Pathfinder Associative Networks for the Validation of Improvement in Information Security Teaching

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Summary — **This article presents the experience of Digital Storytelling realized in the ECTS tutorials of the Information Security subject in order to evaluate the development and evolution of students' knowledge through similarity analysis with Pathfinder networks, questionnaires of satisfaction, and qualitative analysis of the open question evaluations, object of this work, with the final purpose of being able to triangulate the obtained results and to verify the validity of the same ones. Consequently, in this experiment, it is determined that the use of Digital Storytelling in the classroom improves the relationship of very complex concepts that students establish.**

Keywords – pathfinder associative networks, digital storytelling, theory of nuclear concepts; teaching changes.

I. INTRODUCTION

In recent years the concept of digital narrative or digital stories [1] has been taken up as one of the most effective techniques for education. Although, this was already a classic topic, it has recently been revitalized with the ease of producing digital stories with current technologies; mainly by the profusion of accessible tools on the Internet under the Cloud Computing paradigm and the integration of the same, for design, creation, publication and other actions that allow the development of these well-known new technologies and, if more important, the communicative power that multimedia elements contribute to a classic story.

Despite the fact that there are attempts to systematize the creation of Digital Storytelling pieces [2], analyzing the key aspects that contribute the digital multimedia formats and enhancing the emotional aspects or the research or synthesis capacities that they require, there is a lack of systematized concrete experiences about how to use Digital Storytelling in the development and teaching of very specific subjects in classrooms. If they exist, they suffer from a coherent measure on the concrete contribution they suppose in the development of the students' skills.

On the other hand, from the beginning of the implementation process of university degrees in Spain, at the end of the first decade of this XXI century, to the present day, there are many improvement processes and measurements that institutions and teaching teams from different departments and universities have set in motion; based fundamentally on the strategic plans that universities usually have.

The experience described below has been carried out in the Information Security subject [3], which is taught simultaneously in the third year of the Computer Engineering in Information Technology Degree (GIITI) and in the fourth course of the Telematics Engineering Degree (GIT) of the University Center of Mérida, belonging to the University of Extremadura. This subject has a distribution of 4.5 theoretical credits, 1.5 practical credits and 0.3 follow-up activities, programmed tutorials or ECTS tutorials (European Credit Transfer System). The latter correspond to 3 hours in class for each work group formed, which will be discussed later.

The proportion of credits allocated to the ECTS activity is small; however, it should be noted that this figure only corresponds to the face-to-face tutoring sessions. In these sessions the work proposal, the monitoring of the activities and the clarification of the doubts that arise during the activity development are given to the different groups. Nevertheless, in the context of our experience, this face-to-face time has been materialized by developing a group work scheme that contributes to the effective progress of the work. Most of the group and individual work is not performed face-to-face.

We briefly quote the specific competences that this subject addresses, which can be consulted in more detail in [3]:

- Knowledge of the rules and the telecommunication regulations at the national, European and international levels. (GIT).
- Ability to apply the techniques on which the networks, services and telematic applications are based, such as management, signaling and switching systems, routing, security (cryptographic protocols, tunneling, firewalls, collection mechanisms, authentication and protection mechanisms of content), traffic engineering (graphs theory, queuing theory and teletraffic), tariffs and reliability and quality service, in fixed, mobile, personal, local or large distance environments, with different bandwidths, including telephony and data . (GIT).

- Ability to understand, apply and manage the guarantee and security of computer systems. (GIITI).

In addition, the assigned transversal competences are not less important, so that for the current subject, these are:

- To communicate effectively (in expression and comprehension) in oral and written form the knowledge, procedures, results and ideas related to ICT, with special emphasis on the writing of technical documentation.
- To have motivation for quality and continuous improvement, acting with rigor, responsibility and professional ethics

On the other hand, a list of the contents, that are taught in this subject, is the following:

- Module I. Principles of Security / Introduction
  - Topic 1. Introduction to Computer Security
  - Topic 2. Legal aspects of Computer Security
- Module II. Cryptography
  - Topic 3. Introduction to Cryptography.
  - Topic 4. Private Key of Cryptography
  - Topic 5. Public Key of Cryptography.
  - Topic 6. Summary Functions.
- Module III. Network Security: Internet
  - Topic 7. Perimeter security.
  - Topic 8. Other security tools.
  - Topic 9. Secure network services.
  - Topic 10. Security Protocols.

Given the active concern that the teaching team of this subject has always had regarding the education [4], since the first academic year 2012-13, the questionnaire SEEQ (Student's Evaluation of Educational Quality) began to be carried out [5], and it has been performed from year to year [6] to the present day. Precisely, the evolution of these results is what we present in this work.

In addition, the University of Extremadura also carries out, in each academic year, its own quality measures and the students' opinion surveys, managed by the Vice-rector of Quality through the strategic plan that has been set in motion («PlanEstrategicoUEx.pdf ", 2010). The opinion offered by each teacher's students is processed and used for the preparation of a report that is provided to the faculty and the managers of the University. However, in spite of already having an official system as described, this teaching team wants to try the subject evaluation to be summative and formative [7] that allows identifying the strengths and weaknesses of the teaching-learning process followed by a teacher. It will enable the professor to reflect and make the necessary decisions, and thus improve those deficiencies detected or insufficient aspects within the actions performed in the classroom.

II. OBJECTIVES

The main objective is to validate if students, from the first day of attendance to the subject, become active individuals of the teaching-learning process; and also, if it is maintained a high level of motivation by the teaching team of the subject, and in this way the students will improve the acquisition process of transversal and specific competences of the subject. This time we will validate it with the Pathfinder Associative Networks [4] by collecting data before and after the completion of Digital Storytelling.

III. THE USE OF DIGITAL STORYTELLING

While there are numerous definitions of Digital Storytelling, there is little controversy about what it is. In summary, Digital Storytelling can be defined as storytelling with the support of multimedia elements (images, audio, music, text, etc.) and their actions (transitions, accelerations, etc.) [8]. The possibilities offered by new technologies at present make us think of a new language or, rather, new forms of expression and communication, evidenced in the current boom of products related to expression and multimedia communication (animated powerpoints, memes, videos, etc.). Some author [9] defines it as a new genre, cited by [9].

This paper evaluates whether the change of the teaching method, through the introduction of Digital Storytelling, has been perceived by students as a complete improvement of the teaching-learning process, regarding the students' perception from previous courses, where this tool has not been used.

The use of this tool has been introduced as a pilot test within the ECTS activities. For this, work groups of four randomly selected students have been formed. All the groups have done the work on the same subject, specifically "Encryption in Blocks", and as a final result of the elaborated work, they have exhibited in class the Digital Storytelling that they have produced.

Several methods have been used to evaluate the development and evolution of students' knowledge, and the competencies associated with this activity throughout the school year. The methods employed have been Pathfinder Associative Networks [10]; the data collection in open format in each ECTS face-to-face tutorial, from which an evaluation and analysis qualitative, using WebQDA software, has been made [11]; the SEEQ questionnaire detailed in this paper; and finally, a questionnaire of satisfaction on the use of Digital Storytelling as a teaching-learning technique, for a fullest possible validation of this pilot test that has been developed.

IV. PATHFINDER ASSOCIATION NETWORKS

Within the various uses that have been given to the Theory of Nuclear Concepts [13], [14], hereinafter TCN, in Engineering, we can highlight the uses made in the doctoral theses of [4] and [15], both developed in the University Center of Merida, belonging to the University of Extremadura, in the degrees of Technical Engineering in Telecommunication and in the Degree in Computer Engineering, respectively. The example, which we present in this document, is one of the many carried out using TCN and its associated Pathfinder Associative Networks (RAF) technique [16] in order to know how students learn.

V. METHODOLOGY

Our interest in this experience was to introduce the Digital Storytelling within the ECTS activities of the Information Security subject and measure the increase of knowledge that occurs in the group of students.

For this, a mixed exploratory research design has been followed [17] in which the collection, analysis and findings are proposed in a qualitative stage, then to continue the interpretation of the phenomenon from a quantitative stage. Also, to avoid any interaction from the research team, it is proposed to collect data through texts introduced by the students in response to an open question: ¨ Tell everything you know about Block Ciphering ¨. In this way, the student is free to connect ideas and concepts without any restriction.

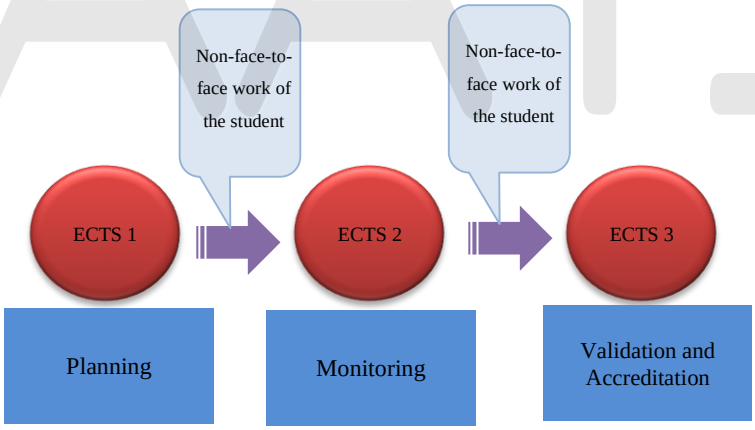

Fig. 1. Phases of Digital Storytelling realization in Higher Education.

We have followed the scheme of Fig. 1, where we can see the three ECTS milestones, or face-to-face sessions of students and teaching staff in the classroom, which were developed throughout the semester. The first milestone (ECTS 1), called Planning, was developed in the third week of the course and, although the concrete details are explained later, we can briefly state that it is where all the necessary instructions, for the implementation of the students' activity, are given; a brief formation on work group; and the design and creation of digital stories. Phase 2, Monitoring (ECTS 2) had the purpose of verifying the work status up to that time, reviewing the scripts, reorganizing the objectives if necessary, and, above all, motivating students to continue looking for the pursued goal, discussing and debating about the difficulties encountered until that moment. Finally, in the third milestone (ECTS 3), which took place in the penultimate week of the course, is where the Validation and Accreditation of the work developed by the students was carried out.

In each of the phases we have evaluated with different tools the students' knowledge about the subject of interest, through similarity analysis with Pathfinder networks [4], questionnaires of satisfaction and by means of the qualitative analysis of open question evaluations, object of this work, with the final goal of being able to triangulate the obtained results and to verify the validity of the same ones, if any. We have defined the most relevant categories that have been reflected in them, which will allow us in future works to graphically represent the evolution of students' cognitive structures because of the concepts association, according to Theory of Nuclear Concepts [18].

A. Data Collection

In the process of collecting data through Pathfinder Associative Networks, the MeBa software [4] was used, where the procedure of collecting information has been followed in order to be able to form the RAF and move forward to the TCN. In this experiment the data were recorded on two occasions, one before the instruction and the completion of the Digital Storytelling, that is, in the moments ECTS1 and ECTS3, according to Figure 1. For this, the students had been answering a similar entry to that reflected in Fig. 2, where they had been asked about the relationship of the concepts two by two.

Fig. 2. Data entry example with Meba software.

In our concerning subject, the concepts that were asked to the students to be related, on the subject of "block ciphering", were:

- Chained blocks
- Initiation vector
- Block feedback
- Error propagation from one block to another
- Flow Encryption
- Independent blocks

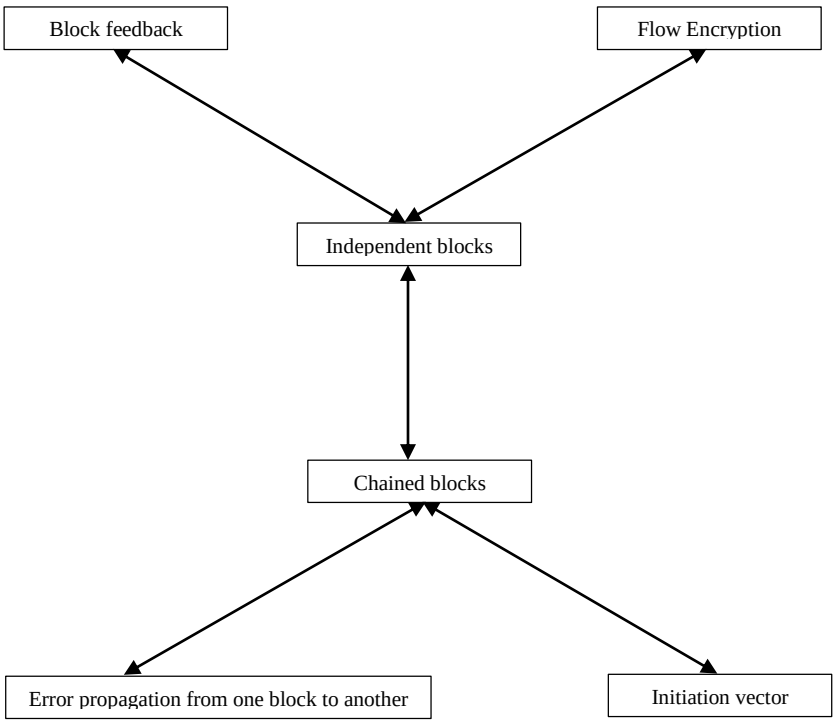

Fig. 3. Network of Science

The network of science calculated as described in [4] is shown in Fig. 3, and in front of it the comparisons of each student's networks will be made before and after, not only of the instruction, but after the completion of the work on DST.

In front of this network of science the students' similarity comparisons have been made before and after the development of Digital Storytelling, and over the same concepts. Once obtained the RAP and eliminated the networks of those students with negative coherence as described in [4], we obtain the similarity indexes of each student's networks before and after, whose comparison can be seen in the Fig. 4. We can also see how in the great majority of the students there is a significant increase of similarity, once they have done the work on DST, excepting the student 3 and 10; in the first case there is a drastic decrease that we should study carefully, but in the case of student 10 there is a very small decrease.

Consequently, within the scope of this experiment, we can appreciate that the use of Digital Storytelling in the classroom improves the relationship of very complex concepts that students establish.

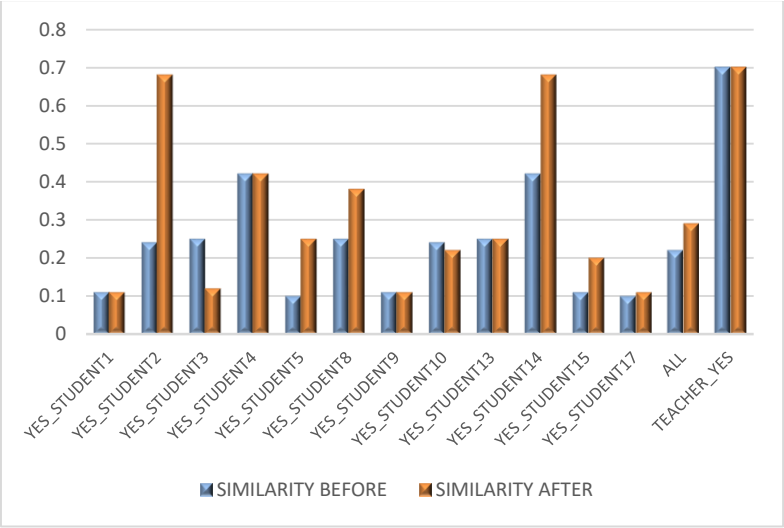

Fig. 4. Comparison of similarity of the average networks before and after each student in front.

In the comparison of the students' average networks before and after the instruction regarding the network of science, see the column of "All", we can also appreciate that there is a slight increase of similarity, specifically, as the average network that is, has gone from 0.22 to 0.28 which on average is very well as explained in [4].

Finally, in the column "Teacher_yes" we see that the similarity is maintained and it is also very high in relation to the network of science; although, it is not exact, given that on one side there is the network of science and as a close approximation would be the teacher's network.

VI. CONCLUSIONS

As it has been verified in the results of this first experience, the students have worked creating DST pieces and, with this, they have managed to obtain a better association of concepts in a natural way, without any specific preparation for the tests that they were demanded to take, since in the second data collection of the RAP they had already realized the experience with Digital Storytelling.

Although, this experience pays attention exclusively to the assimilation of complex concepts, it is proposed to experimentally measure the improvement of the different abilities considered to be strengthened by the STD use. This would provide concrete methods and action guides to carry out the experiences in classrooms in a way much more focused on the pursued objectives.

Finally, we propose an improvement in the experience with the measurement of knowledge through quantitative and qualitative measurements on the content analysis of the free texts that the students can develop in the tests, so that there is no intervention of the researchers at the time to suggest the concepts.

GRATITUDE

Special gratitude to all the students who have taken the Information Security subject at the University of Extremadura and devoted part of their time to answering the questionnaire of valuation, once the whole teaching-learning process has been completed.

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