hughes, 2007).**

**The basics of Computer Science are related to the following areas: i) Software Engineering, as a basis for the construction of the virtual course learning objects. ii) Programming**

languages needed to program the virtual learning environment supported by ICT. iii) Databases, to manage the status of student learning to navigate the virtual course. iv) Computer Networks, for the operation of the course under the macro virtual Internet. v) Security in computing, in order to meet security processes data stored in the course. vi) Operating Systems in order to manage both the virtual course within the Blackboard platform, and management processes processing requirements of both users (students) in the virtual learning and teachers in virtual teaching. vii) Quality standars, to be met by the construction of the virtual course supported by ICT, such as SCORM and IMS.

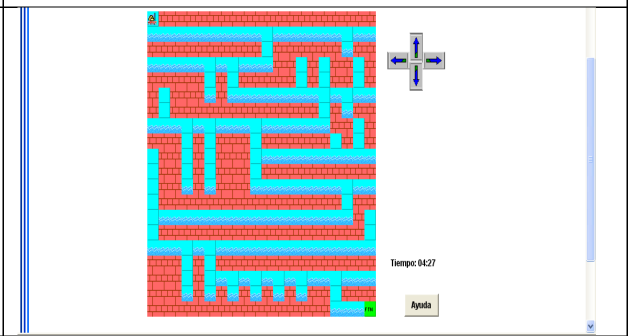
## DEVELOPMENT OF METHODOLOGIES SUPPORTED BY ICT IN THE BLACKBOARD PLATFORM

The development of the methodologies proposed in this research paper will be applied using the virtual course Algorithms and Complexity – A&C, designed (Capacho, J, 2004) and programmed (Cure, V., & Fandiño, E (2005)) in the the Blackboard platform. In development it is important to mention that the course – A&C was designed in Web_CT; but as Web_CT was acquired by Blackboard, the virtual course – A&C is currently running on this platform.

The teaching methodology of the subject Computers, complexity and intractability – CCI is Game theory which is based on the behaviorist approach. The Game has the following steps: 1) Presentation of the topics of CCI. 2) Activation of drill and practice games, structured on learning objects within the Blackboard platform. 3) Operation of the object of learning by the student. 4) Evaluation of the student learning or Assessment. 5) Reinforcement given to the student via the learning object. 6) Decision on the level of student learning. This decision allows: 7) Browse again learning objects or alternatively 8) continue with the next module of the course of A&C. It should be borne in mind that each game has a difficulty level, which represents the highest or lowest learning achievement acquired by the student during the game.

The application of the methodology is shown in Figure 1, below:


Game theory with difficulty levels




Game theory using mazes

**Figure: 1**
**Virtual learning using Game Theory.**

Greedy algorithms module was developed based on the Gestalt theory, applying the methodology of problem solving in virtual environments. The steps of this method are: 1) Student applies previous knowledge to new situations. 2) State the problem to be solved algorithmically. 3) Use the basic skills for the construction of greedy algorithms. 4) Define the figure and ground of the resolution of the problem (Human Computer Interface). 4) Translate the algorithms in a high-level languages (Java). 5) Run the program (JAVA). 6) Evaluate the results generated by the program. 7) Improve the program in terms of response time and memory space used.

The results of the interfaces for the problems solved by Greedy Algorithms: Make Change and Memory Management in Operative systems are shown in Figure 2.


**Figure: 2**

**Methodology of problem solving in virtual environments**

**The problem of the shortest path in A&C was developed based on the postulates of Piaget's theory, and the teaching methodology used was the personalized teaching supported by ICT. The steps in this methodology are: 1) Organization of the learning structures in the virtual course on the problem of the shortest path. 2) Explore the student's preconceptions on the topic of algorithmic cases of the shortest route problem, or student's concrete knowledge structure. 3) Interaction of students with learning objects related to the topic. 4) Assimilation and accommodation of the virtual environment content structures with students' cognitive structures. 5) Self assessment of student's knowledge structure change through the same learning objects. 6) Assessment of the student's learning by the professor. 7) Design the student's learning improving plan in the virtual environment.**

**The evidence of the use of the personalized teaching using ICT is represented by: 1) Conceptual map of the organization of the shorter route problem on the virtual course (Figure 3. 2) Test exploring student's preconceptions. 3) Use of learning objects for the shortest route (Figure 4). 4) Check the assimilation of knowledge structures in the student, through the construction of a Java program (Figure 5). 5) Assessment and improvement of student's learning process.**

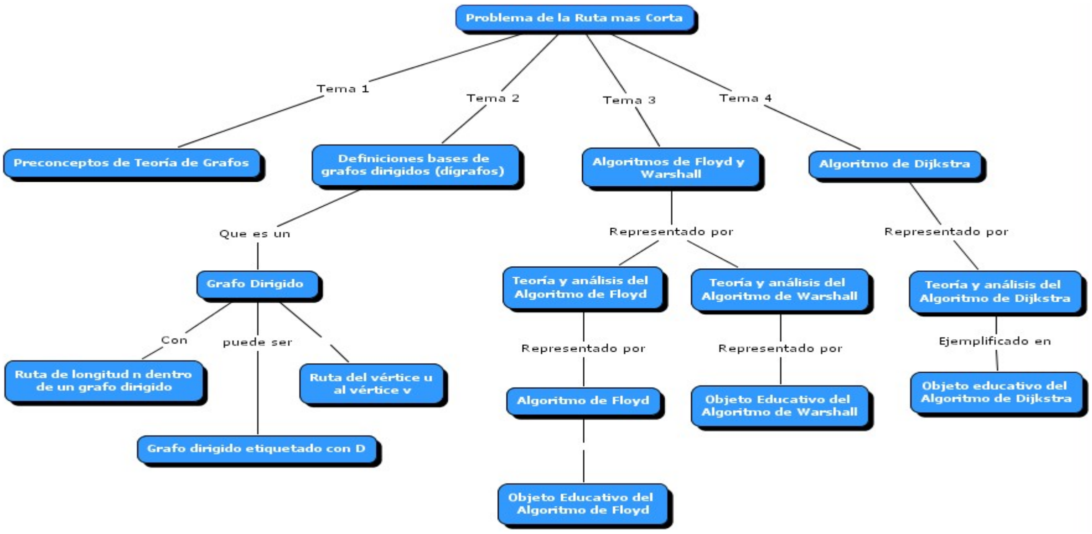



**Figure: 3**
**Conceptual map of the shorter route problem (Shortest Path Problem).**

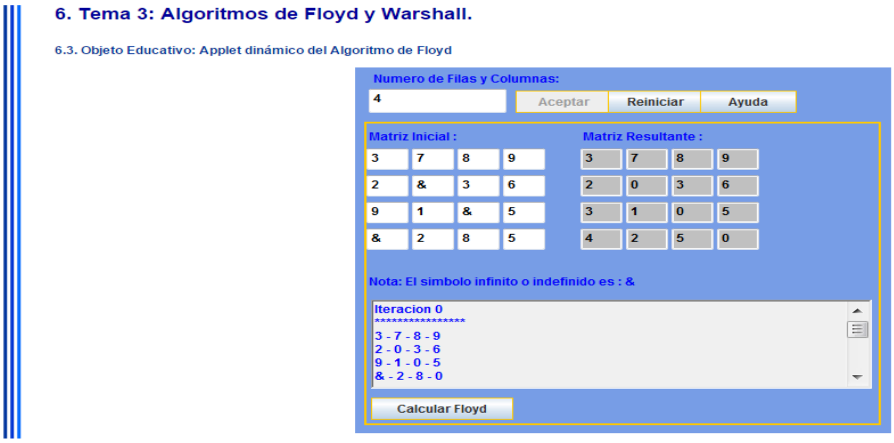



**Figure: 4**
**Learning object for the study of the Shortest Path Problem.**

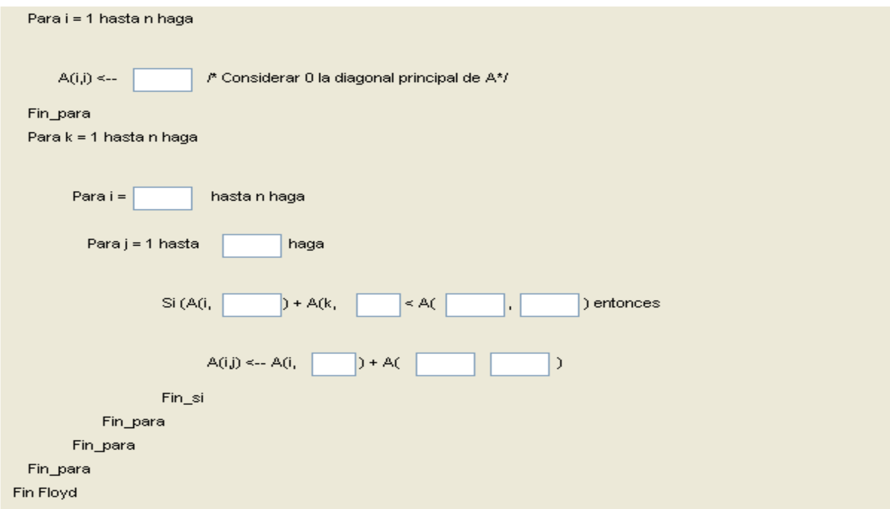



**Figure: 5**
**Check student learning using personalized teaching (Communication interface in JAVA for the Shortest Path Problem).**

**Project based approach has its foundations on the Dialectical Psychology and Vigotsky's postulates, and it was used in the Module Graphs Theory with the following steps: 1) Navigate the contents of the virtual module Graph Theory applications. 2) Interact with learning objects (Figure 6) module related to the coloring of graphs and Ford and Fulkerson's algorithms. 3) Review research articles of the Association for Computing Machines and the IEEE Computer Society (ACM/IEEE-CS) related with the development of the module. 4) Write a representative essay of the theoretical and practical part of the reviewed article. 5) Socialize the writing by placing it in the forum of the Blackboard virtual platform. At this point student's learning improves due to the interaction with their peers and professor in the virtual course. 6) Build a second version of the writing based on the results obtained in the forum. 7) Assessing student learning content in the final writing essay. This not only represents the student's research level in Graph theory but also knowledge threshold applying Dialectical Psychology concepts in virtual spaces.**

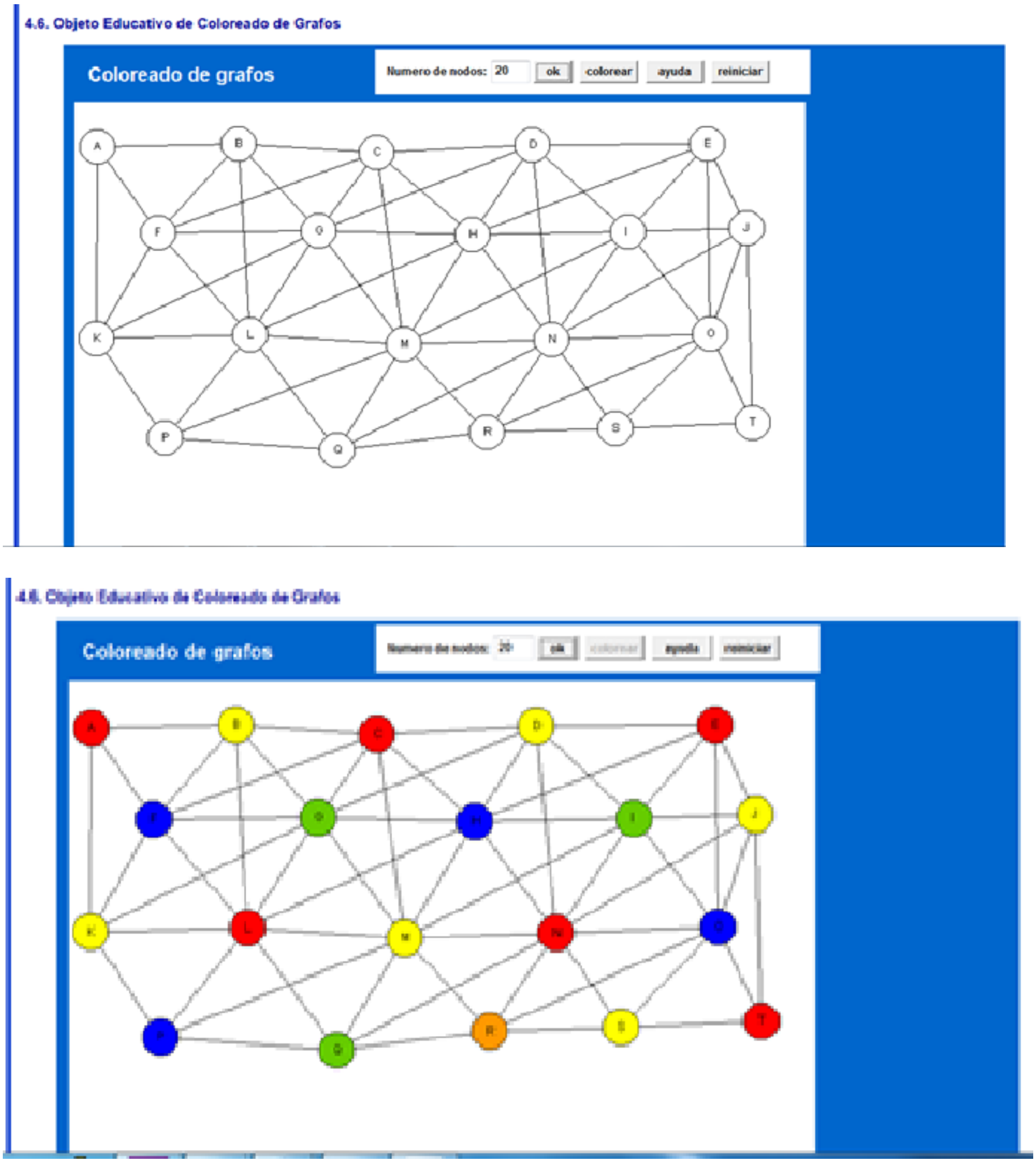



**Figure: 6**
**Learning object representative of Graph Coloring.**

**The constructivist approach was implemented in the teaching methodology of the module 'Recurrence Equations' with the following steps: 1) Interaction of the student (knowing subject) with the virtual course.2) Exploration of the initial student knowledge structures. 3) Interaction of students with recurrence equations learning objects (Figure 7).. 4) Constructivist activities implementation (social discourse among participants using the network in order to understand and transform student learning with their peers and teacher). Socialization of virtual classroom activities supported by ICT. 5) Generation of cognitive imbalances in the student. 6) Socialization of the module learning through the network and between peers. 7) Assessment of student learning in the virtual module. The results of the progress in the student's learning in solving recurrence equations are shown in Figure 8 (Difficulty levels by solving the equations: i) Easy O(n) , ii) Intermediate $O(2^{n+1})$ , iii) Difficult $O(n^2)$). Solving recurrence equations by constructivism, allowed students identifying the preconceptions of this type of equations, investigating the theoretical methods of solving recurrence equations, and obtaining the solution of the equation (T(n)) and the order of complexity (O(n)).**

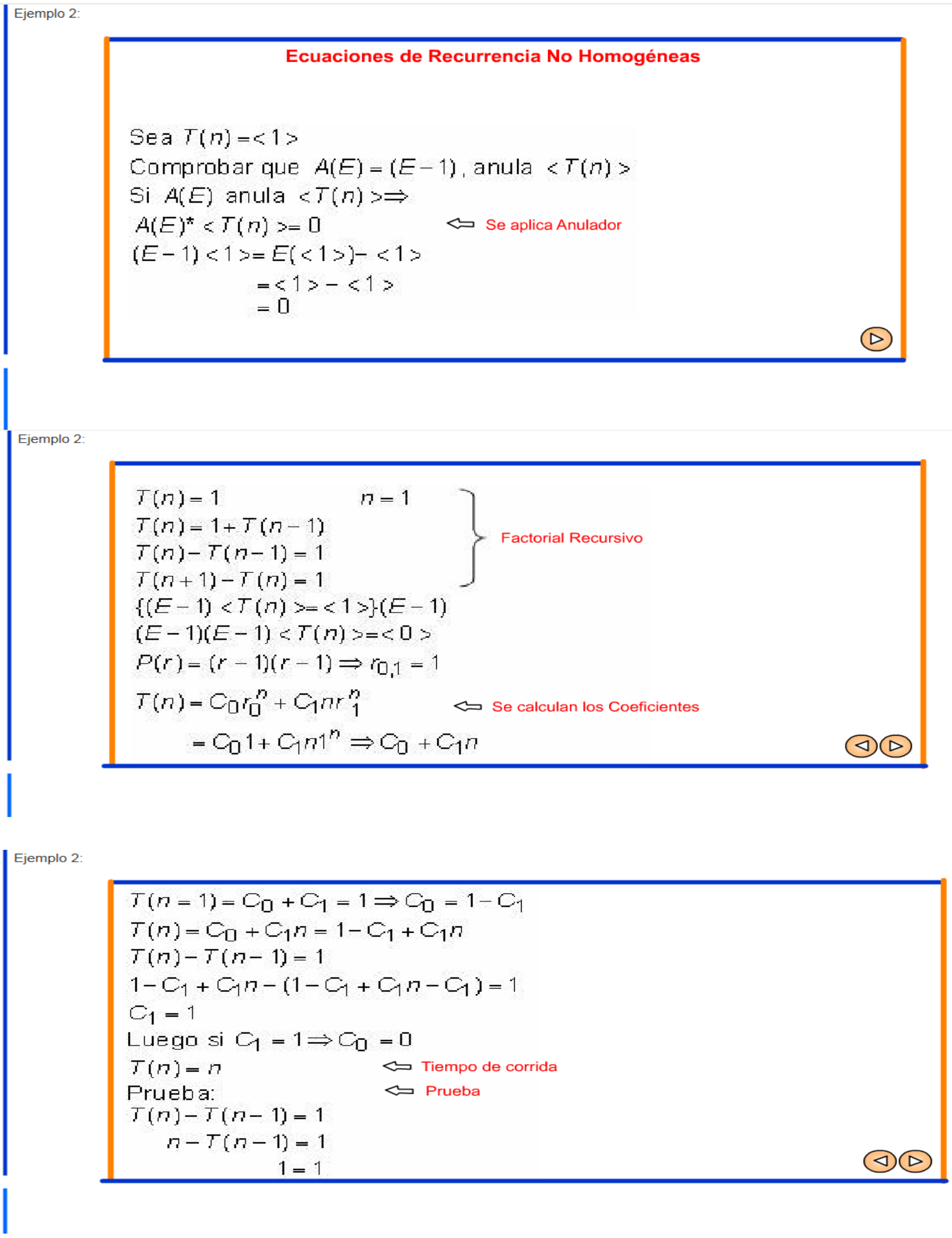



**Figure: 7**
**Learning object supporting the resolution of recurrence equations.**

| | | |
|---|---|---|
| $T(n) = T(n-1) + 1\ , Si\ n > 1$ $T(n) = 1\ , Si\ n = 1$ | $T(n) = 4 * T\left(\frac{n}{2}\right) + n\ , Si\ n \geq 2$ | $\sqrt{a_n} = \sqrt{a_{n-1}} + \sqrt{a_{n-2}}$ $a_0 = 1 \quad y \quad a_1 = 1$ |
| $T(n) = n$ | $T(n) = 2n^2 - n$ | $T(n) = C_0 2^n + C_1(-1)^n$ |
| $T(n) \cong O(n)$ | $T(n) \cong O(n^2)$ | $a_n \cong O(2^{n+1})$ |

**Figure: 8**
**Student progress using the constructivist approach.**

**Recognizing the difficulties of the collaborative learning with ICT in educational practice because of the time to develop the activities and the evaluation of the learning of students (Fung*, 2004), this teaching methodology was used in the course of A&C in the module Dynamic Programming - DP, carrying out a collaborative project of coding algorithms in a programming language on DP. The method of teaching virtual collaborative projects to develop the theme of Dynamic Programming is supports by conceptual maps and learning objects. One of these objects shows the resolution of the Knapsack Problem. The problem is given a backpack of capacity M, fill its capacity with the combination of N objects. Each object has a weight (Pi) and a utility value (Vi). The aim is to fill the Knapsack so that the gain of all objects carried in the backpack is maximized. These contents should be studied by students with the guidance of the teacher and the virtual tutor before applying the collaborative project. The learning object Knapsack Problem is shown in Figure No. 9.**

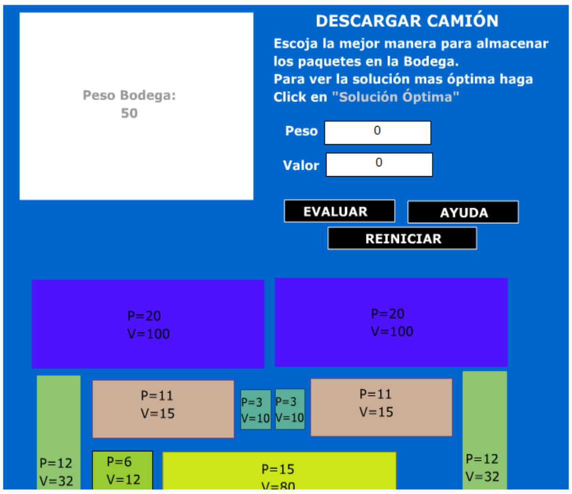




**Figure: 9**
**Learning Object: Knapsack Problem.**

The collaborative project was structured as following: 1) The class was divided into subgroups of students, who were equivalent in their academic performance in accordance with the previous grades of Dynamic Programming topic. 2) Students and professor identify problems feasible to be solved by Dynamic Programming. 3) State the problem to be solved in the project. 4) Solve the problem algorithmically by using Dynamic Programming. In this step, the student receives reinforcement guides by the assistant professor (Rua, 2015). 6) Encode the problem to be solved in Java language. 7) Socialize the results of the problem through the network in the forum. 7) Improve problem algorithmic solution, in accordance with the recommendations of the professor and fellow-students of the class. Interface of one of the reinforcement guides for the collaborative project is shown in Figue 9.

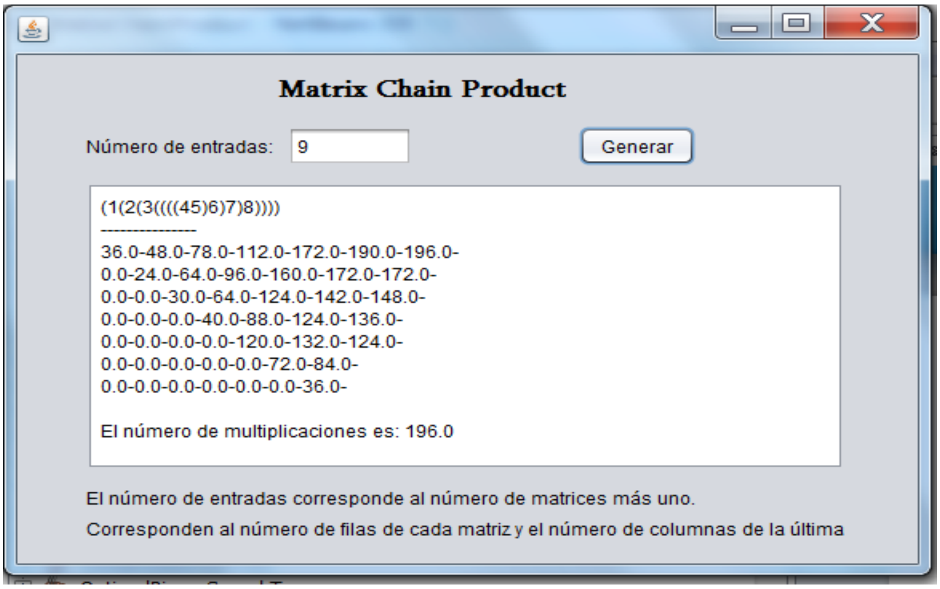



**Figure: 9**
**Matrix Chain Product using Dynamic Programming (Sedgewick, 1992, p. 598).**

The main objective of Product Chain Matrix is to find the minimum number of scalar operations of a set of matrices, which can multiply. Given the matrices $A_{34}$ $B_{43}$ $C_{32}$ $D_{25}$ $E_{54}$ $F_{46}$ $G_{63}$ $H_{32}$, then the minimum number of scalar multiplications is 196. The optimal parentización is (A(B(C((((DE)F)G)H)))).

Keep in mind that mathematically the number of ways in which you can parentizar n variables is equal to Catalan Number. This number is represented by the mathematical expression

$$NC = \frac{4^{(n-1)}}{n * \sqrt[2]{\pi * n}}$$

## FUTURE RESEARCH

The virtual teaching methodology presented in this paper has a formal support in Psychology, Education and Computer Science. Therefore, the following step is to do an analysis of the relationship that currently exists between the theories of psychology and education with the learning processes in virtual spaces supported by ICT. If this relationship is made, it can be ensured that the process of virtual learning is done with an educational, pedagogical and teaching sense, aiming at achieving a significant student learning. The proven teaching methodologies ensure the student's learning from an initial state to a final state of learning, i.e. since before interacting with the virtual course until after receiving the support of the course. Therefore, in the process of virtual training it is required intermediate states of student's learning, where the points of improvement of the teaching-learning virtual process can be identified. The course was built in the Blackboard

**platform with connection to the Java programming language; objects work in the domain of the vision, then, it is important to investigate and build learning objects in the domains of touch and smell associated with the Algorithms and the Theory of Complexity.**

## CONCLUSION

**The research process to create and test teaching-learning methodologies applied to the learning in virtual spaces supported by ICT, leads to conclude: i) The research was carried out in time series of the year 2011 to 2014 (8 semesters). ii) In these years around 175 students were training in the subject Algorithms and Complexity - A&C, with a maximum of 30 students and a minimum of 15 students per course. iii) Taking into account the status of learning of the pretest (before using the virtual module) and those of the post- test (after learning with the support virtual module), students achieved their best performance in the module 'Greedy Algorithms'; (iv) The methodology with the best student learning performance level was that of problem solving, with an efficiency of 70 % (Figure 10). The reasons of this qualitative performance are: Allow solving complex problems using the computer (Traveling Salesman problem, in Computer Science). Verify the theoretical results with those shown in the computer. Designing communication interfaces in the platform supported by ICT. Improve the programming language JAVA in Greedy Algorithms; v) The maximum increase in average of learning achieved by students was 43.8 per cent of the pretest to the test. vi) The minimum increase in average of learning was 21.5% in the topic of computers, complexity and intractability. (vii) The average of the total increase of learning supported by the platform Blackboard was 22.3%.**

| | Computers, Complexity and Intractability | | | Recurrence Equations | | | Divide and Conquer | | | Greedy Algorithms | | | Dynamic Programmin g | | | Shortest Path Problem | | | Graph Theory | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | P | T | PIL | P | T | PIL | P | T | PIL | P | T | PIL | P | T | PIL | P | T | PIL | P | T | PIL |
| 2014 02 | 2.0 | 3.1 | 22.0 | 2.6 | 3.6 | 20.0 | 2.1 | 3.6 | 30.0 | 2.0 | 3.7 | 34.0 | 1.6 | 4.3 | 54.0 | 2.0 | 4.1 | 42.0 | 2.0 | 4.1 | 42.0 |
| 2014 01 | 3.0 | 3.5 | 10.0 | 2.5 | 3.7 | 24.0 | 1.0 | 3.7 | 54.0 | 1.3 | 4.8 | 70.0 | 2.1 | 4.2 | 42.0 | 2.0 | 4.1 | 42.0 | 3.0 | 3.9 | 18.0 |
| 2013 02 | 2.3 | 3.3 | 20.0 | 3.1 | 3.6 | 10.0 | 2.6 | 3.6 | 20.0 | 2.1 | 3.7 | 32.0 | 2.0 | 3.7 | 34.0 | 1.6 | 3.7 | 42.0 | 2.5 | 3.4 | 18.0 |
| 2013 01 | 2.5 | 3.0 | 10.0 | 2.8 | 3.7 | 18.0 | 2.4 | 3.7 | 26.0 | 2.0 | 4.0 | 40.0 | 1.8 | 3.5 | 34.0 | 1.4 | 4.0 | 52.0 | 1.5 | 2.7 | 24.0 |
| 2012 02 | 2.1 | 3.6 | 30.0 | 1.2 | 3.3 | 42.0 | 3.0 | 3.3 | 6.0 | 2.6 | 4.5 | 38.0 | 1.4 | 3.5 | 42.0 | 1.8 | 3.7 | 38.0 | 2.9 | 4.2 | 26.0 |
| 2012 01 | 1.6 | 4.0 | 48.0 | 2.6 | 3.4 | 16.0 | 1.6 | 3.2 | 32.0 | 1.1 | 4.0 | 58.0 | 1.7 | 3.5 | 36.0 | 2.6 | 4.2 | 32.0 | 3.2 | 3.5 | 6.0 |
| 2011 02 | 2.4 | 3.7 | 26.0 | 2.4 | 3.4 | 20.0 | 2.4 | 3.4 | 20.0 | 1.6 | 4.0 | 48.0 | 3.0 | 3.3 | 6.0 | 2.9 | 3.3 | 8.0 | 3.0 | 3.3 | 6.0 |
| 2011 01 | 2.9 | 3.2 | 6.0 | 2.2 | 3.6 | 28.0 | 1.5 | 3.6 | 42.0 | 2.5 | 4.0 | 30.0 | 2.3 | 3.0 | 14.0 | 2.9 | 3.0 | 2.0 | 1.0 | 3.0 | 40.0 |
| Average | 2.4 | 3.4 | 21.5 | 2.4 | 3.5 | 22.3 | 2.1 | 3.5 | 28.8 | 1.9 | 4.1 | 43.8 | 2.0 | 3.6 | 32.8 | 2.2 | 3.8 | 32.3 | 2.4 | 3.5 | 22.5 |
| P : Pre-Test | | | | | | | | | | | | | | | | | | | | | |
| T : Test | | | | | | | | | | | | | | | | | | | | | |
| PIL : Percentage Increase in e-Learning | | | | | | | | | | | | | | | | | | | | | |

**Figure: 10**
**Results of assessment in teaching and learning methologies supported by ICT applied in Algorithms and Complexity.**

**The qualitative results of applying game theory are: i) A high level of motivation. ii) Learning at student's own pace, according to the choice of game difficulty level. iii) The ability to receive feedback from the game in order to improve their learning. iv) Students' highest level of attention to handle learning objects in the domain of audio, vision and touch. However, the difficulties in using the methodology are: High response time of learning objects for large values of input data (n >> 1 million); lack of stability in the**

**operation of the game, because of the type of student computer browser. It is of utmost importance to note that the above problems are technical ones in the process of communication between the server hosting the virtual course and the student computer, and are not relevant to the virtual educational concept of the game.**

**The use of Gestalt theory applied to the process of learning with ICT gave the following qualitative results: i) A high interest from students. This interest is evidenced by the use of algorithm in solving practical problems. ii) Allows the design of human-machine communication interfaces. iii) Makes possible the practical resolution of problems by using a programming language (Java), which is motivating for students for the possibility of designing software elements. iv) Students can check the results through operating results JAVA programs. The aforementioned qualitative results validate the high performance of students in the module Greedy algorithms. The actions to improve the application of this methodology are: homogenize students' learning level at the beginning of the virtual module; and a higher level of attention of the virtual tutor to students in order to develop the problems of high level of complexity related to operating systems or computers´ networks using algorithmic.**

**Applying personalized teaching (based on Piaget's principles) using ICT in virtual methodology brings about the following results: i) Students' understanding of the conceptual structure of shortest path problem module. This is evidenced by the use of concept maps and the correct organization of teaching content in a tree structure. ii) Students' learning achievement from a concrete thinking to a formal one, evidenced by the fact of 32.3% increase in learning. This implies student's formal thought to achieve the learning object requirements (Figure 5.). Although, the methodology is appropriate to virtual education, it is necessary to take into account that the virtual tutor should design an outline for each student, greatly increasing the professor's and virtual tutor's times to attend students.**

**The implementation of the project-based methodology in algorithms course allowed the starting of research processes in algorithmic complexity. This is one of the most difficult virtual methodologies. The difficulty is justified not only by the research level but also for technological resources required. Based on the above mentioned, the qualitative analysis of the project-based methodology allows in virtual education: Review the state of the art of the topic of the project that the student is virtually developing. Motivate the students because they themselves selected algorithmic topic to research in complexity. Writing a research paper from the undergraduate generates multidisciplinary interaction between undergraduate and graduate level training because students participate competitively for the best paper at the time of socializing research results in the virtual classroom as part of Psychology Vygotsky dialectic. Students then expect feedback to generate a second version of the research paper. Finally this virtual learning approach demands a high amount of time for the teacher to guide and correct the state of development of all research papers of students.**

**This methodology was applied to assess the students' learning output according to ABET (American Boarding for Engineering and Technology) Standard h). This standard is related to the competencies the student must learn to understand the impact of engineering solutions in a global, economic, environmental and social context.**

**The related results use a rubric, and for the first half of 2015 used the scales: Very poor, poor, good and very good for a sample of twenty two research projects. Regarding the standard mentioned the results are: i) In global and environmental contexts: 9% very poor, 0% poor, 50% good, and 41% very good. ii) Meanwhile the relevant results values for economic and social contexts are: 5%very poor, 0% poor, 23% good, and finally, 73% very good. The need for linking this methodology in this paper is to demonstrate the importance of ensuring the quality of training students in learning processes in virtual spaces using the project-based methodology, and to make relevant that virtual actions are essential to support international accreditation processes.**

Applying the constructivist approach supported by ICT is a challenge when it is used in Algorithms. The challenge is to get students preconceptions evolve from a state of early learning to a final moment of learning. Before starting the virtual module, all students have different preconceptions. These are supported by the mathematical knowledge. The structure of the process is that this knowledge is different in all students. Then, starting from different bases all students must achieve the same response to solve the equation of recurrence. Therefore, the approach application time is high, and it is also high the diversity of mathematical approaches to reach the same response. This was the reason why the advancement of learning level was not as high as it was expected. The level of learning achieved in the approach was 22.3%.

Collaborative projects methodology implemented in the virtual Dynamic Programming module produced the following results in qualitative terms: Students integrated theoretical and practical strengths in project groups. Development time of projects in the JAVA programming was shorter than when programmed individually. Solving problem results are most effective. The time of consultations to virtual tutor and teacher decreased considerably when making virtual collaboration projects. Then, students classified the methodology functional and useful as an activity prior to a real job in a company.

Aditionally, the teaching methodologies presented in this paper meet the teaching competencies and learning methods in accordance with the UNESCO suggestion. They also help constructing virtual courses that increase both knowledge and learning of the curriculum in both virtual and face-to-face modalities. (S. E. Sergis & Sampson, 2014).

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