Advances in Intelligent Learning Environments

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Advances in Intelligent Learning Environments

María Lucía Barrón Estrada
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Editorial

Artificial Intelligence is now more real than ever; it is easy to find everywhere many intelligent devices and applications that contribute to ease our lives. Artificial intelligence is also present in Education providing intelligent environments that deliver personalized material for every student, adapt the teaching strategy according to the emotional state of the student, or dynamically deliver knowledge in a gamified environment, among others.

Researchers all over the world have demonstrated that using artificial intelligence techniques in Education is possible to deliver robust software systems that help students to acquire knowledge and learn at their own pace in different virtual or digital environments. Artificial Intelligent (AI) techniques can be very helpful in supporting human learning, transforming information into knowledge, using it for tailoring many aspects of the educational process to the particular needs of each actor, and timely providing useful suggestions and recommendations.

In this workshop our goal is to offer researchers an opportunity to show how they are exploring new ways of applying AI techniques to education.

In this volume we present ten research works in some of the most interesting fields of intelligent learning systems.

The papers were carefully chosen by the editorial board on the basis of three reviews by the members of the Technical Committee. The reviewers took into account the originality, scientific contribution to the field, soundness and technical quality of the papers.

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Authoring Tools and Virtual Environments in Intelligent Tutoring Systems: Challenges and Opportunities

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Abstract. Authoring tools in Intelligent Tutoring Systems (ITS) are designed to make it easier for tutors the use of Artificial Intelligence tools. Authoring tools allow tutors to develop adaptive, learner-centered courses that promote interaction between students and virtual tutors. This article presents a review of Virtual Reality (VR) tools for the creation of Virtual Learning Environments (VLE). In particular, we provide an analysis regarding how this kind of tools can be combined with authoring tools in ITS to achieve VLE that present to students realistic, interactive and immersive educational content. Finally, we discuss some challenges and opportunities in the design and implementation of authoring tools and tools of VR for the generation of VLE.

Keywords: Intelligent tutoring system, authoring tools, virtual reality, virtual learning environment, intelligent virtual agents.

1 Introduction

An Intelligent Tutoring System (ITS) acts as a private tutor of the student. An ITS can adapt to the pace of learning of each student, has a high degree of interactivity and provides the necessary feedback to each student so that they can achieve their learning goals [13]. An ITS must have autonomy to act according to the needs of the student, allowing students to apply the practice of their knowledge and skills more effectively than with traditional lessons.

The architecture implemented in such systems is basically based on three modules [27]: **Expert module:** It contains the description of the knowledge or behavior that represents the domain or teaching, i.e., the educational resources of a course. It allows an ITS to compare actions and choices of the student with the expert, in order to evaluate what the user knows and does not know. **The student module:** It assesses the information or performance of each student to determine their knowledge, reasoning ability, and perceptual skill. **Pedagogical**

module: It encodes the teaching methods that are appropriate for the target domain and the student. It is the engine of execution of the adaptive system. Based on knowledge, experience and learning styles of the students, the model selects the most appropriate educational intervention.

Altogether, these modules perform specific tasks, which support actions taken by each student that is implemented through another module called interface or communication module. A general system architecture of an ITS is shown in Fig. 1.

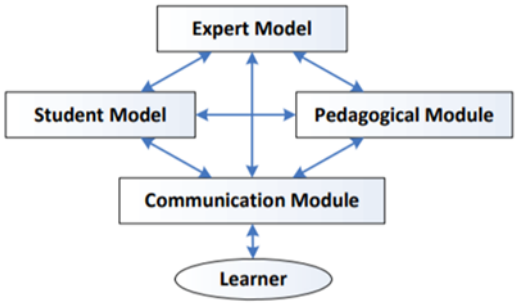

Fig. 1. Components of an ITS [27].

In ITS, authoring tools create academic content without requiring the tutor to have programming skills or technical skills. Authoring tools allow tutors to create learning content based on the activities defined in their interactive courses, learning objects (LO) and self-assessment online. Examples of such tools include RIDES [12], XAIDA [16], SIMQUEST [20], ITSB (Intelligent Tutoring System Builder)[13] and EDUCA [25].

The technology of Virtual Reality (VR) has begun to play an important role in the education process. The use of VR in ITS presents several advantages such as improved user experience through the use of interactive objects in educational settings. In particular, a Virtual Learning Environment (VLE) can be defined as a virtual environment based on a specific pedagogical model. An ITS combined with VLE tools is also called an Intelligent Virtual Environment for Training (IVETs). The interaction of the user in a VLE is usually supported by the use of pedagogical agents, which are usually implemented as Intelligent Virtual Agents (IVAs). These IVAs are embodied in virtual worlds and take the role of tutors, interacting with students and other IVAs in the VLE. In general, an IVA is capable of perceiving, adapting, and reacting to its environment. An IVA may supervise the activities of students, providing a feedback of tutoring. Course materials may be developed with these tools so that tutor-to-student interaction is more realistic. These IVAs are designed and programmed according to a process by an author. There are several tools for modeling virtual environments

such as SimHuman[1], ACE (Agent Common Environment) [8], OpenSimulator (OpenSim) [15] and Unity 3D [24] for interaction with the user.

Current reviews report isolated efforts regarding the development of ITS authoring tools and VR authoring tools [18,10]. Just a few where found where an ITS authoring tool integrates VR authoring tools capabilities [21,23]. However, authoring tools for ITS can benefit from the implementation of virtual environments as part of the teaching-learning process. For example, VLEs can be created to provide more immersive experiences by allowing the user to be guided by IVAs; interact with other students, a teacher or human tutors using avatars in a virtual world and finally allowing the user to interact with simulated scenarios where conditions are difficult to replicate in reality or involves high costs.

In general, authoring tools lack mechanisms to create academic content based on virtual environments. However, as mentioned above, the use of VLEs as part of the learning process presents several benefits. In this article we present a review of authoring tools for ITSs and tools for the development of VLEs. In particular, we analyze how authoring tools can take advantage of existing tools designed to create virtual environments in order to allow tutors to generate more realistic and immersive academic content, and more realistic and immersive interaction between IVAs and students.

2 Authoring Tools in Intelligent Tutoring Systems

A wide variety of authoring tools for ITSs have emerged over the last 25 years. Some of them have been discontinued, but a few authoring toolsets continue to evolve. Each of these tools has different scope (e.g., authoring for model-tracing, agent-based, or dialogue-based tutors) and a different set of learning theories (e.g., Component Display Theory and Cognitive Load Theory) that drive their design [22].

Currently, there are many authoring tools for ITS. Table 1 shows some of these tools classified on the basis of their design goals. In category *Teacher-centered*, authoring tools are focused on pedagogy and focuses on how to teach. In category *Student-centered*, tools are designed to perform in learning environments in which students can develop skills by practicing and receiving feedback [12].

Tutors through the ITS Authoring Tools are able to design workflows, constraints, content, adaptability rules, which allow the intelligent agent to perform recommendations, counseling and evaluations as a human tutor. A brief description of the most important of them are shown in Table 2 as a comparison.

3 Virtual Reality in Education

Since the 90's, VR technology has been used in educational desktop applications where students interacted with 3D simulations [3]. In the last 15 years, VR in VLEs has gained great importance in the process of teaching and learning. For

Table 1. ITS authoring tools by category.

Category	Authoring tools	Focus
Curriculum	DOCENT [26],	Teacher-centered (teaching process)
Sequencing and Planning	IDE [17], ISD Expert, Expert CML [7]	
Tutoring	Eon [5],	
Strategies	GTE, REDEEM [2]	
Multiple	CREAM-Tools,	
Knowledge Types	DNA, ID-Expert [11], IRIS, XAIDA [16]	
Intelligent/adaptive	CALAT [9],	
Hypermedia	GETMAS, InterBook, MetaLinks	
Device	DIAG,	Student-centered (learning process)
Simulation and Equipment Training	RIDES [12] , SIMQUEST [20], XAIDA [16]	
Domain	Demonstr8,	
Expert System	D3 Trainer, Training Express	
Special Purpose	IDLE-Tool/IMap, LAT	

example, using VLE with VR simulation, students visited places or recreated the history [25].

The teaching design based on VR technology has enabled teachers to use tools such as Unity (see Fig. 2) to recreate VLE from real places where students can participate in realistic activities in that environment. For example, the tool Unity 3D can generate virtual and VR environments for education through virtual characters and 3D components with animations that can be used by an agent module that implements a tutor.

OpenSimulator (see Fig. 3) can generate alternative virtual worlds for education where tutors create a space with students to design laboratories and objects that are used to learn the content and skills. Likewise, OpenScenegraph is a tool designed to facilitate the creation of virtual reality worlds where tutors are virtually represented by IVAs and students are represented by avatars, as well as virtual objects that can interact in this VLE.

In a VLE, it is possible to have IVAs that can take multiple roles. For example, an IVA can be designed as an Expert Agent, a Tutoring Agent, a Communication Agent, a Student Modeling Agent or a World Agent. The definition of the role of each IVA depends on different scenarios where having an interaction with the user is needed. IVAs allow a more human-like interaction with users. They allow applications to have more expressive and emotional content since an IVA can be based on 3D models that closely match a person's face and body. The expression of emotions in IVAs can increase user's creativity by creating an illusion of life. A VLE that integrates IVAs promotes a more natural interaction between the virtual tutor and the user, so that students will have a more effective communication.

The creation of a virtual environment requires a script or design of the elements that inhabit that environment, such as 3D objects, agents, avatars. Depending on the environment, IVAs are added for IVA-user and IVA-IVA interaction. Currently, there are tools for the design of virtual environments such as Second Life (SL) [19], OpenSimulator (OpenSim)[15], OpenScenegraph[14], Agent Common Environment (ACE)[8], SimHuman[1] and Unity[24]. Table 3

Table 2. Authoring tools in intelligent tutoring systems.

Tools	Functionality
RIDES[12]	Helps the author to visualize the relationships between the elements of the curriculum (such as topics, courses, concepts, and procedures). It allows to develop simulations.
XAIDA [16]	Offers training in maintenance in four areas: the physical characteristics of a device, theory of operation, operation and maintenance and troubleshooting procedures.
SIMQUEST[20]	Develops systems of "simulation-based learning", the author creates the simulation model, the interface of the student, instructional design and the environment.
ITSB [13]	Designed and developed for teachers in ITS building in multidisciplinary areas. The author can add materials of the course, questions and answers, etc. As well as modules with their objectives, evaluations, etc.
EDUCA[25]	Develop adaptive learning material in a Web 2.0 collaborative learning environment. Another feature is the export the material to content SCORM (Sharable Content Object Reference Model) for use in online platforms.
CTAT[4]	Developed to support problem-based task domain. Requires familiarity with the Java Expert System Shell (JESS) production rule language. CTAT is currently available as binary (executable) code.
GIFT[6]	Strives for authoring toolsets that are easy to access and use, and support authoring in multiple task domains (cognitive, affective, psychomotor, and social). Its vision is for a shell tutor or architecture where a variety of ITSs can support training in a variety of task domains.

shows some of the tools for the generation of most commonly used virtual environments.

Table 3. Comparison of VR tools.

Characteristics \ Tools	SL	OpenSim	OpenScenegraph	ACE	SimHuman	Unity
Access to accounts	X	X		X		
3D design. Object Scheduler	X	X	X	X	X	X
Virtual Worlds	X	X	X	X	X	X
Intelligent Virtual Agents (IVAs)	X	X		X	X	X
Interactive Script		X	X	X		X
Programming Knowledge		X	X	X	X	X

4 Challenges and Opportunities

Through the literature review it has been identified tree scenarios where VR and ITS converge: Virtual Learning Environments, Simulations, and Intelligent

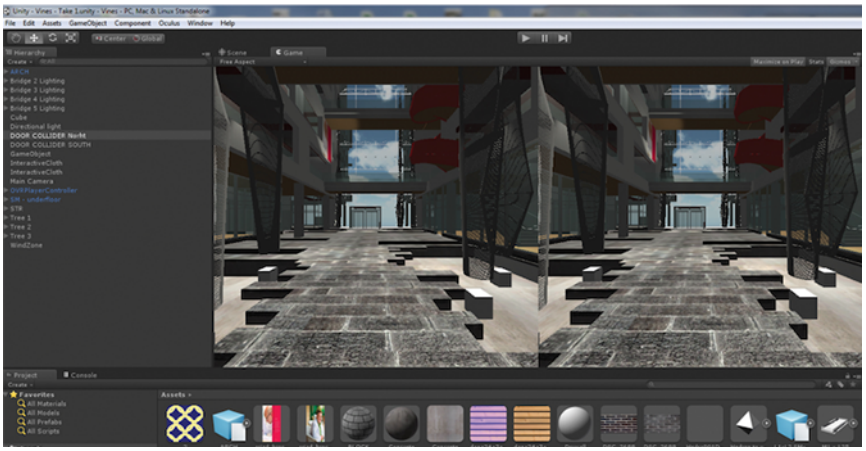

Fig. 2. Screen of a unity implementation [24].

Fig. 3. OpenSimulator 3D virtual world environment[15].

Virtual Agents. Furthermore, we visualize some major challenges and opportunities:

– Traditional ITS are focused on tutoring students in online courses by simulating the behavior of a human tutor and adapting to the student's behavior in order to offer help when required. In order to achieve more realistic behaviors in ITS, it is necessary to include IVAs. However, IVAs should become more autonomous, capable of learning, have more natural and adaptive interactions according to the dynamics of the conversation with the user and changes in the environment. Also, providing a realistic representation of a human tutor to address some aspects related to factors that influence on learning, e.g. motivation, stress and feedback.
– The development of virtual environments with VR requires the simulation of virtual worlds inhabited by IVAs, where learners and human tutors are

capable of interacting like if they were in the same place.
- The overlap of the capabilities of VR and ITS could be addressed through the integration of VR authoring tools and ITS authoring tools providing ways for developing, integrating and reusing Virtual Environments, Simulations and Intelligent Virtual Agents.
- Currently one of the opportunities for developers of E-Learning platforms is the creation of VR environments capable of adapting to educational strategies where a more affective learning experience is implemented.
- Finally, it is necessary to enable the tutor to take advantage of VR on e-learning environments through ITS-VR Authoring tools without requiring technical knowledge on VR design and development to create IVAs, Simulations and Learning Virtual Worlds.

5 Conclusion

This paper analyzed the challenges and opportunities of combining ITS Authoring tools with Virtual Reality tools for creating academic content. We found that usually the development of simulations using VR to model explanations is highly expensive or requires complex scenarios to be replicated. Nevertheless, the literature review showed a great variety of ITS Authoring tools that allow the creation of educational content. We identified some of such tools aimed at helping the author to create simulation models for instructional design and virtual environments, which are based on free software. As future work, we are planning to integrate VR authoring tools within ITS authoring tools to improve the creation of intelligent tutors in realistic, interactive and immersive content.

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Building a Corpus of Phrases Related to Learning for Sentiment Analysis

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Abstract. Learning-centered emotions unlike basic emotions emerge during deep learning activities and they have an important relation to cognitive processes of students. In this paper we present the creation process of a corpus of phrases (opinions) related to learning computer programming. Opinions (textual phrases), are categorized in different emotions related to learning such as frustrated, bored, neutral, excited, and engaged. The main contribution of this work is the creation of the corpus of sentences related to learning in Spanish that can be used to analyze text dialogs in order to detect the student's emotions and improve the teaching process adapting the content to the cognitive needs and also, to the affective state of the student. We present the study and the results obtained about the corpus of textual opinions.

Keywords: opinion mining, sentiment analysis, intelligent tutoring system, intelligent learning environments, learning-centered emotions.

1 Introduction

Emotions play a fundamental role in education. Learning is traditionally performed only within the classrooms in schools and was considered only the cognitive status of students, however, different technologies have been developed to address the need to integrate the emotions in the teaching-learning process. These technologies include some Intelligent Tutoring Systems (ITS) and Intelligent Learning Environments (ILE), which were designed to capture and identify the emotions of the users, but most of these conventional systems work only with basic emotions [1].

Humans express emotions in different situations of daily life. Basic emotions like anger, happiness, sadness, and fear have been studied by Ekman [2]. However, there are other types of emotions that emerge during deep learning activities, among which are emotions like confused, boredom, frustration, engagement, and excitement; these are known as emotions centered on learning [3, 4]. Emotions centered on learning play an important role in students because they affect different aspects such as cognitive

mechanisms and retention of information [5, 6]. There are many different ways to recognize emotions (face image, voice, text, corporal expression, heart rates etc.) but one of the most used today is based on the textual opinions expressed by users in several social networks. Currently, most of the tools to recognize emotions in text work with phrases written in English and those phrases are not focused on the learning field. In order to include an emotion recognition module based on textual opinions in an Intelligent Tutoring System we decided to create a corpus of phrases written in Spanish which are related to learning.

In this paper, we describe the development of an Educational Resources Assessment System, which is used to show the student several learning objects (LO) in order to capture textual opinions about them. The system generates a database (corpus), which contains the opinions provided by the students during the learning process when he/she access the educational resources. This corpus is used to train a classifier to recognize emotions and this classifier can be used to incorporate changes and improvements to the contents of the courses and other didactic elements in both ITS and ILE.

The main contribution of this work is the creation of a new database of phrases written in Spanish related to learning in the field of computer program development; to achieve this, a system was developed to capture and store students' opinions about learning objects; and finally, the implementation of a classifier algorithm to recognize learning emotions based on sentences written in Spanish.

This article is organized as follows: Section 2 presents the related work, Section 3 describes the Educational Resources Assessment System. Section 4 shows the process of creating the corpus of textual opinions and finally, conclusions are presented in section 5.

2 Related Work

In the last decade, the proliferation of internet sites where users express their opinions provoked as result the need to process these opinions automatically to obtain relevant information that could be used to make decisions so arose the opinions mining area. For Feldman "Sentiment analysis (or Opinions Mining) is defined as the task of finding the opinions of the authors about specific entities" [7]. Medhat, Hassan, and Korashy [8] distinguish Sentiment Analysis (SA) from Opinion Mining (OM) defining SA as "the computational study of the opinions, attitudes, and emotions of the people towards an entity". They said that OM extracts and analyzes the opinion of the people about an entity while SA identifies the sentiment expressed in a text and then analyzes it. Thus, the objective of SA is to find opinions, identify the feelings they express and then classify its polarity.

Medhat, et al [8], propose three main levels of SA classification: document level, sentence level, and aspect level.

- *Document Level SA:* considers the whole document as a basic unit of information and assumes that the document contains the main opinion expressed by the author.

- *Sentence Level SA:* this level is intended to classify the feeling expressed at the level of each sentence.
- *Aspect Level SA:* intends to classify the sentiment with respect to the specific aspects of the entities.

Sentiment Analysis is important in different areas like Business Intelligence where tracking public viewpoints could lead to prediction in sales as well as to better reputation management and public relations [9], but in education can be used to collect students' opinions on topics or learning strategies and this information will serve to perform the analysis of feelings and its outcome may be used to improve course materials, teaching strategies, the personalization of contents, among others as well as can be used within Intelligent Tutoring Systems (ITS).

Sentiment analysis has been used in the educational field in several works as presented below. Altrabsheh, Gaber, and Cocea [10] present Sentiment Analysis for Education (SA-E), where they describe an architecture to analyze the feedback from the students using the sentimental analysis on Twitter. Here the students used Twitter to express their opinions about the learning material of the course and those opinions were used by the teacher to adjust the teaching style according to the results.

Ortigosa, Martin, and Carro [11] implemented a hybrid method for sentiment analysis in SentBuk which is a Facebook application to retrieve users' messages and clasify them according to their polarity. It also provides several features like detecting emotional change, and user classification according to their messages, among others.

The SA method combines two techniques: lexical-based and machine learning, and reach an accuracy of 83.27%. This tool can be used in an e-learning context allowing the personalization of activities for the user according to his/her emotional state.

There are other researchers who have developed works related to this: Rowe [12] in which provides an overview of the few developments in the field of student emotions in relation to feedback based on recent research from social psychology and education. Altrabsheh, Cocea, and Fallahkhair [13] examined different methods so they could use to learn the feeling of feedback from students. Munezero, Montero, Mozgovoy, & Sutinen [14], present a functional system to analyze and visualize the student's emotions expressed in the learning diaries (instruments in which students reflect on their learning experience). In all these works, all the tools developed to analyze student's emotions were based on sentences written in English.

3 Technology

This section presents the development of the Educational Resources Assessment System (ERAS), which was used to create the corpus of textual opinions written in Spanish for the programming area. It also describe the module of analysis of feelings that uses the corpus of opinions for training. This module also performs the classification of opinions by determining the positive, negative or neutral polarity of the student opinion.

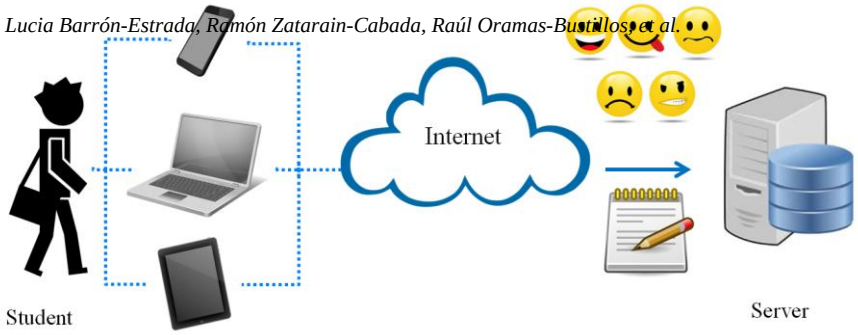

Fig. 1. Functioning of Educational Resources Assessment System.

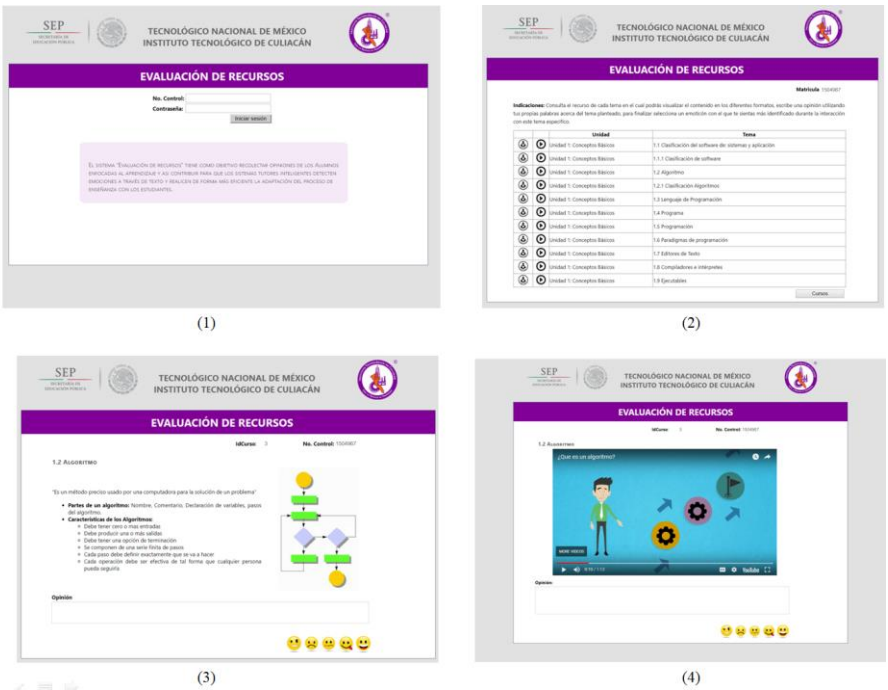

Fig. 2 System Interfaces Resource Evaluation.

3.1 Educational Resources Assessment System

The development of the Educational Resources Assessment System (ERAS) was implemented to generate a corpus of student's opinions written in Spanish which are focused on learning. EARS is a web application that was developed for the .NET platform in Visual Studio 2013, with SQL Server 2008 R2 database to store course information, educational resources, learning objects, users, and opinions issued by students. ERAS is hosted in the URL (http://posgradoitc.ddns.net:8000/).

ERAS was designed to interact with students in order to allow them to express their opinions and comments freely about the educational resources or learning objects of the subjects of a course.

Figure 1 shows how the student interact with the system using different devices with Internet access such as Tablet, Smartphone, Laptop, or PC. The user login to ERAS using his/her personal account and password and then selects the course that he/she wants to study. The system displays the list of subjects and the educational resources available and then the user access a learning object and writes a textual opinion labeled with the emotion that the student expresses at that moment. All student's opinions are registered in a database which is composed of different fields as the student data, the selected course topic, the opinion and evaluation entered by the student and finally the date and time of the student's opinion.

ERAS contains several interfaces, but there are four main GUIs shown in Fig.2. The login interface shows a brief introduction of the objective of the system and allows users to login (see Fig 2(1)). In Fig. 2(2) the second interface presents the topics of the subject selected by the student; there are two different formats (Image-Text and Video) to show the subject of study. Fig. 2(3) shows the learning object selected in format text, image or both and finally in Fig. 2(4) the theme in video format is shown. In both formats, the student is requested to enter a sentence to express an opinion about the learning object and tag it with an emotion related to learning (frustrated, bored, Neutral, Excited and engagement) using an emoticon provided in the interface.

3.2 Sentiment Analysis (SA) Module

This module is responsible for determining the polarity (positive, neutral or negative) of a phrase, sentence or document.

SA module [15], was developed using a Bernoulli Naive Bayes classifier after doing several tests with different classifiers: Multinomial Naive Bayes, Support Vector Machine, Linear Support Vector Machine, Stochastic Gradient Descent Classifier, and K-Nearest Neighbors.

There are a series of metrics that are used to estimate the quality of the classification algorithm that is part of our learning model. The simplest method to calculate the effectiveness of a classifier is the accuracy measure that calculates the percentage of text document correctly classified over the total of documents to be classified. To obtain this value we applied a cross-validation technique with a dataset of 8174 texts in Spanish with 90% for the training data and 10% for the test data.

Table 1. Accuracy values obtained using different classifiers.

Classifier	Accuracy
Bernoulli NB	76.77%
Multinomial NB	75.31%
SVC	75.79%
Linear SVC	74.69%
SGDC Classifier	76.69%
KNN	68.46%

The classifier algorithms we used for the evaluation were: Bernoulli Naive Bayes, Multinomial Naive Bayes, Support Vector Machine, Linear Support Vector Machine,

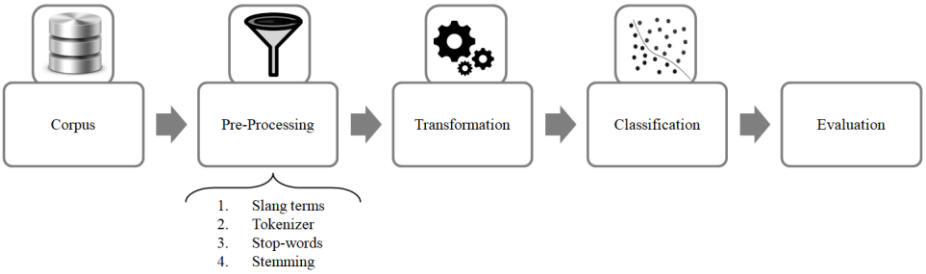

Fig. 3. The algorithm of the SA Module.

Stochastic Gradient Descent Classifier, and K-Nearest Neighbors (KNN). Table 1 shows the accuracy values obtained according to the size of the corpus. The classifier with the highest score was Bernoulli Naive Bayes with an accuracy of 76.77%. In general, Bernoulli Naive Bayes is a robust classifier against irrelevant features and it is suitable for classifying texts.

To test the functioning of the SA module, we used a corpus of phrases labeled with their respective polarity which was collected from Twitter, this corpus is called TASS [16]. Figure 3 shows this process.

A. *Corpus:* a corpus of textual opinions is required as input to the module.
B. *Pre-Processing:* It normalizes the sentences performing 4 steps for each entry in the corpus. The preprocessing is executed in 4 steps:
   1. Slang terms: It moves jargon terms and emoticons to its equivalent text.
   2. Tokenizer: It converts sentences into words by removing points and signs.
   3. Stop-words: It reduces words to its root word.
   4. Stemming: It removes unnecessary words.
C. *Transformation:* It calculates the term frequency (number of times a given term appears in a document or dataset) and reverses term frequency (number of documents in which a given term appears) for each word in the corpus generating a TF-IDF matrix. This is known as extraction of weighting characteristics.
D. *Classification:* It defines a function to predict the tag entered as input.
E. *Evaluation:* It evaluates the learning machine model to predict the polarity (positive, negative) of an input text; this helps us to find a reliable model.

4 Evaluation and Results

In this section, we describe the study and the results obtained about the corpus of textual opinions written in Spanish created by using the Educational Resources Assessment System (ERAS).

4.1 Participants

The study was conducted in August 2017; a total of 53 students, from the computer systems engineering career at the Instituto Tecnológico de Culiacán, participated from which 45 were male and 8 female.

4.2 Material

For this study, ERAS shows the Fundamentals of Programming course. This course contains five chapters. Chapter 1 is related with introduction and vocabulary about programming topic. It contains 10 topics; most of them are presented using learning objects in two formats (text-image or video). All LO were available for access by all students. In this study, the other chapters of the course were not available.

Table 2. Some examples of the opinions in the Corpus related to learning.

Key	Opinions (in Spanish)	Format	Evaluation
E-15	I liked the video very much (Me gusto bastante el video)	Video	Engagement
E-64	I didn't like that the voices were from Spain, besides that figures in the animation are kind of ugly. (No me gusto que las voces fueran de España, además los gráficos de la animación están algo feos.)	Video	Frustrated
E-70	The video is good but I think I need to go deeper (el video es bueno aunque creo que le falto profundizar mas)	Video	Neutral
E-29	Wow, it is kind of complex (Vaya, es algo complejo)	Video	Frustrated
E-67	Perhaps with an example it would be clearer. (Quizás con un ejemplo quedaría más claro.)	Image-Text	Bored
E-71	It would have been better to put a table with their differences and then compare them, and be more diverse. (Hubiese sido mejor poner una tabla con sus diferencias y así compararlas y sea más diverso.)	Image-Text	Excited

4.3 Evaluation of Educational Resources Assessment System

The system was available for 10 days in order to allow students to login and access the learning resources.

After accessing each learning object of a specific topic in any format (text-images or video), the system ask the students to write their opinion with a sentence (15 to 255 characters long) with respect to the content of the studied topic, they also have to label the opinion with an emoticon representing their emotional state: frustrated, bored, neutral, excited and engagement. The system recorded a total of 851 student´s opinions labeled with an emotion. Table 2 shows some examples of the student´s opinions that are in the corpus.

With the information obtained, a group of teachers validated that the opinions of the students had a relationship with the emotion captured with the emoticon which was associated. A 5% of inconsistencies were found and rectifications were made. It was also detected that 20% written opinions were definitions of basic terms such as algorithm, computer, among others so that these opinions were considered with the neutral emotion. Subsequently, we used the Feeling Analyzer Module to validate the coincidences with the emotional content of the texts, considering frustrated, bored, as a negative and neutral emotion, excited, and engaged as a positive emotion, since the Feeling Analyzer Module only recognizes polarity positive or negative. We found 458

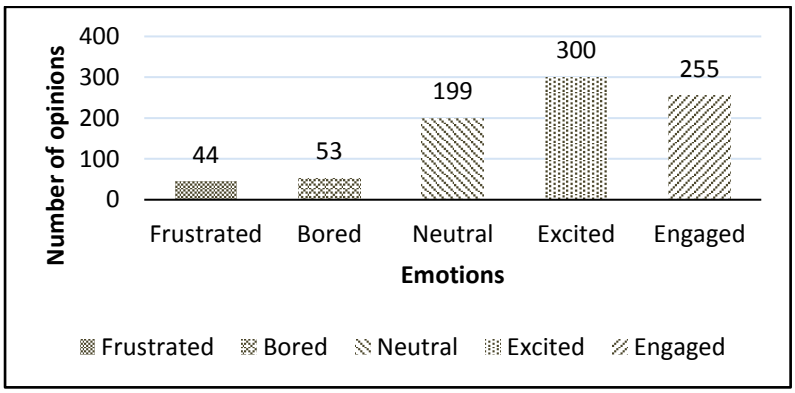

Fig. 4. Distribution of opinions in the corpus.

Table 3. Accuracy values obtained using different classifiers.

Classifier	Accuracy
Bernoulli NB	40.70%
Multinomial NB	40.70%
SVC	33.72%
Linear SVC	30.23%
SGDC Classifier	23.26%
KNN	36.05%

matches which are 53.81% of the total 851 opinions. Finally, the 458 emotions were incorporated into the corpus of the Feeling Analyzer Module.

4.4 Corpus of Reviews Focused on Learning

One of the main objectives of the ERAS was to collect opinions from students to generate a new corpus of opinions in Spanish to recognize emotions focused on learning (frustrated, bored, neutral, excited and engagement) with the aim of SA module which only recognizes two emotional states: positive and negative.

Of the 851 opinions (754 Positives and 97 Negatives), there was a neutral, excited and engaged emotional tendency which indicates that we must include resources that induce students to write negative comments. Figure 4 shows the distribution of the opinions collected in the first experiment.

With the new corpus based on emotions (frustrated, bored, neutral, excited, engaged); obtained with the ERAS application, the following classifiers were trained: Bernoulli Naïve Bayes (BNB), Multinomial Naïve Bayes (MNB), Support Vector Machine (SVM), Linear Support Vector Machine(LSVM), Stochastic Gradient Descent (SGD), and K-Nearest Neighbors (KNN); using cross-validation of 90% for training data and 10% for test data.

Table 3 shows the accuracy values obtained according to the size of the corpus. The classifiers with the highest score were BNB and MNB, both with an accuracy of 40.70%. The level of prediction is low since the corpus size is small and it is not balanced, as shown in figure 4.

5 Conclusions

In this paper, we describe the development of a system to generate a corpus of textual opinions in Spanish, labeled with emotions based on learning. The corpus generated with the ERAS system contains 851 textual opinions and each of them is tagged with an emotion related to learning.

At this time, the ERAS system remains available for more participants to express their opinions on educational resources and we expect to expand the number of opinions in the corpus in a few months balancing the occurrences of each of the emotions related to learning in order to improve the accuracy of the classifier.

On the other hand, the corpus will be used later for the administrator of an Intelligent Learning Environment to make decisions about the relevance of the educational resources contained in the system and to propose changes or improvements. This will help Intelligent Tutoring Systems detect emotions through text and make the teaching process more efficient for students, adjusting the content to the particular needs of each of them.

For future work we will take into consideration the inclusion of exercises for the development of Java programs in the ERAS system, this will also create a bank of problems for the learning of computer programming as well as will expand the corpus of opinions in this area of knowledge.

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Coverage, Opinion and Speculation: Key Features Analyzed by TURET 2.0

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Abstract. Developing a thesis is a process that demands time and dedication by the student since it is necessary to comply with conditions and norms established by institutional guides of the universities. This work describes a computational web tool that allows to evaluate the conclusion section of a thesis, focusing on three aspects: "Coverage", i.e. the connection between the general objective and the conclusion, "Opinion", value judgments about the concluded research, and "Speculation", i.e. evidence of a reflection on future work. This tool is incorporated into TURET 2.0. With the release of this updated version, TURET becomes a tool that the student can employ to analyze his/her thesis draft under acceptable parameters before submitting it to his/her adviser for further review. TURET will provide the analysis of the lexical richness and the analysis of key features of a conclusion section. We present details about the performance and the interfaces of the computational tool developed.

Keywords: E-learning, natural language processing, coverage, opinion, speculation, thesis conclusion.

1 Introduction

The completion of a bachelor's, master's or doctoral degree is usually accompanied by the realization of a thesis. The student carries out a research project according to his career and investigates it thoroughly until generating a document that contains the most accurate description about the main subject of the project. Writing the thesis is laborious, and often occurs that the student has no idea of what to write in such document [1]. An additional problem is complying with the parameters that are

suggested by the methodology book authors and institutional guides. So, writing the thesis is really an arduous work.

Students can easily find different guides and steps to follow on internet to develop a thesis. However, there is no guarantee that students achieve the target using only a guide, i.e. elaborating a thesis is more than just following steps of a web page [2, 3]. It is necessary that students write their own first draft and improve it with the observations of the academic reviewer. Theoretical foundation to develop it represents a methodology and designs already established to be carried out correctly. For students, it is essential to know that there exist some key elements that must be fulfilled in some of the thesis sections, such as coherence, argumentation, opinion, or speculation. These features provide support for a thesis to have a better internal structure. We focus on the analysis of conclusion section, since it focuses on the results obtained from the project.

A pattern that summarizes what is expected in a conclusion section is provided by Teaching & Learning Centre at University of England, Australia (UNE)[1]. This pattern goes from the specific to the general, and begins with a reformulation of the problem, followed by key findings (the student should express his thoughts and opinions, avoiding a list of results), and ending with recommendations and future work. This guide pattern is like the conclusion of a scientific article, but more extensive.

In the five-paragraph essay paradigm [4], the introduction and conclusion share the main topic, this is the theme or subject matter of the essay. This approach is similar to the conclusions section, since the conclusion should be related to the general objective (considering methodological guidelines), in the initial paragraph of the conclusion. The Online Writing Lab at Purdue University provides an outline to write the conclusion section, emphasizing that the conclusion must contain well-argued viewpoints and avoid inclusion of additional items that are not contained within the thesis [5]. Future work and recommendations included in the conclusion are evidence that the student has gone beyond the solution of the problem and can identify possible derivations of the work.

For this purpose, in previous work [6], three main subcomponents (models) were designed to identify in the conclusions the following features:

- Coverage: The model seeks to assess whether some of the sentences of the conclusion section have some connection with the general objective. This will reveal that the proposed solution to the problem is discussed.
- Opinion: Value judgments and reflections elaborated by students are key features of a conclusion. With the proposed model in this work, we attempt to assess whether the conclusion has some level of opinion. The idea is to help the student to undertake a process of analyzing his results and that the conclusion is not just a list of completed activities.
- Speculation: Our proposed model identifies the presence of speculative terms in conclusion sentences. As a result of the reflections of the research already done by the student, we expect that the conclusion shows evidence of future work or possible derivations of it.

[1] https://aso-resources.une.edu.au/academic-writing-course/paragraphs/conclusion-paragraphs/

Our computational tool fits within the systems performing Automated Writing Evaluation (AWE). Also called Automated Essay Scoring (AES), such task refers to the process of evaluating and scoring written text using a computer system. These systems build a scoring model by extracting linguistic features on a specific corpus that has been annotated by humans. For this task, the researchers have been using artificial intelligence techniques such as natural language processing and machine learning algorithms [7].

In this context, the system Writing Pal (WPal) offers strategy instruction and game-based practice in the writing process for developing writers. The AWE system in WPal, assesses essay quality using a combination of computational linguistics and statistical modeling. The authors selected different linguistic properties and were used as predictors [8].

In a related work, lexical richness is studied in terms of lexical variation and sophistication, analyzing its relationship with oral proficiency in L2 learners [9]. The main conclusion was that helping learners to increase their knowledge of less-commonly-used words will impact positively on their lexical variation and the overall lexical richness, as we aspire after draft assessment.

2 Coverage, Opinion and Speculation

To analyze the text, some text analysis tools of open source are necessary, among which is Freeling[2]. One of the main functions that allows to achieve this tool is the lemmatization of words, i.e. obtains the infinite form of the word, removing the conjugation in any form, and leaving the word in its base form.

In order to apply Freeling on line, the API provided by the UNAM[3] server was installed. The next step was to remove empty words such as prepositions, conjunctions, articles, pronouns, and so on. Freeling does not have this functionality, so the tool to use is NLTK[4] that has a range of options for the Spanish language. Attached to this tool, the removal of symbols allows to have more control over the analysis to perform, so that only the content words that are important to obtain the expected result are left. Having already the preprocessed text, it is possible to begin to carry out the study for the features of interest, i.e. Coverage, Opinion and Speculation. Below, we provide the expressions applied to compute each characteristic. These formulas were proposed in [6].

Coverage equation:

$$C = \frac{\#(So \cap SC_i)}{N}, \tag{1}$$

C = Coverage,
So = List of words of an objective,

[2] http://nlp.lsi.upc.edu/freeling/
[3] http://www.corpus.unam.mx/servicio-freeling/
[4] http://www.nltk.org/

SC_i = Sentence i of conclusion,

N = Number of terms in the objective.

For Coverage measure the paramaters are:

Absence of connection < 0.12, 0.12 < Acceptable < 0.41 Strong connection > 0.41.

Opinion equation:

$$T = \sum Wi \left(\frac{On + Op}{N}\right), \quad (2)$$

T = Score (the result is obtained by adding the average load of each word of the sentence).

On = NegativeScore,

Op = PositiveScore,

N = Number of occurrences (noun, pronoun),

Wi = each word of sentence.

For Opinion measure the parameters are:

No Opinion < 7.84 7.84 < Yes, a Little < 26.98 Yes, a lot > 26.98.

To achieve the result of the analysis, it is necessary to obtain the values that will be entered in each one of the formulas. In the case of the connection, one must find the similar words that exist between the objective and each one of the sentences of the conclusion. The number obtained from this comparison will be divided by how many words the objective contains. The formula applies for each of the conclusion's sentences and the result, that will be obtained as the user's score, will be the maximum value obtained in the formula.

For Opinion feature, SentiWordNet[5] was employed, this lexical resource contains more than 117 000 records among which we can find a little more than 900 000 words that express an opinion that has a certain weighting of sentiment either negative, positive or objective. The same word can appear more than once since its opinion level changes depending on whether it is being used as a verb or noun. It is noteworthy that to carry out this analysis, it was necessary to translate the words from Spanish to English language since SentiWordNet was developed for the English language.

The third model aims at identifying evidence of sentences that describes future work or derivations of the research. For this purpose, we resort to two lists of speculative terms. The way to obtain these values was through a comparison of 227 speculative terms [6], based on some sources and research works that are the theoretical basis of TURET 2.0. In order to carry out the analysis of this model, the list of words was compared with the text of the conclusion in its original form before lemmatization. If there were more than two similar terms in the text, it can be inferred that the student evidenced future work.

[5] http://sentiwordnet.isti.cnr.it/

3 TURET 2.0

TURET2.0, mentioned in the title of this article, is the complement to an earlier version that was developed to analyze the lexical richness existing in the different sections that are part of a thesis [10].

TURET is developed in Django 1.11 which is a framework that allows to create Web pages without the need to be repeating code, ordering it with models and a database administrator that facilitates the storage of the information. To be programmed, the language Python was used with a series of special functions that give the possibility to make a connection between the code of the frontend and the backend, i.e., besides being the base language of Django, it also serves as intermediary to show to the user the variables in the web page.

HTML5 was employed to develop the interface that would be displayed to the student. Django presented itself as the best choice. The data derived during the analysis, are shown to the user in the corresponding categories and one of them stores all the results. Notes and grades that the user obtains, are stored in the database that can only be viewed by users who have an administrator account, this will allow them to follow the progress of the student, as well as keep a record of each of the analyses that will be helpful when the instructor wants to evaluate that has helped the intelligent tutor to thesis.

The student's evaluation will serve as a reference to reach some improvements concerning the three models that are being evaluated in its conclusion. As part of the notes shown in the interface when is returned to the student the rating on his models, it adds a small extra content that indicates what his level has been, either low, acceptable or an excellent level, and in turn, will indicate the value the student must obtain to reach the next level.

4 TURET and the Conclusion Analyzer

The interface was done as friendly as possible to the student so that it was not difficult to use it and at the same time, it provides an easy to interpret result. In the top bar, as Figure1 illustrates, a link was placed so that the student can go to the previous version of Turet and thus analyze the lexical part of his thesis. Only users who registered correctly can use the analyzer, because it is mandatory to have the results of their evaluations in order to be saved in their database records.

At the time of registration, the student has to complete the form with actual data and at the same time, verify that the information that is being provided is correct. The data entered in the sections of the form will be used only to maintain a profile to the user and has its own advances that can be analyzed by the advisor in progress for a better final review.

In Figure 2 the text boxes placed under the blue button show the information of the analysis result. Note in the example that the objective and conclusion of one of the thesis that has already been evaluated by a committee of reviewers has been supplied.

Fig. 1. Conclusion Analyzer [https://utnturet.herokuapp.com/].

Fig. 2. Analyzer interface.

As shown in the result, the student has obtained a “strong connection” between his initial objective and the conclusion. TURET informs the student that has reached an excellent grade. In the part of the Speculation, the student has used three words that indicate a future work, otherwise TURET send a message to student that is necessary to incorporate a text that contains future work

By clicking “Show all the details”, a window that contains the detailed description of the computation done by each model is opened. The sample analysis shows an objective and a conclusion of an element in our corpus.

In Figure 3, the similar words that have been found between the objective and the conclusion are 24, in this case. The sentence that has a greater connection and that is the one shown as evaluation is taken into account. In the event that the student wants to copy the complete sentence of the objective and pass it to the conclusion, it has a maximum acceptable value to avoid giving it an inadequate grade.

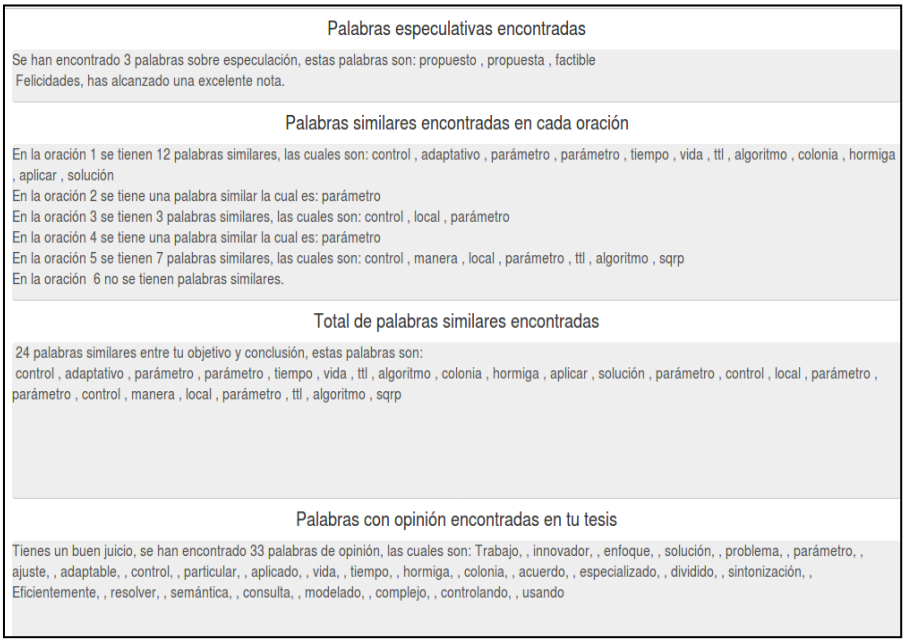

Fig. 3. Detailed analysis of the results.

In a proposed example, 12 similar words have been found between the objective and the conclusion in sentence 1. When doing the analysis of the value judgments that the student has given to reaffirm his arguments on the content of his thesis, the conclusion of the example has given a grade of 4.17, which is low.

Table 1. Grade obtained from the used example.

Model	Grade	Result
Speculation	3 words	Acceptable
Opinion	4.17	Low Judgment
Coverage	0.54	Strong Connection

To reach the acceptable level, it is necessary to have a note higher than 8 and if the student wants to reach a strong connection he has to overcome the 26.98, this is a grade almost 4 times higher than the one the student has obtained in this example supplied.

Considering the values achieved in the assessment by TURET, depicted in Table 1, the student has reached an acceptable grade in 2 of the 3 categories that are being evaluated and the only one that a low grade was obtained, is far from being outstanding. Noteworthy, that the thesis was reviewed by an advisor and he gave his approval to it.

If we take into consideration the result of the analysis of this thesis, we can determine that it is necessary to implement this type of tools for the advisor to take care of these small details before giving the approval.

5 Conclusions

TURET 2.0 is a tool aimed at supporting students to guide them in the writing of their thesis, it is a mistake to think that this will get rid of the academic advisor, on the contrary, this is a tool that comes to reduce the extra time dedicated by the advisor and the student to correct common errors. It is expected in the future to carry out a pilot test with students who are either developing a research project or elaborating their thesis.

The conclusion can be analyzed as often as necessary to make sure that the student is following the right path without deviating from the initial objectives, this allows the student to check the advances that is taking as he progresses in his writing.

In addition, TURET 2.0 is expected to expand the functionality to make the analysis more customizable. TURET has been complemented to the present and is intended to expand with other models, so that students have a complete tool that allows them to have a thesis with a more than admissible writing, with a high degree of possibility to be accepted in a shorter time after its review.

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Cybersecurity Teaching through Gamification: Aligning Training Resources to our Syllabus

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Abstract. A shortage in Cybersecurity professionals is happening. Universities that offer IT related courses had implemented at least one class related with information security or cybersecurity, we believe that the training and experience gained by students during the term could be improved by using gamification. Gamification was defined as the use of game design elements in non-game contexts, in this context we use game design elements to help the learning process. Gamification has gained attention recently because it had shown that it can achieve positive results most of the time. In this work we offer a classification taxonomy for cybersecurity training resources based on gamification, then we collect and classify a list of training resources that can be used in cybersecurity lecturing. Finally we align some of these resources to the content of our syllabus in Polytechnic Universities system, so instructors and lecturers could improve the learning process for students. We also expect to raise interest on cybersecurity field from students, so we can help to minimize the professional shortage.

Keywords: Cybersecurity, gamification, teaching.

1 Introduction

The frequency and high impact of cyber attacks and cybercrime had been increasing in recent years. Numerous attacks on web applications and IT systems in every day, all time connected actual world, IT security has become a major concern for public and private sectors. More technical experts are demanded into the workforce, also people in management roles should have security knowledge at certain level. Training those experts face unique challenges, like the fast pace IT security moves. Dabrowski et al. [8] consider that security education should not merely rely on technical aspects, but the focus should include the mindset and typical methods of attackers to keep up with their pace. A key element to teach this skill set to students are real-world exercises within a controlled environment. Chotia and Novakovic [5] state that live security exercises, such as Capture The Flag (CTF) competitions, are a popular and fun means of engaging with cybersecurity topics.

While students with majors in cybersecurity will have their syllabus full of training and maybe certifications, it is our perspective that students in IT related fields should have at least one course of information security with a balanced proportions on technical and management skills.

Deterding et al. [10] define "gamification" as the use of game design elements in non-game contexts. Among other tasks gamification is used to engage users and help with the learning process [13]. Recently Li and Kulkarni [15] concluded that gamification is a very effective way of learning.

At the end, if Gamification is integrated properly, it can achieve positive results most of the times. Previous work had shown that gamification is a good option for training and prepare IT students on cybersecurity skills. Recently more people are designing courses and materials for cybersecurity with game elements in mind, so as a result there are several security training courses available, but as Gondree [12] states: there is a lack of alignment to curricular outcomes. Most of those training materials cover specific deep knowledge, meanwhile other material had been developed with a complete syllabus in mind, therefore it is not easy to adapt it to your own syllabus.

To address this gap, our contributions of this study are two fold: First, we collected a list of available resources for cybersecurity training that include game elements. Second, we aligned some of these resources with the syllabus of the Information security course taught in more than 40 Polytechnic Universities in the country.

The remainder of the paper discusses briefly the related work in Section 2, presents the details of our proposal in Section 3. Finally, Section 4 concludes the paper.

2 Related Work

Gamification has seen recenlty different applications [25], from marketing, fitness and health, employee motivation, and social media and website engagement. This technique aims to apply experience from psychology, human computer interaction, and game development to improve engagement and motivation to promote desirable behaviour.

Gamification has also been previously applied in security education and training. From different perspectives and different outcomes since last decade. Shiffman's book [24] about hacker challenges is a combination of story telling and solve the puzzle. Each chapter presents a case and enough evidence for the reader to solve it. Control-Alt-Hack [9] is a table top card game to introduce people to information security concepts and white hacking world. Serious games, which involves professional game development engines and formal development process have been discussed also. Thornton and Francis [28] presented and discussed all the process to develop a serious game for IT and security training. The authors described the elements for the game design process,compare game engines available and evaluate their results with the students. Using a different approach, computer security competitions are very popular these days, with some

of them emphasizing the competitive and entertainment aspects of breaking the systems, other actually have their main purpose for training. Gondree et al. [12] discuss about the cybersecurity competitions and games and how it is necessary to adopt a common vocabulary to express the games goals and characteristics. They also discuss talk about competitions like iCTF, DC3 Forensic Challenge, CyberPatriot, CCDC, PlaidCTF, CSAW CTF where training and education are their main role.

At least three frameworks to deploy Capture the Flag contests are freely available as open source software [27,19,3]. Also Backman [1] presented in details how to deploy and organize a CTF competition for undergraduate students.

Chothia et al. had been working in innovation and development of improved course materials. In 2015 the authors presented an offline CTF system which includes 5 learning activities [5]. The estudents can download the system and play in a controlled environment. In 2016 the authors developed a new course on pentesting using IoT devices, this course was thought at Birmingham University with great engagement and response from students [6]. In 2017 the authors included a story telling, intelligent component on a virtual machine to teach a course on information security in 11 weeks [4]; students chose their own adventure in the game.

Overall, scholars are creating new games, frameworks and systems to adapt their courses. In some cases they are developing courses and games at the same time. Our proposal is to collect available training resources, and align them to our syllabus, offering options for the lectures or instructor to chose, in the context of the Polytechnic Universities System.

3 Our Proposal

In the context of the Polytechnic Universities subsystem, different study programs related with Information Technologies and Telematics include at least one course about Information Security or cybersecurity. This course should follow the same syllabus in all the subsystem, with more than 60 universities around the country. In this work we are proposing to engage the students with more interest in the subject and developing deep knowledge about cybersecurity through gamification. To accomplish this purpose, we first present a classification taxonomy for cybersecurity training resources with relation to gamification, then we identify free available resources or material as such as CTF, vulnerable apps, games etc. Finally, we align these resources with different topics in our syllabus.

Cybersecurity training resources taxonomy We modify the classification taxonomy presented by Beuran et al. [2], adding resources employed, play type and target audience. We summarize this taxonomy in Figure 1.

Content oriented Training resources can have focus on attacks (**A**), defence (**D**), analysis/forensics (**AF**), or could be a hybrid combination (**H**). Attacks will train attendants from the attacker perspective or pen testers. Hybrid orientation will include different tasks for the train

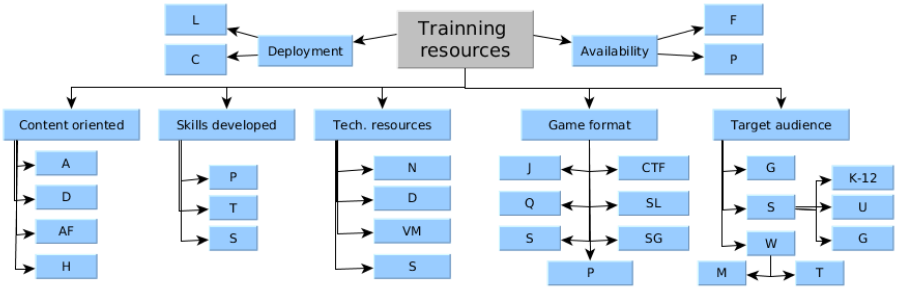

Fig. 1. Cybersecurity training resources taxonomy

Skills developed Training resources will focus in development of different levels of skills, like personal skills (**P**), were the attendant will work by herself. Or team skills (**T**), were the attendants need to collaborate during the training. Even it is possible to develop special skills (**S**).

Technical resources For IT personnel, running security training in the main facilities usually is uncomfortable because some of the risks these training represents. For some training resources it is not necessary to have any special technical resources (**N**), for others only a desktop computer (**D**) will be enough. However, Virtual machines (**VM**) or specialized laboratories (**S**) could be required for some training resources.

Deployment Resources can be deployed as local (**L**), like installing VM's on the students' laptop, or installing a CISCO network laboratory, or they can be available remotely, we consider them as if they were in the cloud (**C**).

Game format In gamification, the type of playing is important. The most common types are: jeopardy style (**J**), question based (**Q**), simulators (**S**), puzzle or challenge based (**P**), capture the flag style (**CTF**), story line games (**SL**) or serious games (**SG**).

Target audience Training resources are developed for a target audience, as such as general public (**G**), students (**S**) or workers (**W**). There exists cases where training resources could be developed for one target audience, but used by other like students taking advance classes, in this case the original target audience prevails for the classification

Availability Training resources could be available trough payment (**P**), or could be freely available (**F**).

Cybersecurity training resources In this part we compile a partial list of cybersecurity training resources. Our main focus is to present resources that involve any level of gamification to help the learning process. From a book that present scenarios and challenges in 2001 to modern serious games and on-line challenges that help with professional training. This list is presented in Table 1.

Table 1. Training resources.

Name	Content Oriented	Skills	Tech. resources	Deployment	Game format	Target audience	Availability
Hacker's Challenge: Test Your Incident Response Skills Using 20 Scenarios. [24]	A	P	N	L	ST, Q	G	P
Game of Threats	H	T	D	C	S, C, P	W	P
CyberCIEGE [20]	H	T	D	L	S, SG	PS	F, P
NetRiders Competition [7]	D	P	D	C	Q	S	P
Control-Alt-Hack [9]	H	P	N	L	C	G	P
d0x3d! [26]	H	T	N	L	C	G	F
Cybersecurity Lab [21]	H	P	D	C	ST, P	G,S	F
The Fugle Company [29]	D	P	D	C	S, ST	WM	F
Hacknet_ labyrinths [17]	A	P	D	C	S, P	G	P
True Key [18]	D	P	D	C	S	G	F
Hacker Experience [16]	A	P	D	C	S,ST,SG	G	F,P
iCTF [27]	A,D	P,T	VM	L	CTF	S	F
Root-the-box [19]	A,D	P,T	VM	L	CTF	S	F
EduRANGE [3]	A,D	P,T	VM	L	CTF	S	F
Wombat platform [30]	H	T	D	C	S, C	S,W	P
WebGoat [22]	A	P	VM	L	CTF	G	F
Damn Insecure and Vulnerable App [14]	A	P	D	L	CTF	G	F
Damn Vulnerable iOS app [11]	A	P	D	L	CTF	G	F
Metasplotaible [23]	A	P	VM	L	CTF	G	F

We are aware of the quick evolution of the field, and the vast amount of resources that pop everyday on the Internet. So we also offer a list of websites where you keep tabs on challenges and resources for cybersecurity training. This list of resources about training resources is presented in Table 2.

Overview of our cybersecurity syllabus Our official syllabus includes 5 main learning units to develop over 75 hours course.

Introduction to information security In this unit the student will be aware about the importance of cybersecurity in daily live basis. Also, how cybersecurity impacts the rest of topics in computer science and TI.

Standards, policies and good practices of cybersecurity In this unit the student will grasp the knowledge about established security standards in the industry. He will also explore the security policies and good practices that every company should have implemented, and the importance of having them in place.

Physical security (data, computers) This is a technical unit where students will learn how to protect their personal information resting in a computer. Fundamentals of cryptography and data protection are covered here.

Network and Internet security This is another technical unit where students will learn about security of data in transit, security of network devices and the dangers of software facing directly to the Internet.

Hot-topics in cybersecurity This unit is open to keep the fast pace of evolution in cybersecurity topics. It should be adapted each term for the current class. The mechanics of the unit is designed to offer students different options

Table 2. Cybersecurity training resources.

Url	Description
https://ructf.org/	RuCTF is a challenge in information security among russian universities.
http://www.wechall.net/about_wechall	A challenge site is mainly a site focussed on offering computer-related problems. Users can register at such a site and start solving challenges. There exist lots of different challenge types. The most common ones are the following: Cryptographic, Crackit, Steganography, Programming, Logic and Math/Science. The difficulty of these challenges vary as well.
https://ctftime.org/	a place, where you can get some another CTF-related info - current overall Capture The Flag
http://www.yashira.org/	Web site of IT challenges in Spanish.
https://www.hacking-lab.com/index.html	Hacking-Lab is an online ethical hacking, computer network and security challenge platform, dedicated to finding and educating cyber security talents.
http://smashthestack.org/wargames.html	The Smash the Stack Wargaming Network hosts several Wargames. A Wargame in our context can be described as an ethical hacking environment that supports the simulation of real world software vulnerability theories or concepts and allows for the legal execution of exploitation techniques. Software can be an Operating System, network protocol, or any userland application.
https://w3challs.com/	W3Challs is a penetration testing training platform, which offers various computer challenges, in categories related to security: Hacking, Cracking, Wargame, Forensic, Cryptography, Steganography and Programming. The purpose of this site is to offer realistic challenges, without simulation, and without guessing!
https://hack.me/	Hack.me is a FREE, community based project powered by eLearnSecurity. The community can build, host and share vulnerable web application code for educational and research purposes. It aims to be the largest collection of "runnable" vulnerable web applications, code samples and CMS's online.
https://www.root-me.org/?lang=en	The fast, easy, and affordable way to train your hacking skills.
https://www.hackthis.co.uk/	Want to learn about hacking and network security? Discover how hacks, dumps and defacements are performed and secure your website against hackers with HackThis!!
https://www.vulnhub.com/about/	To provide materials that allows anyone to gain practical 'hands-on' experience in digital security, computer software & network administration.

to conduct research in a relevant topic of their interest.

It is not possible to include gamified resources in all units, but we aim to engage our students with extra work in those appropriated topics. It should be noted that offered degrees are not as cybersecurity specialists, but we are aiming to attract more students to this field.

Proposed Resources to Use With Our Syllabus Among all the resources available, we chose a handful of them that can be aligned and used with our curriculum. For the introduction topic, games developed for AV companies (True Key, the Fugle company) should be employed to present basic topics to the students in a very attractive way. If the game card Control-Alt-Hack is available, students should expend some time playing it.

For physical security, CTF offline games, like the ones offered by vulnhub can be used to help students to better understand the structure and insecurities of an operating system. These resources could also be employed in Operating Systems class to include cybersecurity topics. For Network security, training

materials from NetRiders competition should be used. Networking labs related with NetRiders are available to Polytechnic Universities' students.

Finally for hot-topics in cybersecurity, if the topic chosen by the instructor is attacks for example, resources for attacks must be used as such as vulnerable systems or apps. The VM offered by Chothia [4] should be a good exercise for the students in this section.

4 Conclusion

Gamification is a new tendency to engage with students and help them to learn in a different way. Cybersecurity is a very hot topic nowadays, which is or it should be taught in every undergraduate program, however we are making special emphasis in IT degrees in the context of the Polytechnic Universities System. We aligned available resources to teach cybersecurity through gamification and presented them in this study. We are implementing our approach in the current semester and our expectations are into improve highly the students marks and help them to decide if they want to fill the cybersecurity professionals shortage. Our approach can be implemented and used by other Universities with similar syllabus or curriculum. As the field quickly evolves, instructors and teachers must keep active and updated in this field.

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Development of an HTML5 Library for Building SCORM Learning Objects

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Abstract. This work presents the development of an HTML5 library that allows the building of LO's (Learning Objects) compatible with the SCORM (Shared Content Object Reference Model) standard and the way in which they have been implemented within the "Learning Management, Capture of Experience and Content Repository" (GACER, for its acronym in Spanish) learning platform from the National Institute of Electricity and Clean Energies (INEEL, for its acronym in Spanish). It describes the way in which they are usually developed, as well as the main advantages of using this new tool as to improve the contents interactivity level through the integration of 3D animations and their accessibility from mobile devices.

Keywords: SCORM, HTML5, LMS, e-Learning, m-Learning, learning objects.

1 Introduction

Many institutions confront different situations that induce them to use training systems. The professional updating and the rotation of staff are some of them, being very important the recovery of the workers' knowledge to be able to retransmit it. There are several ways to accomplish this task and e-learning is one of them. With the objective of offering a quality product within this modality, INEEL uses the SCORM standard, which according to the definition provided by the author in [1] is *"a set of technical specifications in learning area through the Internet (e-learning) that define the structure of the contents; their behavior and the behavior of the LMS when it comes to hosting and executing said contents".*

The way in which this learning material has been developed, until recently, completely fulfilled the requirements of the projects. However, the current trends, the breakdown of some technologies and the requirements of the projects have resulted in this type of material not satisfying to the best degree the clients expectations, mainly due to the low level of interactivity and personalization of the learning material.

2 Related Work

In [2], authors explain in detail the way to achieve SCORM activities configuration, involving sub-activities or several SCO (as named in SCORM standard, being learning objects containing teaching materials), following the guidelines proposed by ADL with Template 10 and Educative Model 3.

In [3], authors explain an application of pedagogical tools to an on-line course for e-learning, including an example of a course specification showing an activity, an example of a script for an activity, and a course development model.

3 Analysis of the Problem

Content development is usually done using authoring tools such as Adobe Captivate, and the main disadvantage of working in this way is that the Flash format (file format included in SCORM packages) is no longer supported by systems in current mobile devices such as Android and iOS, because manufacturers of this systems have determined that their use poses a risk to user information and impairment of device performance. Because of this, we have chosen to use HTML5 for the development of the tool which completely solves this problem.

For issues related to professional profiles that can participate in content development and game development work, there are various opinions on which of both alternatives is best. But opinions agree when talking about the advantages that comes with using a mobile device to present this material including playback and video. In [4] the author mentions *"HTML5 is very well supported on mobile devices, and on iOS devices CSS3 3D transitions even hardware accelerated. The video is fully compatible with native (often hardware-based) H.264 capabilities for web application and video playback"*. Table 1 shows some of the main advantages HTML5 has over Flash technology.

Table 1. Comparison of Flash and HTML5 technologies

Characteristics	Technologies	
	Flash	**HTML5**
Compatibility with mobile devices	NO	YES
Independence of plugins for execution	NO	YES
Prescription of proprietary software for use	NO	YES
Compatibility with current web browsers	NO	YES
Life expectations	NO	YES

The author also mentions that there are already authoring tools that allow export to HTML5. However, even using some of them, there are still a number of disadvantages, which will vary according to the software used, of course, the degree of customization that is desired to reach the product and the requirements of the project.

4 Main Drawbacks of Some Authoring Tools

In the first instance, it is important to recognize that this type of tools offer many advantages, mainly that for the elaboration of contents with a low level of interactivity can be dispensed, in many cases, of a software specialist. However, there are a number of drawbacks described below:

- Non-admission of 3D animations.
  It is not possible to include 3D animations in LO's and with detection of actions on the animation. In addition, the material must be considered capable of running on mobile devices without requiring special hardware.
- Incompatibility with some web browsers.
  The material requires the use of a content player, which is not compatible with some web browsers such as Internet Explorer and Firefox.
- Software license payment.
  These tools, for the most part, are proprietary software, so they require the purchase of a license, which is usually expensive.
- Dependency of a company that owns.
  The user is limited to the functions that integrate these tools at the time of purchase. To access new features will be subject to the appearance of an update, which can take a long period of time.

  Some of these tools have the ability to include scripts to control the SCORM-LMS interaction, however, it is still difficult to apply new technologies and functionalities without resorting to source code modification, which is complicated to alter when they have already been applied techniques such as code obfuscation or minification.

5 Technological Solution and First Results

An HTML5 library has been developed that allows the elaboration of interactive LO's compatible with SCORM and that solves the problems listed in the previous section. The main technical details of development are shown below:

- Type of tool: Web, HTML5 library.
- Content definition language (markup language): HTML5.
- Programming language: JavaScript.
- Metadata description language: XML.
- Learning Objects Standard: SCORM.
- Design regulations (visual appearance): Material Design.
- Compatibility: With current web browsers (including mobile, obviously).

The library has the following features:

- Generation of views and inclusion of navigation controls: Integration of controls that facilitate navigation between different views is allowed. These features allow you to show the content in a better organized way.
- Insertion of multimedia content with scalable design: Insertion of multimedia elements, including 2D and 3D animations, to which scalability functions are applied to preserve a persistent appearance between different screen sizes.

  Attractive visual design of components: The design rule *Material Design* has been applied, which gives a more attractive and modern appearance to the components used within the LO's.
- Easy integration of 2D animations: We worked on the inclusion of functions that allow the loading of 2D animations in a simple way, non-simultaneous execution with other animations to avoid slowing, etc.
- Easy integration and correct operation of 3D models: In this activity, a basic script was developed for the implementation of 3D animations in a web using HTML5 and JavaScript, through the library Three.js. An example of this implementation can be seen in Fig. 1.

  The script involves, among other things, the following functionalities:
  - Adding interactive properties to each of the 3D elements, such as zoom, rotation, and navigation in the scenarios.
  - Configuring events to detect user interactions.
- Inclusion of interactive learning activities.

  They are included were interactive activities are, to contribute to user participation during the learning process; the puzzle is an example.
- Template for the preparation of evaluation activities.

  Templates were integrated to allow evaluation. An example is the exams with questions of type True / False, multiple choice, etc.
- Monitoring user activity and interacting with the LMS using CMI tracking elements.

Fig. 1. 3D Animation inserted in an SCO

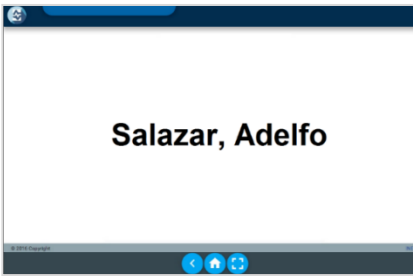

Fig. 2. Obtaining the value of the cmi.core.student_name.

It was possible to establish communication between the LO's and the LMS platform by developing the drivers "cmi_controller1.2.js" and "cmi_controller2004.js" for versions 1.2 and 2004 respectively.

Some of the CMIs with which it is possible to interact are:

- **cmi.core.student_id**: Identifies the connected student.
- **cmi.core.student_name**: Name of connected student (Fig. 2).
- **cmi.core.score.raw (RW)**: Qualification of the evaluation activity.
- **cmi.core.score.min (RW)**: Minimum assignable score.
- **cmi.core.score.max (RW)**: Maximum assignable score.
- **cmi.core.lesson_status**: Indicates if the student has finished and satisfies the conditions of the SCO.
- **cmi.core.exit**: Indicate how or why the student left the SCO. Allows the completion of the activity.

6 SCORM-based LO's Development Methodology

Next, the roles and work methodology, represented in Fig 3, are described, which are typically followed in INEEL for the elaboration of the SCORM contents (in [5], an extended and detailed description of this methodology is presented).

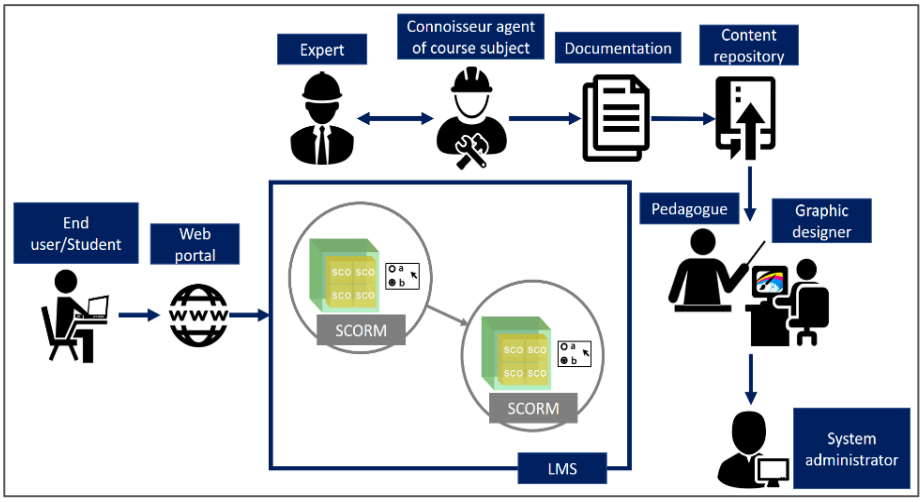

Fig. 3. SCORM content development methodology.

- **Expert**: Person, in the team, with extensive experience and the highest degree of knowledge about the subject of the LO's, generally, part of the client team.
- **Connoisseur agent of course subject**: Person with domain of the course subject and responsible for establishing direct communication with the expert to be able to relay the information provided.
- **Documentation and content repository**: The agent explicitly documents the information provided by the expert and stores it in a content repository.
- **Pedagogue and graphic designer**: The pedagogue analyzes the documented information and determines the way in which it will be presented to facilitate learning of users. Graphic designer elaborates the multimedia contents.

- **System administrator**: Person responsible for preparing the training environment and preparing the LO's based on the information provided by pedagogue and designer.
- **End user/Student**: Person who accesses the web portal and consumes course information.

7 Results

This tool allowed the elaboration of the first content corresponding to the Smart Grid course integrated to the INEEL GACER platform. Currently this material is available in the Smart Grid Laboratory and it is used to promote the capabilities of the Advanced Training Systems and Simulation Department (GSACyS, for its acronym in Spanish) from INEEL.

Specifically speaking about the tool, a basic development was established for the integration of practically any resource within the LO's, given the source code disposition and access to all the main functionalities developed for the composition of the library. It is mention also that to use this tool it is enough to have basic knowledge of HTML5 because, as mentioned before, the described functionalities have already been programmed and the content developer will only need to make the layout or definition of tags according to the development process that is described in a respective SCORM content development manual included with this tool.

8 Future Work

It has been considered mainly to continue the development and refinement of some features that already integrate the library, mainly regarding the inclusion of a greater amount of interactive activities of learning and evaluation, the manipulation of all the elements CMI in the versions 1.2 and 2004 of the standard SCORM, as well as the maximum simplification of the use of the tool, since in spite of already being able to elaborate the contents only by the definition of the document HTML5, it still can facilitate and improve the learning curve on the use of the tool.

9 Conclusion

This development allowed to break with some paradigms of work and give solution to the new formation needs, as well as to satisfy the change in the habits of consumption of information and the levels of interaction demanded presently, which allows to continue like distinguished producers of systems for online training and courses and to make contributions of greater satisfaction to customers' demands. This solution brings us one step closer to automating online courses delivered through an LMS, where the implementation of cmi tracking elements is the last step of the intelligent tutoring.

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GAMeNT: A Framework to Formalize the Serious Game Design and Development

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Abstract. Games and video games entertain us and allow us to socialize and learn. Trying to take advantage of the interest in them and their characteristics as tools for education, the development of Serious Games has become popular. This paper presents the GAMeNT Framework which consists of an architecture and a methodology that guide the design and development of Serious Games. This framework was developed from a videogame framework, as a starting point, and it took into account the Serious Game inner elements to create the resultant architecture. The methodology was made after reviewing videogame's design processes and adapting them to include the Serious Games' elements.

Keywords: Serious games design, videogame framework, interactive storytelling, virtual agents.

1 Introduction

The games have always existed, they have helped us to entertain, to socialize, to learn, etc. This fact has remained since long ago. The Human being is vastly creative in the development of entertainment; one way is through the videogames, which are games that are played in electronic devices and that show us different experiences.

As part of improving said experiences, the storytelling it's a very important factor because it allows a better immersion in the game by making use of the virtual agents.

The videogames are an important part of the people; they represent an important business market that accounted for more than $99.3 billion global revenues in 2016 [1]. Nowadays, there exist different areas of development in videogames, one of them, the Serious Games, tries to take advantage of the videogame's interest, characteristics, and technologies, in order to improve the education.

The Serious Games (SG) differ from the entertaining games in which instead of just fun, they also look for the provision of knowledge or the development of skills in those who play them [2]. This work defines one framework for the design and development of SG. The objective of the framework is to produce SG that provokes

immersion of the players into the game; this could be achieved through the integration of Socio-Emotional Virtual Agents in an Interactive Storytelling.

2 Related Work

One of the difficulties that come up each time someone develops SG is the lack of a formal work that describes the internal elements to design and develop them. This occurs even though there exist in the literature several works that deal with the design and development of videogames. Section 2.1 describes the existing architectures, Section 2.2 summarizes the methodologies, and Section 2.3 revise some SG.

2.1 Architectures for Videogames

The work in [3] is one of the first designs proposed for videogames; it defines a game as relations among mechanics, dynamics, and aesthetics. Later in [4], the technology and story are incorporated as key parts in the game design.

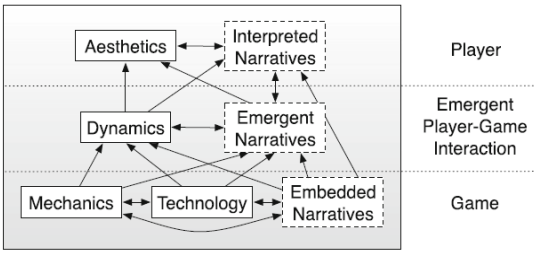

Fig. 1. Architecture of MTDA+N [5].

Table. 1. Description of MTDA+N architecture.

Components	Definition
Mechanics	Describes data representation and algorithms of the game.
Dynamics	Describes the run-time behavior of the mechanics acting on the players' inputs to the game and the results of this player interaction in the game over time.
Aesthetics	Describes the desirable emotional responses evoked in the player.
Embedded Narratives	They are the stories told by developers through narrative, mechanics, and gameplay.
Emergent Narratives	They are a meaningful sequence of events that emerges during player–game interaction.
Interpreted Narratives	They are the mental representations of the player and the interpretations of the projected or emergent narratives of a game.
Technology	They are Tools and Systems used to implement or deliver the gameplay.

Finally, these previous works were integrated into the MTDA+N architecture proposed by [5] to develop videogames (see Figure 1). The main contribution of [5] is the definition of the design of a game through the three main layers, *game*, *player*, and *player-game interaction*.

See Table 1 for the description of the components of MTDA+N's architecture. Note that this work divides the story of a game, included by [4], in three types of narratives.

2.2 Methodologies for the Development of Videogames

The revised architectures only provide information about the components of a videogame and their interactions. However, in order to develop a videogame, it is necessary to count with instructions that guide in this procedure. Normally, these instructions are organized in the form of methodologies. For example, the methodologies proposed in [6, 12] serves as guides from the game design to its implementation, these methodologies are shown in Table 2. Note that, for these methodologies, a game must have a goal clearly defined, and a theme that expresses that goal, i.e. the environment of the game.

Table 2. Methodologies of Game Design

Crawford's game design sequence [6]	**Fullerton's game design methodology [12]**
1. Choose a goal and a theme	1. Conceptualization
2. Research and preparation	2. Prototyping
3. Design Phase	3. Digital Prototyping
3.1 IO Structures	4. Playtesting
3.2 Game Structure	5. Functionality, Completeness, and Balance
3.3 Program Structure	6. Fun and Accessibility
3.4 Evaluation of the design	
4. Pre-programming Phase	
5. Programming Phase	
6. Playtesting Phase	

2.3 Successful Serious Games

There are different renowned serious games that are reported in the literature. In [7–11] are reported several of different learning areas that involve flight simulations, the solution of puzzles, army's life, among others. As videogames, these projects share common implementation elements as Static and Dynamic Objects, Events, and Non-player Characters (Virtual Agents), but they also share some others relative to SG, which are the inclusion of Narratives or Interactive Storytelling.

Summarizing, even though the work of [5] could be considered as a great advance in the definition of videogames, it lacks a formal methodology to develop them, as the ones proposed in [6,12], which guide from the game design to its implementation. Also, the work of [5] is too general and does not facilitate the design of SG.

The present work presents the framework GAMeNT as an evolution of [5] towards the definition of SG. GAMeNT integrates learning content in the design to create such type of games, and it unifies both design and the methodology for its development. The following section details in depth the framework.

3 GAMeNT Framework

The proposed SG framework is called GAMeNT. This name comes from the acronym of Spanish words ***G****ameplay*, ***A****prendizaje*, ***Me****ta*, ***N****arrativas*, and ***T****ecnología*. The words in Spanish stand for gameplay, learning, goal, narratives, and technologies, which represent the five most important modules that appear in its architecture for SG. As defined before, a SG needs to establish the learning content so, the GAMeNT includes it as the main module.

Being said that, this work evolves MTDA+N not only to design but also to develop SG. To do so, GAMeNT includes in its design the specification of the goal of what it is required to teach in-game, and it defines the synergy between this learning process and the elements involved in MTDA+N to reinforce the content to teach. Also, it guides on the construction process through a methodology.

The remaining of this section presents in Section 3.1 the architecture proposed by GAMeNT for the design of SG, in Section 3.2 the implementation elements derived from the architecture, and in Section 3.3 the methodology that guides through the implementation.

3.1 GAMeNT Architecture Components

The GAMeNT architecture is shown in Figure 2. It is formed, as commented previously, by the modules *gameplay*, *learning*, *goal*, *narratives*, and *technologies*. These modules are organized in the layers *game*, *emergent player-game interaction*, and *player*. The architecture reflects the synergy that allows the design of SG. The remaining of this section details the purpose of GAMeNT modules.

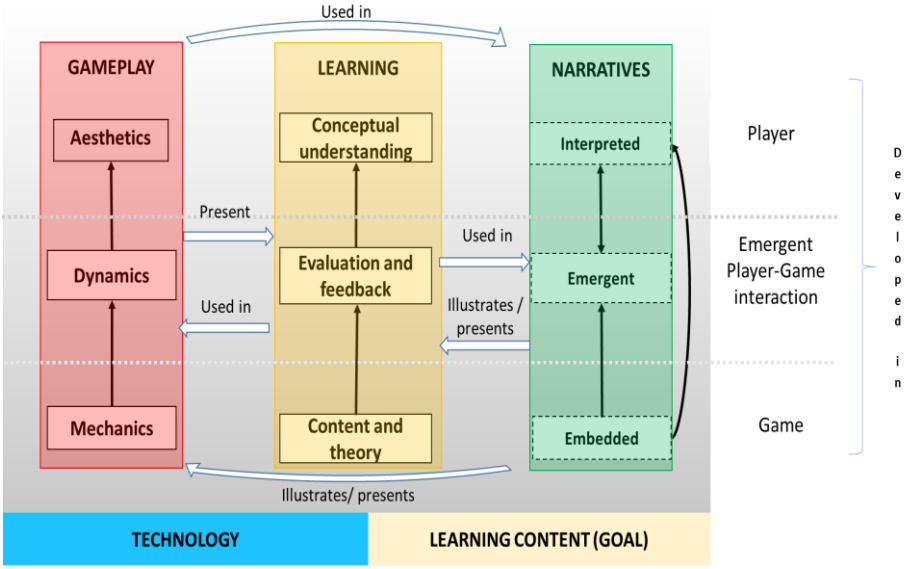

Fig. 1. Graphical Scheme of the GAMeNT architecture.

Learning Content (Goal). This is the first base module that must be considered in the design of SG; it has as purpose to define the learning objective that will be pursued. Around this objective is defined the technology that should be used, and are building the gameplay, the learning, and the narratives.

Technology. This is the second base module for the design of SG. It leads the specification of technology required for gameplay, learning, and narratives. Mainly, it is used to define the scope and limitations in terms of interfaces, controls, game and develop platforms, graphic environment, language, etc.

Gameplay. This module group the Mechanics, Dynamics, and Aesthetics. GAMeNT uses the definitions of [3] shown above in Table 1, with a slight difference in Aesthetics, where not only are specified the emotional responses in the players, but also the visual and auditory aesthetics; this is done to aid in the creation of a better immersion.

Learning. This module explicitly defines the learning elements related to the learning objective pursued by the SG. The content and theory elements are the methods and/or methodologies to resolve a given problem. The evaluation and *feedback* elements are an essential part of the learning process, because they measure the actual state of the learner according to its actions or given answers; it also gives a feedback of its strong and weak points, how good were the answers, what areas need to be improved, and why [13]. The *conceptual understanding* element is developed in the player layer and it references to the understanding of the topic as a concept instead of the factual understanding. As said by [14], the conceptual understanding is more important than the factual understanding because the former one its deeper and harder to evaluate due to it requires the understanding of the topic, and not just memorize them.

Narratives. The Narratives module makes reference to the Storytelling inside the Serious Games, this module is used to present the Gameplay and the learning components in an enjoyable and entertaining way to the player, making a better immersion in the game through the story presented in the narratives.

3.2 GAMeNT Implementation Elements

As it was previously said in Section 2.3, a SG has as implementation elements Static and Dynamic Objects, Events, Virtual Agents, Narratives, and Interactive Storytelling. The interactions of these elements inside the GAMeNT architecture is shown in Figure 3; they are used to achieve a better cohesion among the modules, and are described as follows:

- The *Static Objects* let us have what doesn't change inside the game, this help to create the embedded narratives and the content and theory of the learning;
- The *Events* are used to show a content along the interaction of the player with the game environment through the emergent narratives; they also allow to create the way in which the player can be evaluated and given feedback;

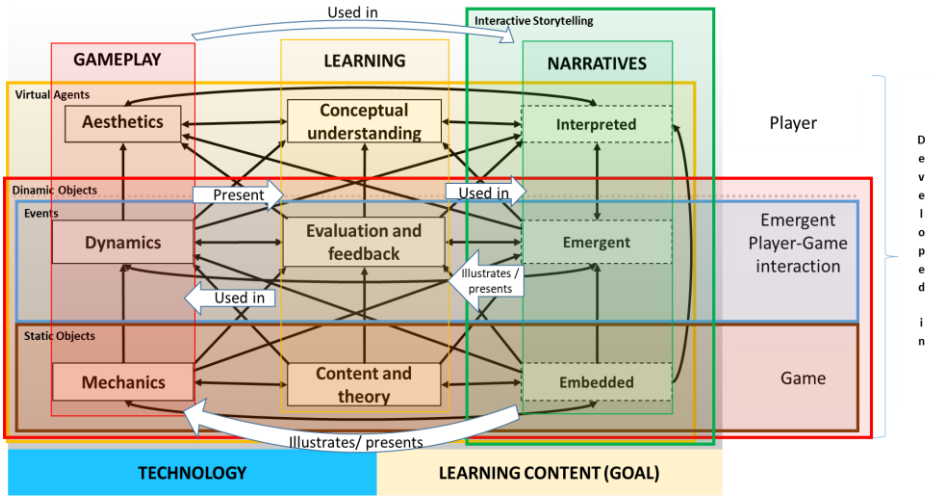

Fig. 3. Serious game elements in the GAMeNT architecture.

- The *Dynamic Objects* are elements with a defined behavior, and that will be used along the content and theory, the evaluation and feedback of the learning, and the embedded and emergent Narratives of the emergent Player-Game interactions; and
- The *Virtual Agents (or NPC)* are dynamic elements inside the game which are used to convey information to the player; it is expected that the NPC has an emotional response in the player, thus having defined Aesthetics. The NPCs serve to allow the realization of the embedded and emergent narratives, and the narratives interpreted by the player by the given socioemotional behavior. Using the agents, it will be easier the assimilation of information, and the conceptual understanding because they help in the creation of more realistic simulations.

3.3 Methodology to Apply the GAMeNT Architecture

In order to facilitate the use of the architecture, the framework GAMeNT integrates a methodology to design and develop SG. The steps of this methodology are as follows:

1. Establish the learning content (Goal) and the environment of the game (theme).
2. Research and prepare the learning content and the thematic:
   (a) Review the state of art of the works that have been used the goal and theme selected to know how they have been approached and the qualities of them.
   (b) Find and understand information about the learning content to prepare the theoretical content to present in the Serious Game.
   (c) Research and understand the info about the theme to be allowed to design:
      (i) The game environment to present in the Storytelling.
      (ii) Environment Dynamics.
      (iii) Environment Aesthetics.

3. Create diverse ideas or concepts for the game to be used, improved or discarded as appropriate:
    (a) Propose game environments and their visual and auditory elements that conform it.
    (b) Establish: (i) Theoretical content, (ii) The Evaluation, (iii) The Feedback.
    (c) Propose the Narrative idea developed in the game.
    (d) Obtain level ideas to show in the game and their respective elements:
        (i) Mechanics, (ii) Dynamics, (iii) Aesthetics, (iv) Narratives, (v) Learning Content
    (e) Design the Virtual Agents:
        (i) Define their Interactive Storytelling roll, (ii) Define their learning roll, (iii) Mechanics, (iv) Dynamics, (v) Aesthetics.
    (f) Create events to show the learning content during the game levels:
        (i) Propose their Dynamics, (ii) Propose their Aesthetics.
    (g) Propose object whose will have interaction with the player and their elements:
        (i) Mechanics, (ii) Dynamics, (iii) Aesthetics.
    (h) Create elements for the player evaluation and feedback:
        (i) Propose Dynamics and events for the evaluation, (ii) Propose Dynamics and events for the feedback.
4. Perform the design phase:
    (a) IO Structure, (b) Game Structure, (c) Program Structure, (d) Evaluation of the design.
5. Create physical prototypes to corroborate that the mechanics perform their task.
6. Create digital prototypes to corroborate that the core system of the game is as desired/ Implementation of the game.
7. Playtesting.
8. Prove that the game is functional, internally complete and balanced.
9. Verify that the game still gives the desired experience and its usability.

This methodology was developed based on [6, 12] methodologies. These works are used as a complement of each other because while [6] makes emphasis in the design and preparation of the story, and the establishment of the learning content given it is a learning game, [12] focusses in the game design and its functionality.

In addition, the proposed methodology considers the implementation elements required in the design (see Section 3.2). In the methodology of GAMeNT, the steps 1 and 2 are focused on getting the necessary knowledge to design the SG. The steps 3 and 4 design the internal elements and the structures of the SG. The steps 5 and 6 are focused on development. Finally, the steps 7 to 9 are focused on the testing and verification of the desired experience, giving the same opportunities to their players.

4 Conclusions and Future Work

This paper has presented the GAMeNT framework that integrates design and development of Serious Game (SG) from the combination of architectures and

methodologies. The main contribution lies in the formalization of the design and development of SG by explicitly indicating its core elements. With the GAMeNT framework, it is possible that newcomers can design a complete SG because they would only need to follow the methodology. It remains as future work to continue the exploration of alternatives that shifts from a conceptual model to a software framework and grants a set of elements to speed the implementation process; this represents the key component in future attempts to integrate the use of an established behavioral model for virtual agents, and tools that aid in the design and development of a wider variety of SG.

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Hands Skin Segmentation and Tracking for Interaction with an Augmented Reality Entity

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Abstract. Time invested in education has been growing in recent years and it is a subject of interest not only for schools, but also for companies, due to the time and money saved because of a correct understanding of the development of an activity. To contribute to learning, different techniques for the development of learning objects have been investigated. Novel techniques involve the use of augmented reality. In this research paper, the implantation of two innovative areas belonging to the computer science to support the learning process is presented: augmented reality and image processing. Through augmented reality we project virtual entities to the user computer screen and through image processing techniques, we perform the detection of an object that allows the interaction with the virtual entity without the need to use any special equipment.

Keywords: Augmented reality, image processing, virtual reality, learning object, object segmentation.

1 Introduction

Some of the most recent computational techniques used to support the learning process are virtual reality (VR) and augmented reality (AR), however, the difference between them is not clear in many cases.

In [1], the authors provide the following VR definition: "VR is high-end user-computer interface that involves real time simulation and interactions through multiple sensorial channels. These sensorial modalities are, visual, auditory, tactile, smell and taste". In the definition, real time means that the computer can detect a user's input and modify the virtual world instantaneously. In [2] is specified that the human brain can process between 10 and 12 images per second and detect them as a simple image and with a higher number of images will produce the sensation of visual continuity, so in VR, computer must be able to process more than 12 images per second.

In [3], AR is described as a reality in which virtual content is seamlessly integrated with displays of real world scenes, the formal definition proposed by the authors is: "AR is a combination of technologies that enable real time mixing of computer generated content with live video displays".

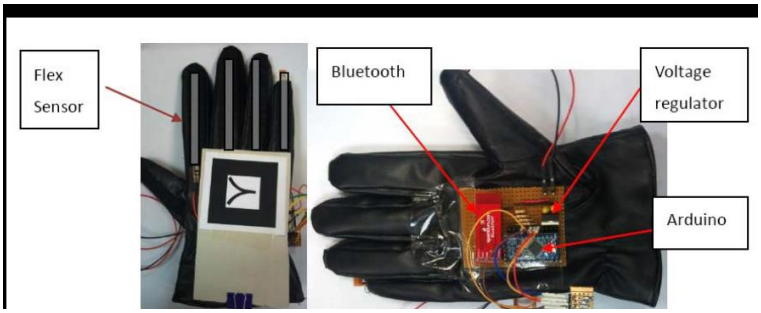

Fig. 1. Glove developed for the rehabilitation process.

Fig. 2. AR projection based on Feature Points.

Both, VR and AR consider the use of virtual entities, however, the most important difference is provided in [4]: "VR technologies completely immerse a user inside a synthetic environment. In contrast, AR is taking digital or computer generated information and overlaying them over in real time environment".

2 Related Work

In [5], the authors propose the use of glove with many sensors adapted to it, to interact with virtual entities using AR. The proposed methodology aims to support the rehabilitation process. The system is able to get a measure of any finger movement which is not relevant to the method proposed in this research work. Despite of being a good option to the rehabilitation process, the acquisition of the glove is crucial to interact with virtual entities to perform the rehabilitation process.

3 Digital Entities Modeling

To develop both, virtual environments and virtual entities, VR uses different software tools to create, first, a mesh model of the entity and then create the environment, once created the environment, the entity is exported into it. Finally, when the environment and the entities are mixed, the project is produced and exported to a device (lenses usually), in [6] this process is detailed.

In AR, the entity modeling process is a little different, the entity could be developed through software tools too, however, usually the environment is the real one recorded through a camera or any other scanner. To introduce the entity in the real world, often AR uses pattern recognition algorithms to project the virtual entity in the pattern usually

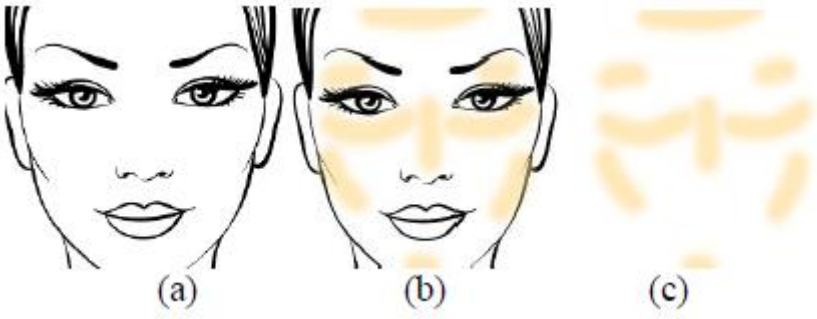

Fig. 3. Region detection to virtual entity projection.

printed in a sheet of paper, in [7, 8, 9], the use of this way of AR is detailed. Additionally, in [10], another way to combine the real world and virtual entities is exposed: training a machine learning methodology to recognize a specific object in the real world and project the virtual entity in it.

The machine learning algorithm is K nearest neighbor, and the data collection of the object where the virtual entity is going to be projected was obtained by Scale-invariant feature transform (SIFT) feature detector and descriptor, Figure 2.

Despite being a good strategy, the use of feature detectors and descriptors not only in AR, but also in all the computer vision field, still presents a great area of investigation, because of that, its effectiveness in an environment with uncontrolled conditions depends on expensive computational techniques like Random sample consensus (RANSAC). In [9], this problem is exposed and to try to face it, authors propose a methodology based on artificial neural networks called DeepAR, they compare their technique against Oriented FAST and rotated BRIEF (ORB) feature detector and descriptor. According to their results, their algorithm got a better performance than ORB; however, they mentioned that they needed in some occasions more than 200 iterations.

Authors in [10] present a little bit different way to detect the region where the virtual entity is going to be placed: Face Detectors, see Figure 3.

They implement the Qualcomm Snapdragon (Software Development Kit) SDK to detect a face. The SDK allows to detect some specific regions into the face: eyes, eyebrows, nose, chin and ears. Once detected the face, an image developed using Adobe Photoshop and which contains the makeup for the regions mentioned of the face is projected over the face.

4 Entity Interactions

Once developed and displayed the digital entity, it is necessary to establish a means of control to interact with them.

In the case of VR, the interaction with the digital environment is performed by sensors located in any specific body part, with which is possible to get a measure and

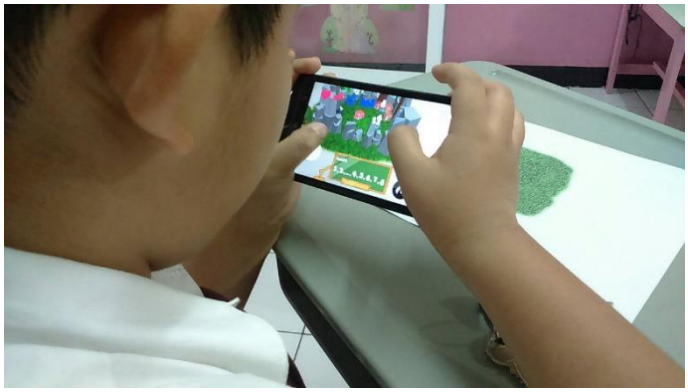

Fig. 4. Virtual entities projection through mobile device.

extrapolate it to the virtual environment. In nowadays is commonly interact in the virtual environment through buttons located on VR lenses.

A common way to interact with virtual entities is through mobile devices (smartphones principally). Research in [11, 12] promote this methodology. In [11], authors use SIFT to detect features in the image and the bag of words technique to recognize a specific object recorded by the cell phone. To solve the problem of processing capacity, they divide their system in a client-server architecture; the client part (cell phone) detects features and project the digital entities, after that, the system send the image recorded to the server through a conventional Wi-Fi connection. In the server part, the object recognition process is developed by the bag of words technique. In [12] an Arithmetic Learning game based in AR is presented. This research provides a client-server architecture, they use libraries, toolkits and SDKs to develop both, pattern recognition and entities modeling, however, they do not specify which ones, Figure 4.

Many techniques to project a virtual entity in the real world have been proposed, many techniques to interact with virtual entities too, however, almost all of them are based on the use of a hardware (gloves or touch screen of mobile device). To avoid the use of sensors or a mobile device, we propose the use of image processing techniques to recognize a specific object or body part recorded by a webcam and use it to interact with the digital object projected (pointer). With that methodology, the user will not need any other device additional to his/her computer with a webcam, however, the process of recognition and interaction with the digital object must be developed in real time (at least the software must be able to process more than 12 frames per second).

5 Application Development

In nowadays, many software tools are available to develop the virtual entities, either in third dimension or two dimensions. In this research project, we opted for the use of two dimensional images. To provide a high quality, the images were developed using Photoshop of Adobe. The size of the images is delimited by the webcam resolution, in

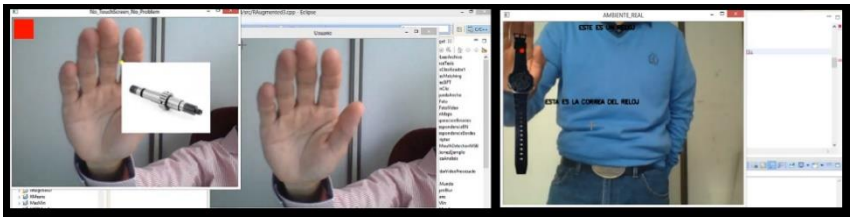

Fig. 5. JPG and PNG Image format comparison.

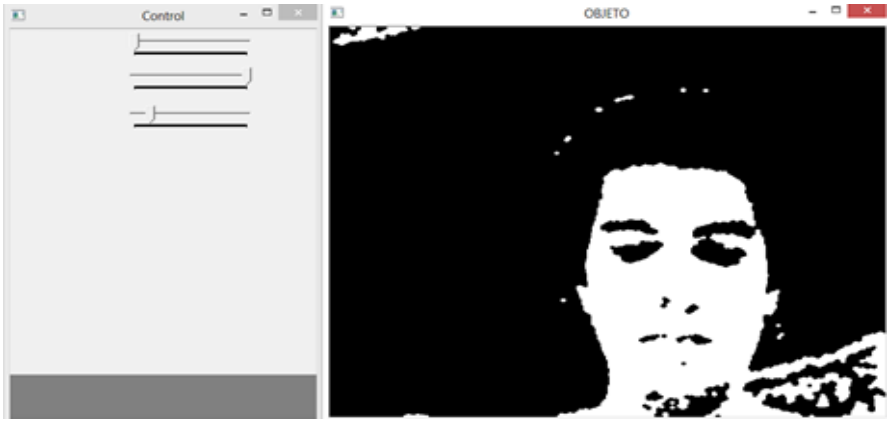

Fig. 6. Skin segmentation.

our case the webcam resolution is 640x480 pixels, so the images created through Photoshop must be smaller than this size.

After some experiments, we chose the Portable Network Graphics (png) format for images. The principal reason to select this format is because of its transparency, the use of a Joint Photographic Experts Group (jpeg) or a Windows bitmap (bmp) format will produce a solid surface around the image (image background), while it is projected to the video of the real environment, Figure 5.

5.1 Color Model

Many color models have been proposed until nowadays, some of them are: red, green, blue (RGB), Hue, Saturation, Lightness (HSL or HSI) or Hue, Saturation, Value (HSV), among others. The models contemplate different parameters to conform all the variety of colors, for example, from the RGB model uses colors Red, Green and Blue to conform all the colors, from black (0,0,0) to white (255,255,255).

5.2 Digital Entities Projection

Detect a specific surface to project the entity is not the main objective of this work, but rather the projection of the virtual entity and set a specific interaction zone on the object to interact with it. The main consideration when the entity it is going to be projected is

Fig. 7. Virtual entity projection and interactive zones.

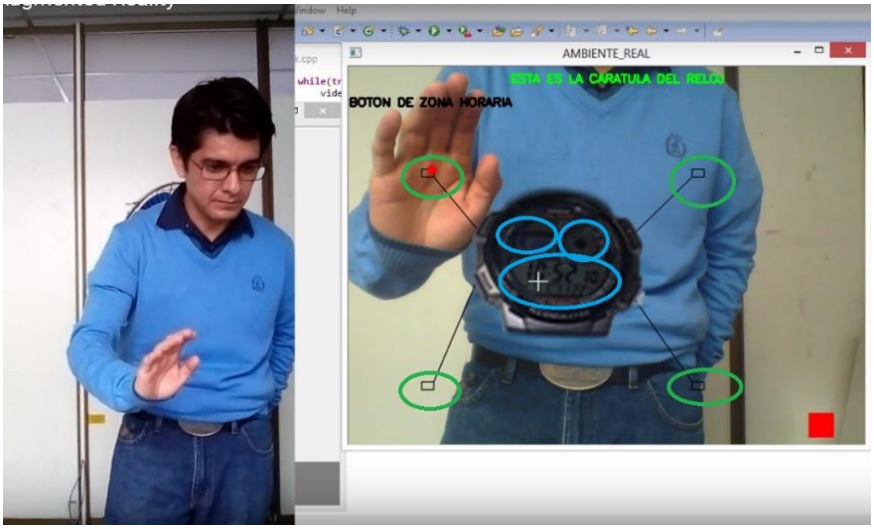

Fig. 8. Update interactive zones.

the opacity. Independently of the color model selected, is important to consider the opacity as another different color channel. For example, if we choose the RGB model, a fourth color channel must be considered "opacity (O)", redefining the model as RGB-O

5.3 Digital Entities Interactions

To interact with a digital entity, we have defined some specific areas on it; these are going to change depending on the image displayed on the user screen. When the cursor

is over the interactive zone, a bigger image of the area is going to be displayed together with a resume of it; we decided to use a body part (hand) as a cursor.

Before to applying an algorithm to recognize the object selected as a cursor, we must segment it from image recorded by the webcam, in order to delimit the region of the hand we must be able to detect the skin region. Due scene luminosity, it is difficult define some specific values to segment skin color and make easy hand detection. As a way to help on skin color detection independently of scene luminosity, a control panel is provided to establish the best color channels combination according of the luminosity at that moment, Figure 6.

Once segmented the object selected, we are able to apply an algorithm to recognize it. At present, many algorithms to develop the object recognition task has been proposed. On this work, we have selected Hu invariant moments [12]. To obtain the Hu invariant moments of the object selected, it is necessary binarize the object image. Once segmented the image we are able to apply the Hu equation (1).

Consider f(x,y) as the intensity of pixel (x,y) in a region. The moment of order (p+q) for the region is defined as:

$$m_{pq} = \sum_{x} \sum_{y} x^p \, y^q \, f(x, y). \tag{1}$$

6 Model Implementation

The algorithm proposed was implemented in a computer with the following characteristics:

- Processor: Intel Core I3, 2.40GHz, 64 Bits,
- RAM: 4.00 GB.

6.1 Performance

To evaluate the algorithm performance the following test was proposed. We defined two types of interactions:

- Displaying information about the actual model displayed on the screen. That means, define zones that show a summary of it, Figure 7.
- Displaying a model about the selected zone. That means, when the user overlaps the cursor in that zone, the actual model must be replaced for a model of the selected zone.

At the beginning of the test, the principal entity selected to interact with, is displayed. The specific interaction zones for actual image are stablished.

Zones under green ellipses display information about that specific part, while zone under blue one, update the principal entity with the zone selected and the new interaction zones are calculated, Figure 7 and Figure 8. The behavior on this level are similar that the mentioned before: Zones under green ellipses display information about

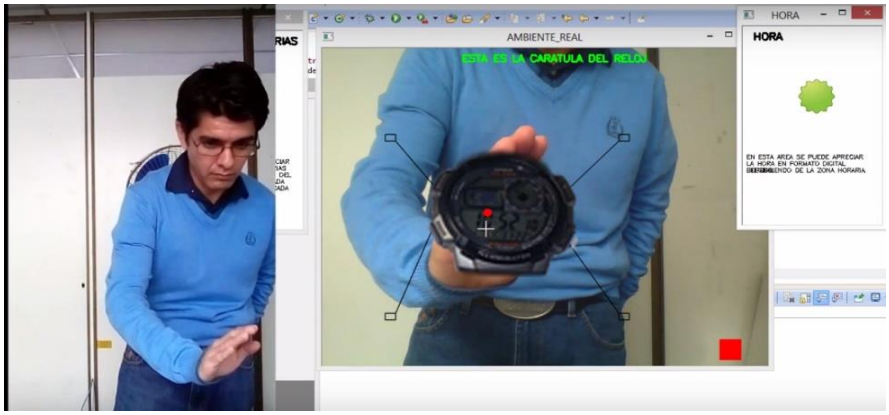

Fig. 9. Summary about hour zone.

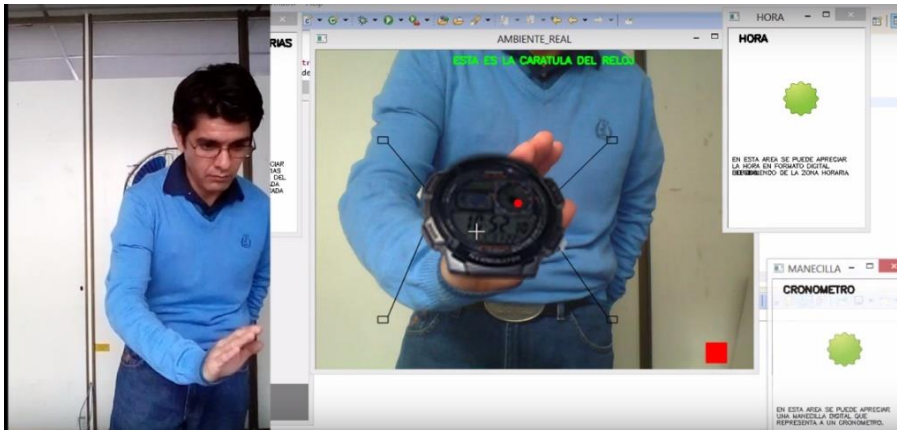

Fig. 10. Summary about chronometer zone.

Table 1. Activity time performance.

Activity	Time (milliseconds)
1 Recognize the skin color after establishing RGB values through control panel.	137
2 Display the virtual entity on screen	35
3 Display information about specific zone of the entity	18
4 Update the principal virtual entity	25
5 Open a window with information about a specific zone	19
6 Reestablish the principal virtual entity	32

that specific part, however, zones under blue ones, provide information in a new window, Figure 9 and Figure 10.

The red area works as a button to reestablish the principal virtual entity and close the windows opened.

After run 10 times this application, we provide the following summary of time performance for each activity, see Table 1.

7 Conclusions

In the present research work, a way to interact with virtual entities in augmented reality is proposed. The method is based on Hu invariant moments to recognize the object to be used as a cursor. Once recognized the cursor, algorithm is able to process more than 12 images per second, because of that, its performance is considered on real time according to [2]. The control panel to face scene luminosity variation is necessary to segment efficiently the cursor object.

8 Future Work

Because of present research work, we propose two principal future activities:

- The development of an algorithm able to recognize not only the hand as a cursor, but also the specific hand gesture to associate it with a specific action.
- To study the effects of the luminosity in objects to define a specific range of acceptable performance of the algorithm.

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Personalization of Learning Objects through Knowledge Management Process

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Abstract. The correct average of the knowledge has been getting more attention for companies in nowadays because the competitive advantages, if there is rotation of workers. The use of employee's experiences in addition to the literature contained in books or reviewed on the internet allows the development of personalized and reusable learning objects useful in a specific topic. The knowledge management process, professional team necessary to recover and process experiences from experts and an example of tools to produce and distribute the learning objects are also provided in this research.

Keywords: learning object, SCORM, LMS, knowledge management process.

1 Introduction

An increasing number of companies have been destining resources to catch the knowledge acquired by their employees with different purposes, two of the most important are: hold back the experiences of employees near to the retirement and help in the self-training process. In both cases, develop learning objects (LO) which contain not only information about books or papers, but also the specific experiences recovered by people who has been developing that activity is essential to get useful learning objects. To achieve LO with that specific characteristic, a multidisciplinary team is required. It is possible separate the team according to their particular objectives on the project, on these research two parts are proposed: "process team" and "software team". In resume, the first one is responsible of recover information about the theme to develop, the second one, must represent that information recovered through interactive activities to stimulate the learning process. Because different ways to learn, the incorporation of a pedagogue on software team is proposed. On the following section, the knowledge management process is described.

2 Related Work

In [1] authors explain in detail the sequencing of learning objects on LMS based on SCORM standard using cmi element and JavaScript, being learning objects containing

teaching materials, following the guidelines proposed by ADL. In [2] authors explain an application of pedagogical tools to an on-line course for e-learning, including an example of a course specification showing an activity, an example of a script for an activity, and a course development model. In this research work, a knowledge management process is presented.

3 LO Construction

The success of the LO will depend of how much it brings to the learning process and the interactivity which it was developed [3]. To produce useful LO is really important complement the information obtained by the literature with the tacit knowledge earned by experts through the time invested developing a certain activity.

3.1 Process Team Interaction

Currently, many techniques to translate the tacit knowledge to implicit have been exposed, however, this research consider a set of direct interviews between an expert and the process team as the best way to achieve that objective. The number of meets will depend on the theme length and it complexity; usage of a video camera is proposed to review agreements or at least notes about the meets must be developed by the process team. Once completed the interviews, process team should to share their video records or notes, with the software team to transform them on interactive activities [4].

3.2 Software Team Interaction

Together with a member of process team and with the pedagogue, the software team translate notes or video records in learning objects through use of an authoring tool and many design tools such as Flash of Adobe. The usage of an authoring tool makes easier the LO production because software team does not require language programming capabilities, the authoring tool add automatically the elements required to communicate the user interactions on the LO and the platform that reproduce the LO, usually a Learning Management System (LMS) [5]. To set a minimum of interactions (among others measures) the SCORM (Sharable Content Object Reference Model) standard was published. Both platform and LO are involved by SCORM [6, 7], that makes easier get a measure of the user average, however, by the same standard the navigation (principally) is affected, allowing only a sequential review of the LO and giving to the user the capability of review all the themes contained on the LO without any restriction which is a problem in case of an exam (for example). On the following section, the development of personal knowledge paths is explained.

3.2.1 Developing Personal Learning Paths through LO

As was mentioned before, SCORM standard includes both LO and LMS. To get a measure about the interactions of users on the LO, SCORM propose a set of tracking

elements called “cmi elements”. The use of cmi elements allows to the software team get measures about many aspects during user interaction such as time spend on a specific activity or even in a slide, correct answers on a test, the last slide visited, etc. SCORM propose more than 20 different cmi elements, which could be used to develop rules and achieve a specific learning path for the users. However, according to SCORM rules, any activity on a LO must be related with other, so, to link them, a JavaScript function is used.

The user name is stored on LMS on *cmi.core.student_name*. To verify the function, the Fig. 1 is displayed, these figure contain a print screen about a LO contained in a LMS.

Fig. 1. CMI element evaluation.

To get for example, the qualification obtained in a test, the "*cmi.core.score.raw ()*" must be employed. Once finished the LO and their rules of behaviour based on user interactions, software team proceeds to publish the LO. Publish is the process by which

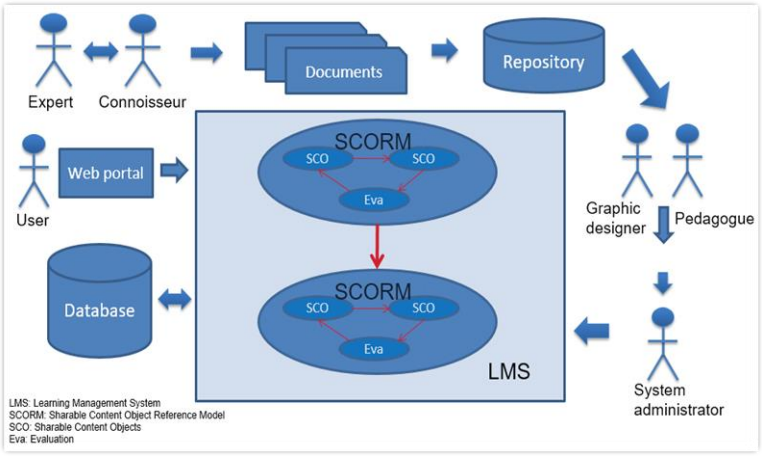

Fig. 2. LO creation process.

the authoring tool add automatically the code required to enable communication between the LO and the LMS. The publish result is a ".zip" file which software team must upload to the LMS. In Fig. 2, the process and the necessary team is presented.

3.2.2 Program Code

The code allows ask to the LMS for the user name to use it in a specific activity. JavaScript code to get cmi elements from LMS are listed.

```
var EstudianteNombre=' ';

EstudianteNombre=GetStudentName();

if(EstudianteNombre==''){
EstudianteNombre='No se encontro el nombre';
}
if (typeofwindow.cp==='undefined') {
varobjCp=document.getElementById('Captivate');
if(objCp&&objCp.cpEISetValue) {
objCp.cpEISetValue('m_VarHandle.studentName', Estudiante-
Nombre);}
}
else {
if(cp.vm && cp.vm.setVariableValue){
cp.vm.setVariableValue('studentName', EstudianteNombre);
}
}
```

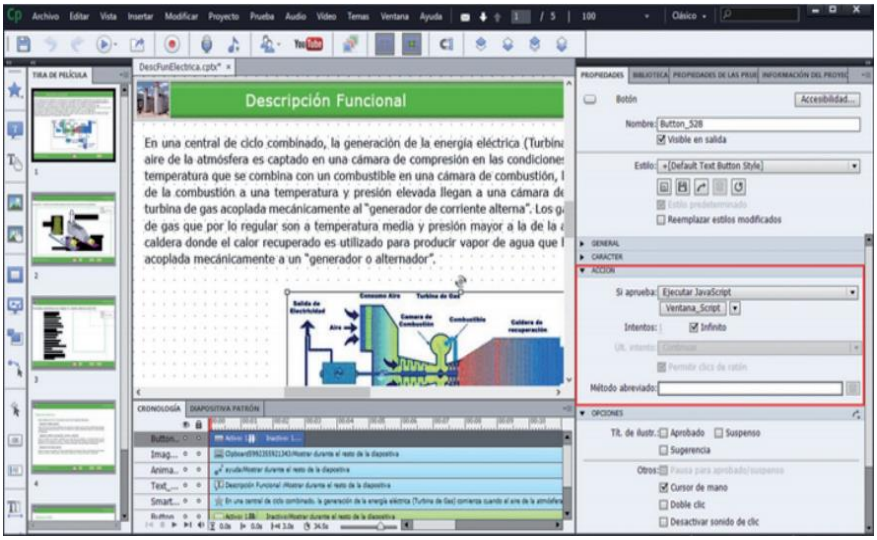

Fig. 3. Captivate interface.

4 Application of the Process

Following the proposed process with team specified a set of LO related to energetic field was developed. Together with the process and software team, a group of five experts were involved. The process team was integrated by three engineers (closely related to energetic field), the software team conformed by two graphic designers and 3 software engineers was required to develop an interactive LO conformed by 126 topics encompassed on themes such as: "Principal Generation System", "Auxiliary Service System", "Measure, Control and Protection System" and "Principal Transformation System".

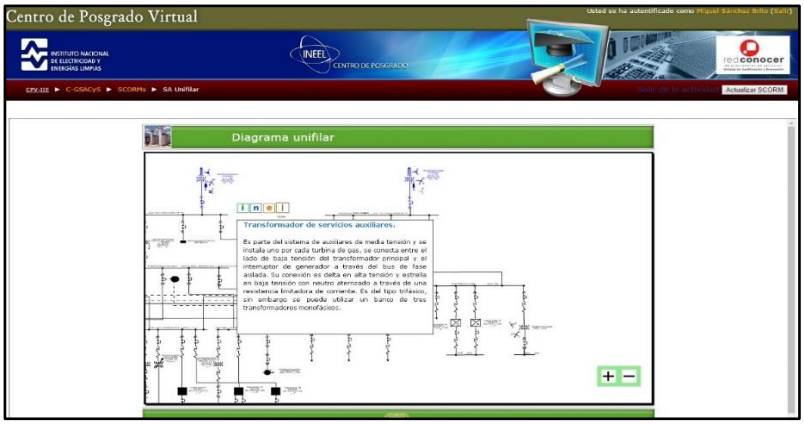

Fig. 4. Sample of the Developed Learning Object.

To produce the LO the authoring tool "Captivate" from the suite of e-Learning tools of Adobe in addition with design tools such as Photoshop and Illustrator and Flash to create interactive activities were used. In Fig. 3, a print screen of Captivate interface is presented.

The functionality of the LO was evaluated on a LMS Moodle platform where the Postgraduate Virtual Center of National Electricity and Clean Energy Institute is placed. In Fig. 4, a topic developed by the LO uploaded to the LMS Platform is showed. On this particular case, many interactions must be developed: a zoom function to visualize in detail the diagram, a brief description of the element selected from the diagram activate through click actions, 3 different buttons linked to different fields of a database, buttons allow to see: standards applied for the selected element (n), a long description of the element (i), specifications applied for the element (e) and a list to daily verification of the element on the real workday.

5 Conclusion

The correct average of the knowledge has been getting more attention for companies in nowadays because the competitive advantages. The use of employee's experiences in

addition to the literature contained in books or reviewed on the internet allows the development of personalized and useful learning objects in a specific topic. In conclusion, the knowledge management process, professional team necessary to recover and process experiences from experts and an example of tools to produce and distribute the learning objects are also provided in this research work.

6 Future Work

The use of Flash tool to develop interactions on activities, inhibit the possibility to access the LO through mobile device, because of that a new methodology using a different tool or even develop the interactions through a programming language must be applied.

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Probabilistic Relational Learner Models Based on Competence Maps

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Abstract. We present a proposal for a computational representation of competence maps that emphasises relationships of inclusion/part-of and specialization/generalization, and a generic approach to the construction of probabilistic relational learner models based on those competence maps, in which conditional probability tables are built on the basis of the kind of relationships between competences and, for the case of inclusion/part-of relationships, on the number of those relationships. We justify the use of *noisy-or* as a substitute for composite conditional tables produced by a competence being part of many other competences. Preliminary testing of both frameworks, for computational representation of competence maps and the construction of probabilistic graphical models from them, suggest coherence with reality.

Keywords: Competence map, relational probabilistic models, learner modelling, conditional probability tables.

1 Introduction

Competence-based education is a world-wide but relatively recent trend [1] which tries to go away from fact memorisation by establishing what students should be capable of doing with their knowledge (i.e. their *competences*), there is still much to do in order to fully implement competence-based education. Most importantly, teachers need to think in terms of competences while teaching and evaluating their students.

Today, a large number of educational programmes are defined in terms of the competences their graduates are going to have, and the competences students are going to develop on each course [3,8,9]. Yet, most of the information regarding competences is held in the design phase, in the documents describing the programmes and course designs. You may find some information regarding competences in some textbooks and online courses, appreciate less competence orientation in learning activities, a little bit of competence-based evaluation by teachers and, finally, almost no information regarding what competences the students have develop (and to which level) in their kardex, and even less information on that in their certificate.

Furthermore, evidence regarding the development of competences do not accumulate, and that is particularly the case for transversal competences, such as problem solving and team collaboration. Many such competences are develop along many courses, specialised in several context (e.g. problem solving in mathematics, in communication, in biology), yet there is no accumulation of evidence regarding the general case, nor we use it to tailor teaching (e.g. a student that has proven to be a good problem solver in other fields of study may need a different teaching that a student who has proven otherwise).

On the particular case of online learning, much of the work of gathering information regarding the development of competences by students can be automatized, so that it is carried out by the learning management system, but it is generally the case it has no information regarding competences, nor information regarding commonalities of competences among several activities dispersed along a few courses.

So our proposal goes on the way of attending these problems by providing the system with detailed information regarding competences, their interrelationships, and their relations to course activities, so that evidence of their development by students can be accumulated, and visualised by anyone interested and proper permissions. Furthermore, we propose mechanisms for evidence propagation, so that knowledge about the student having developed certain level of some competences can be transformed into knowledge concerning the indirect, preliminary development of related competences.

2 Related Work

Most of the work in computational encoding of competences has do to with their description and cataloguing. Consequently, the standard developed on this subject attends precisely these topics [1]. The establishment of relationships between competences is let as optional in the standard, as well as in other tools that support the construction of competence maps, such as COMET [7].

More related work has been focused on the construction of hierarchies of competences (Competence Structures) using relationships of type inclusion/part-of for learner modelling [6], a relation type and goal shared with the work reported here. However, the authors could not find further information regarding

the implementation of a belief propagation mechanism that makes use of the hierarchical structure.

3 Competence Maps

Our competence maps are built on a notion of *competence* as the ability to perform a given action in a given context, which demands the mobilization of various cognitive resources (knowledge, skills, attitudes and values) [5], and two kinds of relations among competences: inclusion/part-of, and specialization/generalization. An example of such a competence map is given in Figure 1.

3.1 Inclusion/Part-of

This relation takes into account the observation that competences come in different sizes in educational programmes. There are small competences that clearly decompose into a few attributes, and there are large competences that look like complex agglomeration of attributes, while its process of execution seem to decompose into subprocesses—for example, in the domain of Physics, mathematical competences could be regarded as basic competences, as only their products may be of interest, while physics competences would be described in detail, decomposing them into sub-competences. So in our competence maps we distinguish between *simple competences* that decompose directly into its attributes (knowledge, skills, attitudes and values), and *complex competences* that decompose into *sub-competences*. In the second case, the *super-competence*'s attributes are composed by those associated directly to it, plus the ones associated (directly or indirectly) to its sub-competences.

There is no restriction in the number of (super)competences that include a given (sub)competence. For example, as shown in Figure 1, operating mathematical language to achieve a result to be interpreted in context can be seen as a competence that is a necessary component of problem solving in natural sciences such as Physics and Chemistry.

3.2 Specialization/Generalization

This relation takes into account the observation that there are competences that seem more specialised than others; competences that, on one side, seem to include additional attributes (e.g. 'writing formal letters with Microsoft 365') while, on the other side, seem to lack of generality in comparison to other competences (e.g. 'writing formal letters with a word processor'). So in our competence maps a competence can be specialised or generalised by another competence through the addition[4] of attributes such as knowledge, skills, attitudes or values.

In contrast with the inclusion/part-of relationship, while a competence can be specialized by many other competences, a competence can only specialise a single other competence—in the same way that, in many object oriented programming languages, a class can only specialise another class, not multiple ones.

[4] It could mean *replacement*, but we are not considering it, yet.

3.3 Interplay of Relationships

Both kinds of relationships among competences are not isolated one from the other. If a competence specialises a complex competence, it inherits not only its attributes but also its structure (see example in Figure 1); that is to say, it becomes a complex competence with the same number of sub-competences, each one a specialization of a corresponding sub-competence in the original competence.

3.4 Example

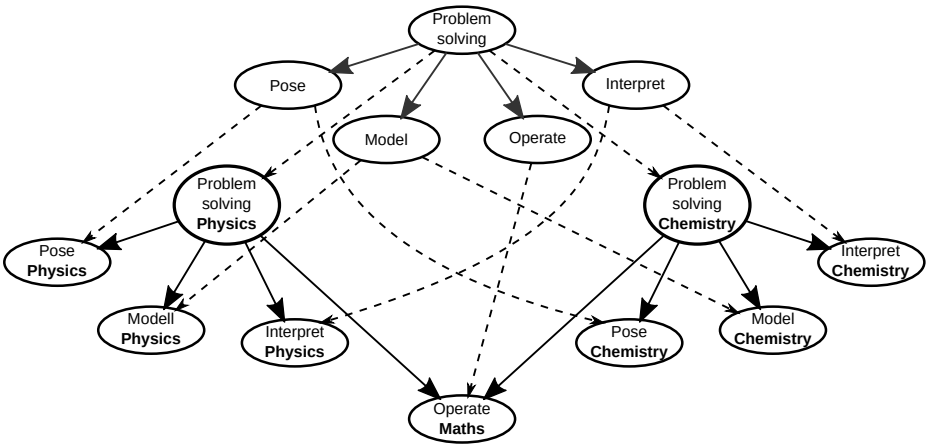

Fig. 1. Example of a competence map for a simplified version of the problem solving competences in Physics and Chemistry.

Figure 1 demonstrates what has been explained so far, using the competence for problem solving to illustrate both kind of relationships and its interplay. The figure includes a complex generic competence for problem solving that gets specialised (dashed lines) into problem-solving competences in the fields of Physics and Chemistry, so both specializations inherit the structure of the generic competence, and their sub-competences (solid lines) specialise the corresponding generic sub-competences of the generic competence for problem solving.

In this example, operating the mathematical language is considered a necessary sub-competence for problem solving in both fields, so this appears connected both to problem-solving in Physics and to problem-solving in Chemistry, and specialises the generic competence for operating in a formal language.

4 Probabilistic Relational Models

A competence map as the one shown above can be used as the base for a probabilistic relational model [4] of the competences being developed by a student, using

the relationships between competences for propagating evidences regarding the level of competence developed by a student. For example, if we know a student has demonstrated a high level of competence in problem solving in a few fields (e.g. in physics, mathematics, communication, social conflicts) then we can infer it would not start from zero in problem solving in another field (e.g. in chemistry) but rather exhibit a certain level of development of the problem-solving competence in that field from start. Furthermore, a competence maps as the one shown above allows modelling of the development of a generic problem-solving competence that corresponds to the intuitive sense of the student being generally good at problem solving.

A first approach to developing probabilistic relational model from a competence map would be to base the construction of the conditional tables only on the kind of the relationship and, for the case of the inclusion/part-of relationship, on the number of sub-competences. In that way, the conditional tables can be constructed automatically from a set of principles and rules, as shown below.

4.1 Principles

Levels of competence. According to the educational theory of social constructivism [10] we consider three levels of competence:

- *Low*. The student cannot perform the action on its own nor with the support of others.
- *Medium*. The student can perform the action with the support of others, but not on its own.
- *High*. The student can perform the action on its own, without the support of others.

Conditional probability tables. The definitions of conditional probability tables per relationship type, as well as their composition in cases of multiple connections upwards, is based in the following assumptions:

1. If we believe that someone has achieved a high level of development of a competence, we would expect a better performance in a specialization of such a competence than if we know nothing about the development on the first competence. That is so because the specialization inherits the attributes of the original competence.
2. On the other hand, if we believe that someone has problems with a competence, we would expect they to have similar problems in most of their specializations. That is so because attributes not fully developed in the original competence are also inherited by its specializations.
3. The strength of the relationship between a given competence and another that specializes it does not depend on the existence of other specializations of the same competence.

4. If we believe that someone has achieved a high level of development of a super-competence, we would expect a relatively good performance in each and every one of their sub-competencies (with outstanding performance in some of them, and not so good performance in some others).
5. On the other hand, if we believe that someone has problems performing a super-competence, the difficulty could reside specifically in any of its sub-competences, or accumulate from difficulties in several of them.
6. The strength of the relationship between a super-competence and any of its sub-competences depends on the total number of sub-competences. That is so because the more sub-competencies, the more the performance impact of one of them on the performance of the large competence is diluted (considering an even share of attributes among sub-competences).

4.2 Conditional Tables for Specialization/Generalization

On the basis of principles 1 to 3 we can sketch the conditional probability table for a specialization/generalization relationship:

Table 1. First approach to the conditional probability table for the specialization/generalization relationship.

	Low	**Medium**	**High**
Low	Large	Medium	Small
Medium	Small	Large	Large
High	Very small	Small	Medium

If someone has the capability to perform an action on their own (high level of competence) in certain type of situations, it is likely to be able to do it in any situation that demands some additional resources (knowledge, skills, attitudes and values), although it is more likely that they will need some help, because they may lack some of the additional resources. Yet there is still the possibility that the specialization is so strong that they can perform the action in the new situation, even with support from others.

If someone has the ability to perform an action with support from others in certain kinds of situations, it is unlikely that they can perform it on their own in any kind of situations that demand even more resources. They are likely to need more support than before, or even they may be unable to perform the task at all. Yet, it may still be the case that having most of the additional resources could help them to perform the action, even without help.

If someone is unable to perform an action in a certain type of situations, even with support from others, it is very unlikely that they can perform it in any kind of situations that demand additional resources, unless their having of those additional resources provides them with some lever for compensating their

lacks in the original ones. Yet, it seems more unlikely that they can perform the action on their own in the more demanding situations.

There are many ways to assign relative numerical weights to the fuzzy notions of probability used in the table above. We have considered three of them (see Figure 2): a linear distribution (1, 2, 3, 4), that provides a weak differentiation of probabilities; the standard normal distribution (cumulative probability at -3, -2, -1 and 0), that provides a strong differentiation of probabilities; and the binomial distribution with six trials (1, 6, 15, 20) and probability equal to 0.5, as a compromise between the previous ones.

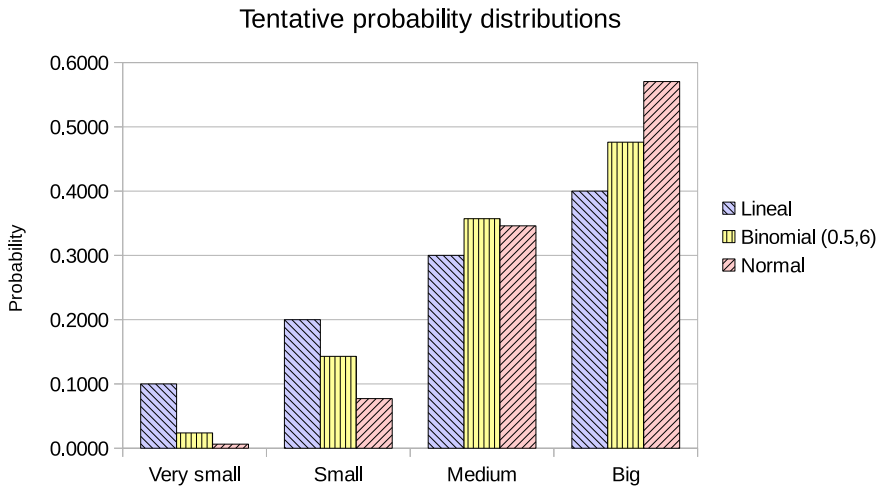

Fig. 2. Linear distribution, binomial distribution with six trials and probability equal to 0.5, and normal distribution.

4.3 Conditional Tables for Inclusion/Part-of

Consider the case of a competence C that includes n sub-competencies which we call $C_1, C_2, ..., C_n$. If someone is able to perform on their own the action associated to the competence in certain kind of situations, this means necessarily that they can perform each of its sub-competences without help. That is,

- $P(C_i(\text{High})|C(\text{High})) = \text{Large}$.
- $P(C_i(\text{Medium})|C(\text{High})) = \text{Small}$.
- $P(C_i(\text{Low})|C(\text{High})) = \text{Very small}$.

On the other hand, if someone is able to perform the action associated with the competence with support from others, but only thus, then at least one of his sub-competences must have an average level and none can have a low level. Yet,

in order to do not discard the possibility of a sub-competence with a low level, we can calculate the conditional probabilities as follows:

- $P(C_i(\text{High})|C(\text{Medium})) = (2^{n-1} - 1)/2^n$.
- $P(C_i(\text{Medium})|C(\text{Medium})) = 2^{n-1}/2^n = \frac{1}{2}$.
- $P(C_i(\text{Low})|C(\text{Medium})) = 1/2^n$.

Finally, if a person as a low level in competence C (they cannot perform the associated action, even with support from others) this may be due to problems in the execution of any of C sub-competences. That is, of the 3^n possible permutations of levels of its sub-competencies, only those in which at least one of the sub-competencies has a low level is possible: $3^n - 2^n$. From here we can calculate the conditional probabilities:

- $P(C_i(\text{High})|C(\text{Low})) = (3^{n-1} - 2^{n-1})/(3^n - 2^n)$, because if C_i has a level other than low, at least one of the others must have it.
- $P(C_i(\text{Medium})|C(\text{Low})) = (3^{n-1} - 2^{n-1})/(3^n - 2^n)$, for the same reason.
- $P(C_i(\text{Low})|C(\text{Low}) = 3^{n-1}/(3^n - 2^n)$, because if C_i has a low level, the other sub-competencies can have any level.

The limit of the conditional probabilities as n approaches infinity is $\frac{1}{3}$, so the conditional probability distribution for the case $C(\text{Low})$ is flattened when the number of sub-competencies grows, and it does so rather quickly (with five sub-competences, the difference between conditional probabilities is less than $\frac{7}{100}$).

The full table of conditional probabilities is then as shown in Table 2 below.

Table 2. Conditional probability table for the inclusion/part-of relationship. The top row contains the possible competence levels for the super-competence, while the column on the far left contains the possible competence levels for a sub-competence.

	Low	**Medium**	**High**
Low	$\frac{3^{n-1}}{3^n - 2^n}$	$\frac{1}{2^n}$	Very small
Medium	$\frac{3^{n-1} - 2^{n-1}}{3^n - 2^n}$	$\frac{1}{2}$	Small
High	$\frac{3^{n-1} - 2^{n-1}}{3^n - 2^n}$	$\frac{2^{n-1}-1}{2^n}$	Large

5 Joint Conditional Probability Distributions

The restriction that a competence can only specialize a single other competence reduces the case for a competence to have several relationships upward to the form $<\text{Specialization}, \text{Subpart}_1, \ldots, \text{Subpart}_n>$. Besides, the characteristics of the conditional probability distribution for the inclusion/part-of relation—in the

sense that a medium or high level at the super-competence strongly conditions the level at any sub-competence, while a low level at the super-competence weakly conditions the level at any of its sub-competences—suggests we could combine all the conditional probability tables for inclusion/part-of relationships using a *noisy-or* [2].

6 Usage

Given a competence map, corresponding to an educational programme or course, it is possible to create a probabilistic relational model for every student. Its initial state will be given by the probability distributions for the possible levels at the top competences (e.g. uniform distribution) which will be propagated through the whole map using the corresponding conditional probability tables.

Evidence of levels of competence will come mostly at the lower layers of the competence map, as those competences will be associated to more concrete situations, where student performance will be easier to observe: you cannot observe a student using the idea of a generic word processor, but you can see them using LibreOffice 5 Write. The evidence will be propagated to the rest of the map using the same conditional probability tables, so knowledge about more general competences and peer competences—specializations of the same competence; e.g. using Microsoft Word 365, will be accumulated.

In such a way, competence development along all activities in courses could be accumulated in the learner model, which would provide then a more detailed and accurate description of the state of competences development by the learner.

7 Conclusions

In this paper we have briefly described a formalism for the construction of competence maps with a focus in the relationships (specialization/generalization, and inclusion/part-of) between competences, which in turn can be used as the basis for a probabilistic relational learner model. The overall shape of the conditional probability tables has been deduced, with some details, from the levels of competence and the kind of relationship between competences.

In doing so, we have provided a general framework for the development of competence maps and their corresponding probabilistic relational learner models. The specialization/generalization type of relationship between competences leads necessarily to the notion of "generic/abstract competences", with so few attributes (or none) that it could be said that such "competences" cannot be observed in real life—that is so, because any concrete situation would demand more competence attributes (knowledge, skills, attitudes) in order to perform the task—yet they are powerful organizers in competence maps and provide a natural way for evidence propagation in learner models.

Future work includes the development of competence maps for educational programmes based on competences—such as the National High School System of Mexico, particularly in its online implementations at the Virtual University

System at the University of Guadalajara—, the generation of relational probabilistic models from them. We plan to use data from previous courses, evaluated by experts, so to construct learner models from previous students, and then validate their final states against the criteria from the same experts. Finally, our plan includes the development of mechanisms for the recovery of evidence from the activities in online courses, and visualisation of learner models, so to provide real time feedback to teachers and students about the develpment of competences.

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Text Mining for Domain Structure Analysis in a Training System for Electrical Procedures

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Abstract. Learning environments themselves constitute a source of knowledge to understand and improve educational settings. We have developed some training systems where instructional content consists of separated electrical procedures stored in text documents. Since, the adequate characterization of the domain is a key factor in learning, we conducted a text mining study to understand relationships between topics, tasks and procedures in the training systems. In turn, this knowledge can help to provide students with an adaptive training, to help instructors to plan courses and to improve the training systems. We rely on a machine learning approach applying bag of words model and a clustering algorithm. Results on mining partial instructional content are encouraging since they show some useful relationships. Here, general proposal and preliminary results are presented.

Keywords: Bag of words, clustering algorithms, educational data mining, text mining, training system.

1 Introduction

The advancement of information technologies and the growing usage of educational environments, such as e-learning systems, intelligent learning environments, and massive online open courses, among others, have produced an amazing volume of data. The Educational Data Mining (EDM) is focused in processing such data to provide information about aspects and elements included in the learning process, for instance, student-system interaction, performance of the learning environments, and learning process itself. This emerging field exploits statistical, machine-learning and data mining algorithms [1], and it is defined as an emerging discipline, concerned with development of methods for exploring the unique types of data that come from

educational settings, and using those methods to understand students, and the settings in which they learn [2].

On the other hand, the electrical field requires efficient training in order to minimize training time, costs, and equipment damage, and most important, to prevent accidents that could injure electricians. However, training on electrical procedures faces some problematic situations, such as limited opportunity to practice in an actual installation, since they are operating on a regular basis. To cope with this situation, we have developed several training systems based on virtual reality to support traditional training and also to allow distance training. Trainees attend classroom courses and have field practice and they complement their learning and practice aided by the training systems. This blended training is guided by instructors [3].

The systems provide training on a number of electrical procedures which are composed by a number of steps, and in turn each step is composed by a number of sub-steps. Among other functionalities, the electrical procedures are explained by means of text describing the whole procedure in virtual environments.

The successful of the learning environments depends to a large degree in the adequate characterization of the domain, which allows us to understand the relationships between topics, tasks and procedures. In turn, this knowledge can help to provide students with an adaptive training, to help instructors to plan courses and to improve the training systems.

We conducted a study to understand the similarity among the different electrical procedures. We want to analyze the domain structure by applying EDM techniques to lessons in the training systems. We rely on the Bag of Words model [4] which consists in a statistical processing of the text and a machine learning algorithm, we used *K-means* clustering algorithm [5].

Here we describe our general proposal and present preliminary results. The rest of the paper is organized as follows: Section 2 presents the electrical training systems. Section 3 describes our proposal to analyze structure domain. Section 4 presents the results of the initial evaluation of the student model. Finally, conclusions and future work are presented in section 5.

2 Training Systems

We have developed several systems for training on different electrical topics [3, 6-9]. Fig. 1 shows some screenshots of these systems. They include a number of electrical procedures. Each procedure is composed by a different number of steps, and in turn each step is composed by a different number of sub-steps. Electrical procedures are taught by means of text explanations. In Table 1, a step and three sub-steps are shown (fragment), in each sub-step there are a description and an instruction; the instruction is an action to be executed by the trainee. As the system is in Spanish, texts have been translated to English. In addition, every procedure refers to handbooks and technical reports. The systems keep track of trainees' progress, however we are still working on integrating some intelligence, so such a way they are able to keep a trainee model of trainees and to respond in consequence [10].

Fig. 1. Training systems for different electrical domains. Left: medium tension power lines maintenance, right: underground lines.

Table 1. Example of a step of the electrical procedure "Structure conversion from TS30 to VS30 using a platform". Only four sub-steps are shown.

Procedure: Structure conversion from TS30 to VS30 using a platform Step 35: Place the last insulator, remove the medium voltage line from the temporary conductor holder and rotate the platform		
	Sub-step	Instruction
1	Place the new pin insulator and screw it to the crossarm	Select the 13PC pin insulator from menu of materials
2	The lineman places the pin insulator in the crossarm. The isolator is previously climbed up using the errand bucket	Click on the 13PC pin insulator
3	Proceed to screw and fix the insulator using the 1/2" reversible ratchet with a 15/16" socket. Then the insulator base and the crossarm are covered back with the rubber blanket	Click on the 1/2" reversible ratchet

The electrical knowledge is represented as a tree structure (Fig. 2). However, this representation does not include any relationship like dependence or hierarchy between topics, material, and tools. For example, if trainee correctly executes the first electrical procedure, we do not have any information about other electrical procedures. For these reason, we want to apply EDM techniques to the text describing the electrical procedures.

3 Model for Domain Structure Analysis

Data mining or Knowledge Discovery in Databases is the field of discovering novel and potentially useful information from large amounts of data [11]. Educational data mining methods are often different from standard data mining methods, due to the need to explicitly account for the multi-level hierarchy and non-independence in educational

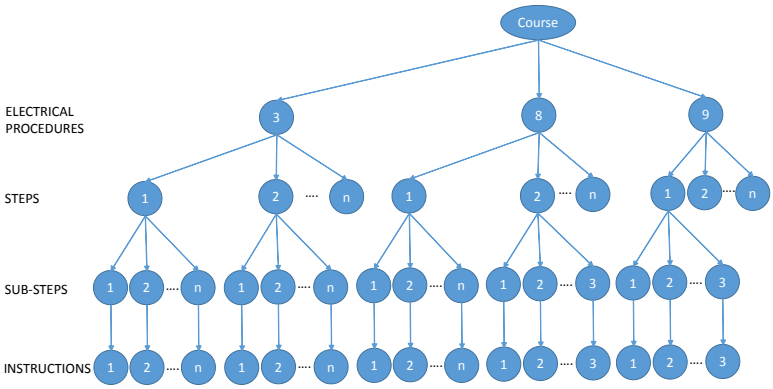

Fig. 2. Knowledge structure for a training course consisting of three electrical procedures composed by steps, sub-steps and instructions.

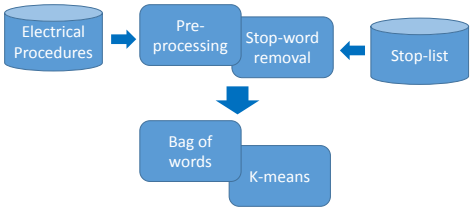

Fig. 3. Proposal for text mining model relying on machine-learning approach using the Bag of Words technique for text-mining.

data [12]. Educational data mining techniques play an important role in augmenting and improving learning environments. Extensive EDM work has been conducted for a wide number of applications: communicating to stakeholders, maintaining and improving courses, generating recommendation, predicting student grades and learning outcomes, student modeling, domain structure analysis [13].

Based on EDM techniques, we built a student model over the performance of trainees in the training systems [10]. Now, we want to analyze and improve the instructional material by discovering similarities and relationships between topics, procedures, tools, etc. We have relied on machine-learning approach using the well-known Bag of Words technique for text-mining.

3.1 Bag of Words Representation

In the *bag of words* (BOW) model, a text (sentence or document) is represented as a feature vector. This model omits grammar and word order, and it is interested in the number of words occurrences within the text [4].

Our initial proposal consists in preprocessing the text to convert it into a bag of words representation and apply *k-means* clustering algorithm. The pre-processing includes to

Table 2. Sample of 4 procedures titles in English and Spanish.

Procedure	Procedure title	
1	Rescue of injured lineman	Rescate de liniero accidentado
2	Installation of stirrups in structure TS30 with platform	Instalación de estribos en estructura TS30 con plataforma
3	Change of pin insulator in the PS30 structure with platform	Cambio de aislador tipo alfiler en estructura PS30 con plataforma
4	Change of fuse cutout (FCO) in structure TS30/RD3	Cambio de cortacircuito fusible (CCF) en estructura TS30/RD3

remove stop-words since they do not provide us with relevant information. This proposal is presented in Fig. 3.

As we mentioned, each training system includes a different number of electrical procedures and every procedure is different from the others as they contain different numbers of steps and sub-steps. As a first attempt, we decided to apply EDM only to the 43 titles of the electrical procedures in only one training system. In Table 2, we show an excerpt of the source text.

To obtain the BOW representation, for each procedure the text was converted in lists of words. For example, for the second procedure we have the list: [“*Instalación*”, “*de*”, “*estribos*”, “*en*”, “*estructura*”, “*TS30*”, “*con*”, “*plataforma*”]. Then, the stop words were removed in each vector. The stop list consists of the words: [*a*, *con*, *de*, *en*, *un*, *una*, *por*, *y*]. For the same example, we obtained the vector: [“*Instalación*”, “*estribos*”, “*estructura*”, “*TS30*”, “*plataforma*”].

After that, a list with all the different word in all the lists is constructed. This list is composed by 67 words and it is the bag of words representation.

After transforming the text into a bag of words, various measures can be calculated to characterize the text. We use term frequency which is the most common type of characteristics, or features calculated from BOW model. Term frequency refers to the number of times a term appears in the text. For our case, electrical procedures titles, we constructed 43 lists to record the term frequencies of all the distinct words.

These 43 lists of 46 elements, can be seen as a matrix of 46x43, an extract is shown in Table 3. The columns represent the words and the rows represent the procedures.

3.2 Clustering

We obtained 67 different words in the 43 electrical procedures, this is a grouping problem. However, as it has been argued, unlike in classification problems, in data grouping or cluster analysis we are not interested in modeling relationships between set of multivariate data and a certain set of outcomes, but we intent to discover and model the groups in which data are often clustered, according to some similarity measure. It is required unsupervised learning techniques to approach this problem, in turn this problem more challenging as the input space dimensionality increases and, as a result, data become more sparsely represented [14].

Tab ency
mea

Ele Pro e Id	S30
1	0
2	0
3	1
4	0

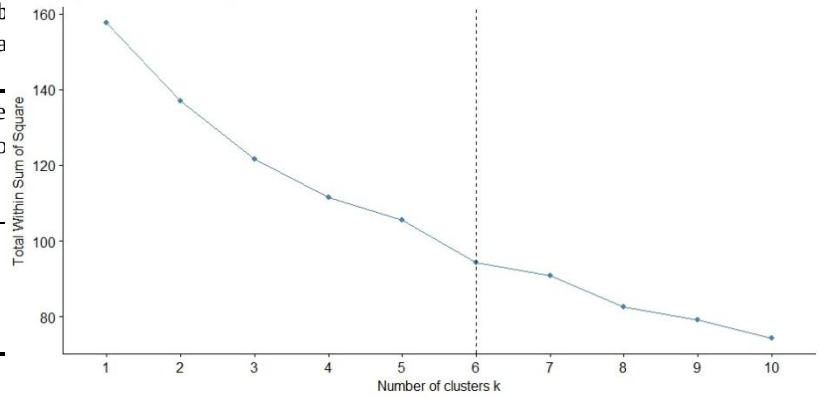

Fig. 4. Result elbow model which does not shows a clear elbow.

We used *k-means* clustering algorithm which allows to group a set of objects in such a way that objects in the same cluster are more similar (in some sense or another) to each other than to those in other clusters. *K-means* clustering aims to divide *n* observations into *k* clusters in which each observation belongs to the cluster with the nearest mean, serving as a prototype of the cluster [5].

Another situation is concerned with how many clusters we need for an adequate grouping. We use the Elbow method [15], which is a graphical device to select the *optimal* number of clusters. To determine the number of clusters, an iterative clustering procedure where *k* is increased by *1* is performed. For each iteration, the within-cluster sum of square is calculated. This is the sum of square distances between each element of the cluster and its centroid.

4 Results

After applying the machine learning approach for text mining, we have the following results. Base on the the elbow model, we determined that 6 clusters are required (Fig. 4) by the vertical dashed line. This is arbitrary since there is no a clear elbow in the graphics, and more clusters could be used. The six clusters are described in Table 4.

In Fig. 5 we present a snake plot of the 6 clusters centroids for the electrical procedures characterized as a bag of words. Centroids ranges from *C1* to *C6*. *X-axis* corresponds to the 67 dimensions of the bag of words, and *Y-axis* corresponds to frequency values. As can be observed, there are a few words that are very distinctive of their corresponding clusters, for instance *installation* for *C1* or *AD30* for *C5*. On the other hand, there is a large overlap on the centroids values particularly for the words *structure*, *change*, and *bucket truck* which appear in most of the clusters. Nevertheless, it can be appreciated that by including less frequent words clusters become more distinguishable.

Table 4. Resultant clusters from the *k-means* clustering algorithm.

Cluster	Size	Description
1	7	This cluster is characterized by the word *installation*. It contains several types of installation procedures. This feature is highly distinctive for this cluster since no other cluster contains it.
2	3	This cluster is characterized by words such as *structure*, *TS30*, *isolator*, and *electric pole*. Thus, it contains the procedures related to the replacement of isolators or electric poles for TS30 structures.
3	15	This is the largest cluster and is characterized by words such as *structure*, *change*, and *bucket truck*. It also includes several types of different structures defined by composite words such as *VS30/RD3*. Consequently, this cluster is related to procedures of change of several types of structures using a bucket truck.
4	7	This cluster is characterized by words *conversion*, *structure*, *TS30*. It contains all tasks which are related to the conversion of structure TS30 to other types of structures.
5	4	This cluster is characterized by words *structure*, *conversion*, *bucket truck*, *AD30*. Thus, it contains tasks that are related to structure conversions, from and to, AD30, using a bucket truck.
6	7	This is the most impure cluster: there is a sub set (4 tasks) which is related to changes of damaged structures using two platforms; however, it also contains tasks with very infrequent words like *injured*, *lineman*, *branch* or *fault*.

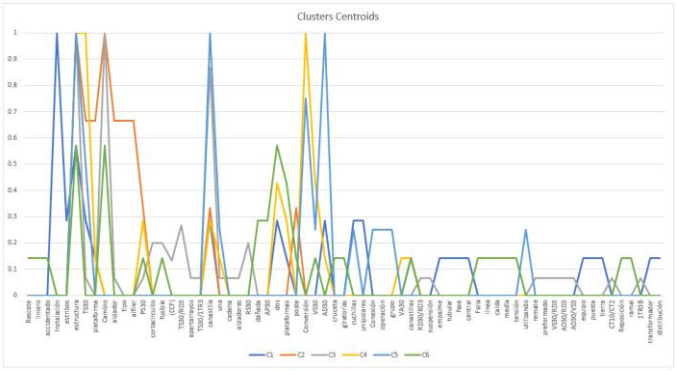

Fig. 5. Snake plot of the centroids for 6 clusters of procedures characterized as a bag of words where X-axis corresponds to the 67 dimensions of BOW, and Y-axis corresponds to frequency values.

Although this clustering separates electrical procedures into *reasonable* clusters, we can also observe that procedures descriptions provide a very limited characterization of the content. This is evident in the large overlap of the clusters in centroid's plot (Fig. 5), and the common words among the clusters (i.e. *structure*, *bucket truck*, *change*). Furthermore, cluster 6 might be divided into two distinct clusters, one containing

changes of damaged structures with two platforms, and the other containing unrelated tasks.

5 Conclusions and Future Work

In this paper, we presented a model to mine instructional content in electrical training systems and preliminary results. We need to do more experimentation before to mine the entire electrical procedure knowledge.

There is a large pool of possible improvements for this work, for example: a) the usage of term-frequency instead of the inverse term-frequency will surely reveal more interesting relations between tasks, even by using BOW, b) stemming and replacing BOW by n-grams will reduce the feature space and reduce redundancy (words *platform* and *platforms* are considered different for our current setup), c) the automation of the stop-word removal procedure will improve time and reduce the appearance of irrelevant words in the feature space, and d) instead of using the elbow rule to select the proper number of clusters, more objective functions such as the Davies-Bouldin index or the Mean Silhouette Coefficient might be used.

Once we have more results, we can analyze the domain structure, and propose applications to several aspects of intelligent learning environments.

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