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Analysis and Design of Digital Tools for University Students

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ABSTRACT:**This paper shows current situation of education in Mexico and how technology can improve the overall picture of higher education. Two digital tools are described, developed to support topics of courses corresponding to the bachelor's degree in Computer Sciences (LCC), offered by the Faculty of Mathematics of the Autonomous University of Yucatan. The tools consist in a simulation of operating systems processing algorithms and an animation of the conversion of numbering systems used in network addressing. It is presented a description of each tool, as well as the implemented methodology used to develop such tools. The subsequent use of these tools in the classroom is intended to strengthen the teaching-learning process on university students.**

Keywords:**Digital tools, higher education, teaching-learning, simulation.**

I. INTRODUCTION

At different educational levels, in Mexico ranging from primary school to higher education, there is a generalized idea about the difficulty that presents the subjects in the area of mathematics and exact sciences. According to results of PISA 2000 of the Organization for Economic Co-operation and Development (OECD), Mexico country is located well below the average of Latin Americacountries, in the assessment called PISA plus [1], as much in the area of mathematics as in the reading comprehension.

In Yucatan, the State where the authors of this work live, the test link of the year 2008 to 2010 reflects that more than 79% of students in upper-secondary education (high school) and about 90% ofjunior high school students obtain results "insufficient and elementary" [2]. As Pariente[3]say "is no secret the lamentable state which suffers education in Mexico. Academics, scholars and organizations, local and international ones, have noticed the many and varied problems faced to the national education system, in particular to higher education".

In institutions of higher education, the courses of the physico-mathematical area present difficulty for students to complete them, reporting fail rates up to 50% [4].

The brief scene described above invitesto urgently carry out actions aimed at improving the current situation of higher education in Mexico. To the authors an ideal starting point is the institution in which they collaborate as teachers and lecturers, where direct contact with technology is ideal to develop solutions in which technology tools help improve the teaching-learning process.

II. USE OF DIGITAL TOOLS IN EDUCATION

To date, a large number of papers have been published in which digital tools are successfully used in the teaching-learning process. Among these works are of Härtel[5], who develops a software to teach physics. Khan [6] and Richards et. al. [7] who use computer simulations to teach science; Jones and Boyle [8] who claim that computers has the potential to create an environment where students can understand an build better their knowledge; to name a few. Success can also be observed when using them in higher education [9] [10] [11]. Thus, several authors have demonstrated the effectiveness of the use of video games, simulations and other tools such as social networks to stimulate the interest of students and thus generate significant learning.

Snir et. al. [12] describe that, since 1993, it was considered that computer simulations could be used to address the problem of teaching to achieve a conceptual change and of understanding. In particular, the computer simulations provide an explicit representation of a set of interrelated concepts, allowing students to perceive situations that cannot be directly observed in laboratory experiments.

III. TEACHING-LEARNING IN HIGHER EDUCATION

There are several theories to address the teaching-learning process, from the traditional education [13]to the competency-based approach [14], passing through various educational models that universities have proposed and implemented gradually in the programs of its educational offerings. However, the greatest challenge it faced by teachers when they face the everyday in the classroom, and

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it is that despite the technological boom of the 21st century, still is much to do to achieve an optimal use of the adoption and use of technology in the classroom.

In the teaching of higher level, particularly in the area of technology and exact sciences, has been observed that the material developed to reinforce the process of teaching-learning through the use of digital tools is very insufficient. This contrasts with the great interest that young people show towards technological devices, which leads to believe that if these resources are properlyused, its use could bring important benefits.

Considering the currently existing problems in education, particularly in the higher level, and in order to perform actions to improve the achievement of students,it was decided to create some digital materials that could be used to support higher education subjects, in the computer science field.

IV. METHODOLOGY

To the development of these materials was carried out an analysis of those issues that, based on the experience and the results of the evaluations carried out by teachers, are particularly difficult for students. Thus, a list of difficult issues by subject was generated and students interested were invited to collaborate with the project to choosein which subjects wanted to work.

The subjects addressed were Computer Networks and Operating Systems. Digital tools that were developed to support the teaching-learning process were the following ones:

Simulation of three algorithms for execution of processes in an operating system known as First Adjustment, Best Adjustment and Worst Adjustment.

Graphic converter of aa binary number to decimal and vice versa for the teaching of IP addressing.

The Adobe Flash CS5.5software was used to the development of the first tool, the interaction was achieved with the use of animations created from ActionScript 3.0. The animation shows the queue of processes and allows to observe the execution sequence that performs the algorithm as well as the total time that it will take the execution of all processes. The second application was developed in third dimension using Blender 2.49b (a software for modelling and 3D animation) with support of the Python programming language.

The following describes each of these tools as well as a brief theoretical framework on which was based the development of each one of them.

A. *Simulation of execution of processes in an operating system*

In the operating systems course, one of the issues that have greater difficulty is the understanding of the process management tasks that the operating system performs. In practice has been observed, when studying this topic in a theoretical way, exists the risk of falling into a memorization technique without really understanding the work that internally performs the operating system, with which the student could hardly apply the acquired knowledge when required to implement. To support this topic, it was developed an interactive animation that simulates the execution of multiple processes, each one on a different processor.

In an operating system, the execution of concurrent processes is the basis of the multiprogramming. To achieve it, the processor must be able to schedule the execution of processes in such a way to exploit to the maximum the available resources. Therefore, when a process requires an input/output operation, the processor must optimize the use of the time and not wait for the end of that operation, so it is required to run one of the memory stored processes. Figure 1 illustrates the actions and states in which the processes transits.

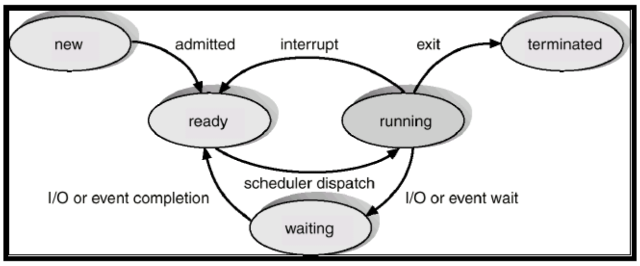

Fig.1. Diagram of execution of processes in an operative system

In the allocation of contiguous memory, all the logical space of a process (Code, Data, Stack) must be located contiguously in main memory, i.e. in consecutive physical addresses, and when a process ends, the memory occupied by it must be released. The three policies commonly used by operating systems are known as the First adjustment, best adjustment and worst adjustment.

The first adjustment policy consists of assigning the first available space with size enough to store the process. Best adjustment policy consists of assigning the smaller area that is large enough for the process requesting. The worst adjustment policy consists ofthe search for and assignmentof the biggest hole available to store the process in question.

In the developed animation, all algorithms receive as input data: the duration and the size of the processes, the order of arrival of the same, the available size of the total memory of the operating system and the space occupied by the operating system. Once captured these data, the user choose the algorithm that wants to simulate and then the allocation of operating system processes is graphically shown.

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The animation consists of 3 screens, in the first is chosen the number of processes to run, are provided their respective sizes and durations; also are indicated the total available memory (between 100 and 512) and the size of the base operating system. During the execution of the process, the user can add new instances of each process into the queue and the animation simulates the execution considering the selected algorithm. Figure 2 shows two execution screens of the developed tool.

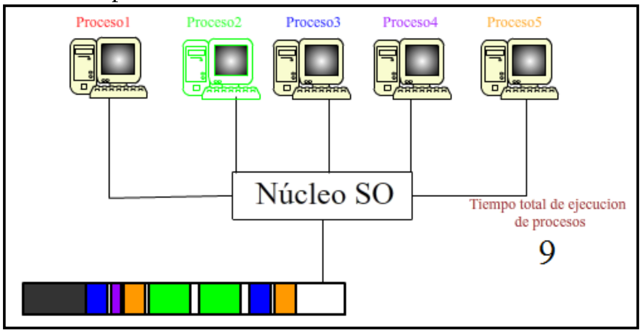

Fig. 2. Algorithm simulating simultaneous execution of five processes

B. *Converter of IP addresses*

In the computer networks course, one of the topics of greatest difficulty for students is related to the binary representation of the IP addresses used in computers and network equipment. Therefore, it was decided to create a tool that will allow the student to dominate the process of conversion of decimal numbers between 0 and 255 to binary and the conversion of binary numbers between 00000000 and 11111111 to decimal numeration.

The range of numbers was delimited from 0 to 255 (in decimal notation) due representing an IP address is via four numbers separated by decimal points and each of the numbers is located in the range of 0 to 255 in the decimalnumbering system, or its equivalent in the binary numbering. The IP address is formed of 32 bits divided into 4 groups of 8 bits where each group can go from 00000000 (equivalent to 0 decimal) to the 11111111 (equal to 255 decimal).

IP addresses are used to identify, in a logical and hierarchical manner, an interface of a device in a network that uses the IP protocol; this kind of addressing corresponds to the network layer or level 3 of the OSI model reference. See Figure 3.

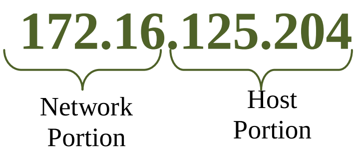

Fig. 3. Structure of an IP address

The developed software allows the user to choose one of two possibilities: enter a decimal number and then find its equivalent value in binary notation, or enter a binary number and subsequently find its equivalent value in decimal notation.

The interface consists of a slot machine, similar to those in casinos, which contains within it a space where the user will enter a number in decimal notation or alternatively move the cubes on the screen to enter a number in binary code.

When a number in decimal format is introduced, the user will have to form the corresponding binary number for which he has a sequence of eight cubes that contain zeros or ones in their faces, he must rotate the cubes to find the desired combination of zeros and ones. When a binary number is entered using the eight cubes, the user will now introduce the corresponding decimal. It should be mentioned that the program can also be manipulated by using the keyboard, using the associated keys, which are those that can be seen in table 1.

TABLE I
ASSOCIATION OF A KEY WITH A POSITION IN A NUMBER

Key	A	S	D	F	G	H	J	K
Position	128	64	32	16	8	4	2	1

The software checks to see if the number introduced in the box or in the cubes corresponds to the combination of zeros and ones that was formed with the entered number; then the software verifies the answers and feedback the user, indicating if the enteredvalue was correct or incorrect. Figure 4 illustrates the interface of the application when a correct conversion has been performed.

Fig. 4. Correct conversion

With the tools that have been developed so far is intended to improve rates of achievement in subjects that these materials directly support: operating systems and computer networks. One of the advantages of the developed software is that it has the modularity feature and the source codes are available, which will allow doing some minor modifications to convert them into learning objects that can be deposited in any virtual repository, besides their incorporation into the courses created in the learning management system Moodle for the corresponding subjects. The populations that will directly benefit from these materials are the students of the Bachelor's degree in Computer Sciences (LCC) as well as the teachers and the university community, in general.

However, since the students were those who chose the topics that would work to develop the digital materials, there was found that the selected subjects do not have a high rate of failure, so it was decided to conduct a study to find out what are the most difficult subjects, as much in opinion of the students as in terms of the obtained grades.

In this sense, the subjects that reflected greater difficulty for students were those listed in table 2. The Mentions column indicates how many students indicated that the subject in question was difficult, the Population column indicates how many students attended the course in the immediate preceding school period and the column Percentage was obtained with the quotient between both values.

TABLE II
LIST OF 'DIFFICULT' SUBJECTS FOR LCC STUDENTS

Subject	Mentions	Population	%
Compilers	9	9	100%
Distributed Systems	5	5	100%
Probability	22	23	96%
Algorithms Analysis	15	16	94%
Vector Calculus	11	12	92%
Integral Calculus	16	18	89%
Theory of Computing	8	9	89%
Differential Equations	13	16	81%
Superior Algebra II	20	27	74%
Superior Algebra I	10	14	71%
Physics for Computing	10	14	71%
Differential Calculus	11	17	65%
Lineal Algebra	7	11	64%
Scientific Computing	3	5	60%
Statistical Inference	3	5	60%
Programming	9	15	60%
Data Structure	5	9	56%
Database	8	16	50%
Software engineering II	2	4	50%
Numeric Algorithms	8	17	47%
Programming Fundamentals	5	11	45%
Computer Architecture	9	21	43%
Theory of Programming	7	18	39%
Languages			
Social Environment	5	14	36%
Discrete Mathematics	4	14	29%
Artificial Intelligence	5	21	24%
Programming of Systems	1	5	20%
Software Engineering I	4	21	19%
Computer Networks	1	6	17%
Computing Management and Audit	1	7	14%
Research Methodology	2	19	11%
Operative Systems	2	24	8%
Operations Research	0	13	0%

As can be seen, the subjects of Computer Networks and Operating Systems were classified in the last places in difficulty, which means that only 17% and 8%, respectively, of the students who attended them, felt that these subjects were difficult when they attended them.

Therefore,the development of digital materials will continue after doing some changes in the methodology, for example, students interested in supporting the project will be allowed to choose one of the more difficult issues of the subjects that require more support, postponing the development of materials for those subjects which are not classified as of the greatest difficulty.

V. CONCLUSIONS

It has been presented an overview of the current situation of education in Mexico as well as the most relevant data regarding higher education. In order to improve this situation, the two developedtools that are described will serve as support to reinforce the process of teaching-learning in higher education subjects, in the area of computer science. Both tools are interactive and have animated elements, with which is intended to achieve a greater motivation in students.

After analysing the difficulty that students observe in the courses supported with the created digital materials, work will continue in new digital materials to support the subjects considered to be the most difficult. In addition, these materials will be put into practice with the aim of achieving meaningful learning, thus improving the performance of university students.

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Biography

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