



# **Integration of formal and informal contexts, for a better learning and a better teaching**

**UNESCO-UNIR ICT & Education  
Latam Congress 2016**



Daniel Burgos  
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(Eds.)



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## PROLOGUE

Informal (and non-formal) learning becomes one of the main open questions in Education, when we discuss how to integrate formal itineraries with the *actual* world, outside the classroom. Furthermore, how to combine the most and the best from both worlds which are, in fact, the one and only? Information and educational resources are everywhere: inside and outside the Internet, inside and outside major mainstreams, inside and outside publishing houses, and a large number of sources. In addition, we count thousands of formal courses, undergraduate, graduate and postgraduate programmes, and other accredited, official ways to acquire competences, achieve objectives and improve the personal background and the options for the future. The key question is how to integrate both, so that the student and the professor work with every single quality resource at hand to reach the same goals, or other complementary goals. Open Educational Resources (including MOOCs, but not only) provide the user (I mean, THE user, from every profile) a never-ending, multi-device, multi-focus, multi-source of knowledge. How can we dare to neglect the right use of this world? How can we dare not to use it, at hand, for so many people in need for Education? And far from that dramatic, obvious question, how can we dare not to make excellent what is already good, to make the best what is already excellent?

This congress, hopefully the first in a series with UNESCO and Universidad Internacional de La Rioja (UNIR) as partners, dives into technology, methodology and policy to make a contribution into the Society. It highlights some challenging approaches along the three main tracks and the invited talks. The final goal stresses the relevance of a required evolution towards a renovated paradigm that takes very much into consideration the current ways of interaction, learning, contribution and sharing that the students, teachers, professors, tutors, administration staff and policy stakeholders deal with, every day, in every classroom, across the World. The whole organization team welcomes you to the proceedings of the congress, as a live proof of the promising integration that we all aspire to.

Daniel Burgos  
General & Scientific Congress Chair  
UNESCO Chair on eLearning & ICDE Chair in Open Educational Resources  
Vice-chancellor for Research & Technology  
Universidad Internacional de La Rioja (UNIR)



## EDITORS' NOTE

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## 1 Introduction

The UNESCO-UNIR ICT & Education Latam Congress was born with the drive of “*Integration of formal and informal contexts, for a better learning and a better teaching*”. Its main focus combines any learning that takes place outside the classroom with the official academic programs.

The congress work on three tracks: 1) Technology & Learning, 2) Educational Methodology, and 3) Educational Policy & Digital Society. A wide range of issues to discuss about, from the analytics applied to learning, cyber security, integration of Open Educational Resources in academic programs, educational innovation or Digital Anthropology.

These proceedings contain a selection of papers presented, in which authors explain their advances in the research areas of the congress. A brief of every contribution is shown in each section of this introduction, according every track described above.

## 2 Track 1: Technology & Learning

The first track of the congress included related papers about technology and learning. Authors talk about visual analytics, learning management systems & ubiquity, eLearning standards, specifications, interoperability and systems integration, among others. In next paragraphs, readers may get an overview of presented works.

Rojas, A. F. et al., in the paper Distributed processing using cosine similarity for mapping Big Data in Hadoop presents the results in implementing cosine similarity for mapping big data in a flat database. For this purpose, the information from movie ratings will be used, so it will result in a recommendation of a movie highly related to another. If the information used for testing is considered real, these results could be useful for the development of a recommendation system for products and services from an organization which has as well the records of their customers’ ratings.

Suing A., et al., in Redesign bachelor's degree in communication. Case study Distance Modality - UTPL in Ecuador shows the redesign of the career of Social Communication for distance learning students made by a team of teachers and researchers in the Department of Communication Sciences of the Universidad Técnica Particular de Loja conducted to attend the provisions of the Organic Law of Communication in Ecuador, which states that all university careers will be redesigned in function of relevance to the needs of their geographical areas, international trends of knowledge and will contribute to achieve the objectives of the National Development Plan of Good Living from 2015 to May 2016

Merchán, S. et al., as part of the initiative to integrate the Significant Learning proposal by Dr. L. Dee Fink into the teaching strategy of the Universidad El Bosque in Bogotá, presents the paper Towards an Integration of B-learning and Significant Learning: A Case study at the Universidad El Bosque with a qualitative research in the form of a case study that is conducted in b-learning courses of the Systems Engineering program in order to assess successes and improvement opportunities for this learning modality.

Merchán, S. and Duarte García, J., present and analyze the experience of applying certain data mining methods and techniques on 932 Systems Engineering students’ data, from El Bosque University in Bogotá, Colombia; effort which has been pursued in order to construct a predictive model for students’ academic



performance. The experience is analyzed according to the results obtained in each of the process' iterations. At the end of the work some recommendations and thoughts are laid out for the future development of this work, and for other researchers working on similar studies. This work is called Analysis of Data Mining Techniques for Constructing a Predictive Model for Academic Performance.

Castillo, J. et al., in the paper Virtual forums as a learning method in Industrial Engineering Organization describe the experiences of educational improvement and innovation carried out in a multi-cultural environment with students of different nationalities of the Engineering School along 5 years. The objective is to change the classic face-to-face educational model of Industrial Engineering School to a new paradigm based on collaboration. They focus on the essential problems and peculiarities of the implementation of this particular e-learning educational system in Industrial Organization Engineering.

Simanca H., F. A. and Abuchar Porras, A., propose a development based on platform Moodle to generate statistic graphics about the student's interaction with activities and resources of the course. Graphics are generated for access and presence, use of resources, activities and participation, established communication, traceability in the platform and interaction among people. Using the LA tool developed, educational processes can be improved because it shows academic progress of students and enables teachers to characterize and monitor students and see in detail their behavior in the virtual classroom. The paper is called Application of a Learning Analytics tools to a Moodle virtual classroom.

### 3 Track 2: Educational Methodology

The second track of this education congress presents papers about methodologies in education. Authors discuss about integration of informal & formal learning, Open Educational Resources and MOOCs, learning strategies and self-guidance, adaptive and personalized learning, for individuals and groups, and teaching methodologies and lesson plans. Following is a brief summary of each work for readers.

Espírito Santo, E., et al., present in the paper Open Educational Resources: initiatives towards culture implementation at a public university a Brazilian public university experience in Open Educational Resources – OER development. They discusse the OER concept in a contemporary approach, i.e., as open to anyone, under an open license that permits no-cost access and free reuse, continuous improvement and repurposing for educational purposes. They present the results reached at the researched university with open education in MOOC's format and the development of open mobile application for physics education (M-Labs) and another for the blind and visually impaired.

Melgarejo, V. E., and Rodríguez H., A. A., taking global Frameworks of ICT4E for developing M&E they expose in Integral schema for Monitoring and Evaluation of ICT Inclusion, Use and Appropriation in Education a design of an integral M&E schema of Inclusion, Use and Appropriation of ICT4E in institutions at Tunja, Colombia. They reached the conclusions that Public Educational Institutions at the city of Tunja are in the second stage of evolution and these always must be line up with national policies and goals.

Llamas-Salgero, F., et al., talk about a Study of the attitude of students towards new technological contexts and neuroscience progress. Technology and Neuroscience have formed a strong collaboration to improve education. They analyse the student's attitudes towards the use of new technologies in the primary school classroom. They designed a questionnaire and gave it to 1.770 students aged between 1–12 years from 50 CEIP (Infant and Primary schools). In general, the results show that whilst students between 11-12 years do not show a rejection of the use of ITC, a low percentage of these demonstrate that they would prefer to use them in a group.

Palacios Osma, J. I., et al. in the paper called Learning platform assessment model LMS, make a proposal to establish a quantitative evaluation system that assesses attributes of LMS platforms, according to institutional requirements. Use and appropriation of a LMS by higher education institutions require a decision that should go beyond economic aspects, especially when there is a mimetic institutionalism in most platforms, which offer similar educational, communication, interaction and management services and tools.

Thomas, J. R., et al., preset a research to know the relationship between knowledge, participation and creativity at an American learning center. The instrument used to evaluate creativity is the test CREA and used



to evaluate the participation and knowledge of the students is the Plickers application. The results indicate that creativity is relating to the participation, and this knowledge. Therefore, due to the relationship between the variables, teaching must include factors such as creativity and interaction for more meaningful learning. The contribution is called Participation and knowledge through Plickers in high school students and its relationship to creativity.

#### **4 Track 3: Educational Policy & Digital Society**

The third and last track of this congress exposes papers about educational policy and digital society. Authors writes about digital learning and ethics, education in Administration and policies, content, self-created content, collaborative content, Cybersecurity, eLearning privacy and overall rights to content, media and research. In the following text, readers can get a sample of articles related to this topic.

Sanchez Rubio, M. and López Civera, G., in Automatic generation of virtual machine for security training explores the applicability of configuration management tools to the design and development of practical content challenges in the field of cybersecurity. Using the tools Puppet and Packer, a series of templates have been developed to create a test scenario. Such scenario has been proposed to contain both vulnerable services and already implemented security measures. Based on this scenario, flexibility of the solution and time saving achieved have been assessed. Through this assessment, it has been determined that the use of these tools is a viable option in developing both small scale scenarios focused on teaching and big scenarios used in cybersecurity events.

Tod Colegrave, P. presents a work called Makerspaces in Libraries: Technology as Catalyst for Better Learning, Better Teaching in which he talks about the product of leveraging technology as catalyst for active learning and engagement within and beyond the physical commons of the library, a blending of formal and informal learning, accented by increased innovation and entrepreneurship across disciplinary and organizational boundaries.

Senderek, R., writes the paper called The systematic integration of technology enhanced learning for lifelong competence development in a corporate context. This paper gives an overview of the nowadays relevant learning enhancing technologies. In addition to this, it suggests a roadmap to integrate technology enhanced learning into the corporate context as well as the existing competence development.

Ramírez Isaza, E., in the work called Contributions of the Analysis Model as a systematization of the Research Project REDCO Red de Conocimiento: CIER Occidente, gives an overview of the research work that Research Education and Virtuality Line of GITT Group (Research Group of Terminology and Translation) of University of Antioquia (Colombia), in alliance with Faculty of Education of the same university, conducted from 2014 to 2016, as one of the five universities that participated in the Project CIER Occidente of MEN (Ministry of Education) and Colciencias, through the Macro Project: REDCO Red de Conocimiento (Knowledge Network).

Gaona-García, P. et al., present a proposal for a navigation system in virtual-reality based on Knowledge Organization System (KOS) in a zoo. The main goal is to analyze the association of concepts in a 3D navigation structure, and basic usability aspects through the use of mobile devices on a population of children aged 10 to 12 years. The rest information in found in Navigation and Visualization of Knowledge Organization Systems using Virtual Reality Glasses: first insights.



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## Distributed processing using cosine similarity for mapping Big Data in Hadoop

Andres Felipe Rojas Hernandez and Nancy Yaneth Gelvez Garcia

Universidad Distrital Francisco Jose de Caldas

**Abstract.** The analysis of big data is an issue that has become very important in recent years. The use of algorithms for processing big data that have generated as a result valuable information to organizations can be considered one of the biggest developments and most important lines of work today. This paper aims to show results in implementing cosine similarity for mapping big data in a flat database. For this purpose the information from movie ratings will be used, so it will result in a recommendation of a movie highly related to another. If the information used for testing is considered real, these results could be useful for the development of a recommendation system for products and services from an organization which has as well the records of their customers' ratings.

**Keywords:** Big Data, Hadoop, Cluster, Cosine similarity.

### 1 Introduction

This paper presents the results and analysis of the use of a recommendation system that implements the cosine similarity algorithm for mapping records from a flat database. The records include information from one hundred thousand movies from the MovieLens database (<https://movielens.org/>) and represent what can be understood as big data with an open and free distribution character. In order to process this information it is necessary the use of distributed computing due to the high computational costs. EMR (Elastic Map Reduce) is a solution of Amazon Web Services that provides a user-friendly environment for cloud distributed computing. Together, there is an environment for data processing in a distributed manner which is intended to analyze the performance and reliability, also the mapping is to analyze the results and what this information can mean for an organization.

### 2 Big Data

Currently, technologies are capable of storing and processing an increasing amount of data. Data of this type is what is known as Big Data. Big data is the term for a collection of large and complex data sets that are difficult to process with traditional data processing tools. Big data can be characterized by three V's: Volume (large amounts of data), Variety (includes different types of data) and Velocity (constant accumulation of new data) [1]. Data becomes big data when its volume, variety or velocity exceed the capabilities of computer systems to store, analyze and process them. Recently the understanding of big data has been expanded by adding two more V components. So, you can characterize big data in five V's: Volume, Velocity, Variety, Veracity and Value [2]. Big data is not only large amount of data, it is actually a new concept that provides an opportunity to find a new vision of existing data.

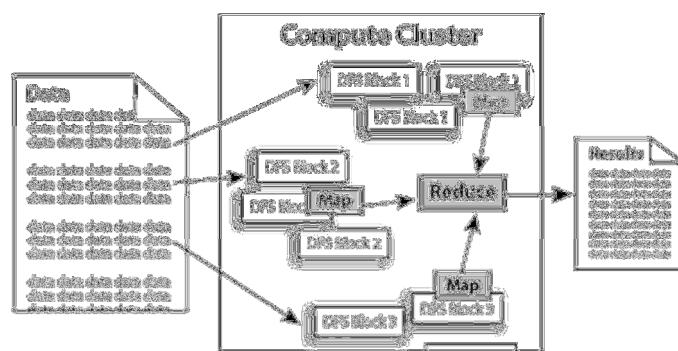
There are many applications of big data: business, technology, communications, medicine, health, bioinformatics (genetics), science, e-commerce, finances, Internet (information search, social networks), etc. Big data can come not only from computers but also from billions of mobile phones, social media messages, different car installed sensors, utility meters, transportation and many more. In many cases data is being generated even faster than it can be analyzed.

Big data can include structured and unstructured information. Unstructured data is the one that either does not have a pre-defined data model or is not organized. Structured data is relatively simple and easy to analyze because, usually this data resides in databases as columns and rows. The challenge for scientists is to develop tools to transform unstructured to structured data [3].

When it comes to big data, grouping it becomes a problem. Often data sets, especially large data sets consist of some groups (clusters) that need to be processed simultaneously. The Cluster method has been applied to many important problems [5] due to the potential of computing distribution. For example, to discover health trends in patient records, to eliminate duplicate address lists entries, to identify new classes of stars in astronomical data, to divide data in meaningful and useful groups and to group millions of documents or websites. To address these applications and many others a variety of clustering algorithms have been developed. There are some limitations in the existing clustering methods. Most algorithms require exploring data sets several times, so they are not suitable to be processed in a single node. Data cluster provides a more reliable and plausible solution for processing big data.

## 2.1 Hadoop

When it comes to big data, it is about challenges such as data rate, data volume and variety of data. EDW and Hadoop technologies can be useful for managing these challenges. Hadoop is an open source framework and is the source of technology that preceded almost every data storage and analysis tools that have been labeled as ‘Big Data’ (<http://hadoop.apache.org>). With Hadoop it is possible to build easily, economically and effectively in a very large scale a data storage and processing solutions system. Hadoop file system (HDFS) allows to send data in Hadoop and then works with them simultaneously on all disks and all servers in the cluster. In the cluster there are multiple computers so Hadoop provides a new approach to distributed computing by implementing an idea called MapReduce (Reduced Mapping). MapReduce is essentially a programming model for processing big data under a parallel distributed algorithm that allows the separation, processing and aggregation of information. Compared with traditional relational database management systems (RDBMS), Hadoop provides improved query response times and integrity with other data analysis products [3].

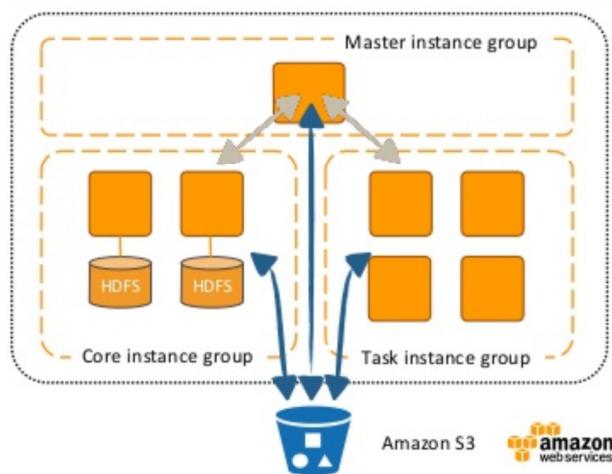


**Fig.1.** Information flow in a Hadoop Cluster (Source:<http://sentidoweb.com/2007/11/21/hadoop-plataforma-para-trabajar-con-gran-cantidad-de-datos.php>).

## 2.2 Amazon Elastic Map Reduce

Elastic Map Reduce (EMR) is a web service from Amazon Web Services (AWS) for fast and cost-effective processing of big data. It simplifies big data processing by providing a self-managed Hadoop framework that facilitates the distribution and processing of big data between instances dynamically scalable called Elastic Cluster (EC2). EMR manages safely and reliably their big data use cases including log analysis, web indexing, data storage, machine learning, financial analysis, scientific simulation and bioinformatics.

EMR uses Hadoop processing for tasks such as web indexing, data mining, log file analysis, machine learning, scientific simulation and data storage [7].



**Fig.2.** EMR Architecture

(Source: <http://www.slideshare.net/AmazonWebServices/clickstream-analytics-amazon-kinesis-and-apache-storm>)

## 3 Cosine Similarity

Cosine similarity erroneously called cosine distance is really a mapping similarity measurement. Cosine similarity is a similarity measurement between two vectors in a space that has an inner product which is used to evaluate the cosine value of the angle between them. This trigonometric function provides a value equal to one if the angle is zero. For any angle between the vectors the cosine would result in a value less than one. If the vectors were orthogonal the cosine would be nullified and if they were pointing in the opposite direction its value would be minus one. Thus, the value of this metric is between minus one and one, i.e. in the closed interval [-1, 1]. This is the formula to calculate the cosine for two vectors with  $S_{ij}$  features (1).

$$\text{Cosine } (a, b) = \frac{\sum_{i,j}^N S_{ij} a_i b_j}{\sqrt{\sum_{i,j}^N S_{ij} a_i a_j} \sqrt{\sum_{i,j}^N S_{ij} a_i a_j}} \quad (1)$$

This distance is often used in information retrieval representing words (or documents) in a vector space. Once represented the documents and queries as vectors we can measure their similarity. An alternative is to use the Euclidean distance but the difference in length between documents would affect the metric. What is most often used is the cosine of the angle between the vectors as a similarity measurement. In text mining cosine similarity is applied in order to establish a resemblance metric between texts. It is often used as a cohesion



indicator of text clusters. The complexity of this measurement is quadratic, which makes it completely applicable to real-world problems. This complexity can even be transformed into a linear one [6].

## 4 Mapping Application

To conduct an analysis of information in big data we proceed with the following steps: preprocessing of the information, distribution, processing, results and analysis. The preprocessing of the information is the identification of variables that are necessary and will be included in the analysis, as well as the collation and digitalization of information that can come from any source, it also cleans data of unnecessary records. In the application this is done during mapping. The distribution is the establishment and distribution of information in a cluster where distributed computing can be done. In this case, it corresponds to the EMR instances. The processing of the information is the core of the entire operation. In this case, it is the cosine similarity mapping. At the end there are the results which provide information that can be analyzed. In this paper all those steps are not discussed since the information used was collected externally by the organization MovieLens.

#### 4.1 Preprocessing of the information

The data that will be used for the application correspond to one hundred thousand movie records whose information is in digital format in a plain text document. This means that it is not necessary to collect, classify nor organize information. What is necessary is to identify the variables to be mapped or more precisely, the variables that are necessary to establish a correlation. If you consider that each record in the database is given of the form [user ID, movie ID, rating, time tag], then when you run the mapping the data will have the form (key: movie ID, [ratings]) discarding the other data because it is not important for the correlation. Previously, all the names and movie IDs are taken from another file in order to use them after the correlation to make the results more legible. The latter is included as another mapping step and only influences the processing time. Below it is displayed a portion of the file containing the movie ratings and the one containing the names. (See Fig. 4 and 5)

22	377	1	878887116
244	51	2	880606923
166	346	1	886397596
298	474	4	884182806
115	265	2	881171488

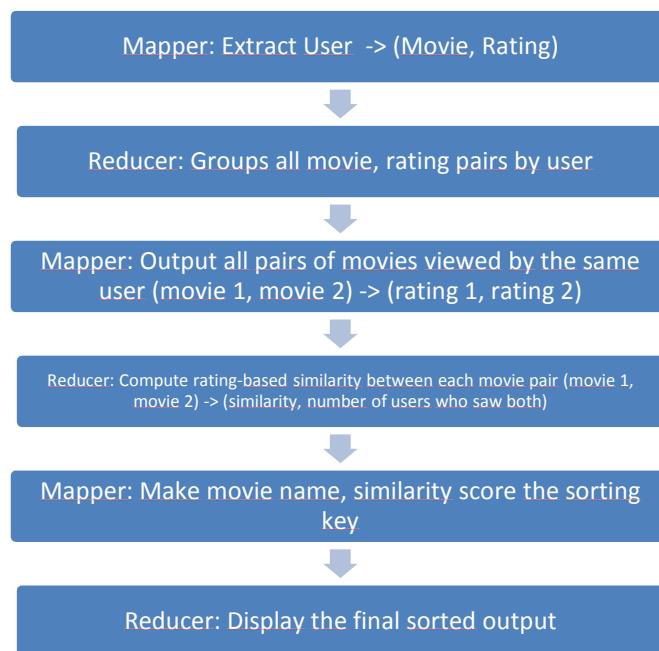
**Fig.4.** Ratings file sample

**Fig.5.** Names file sample

## 4.2 Distribution and processing

For the distribution it is precise the use of the Amazon S3 scalable cloud storage, other of the AWS services. Initially data is uploaded to the cloud, then the mapping and reduction in EMR is executed and finally the response is received on the local computer. The response could be stored in S3 but it is a dispensable procedure in this case. It should be remembered that the purpose of this paper is the performance analysis of the correlation in different configurations of a cluster and then the mapping procedure is the same for all tests.

An initial test is performed as a control sample in a local machine with depreciable features. The same procedure is later done in a slaveless cluster or an EMR machine. Consecutively then the same procedure is performed with more complex cluster configurations as it follows: one master machine and a slave; one master machine and two slaves, and finally one master machine and three slaves. In all cases the same procedure is followed step by step. Mapping for extracting variables, reducing to group movies and ratings for each user, mapping to link paired films with paired ratings, reducing by executing the cosine based similarity correlation, mapping to change the movie IDs for their names and finally reducing to generate an output file. Below is a chart where the whole process becomes clearer. (See Fig. 6)



**Fig.6.** Steps for the correlation test

## 4.3 Results

For this paper the results can be classified into two types: data processing results and cluster performance metrics.

The results of data processing correspond to the result of the correlation of movie records and their ratings. The aim in using the cosine similarity is to provide information that is easily readable and say how related regarding their rating are some movies from others. At the end the result is a set of records of the form [movie

name one, movie name two, correlation level, number of ratings]. Movie name one and two is the filter after merging the name record (See Fig. 2) with the correlation result. The correlation level is a number between zero and one that represents the correlation percentage between movie one and two. The number of ratings corresponds to the number of times movie two was rated. Thus, it can be interpreted that the movie that has more correlation with other is the one that has a higher level of correlation and has been greatly qualified. (See Fig. 7)

```
"Star Wars (1977)"      ["Nell (1994)", 0.95440149533124929, 75]
"Star Wars (1977)"      ["Jumanji (1995)", 0.95454005841416234, 91]
"Star Wars (1977)"      ["Shine (1996)", 0.95478403680312518, 104]
"Star Wars (1977)"      ["Mary Poppins (1964)",
```

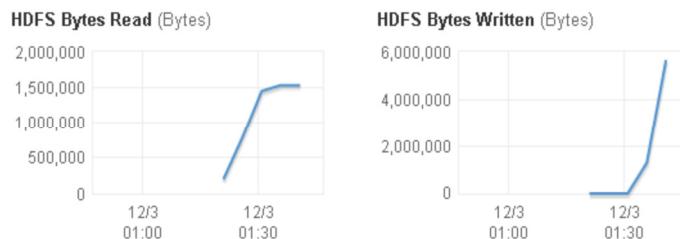
**Fig.7.** Final correlation file sample

The metric results for the tests corresponding to four cluster configurations each one adding a node to the control test are presented below. The identification of each step is mapping (Step 1), the cosine similarity correlation (Step 2) and the organization and result display (Step 3). All the above steps correspond to a MapReduce process (Mapping and Reduction).

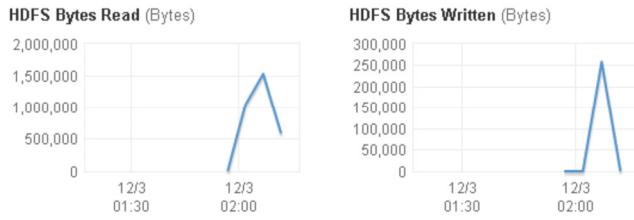
**Table 1.** Runtime Steps for each cluster configuration

Step (time) / Cluster Conf.	Local Machine	(1) Control Machine	(2) Cluster with 1 slave	(3) Cluster with 2 slaves	(4) Cluster with 3 slaves
Step 1	--	2 min	2 min	2 min	3 min
Step 2	--	37 min	35 min	21 min	14 min
Step 3	--	2 min	2 min	2 min	2 min
Total	50 -60 min	50 min	48 min	34 min	27 min

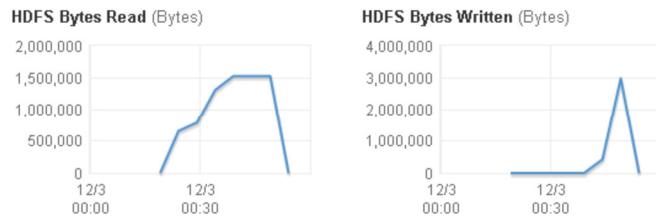
In addition to the relationship between steps and processing time, AWS provides an analytical section wherein the following graphs are generated (See Fig. 8 to 10). These are the ratio of consumption of the clusters HDFS storage system over time given in bytes. It is important the analysis of this data as in a production environment since the ability to improve the performance of a process is a critical procedure.



**Fig. 8.** HDFS file system performance for control machine (1)



**Fig.9.** HDFS file system performance for cluster (2)



**Fig.10.** HDFS file system performance for cluster (3)

## 5 Analysis

Product and service recommendation systems are currently on the web a matter of primary concern. The test of an algorithm than can correlate ratings not only of movies but from any type of product then can take even more relevance. From the results of Table 1 it can be concluded that the use of distributed computing significantly reduces the information processing time in critical processes. However, and contrary to common sense, adding more nodes to the cluster does not make the processing time divide into the number of nodes compared to a single machine. Time is indeed reduced but not in direct proportion to the number of nodes in the cluster.

Regarding the clusters HDFS file system performance it can be said that adding more nodes will affect dramatically the speed and amount of data input and output. It can pass the order of six million byte write (See Fig 8) on a single node cluster to two hundred fifty thousand bytes (See Fig 11) in a four node cluster.

To improve the performance when processing the data there are some changes proposed such as: discard the bad ratings before making the correlation i.e. at the time of mapping, change the correlation type (Pearson correlation, Jaccard coefficient, conditional probability). Although it is not the purpose of this paper, it is a good way to improve the patch. Other changes are adjust the threshold of minimum amount of ratings or minimum ratings, suggest a new similarity that can be correlated as well and take into account the number of ratings. All of the above is not studied in this paper but since these factors directly affect the performance it is worth proposing them.

## 6 Conclusions



Cloud distributed computing by cluster is a very good alternative to traditional computing especially when it is intended to process and analyze big data. Some companies offer services for cloud computing. The Elastic Map Reduce service based on Hadoop is very easy to use, it requires no maintenance or configuration and still, has the processing potential from any other distributed computing environment. It also has the ability to scale according to the processing needs. Using correlation based on cosine similarity is a procedure that can be used as a base for a product recommendation system. Although it is not the fastest correlation it has good reliability and an acceptable computational complexity performance. Finally, although cluster distributed computing is better in volume, variety and velocity this does not mean that the work and process runtime scale linearly compared to the number of nodes in the cluster.

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## Redesign bachelor's degree in communication. Case study Distance Modality - UTPL in Ecuador

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**Abstract.** To attend the provisions of the Organic Law of Communication in Ecuador, which states that all university careers will be redesigned in function of relevance to the needs of their geographical areas, international trends of knowledge and will contribute to achieve the objectives of the National Development Plan of Good Living <sup>1</sup> from 2015 to May 2016, a team of teachers and researchers in the Department of Communication Sciences of the Universidad Técnica Particular de Loja conducted the redesign of the career of Social Communication for distance learning students, as presented below.

**Keywords:** Higher education; communication; law; curriculum; development; chairs; integration.

### 1 Introduction

The redesign of communication studies in distance modality from the Universidad Técnica Particular de Loja (UTPL) is intended to train communicators at grade level, from the humanism vision of Christ that guide's the University, so that they can develop and exercise their profession in an ethical sense, in the context of the right to communicate and have freedom of expression, contemplated in the National Plan of Good Living.

The academic offer is destined for people who cannot attend a presence university program but demands a constant intake of students to gain skills and knowledge for the management of communication technologies, discipline in managing their study time and self-criticism capacity.

The pertinence of communication studies is given by several elements ranging from its conception as a right of individuals to the contribution of development of organizations and technological innovations. Even though communication is a civil right guaranteed in the 2008 Constitution of Ecuador it also requires, among other conditions, professionals trained to handle communication in a responsible manner, educational task's that at a superior level of specialization contend responsibility of the universities.

Communication is, firstly, a fundamental anthropological experience. In an intuitive manner communication consists of exchanging with the other; it is simply not possible the individual and collective life without communication [1]. Therefore, the communicational conception becomes the instrument generating content, which prioritizes the fulfillment of citizen's right to inform and be informed.

For the exercise of communication in Ecuador it is relevant to consider the Organic Law of Communication approved in 2013, which in its Art. - 71 states that: "Information is a constitutional right and a public good; and Communication, which is elaborated through the media, is a public service that should be provided with responsibility and quality." To fulfill the vision of communication as a public service it is necessary the development of communicators capable of generating and sharing quality content in a responsible way, in this context the intervention of the academy is essential. Part of this vital process constitutes the agreements and cooperation conventions with which it pursues to "expand educational programs at a national level, strengthen university networks, promote the approval of the curriculum diagram".

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<sup>1</sup> The National Plan for Good Living 2013-2017 is a tool designed to create public policy with management and public investment. The Plan has 12 National Strategies and 12 National Objectives.



The Career of Communication at the UTPL, as part of the distance educational offer covers up several provinces of the country matching the urban centers of the highest population rate and that are located in equidistant cities to attend the entire territory, also there are the places that historically have attended the demand for education in the communication field. But in addition to this we inform the population interested that the process could not be accomplished without the personal effort of each student, accompanied by a profound sense of ethics.

The Career of Communication at the UTPL articulates with the goals (4 and 5) of the National Plan for Good Living [3], in connection with the training of professionals with conviction service to inform the public, analyze the exercise of power and promote democratic debate; these actions lead to strengthen political, economic, social and cultural development.

As for the epistemological horizon of the profession should refer that is related to the academic traditions in communication sciences, which take form in the XIX and XX centuries, they are associated with three big groups: normative theories; theories of media, culture and society; theories of audiences that constitute the theoretical basis upon which it supports the training proposed in communication at UTPL [4] [5].

The structuring cores that proposes the Communication Program as part of the redesign process, falls into four main groups:

- Management and handling of journalistic information. The transmission of information is the key to communication. Public communication processes centered their sights on the content received by users, prioritizing a service that provides the communication over technology. In this context, it is necessary a responsible communication, with special care in the treatment of information and proper use of ICTs, without neglecting the context of social reality.
- Cultural industries for development. According to UNESCO [6], cultural industries are the ones that carry out creative and artistic tangible or intangible products, with potential to generate income through the exploitation of cultural assets and the production of goods and knowledge-based services.
- Information technology. Since the seventies, technologies have marked the evolution of the media by its form and background; they have consolidated digital media that can coexist with conventional media. Technological tools and digital speeches are imperative for the exercise of communication. Reference to the concept of transmedia, understood as the intentional fragmentation of information across different platforms and supports in order to provide the audience further knowledge of content.
- Strategic communication. Organizational development is the practice that aims to uncover, systematize, formalize and update the internal culture that forms the identity of an organization. Strategic communication is responsible for: "1. Spreading identity within organizations through systematic exercise of organizational communication (also called internal communication); 2. Transform identifying features, characteristic of an organization in symbols or signs that may be communicated systematically to relevant external audiences "[7].

The real problems that integrate the subject matter of the profession start from a recognition of the following issues:

1. The Ecuadorian culture industry generates goods and services that do not supply the national market, which does not express the potential of cultural knowledge.
2. Globalization entails the development of the society of information and represents a risk for local identity because of the existence of current cultural domain.
3. In the country, Internet infrastructure connectivity is limited.
4. The Organic Law of Communication (OLC) determines the equitable presence of public, private and community media.
5. It is necessary to work for a balance in content and in audiovisual genders.



6. Another problem is the use of advertising poorly oriented for social responsibility commitment.

The trends in local and regional development, which are included in the areas of study and performance of the profession, are:

1. The progress of the society knowledge allows greater access to information for education.
2. The digital illiteracy.
3. New forms of communication and Web 2.0, which result in digital convergence.
4. Increased of political participation and the growing interest in political accountability
5. Strategic communication contemplates the art of organizing and planning, using an integral structure of the channels in and out of the organization.

Based on the grounds exposed we search to propose a curriculum planning for undergraduate studies in social communication for distance studies at the UTPL in Ecuador. The research hypothesis is: The redesign of undergraduate studies in communication UTPL reaches a curriculum that integrates the development objectives of the country and responds to a tendency of local and regional development.

## 2 Methodology

The methodology used is qualitative from the review of official documentation produced by the Higher Education Council of Ecuador, regulations and instructions for the redesign of university courses, a review and formulation was conducted between December 2015 and February 2016.

## 3 Results

The proposal's degree in study of the generation of communication products, messages emitted from the media and the normative that guides the practice of communication, to develop edocommunication and transmedia content, which responds to the demands of citizens, users of new media, in relation to Interculturality and the dialogue of knowledge.

We pay attention to the policies and strategies of the objective five of NPGL2 expressing the need to "build common meeting spaces and strengthen the national identity, the diverse identities, plurinational and Interculturality" [3]. The emphasis put in these actions allows the creation of dialogues that promote social integration and inclusion of all citizens in the spaces of empowerment of citizenship. As well consolidating democratic processes that enable peaceful interactions between citizens, transforming the social reality and contributing to a sustainable development.

For this proposal to formalize, the bases are built upon the principal core of the profession, through which specific programs and communication products develop inclusively with a strong accountable identity root. In this manner it would be achieved the respond to the need of improving the quality of products that would be part of the cultural industry of Ecuador.

The redesign proposed by the School of Communication, attends mainly the study, the construction and diffusion of knowledge through professional training from the humanism of Christ, with ethical sense for a wide exercise of communication rights and freedom of expression.

Specifically, the training of journalists proposes the handling of social media, communication tools and research methodologies that allow the inquiry and processing of information that the communicator will provide to the community. Appropriate with access procedures and democratization of information, towards building the knowledge society.

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<sup>2</sup> National Plan of Good Living



In this process of change, the offer of learning communication requires the incorporation of technological innovations and social relations in interaction with internal and external audiences to whom the communication is directed.

The distance learning system of the UTPL has a way of teaching and learning based on "a mediated didactic dialogue between teacher (institution) and student located in a different space from the teacher, which will learn in an independently and collaboratively way" [8]. Since mediation is almost entirely through ICT, we can also define distance education as a technological multidirectional communication system that links multiple teaching resources, a solid tutorial work and an effective support of an organization. For its part, the Council of Higher Education in its Article 4 of Regulation career and academic programs in online modes, distance and part-time learning or convergence of media, consider distance learning as "one in which the teaching component, practical application and experimentation of learning and autonomous learning, are mediated through the use of technology and virtual environments on platforms of interaction, and the articulation of multiple educational resources (physical and digital)" [9].

The distance education model is strengthened with the mission, vision, principles and institutional values. This mode supports its management components that are harmonically overlapped in an educational model based on skills that guide the entire curriculum design; where the student is the central actor in the educational process, the same one that is mediated by a teacher and tutoring, teaching materials and resources equipment and new technologies. This entire set is permanently fed by the evaluation-research that provides information for continuous improvement of processes and the quality of educational services being delivered.

The UTPL specifies its educational model according to the following areas: integral formation of students; responsible learning; teaching organization in teams; competition curriculum and guidance practice; research for learning; the use of educational technologies and the entailment with society.

The integral formation of students occurs in educational activity supervised by the teacher, which promotes to be addressed in a comprehensive way, all the scales of a person (physical, psychological and spiritual) and their different fields of action (individual, social, political, religious, educational), all with the aim of achieving full development with a sense of perfection, through their personal life project. In this area it is necessary to consider the profile and the specific characteristics of students, since these factors also preside modalities and study methodologies applied. A part of the cultural heterogeneity and age, other important aspects to consider are prior knowledge, study habits, learning styles, various family and work commitments, and the degree of professional experience, which starts the formation.

Finally there is an increase of people that access the UTPL with special needs and limitations of various kinds: groups historically excluded from higher education or living abroad Ecuadorian citizens. The UTPL is addressed to anyone who wants to study, regardless of his or her economic, labor, family, geographical and physical background, by making accessible quality higher education to anyone who needs it.

The Universidad Técnica Particular de Loja, inside a stage of technological innovation, undertakes on a new scheme for the delivery of bibliographic material in Distance Modality; which consists in an electronic bibliographic material and an electronic device; these materials include:

- Electronic device type Tablet
- Conventional basic texts
- Didactic guides or guideline texts of various components
- Distance exams

As for the use of educational technologies, the UTPL will rely on the pedagogical and didactic mediation of educational technology, especially virtual learning environments and open educational resources OER, who obey intentionality's macro and micro curriculum defined, and designs well-structured and planned. The use of technology also allows an inclusive educational system, according to the mission and social responsibility of the university.



The technology will encourage the responsible character, free and collaborative learning. From this technopedagogical perspective, it is not the system of studies and the student who will adapt to the requirements and the technological developments, but rather the technological instruments that will be adapted to distance education modality and the type of population involved in this process.

The support resources: Information and Communications Technology are the following:

- Virtual Learning Environment (VLE)
- Academic Chat
- Video collaboration
- Videoconferencing
- Academic Forum
- Physical and virtual Libraries
- Open Educational Resource - OER

The educational model of the UTPL, according to their vision and mission, recognizes Christ as the teacher by excellence. This model is scientifically based on the metaphysical ontological thought of Fernando Rielo [10], founder of the community of Idente Missionaries, in which the human person is defined as a mystical being, inhabited constitutively by someone, by an absolute model, that is present in his consciousness, knowledge and learning, which opens to perfection in him and in all fields of their life.

In the UTPL, the education act includes two key points, according to Fernando Rielo: education in ecstasy and the education in a reciprocal cult, from them different didactic focuses and methodologies of teaching and learning will arise, avoiding reducing the educational act at an instrumental and methodological level.

The end of the pedagogy of the UTPL consists essentially of educating the ecstatic man's ability to come out of themselves and pursue the encounter, to fusion with the absolute, with the truth, that will lead for the full realization, the mastery of a field study, the integration of different types of knowledge, placing them at the service of the integral welfare of the person and society.

In response of the exposed, the proposal formation (Fig. 1) integrates fields of study regarding constructs that organize the knowledge in an inclusive manner, rescuing experiences and processes of reality, for its understanding, prevention and intervention. It also attends tensions and problematic nucleus focused on the following areas:

- Axis of communication. The public, private and community media should guarantee pluralistic, objective and truthful information, so it complies with the fundamental purposes of communication: educate, entertain and inform.
- Axis of development and cultural integration. It is understood by culture expression of citizenship, the dialogic encounter and spontaneous generation of new visions of society.
- Axis of technology implementation. The use of technological tools has evolved and allows new ways of communication, where the citizen has taken a leading role generating basic content that attempts to fulfill the demands of journalism.
- Axis of regulations and citizen participation. Citizen participation is a right consecrated in the Constitution, seeks the integration of actors in the areas and processes that are generated in communication systems based on the normative that regulates community, social and business acts in different media and forms of communication.

Also, the curriculum diagram presents a research model articulated to the purpose of the research training of future professionals in each of the units of curricular organization and of studies.



**Fig. 1.** Curriculum proposal. Elaboration: Own

## 4 Conclusion

The Career of Communication aims to transform the study, construction and diffusion of knowledge about culture, digital technologies and the use of language, using in this process the various tools and communication platforms, to create contents that promote the management of responsible and critical information at the service of the community, the media and organizations. Therefore the hypothesis is accepted: The redesigns of bachelor's studies in communication at the UTPL reaches a curriculum that integrates the development goals of the country and responds to trends locally and regionally develop.

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## Towards an Integration of B-learning and Significant Learning: A Case study at the Universidad El Bosque.

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**Abstract.** As part of the initiative to integrate the Significant Learning proposal by Dr. L. Dee Fink into the teaching strategy of the Universidad El Bosque in Bogotá, qualitative research in the form of a case study was conducted in b-learning courses of the Systems Engineering program in order to assess successes and improvement opportunities for this modality, in relation to the integration of this pedagogical proposal, particularly the Integrated Course Design model by L. Dee Fink. The results found allow to recognize the real development of these courses in order to reflect on it and design timely improvement strategies that can be extended to other Schools and Undergraduate Programs and lead the proposed implementation of B-learning to become a success story and a permanent study case.

**Keywords:** B-learning, Significant Learning, Fink, Assessment, Integration.

### 1 Introduction

Blended learning is not only an alternate arrangement of the teaching-learning environment. Currently, this modality is recognized as enhancing both learning process and outcomes by combining the advantages of traditional teaching and new strategies for building skills in the use of technology [1,2]. “Blended learning is the optimized achievement of learning objectives, applying the right skills to the right people at the right time” [2], which means that in addition to proposing new learning environments, this modality is also interested in the results of the process and the particular characteristics of learners. Additionally, blended learning is presented as ideal to engage in learning processes that meet competence standards and challenges of the 21<sup>st</sup> century [1]. Blended learning can no longer be considered as an alternative, but as a necessity that should be part of a comprehensive teaching strategy [3].

In the same way, integration of technologies in teaching processes has ceased to be an attractive novelty and has become a need. Innovations in this field allow to have tools that promote exchange, cooperation and collaborative construction of knowledge [4], among other skills. In this regard, there are studies that show the impact of ICT use in the performance of students in blended environments [5, 6].

After recognizing the value of blended learning and ICT integration in teaching, the need to address these environments with designs based in pedagogical models is emphasized. In this regard, models have been proposed for the implementation of this modality in Higher Education, where students are active participants in the construction of knowledge by applying Constructivism and Conversation theories together with instructional designs that consider technological, educational, institutional and social perspectives, further enhancing learning experience and outcomes [4].

In accepting the b-learning modality as a proposal for instructional redesign, learning objectives and teaching and assessment strategies proposed must focus on the student and seek the development of different learning dimensions [3], such as critical thinking, problem solving, collaboration, self-directed learning, and knowledge exchange. Pedagogical proposals centered on the learner then emerged, where the teacher is responsible for creating rich learning environments and experiences, rather than being a mere transmitter of knowledge [4], [9]. In particular, the prospect of Significant Learning provides a general framework for proposing didactics



that consider learning as a multidimensional concept [9] which favors instructional design with technology integration [10], [11].

Although there is a sufficient conceptual framework to integrate blended learning with ICT use in the university environment with positive results, other studies show that the student's level of commitment, motivation, availability and understanding of resources and materials are also variables that affect the success or failure of the modality [2]. In this sense, there are studies that show how, in spite of having the conceptual framework, failures in the instructional design of these environments are very frequent [12]. Furthermore, it seems like that are not enough studies to answer the following questions: How useful are the skills built online in face-to-face situations? [13] How is it possible to build 21<sup>st</sup> century skills in a b-learning course in order to achieve meaningful learning? [11].

In order to contribute to the discussion on the relationship between Significant Learning and Blended Learning, this paper presents the results obtained when assessing the implementation of the b-learning modality in the context of the proposal for Integrated Course Design by Doctor L. Dee Fink [9], in three courses of the Systems Engineering Program at the Universidad El Bosque; considering the different elements involved in the teaching-learning process: Virtual setting, characteristics of teachers and students, learning goals and strategies, and assessment activities.

## 2 Institutional context: Implementation of the B-learning modality

The Universidad El Bosque located in Bogota, Colombia has resolved to take on two important challenges regarding its academic work, which has been set out in its 2011-2016 Institutional Development Plan [14]. Firstly, being consistent with global development trends, policies and prospects, the University integrates ICT in a cross-sectional manner in all its strategic axes. That is how the University formulates the integration of online training activities and strategies in some of the courses provided by academic programs. To fulfill this task, the School of Engineering proposed the integration of virtual settings in half the classes agreed, for at least three of the courses that make up its programs, while technologies associated with Web 2.0 were intentionally implemented as a means of formal communication in other courses. Thus, the B-learning modality starts in the Systems Engineering Program, where three senior-year subjects taught by teachers open to and fond of the modality were chosen.

Second, also in 2011, the University regulated its institutional pedagogical model [15], which recognizes the need to respond to the demands for knowledge of the contemporary world, through educational approaches that prioritize basic skills to access the information and technology culture, that favor personal and cognitive balance, and that transform pedagogical processes for students to build quality learning [15]. This is how the potential of learning-focused educational approaches incorporating objectives, strategies and resources that lead to the construction of meaningful learning is identified, and the proposal for the creation of courses for Significant Learning by Professor L. Dee Fink [9] is adopted in the design of syllabi or lesson plans of undergraduate academic programs.

While both processes have advanced positively, from teaching practice and student experience, it is perceived that in some cases the B-learning modality has been limited to transferring classroom strategies to the virtual classroom, without reflecting on the educational implications and impacts they have on student learning. In connection with the creation of courses for Significant Learning, although skills to design lesson plans have been achieved in teachers, in some cases implementation of teaching strategies involving meaningful learning experiences is not yet clear. This situation becomes more complex when the courses chosen to be developed in a blended manner set out a goal to be achieved in two ways: Achieving meaningful learning and doing it in the B-learning modality.

### 3 Basic concepts for the study

#### 3.1 Meaningful Learning

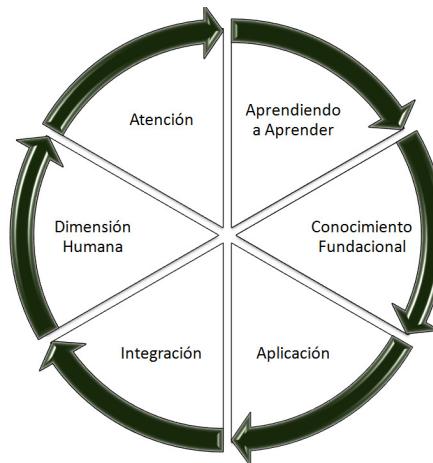
Meaningful learning recognized as a learning theory postulated by David Ausubel [16] states that the construction of knowledge in the individual is the product of the interaction between what is going to be learned (new information) and a previous cognitive structure, in a process of assimilation and accommodation of concepts [17]. This assimilation of concepts does not imply a mere cognitive connection or association, but the modification of a previous cognitive structure and the evolution of new information, when the latter is linked to pre-existing relevant aspects [17]. Unlike behavioral learning theory, meaningful learning suggests that learning is not only reflected in changes in behavior but in assigning meanings to new knowledge as a product of experience.

#### 3.2 Significant Learning for L. Dee Fink

L. Dee Fink in his proposal for creating meaningful learning experiences [18] provides a valuable set of recommendations, including actions that higher education institutions can take to support teaching more effectively. In this proposal, learning activities do not center on passive learning, in which individuals receive knowledge transmitted by an external source, but are more focused on active learning [19], in which the apprentice engage in doing things and reflecting on their actions and achievements, finding meaning in what they learn.

In incorporating new techniques and tools, Fink proposes a comprehensive perspective for active learning because he believes that learning activities must be designed directly and indirectly in three ways: Appropriation of information and ideas, experiences and reflective dialog, forming an integral and indivisible whole. He proposes strategies that allow to increase the learning experience with the integration of modes and experience opportunities to create a reflexive dialog [9].

Fink's proposal, based on the theory of meaningful learning, presents an integrated, interactive six-dimension taxonomy of learning (Fig. 1):



**Fig. 1.** Significant Learning taxonomy



[Traducción imagen en el sentido de las manecillas del reloj: Learning How to Learn, Foundational Knowledge, Application, Integration, Human Dimension, Caring]

*Foundational knowledge*, referring to what is to be remembered and understood; *application*, relating to the implementation and use of skills to develop critical, creative and practical thinking; *integration*, in which connections between people, ideas and areas of life are established; *human dimension*, which aims at the student learning from themselves and from others; *caring*, referred to the motivation, commitment, and responsibility acquired by the student in the course, while learning new values; and finally, *learning how to learn*, the dimension which is to be furthered, consists in building bases, habits and tools for the student to be able to learn on their own, i.e. a self-directed learning, which lasts over time [9]. When thinking about an integrated, interactive learning taxonomy, the overall development of students is favored as it adjusts to current teaching needs. Using this kind of activities, students are led to understand, remember, apply, relate and assess knowledge by learning from themselves and others and acquiring skills for the rest of their lives [20].

To accompany learning activities, Fink proposes assessment strategies focused on the educational evaluation that assesses learning quality achieved by students based on the same learning goals. Therefore, he recommends that it should be *anticipatory*, incorporating exercises, questions and/or problems “that create a real-life context for a particular issue or problem that needs to be handled” [9]; have defined criteria and standards known by students; and be *self-reflective*, giving students the space and opportunity to evaluate their performance and learning process frequently and immediately.

### 3.3 ICT, B-learning and Significant Learning

Blended Learning, as a setting in which methodologies and technologies converge, recognizes the responsibility for integrating strategies in an intentional, planned and careful manner so that the environment set is not the mere sum of classroom and online methodologies, or traditional and ICT-mediated didactics, but rather an appropriate, rich environment for the construction of knowledge that cannot be achieved in the same manner as in the traditional setting. In this learning mode, the teacher uses ICT for the benefit of the student's process, playing a dual role: classroom teacher and online tutor [21].

Regarding learning theories underlying ICT use in teaching and learning, there are countless contributions that show there is no general, static framework, but rather, each of the classical theories of learning and pedagogy have been adapted when one or another technological mediation is proposed. For this reason and due to its very nature, B-learning environments cannot be framed in any learning theory, because they are not a technology per se, but unique environments that are established with respect to the reflection on the learning objectives intended, on which theory is more adequate, and what the most appropriate technologies are for such needs [21]. Consequently, it is completely valid and viable to think about developing meaningful learning dimensions in B-learning environments where ICT are means and mediation for student learning [10].

## 4 Methodology

Given that the aim is to analyze a phenomenon in its natural environment based on the study of several of its constituent elements, this case study with a qualitative research focus analyzes, describes and approaches an assessment of the B-learning modality in the courses of Digital Communications and Equipment, Project Formulation and Project Management offered in the 9th and 10th semester of the Systems Engineering curriculum, in the light of the meaningful learning approach.

The research process was developed in the nine phases proposed by Hernández Sampieri [22]. This section describes the activities carried out for each phase.

Based on the particular research interests of the Engineering for Education line of the Research Group OSIRIS [23] and the awareness of progress and difficulties in the implementation of the B-learning modality at the University, the initial phase, called Idea, recognizes the need to research formally into the phenomenon to provide evidence that allows to devise and implement improvement strategies that lead to the strengthening of the training process and the success of the proposal.

On the second phase, the research problem and variables comprising it are set out. From the preliminary interview with teachers and students, a scenario of apparent discrepancy is identified between planning and execution of courses, between proposed learning objectives and goals achieved, and between the institutional academic proposal and the methodological aspects of each subject. In that sense, the research problem is defined as **the recognition and evaluation of the modality** in relation to the Significant Learning approach of the institutional pedagogical model, characterizing situational factors, learning activities and goals, and assessment strategies that are part of these subjects.

On the third phase, the context in which the courses are developed is studied, identifying actors, artifacts and baseline scenarios for research. This gives way to the fourth phase where the research process is planned, defining a) sources of information, b) timelines for data collection and analysis, and c) data collection instruments. The resulting research design is shown in Fig. 2. For the design of instruments, the criteria chosen for data collection were those identified as variables of the phenomenon to be studied, defining some particular sub-criteria according to the scope of meaningful learning [9].

	Factores situacionales	Estrategias de evaluación	Actividades	Metas de aprendizaje
Sílabos y documentos de planeación curricular		AEM	AEM	AEM
Ambientes virtuales	EAV	EAV	EAV	EAV
Docentes	ES	ES	ES	
Estudiantes	ES	ES	ES	
	AEM	EAV	ES	
	Instrumento de autoevaluación microcurricular y fichas bibliográficas	Instrumento de evaluación de aulas virtuales	Entrevista semiestructurada	

**Fig. 2.** Sources, criteria and instruments.

[Traducción table: 1a fila – Situational Factors / Assessment Strategies / Activities / Learning Goals; 1a columna – Curricular planning syllabuses and documents / Virtual environments / Teachers / Students; debajo de la tabla – Micro-curricular self-assessment instrument and index cards / Virtual classroom assessment instrument / Semi-structured interview]

The micro-curricular self-assessment tool [24] is an evaluation tool whose criteria are based on the coherence between the pedagogical model and the implementation of courses within the classroom. It consists of a set of close ended questions whose axes of inquiry are the existence of or compliance with the following items: *Basic Identification of the Subject, Justification, General Contents of the Course, Objectives Proposed according to Significant Learning Dimensions, General Learning Activities, Assessment Activities, Integration between Classroom and Online Learning Activities, Compliance with Significant Learning Dimensions, Bibliography*.



Regarding the assessment of virtual environments supporting the modality, an instrument was applied based on the E-DREA Model for the Evaluation of Online Courses [25], involving the assessment of compliance with a set of features for 8 components: *Course Structure, Design and Navigation, Multimedia Resources, Contents, Learning Activities, Assessment, Monitoring and Tutoring, And Bibliography*. Table 1 shows the list of criteria and sub-criteria considered for the design of interviews with teachers and students.

**Table 1.** Basic criteria and sub-criteria for the analysis

Basic criteria	Sub-criteria
Situational factors	Specific context of the teaching/learning situation. General context of the learning situation. Nature of topics, characteristics of the teacher and learners
Assessment strategies	Educational assessment: Feedback, self-assessment, criteria and standards
Teaching activities	From active learning: Experience, reflexive dialog, information and ideas
Learning goals	Learning objectives according to the dimensions of the Significant Learning Taxonomy

After preparing and validating data collection instruments, the first phase starts by defining the study sample and access thereto. As a case study looking for a general understanding of the phenomenon, the units of analysis will be the three courses implemented in the B-learning modality in the Systems Engineering Program. In the sixth phase of the study, information was collected by interviewing teachers and students, and applying evaluation forms to syllabus and virtual classroom. A total of 15 interviews (12 students and 3 teachers) were conducted, six index cards were produced, and the evaluation forms were applied to the syllabi and virtual environments of each course.

The seventh phase, consisting in the analysis of collected data to identify the first findings, was supported by the software NVivo [26] in three big moments. In the first one, information from all sources was organized and encoded in the initial criteria and sub-criteria determined for the interviews, according to the research purpose. In the second moment, a first-level analysis was performed to find similarities, relationships and differences among data in the light of analysis categories. The process was completed in a third moment in which, based on the elements comprising the Significant Learning proposal, research findings are interpreted to define the results of the assessment proposed (eighth phase) regarding each of the axes studied. On the last phase of the study, the results are written down in a final research report.

## 5 Result analysis

The results of the study are organized according to the main lines of inquiry (situational factors, learning goals and activities, assessment strategies and feedback), while integrating the testimonies, perceptions and opinions students have with respect to the meaningful learning proposal and the development of courses.



### 5.1 On situational factors Specific context of the teaching/learning situation.

The three courses studied are taught in the last semesters of the academic program and last 16 weeks divided in three assessment periods. The course takes place in two settings: classroom and virtual classroom, the latter containing most of activities and resources for developing the subject. There are three face-to-face sessions in the semester and the others are synchronous or asynchronous meetings through the virtual classroom. Generally, virtual classrooms are structured in sections that start with introductory information of the course. The following sections correspond to the plan for each period and present the resources and activities to be carried out. There are several activities for the theoretical-practical component of the courses, introducing new topics that allow to reinforce the concepts studied in class. Information is provided on the general contents of the subject only in the syllabus or lesson plan.

In relation to the materials included in the courses, there are resources from various authors, both in Spanish and English. Materials that can be viewed online or downloaded for later reading were made available to students, while an effort to provide consistency between materials proposed and objectives set was observed in the provision of resources that illustrate real situations where the concepts discussed in class can be applied and in the attempt to involve students in more meaningful learning experiences.

As for the operation of the virtual setting, students report that they are given access and use from the beginning of the course and, generally, resources work properly, although some technical errors of the platform hinder timely access.

According to the analysis results, it can be said that the context in which the teaching-learning process takes place has sufficient mediations and settings to provide students with meaningful learning experiences.

**General context of the teaching-learning situation.** Overall, the teaching perspectives put in these courses are related to the building of understanding skills in students and the application of fundamental concepts. Just one of the courses outlined as training purpose the integration of some knowledge and the assessment of its impact on the social environment. As mentioned above, although they seem verbs related to competencies, the core of learning purposes is still the concepts or contents. None of the resources and settings provided information to identify the role of these courses in relation to the academic program, reducing the possibility that students understand the importance thereof in achieving their career goals.



**Nature of topics.** In the case of Project Formulation and Project Management courses, the topics that make up the fundamental knowledge of the subjects converge on static contents that have already been defined by authorities on the subject and are accepted by the circle of professionals related to the discipline. In the Digital Communications course it was found that although there is a list of basic concepts of the course, their close links with modern technologies makes these concepts dynamic. Furthermore, this course also has a particular interest in including, as fundamental knowledge, the assessment of the technology-user interaction. From this, it is then deducted that, in two of the courses, theoretical concepts that converge on static contents predominate.

**Characteristics of learners and the teacher.** Most students enrolled in these courses combine their studies with work activities related to their profession, so their expectations have to do with the possibility of integrating theory and practice, with a flexible schedule. Because of this, it is required that students enrolling in the B-Learning modality learn to manage their time of study properly for carrying out weekly activities and assume obligations assigned to them with high commitment, because most online learning activities require them to manage their time independently and responsibly. The autonomy expected from them is measured by the frequency of access to the virtual classroom and timely delivery of assignments. In this regard, it should be noted that students suggest setting fixed schedules for carrying out virtual classroom activities, which reflects their difficulty with self-management and self-regulation.

Based on the research findings, it can be stated that the teacher plays the role of motivator and counselor. His/her role is described by the following features:

- As expressed by the teachers, they emphasize feedback to students, trying to provide it once each activity is completed. In this respect, it is noteworthy that the above contradicts the perception of students, as some of them claim not to have continuous feedback and generally demand greater support by teachers in completing activities and answering questions through the virtual setting.
- Formulates learning and assessment activities based on course design so that learning activities are always dependent on assessment activities and vice versa.
- Defines and uses tools to exemplify the topics of the course, allowing self- and co-assessment of students.
- Motivates students by explicitly relating topics with work, bringing artifacts and materials to illustrate.
- Guides students in their learning process with activities that promote curiosity and make room for reflection.
- Seeks to strengthen team work and apply theoretical concepts constantly in his/her activities.
- Regularly notifies students of the activities to be carried out and summarizes informative material.



## 5.2 On learning goals.

This section of results is analyzed in the light of the dimensions of significant learning taxonomy. Table 2 presents findings according to the goals proposed for students' learning.

In summary, for learning goals there is a high degree of correspondence between those stated for the courses in the first three taxonomy dimensions and those suggested in the self-directed guide for course design [9]. This does not occur in the fourth, fifth and sixth dimensions, which demonstrates the course planners' difficulty to interpret them and set them out.

**Table 2.** Results in learning goal planning

Dimension	Characteristics of learning goals
<b>Foundational knowledge</b>	The goals of this dimension clearly state the topics that the student is expected to <i>understand and remember</i> , in agreement with the guidelines for course design.
<b>Application</b>	It is observed that in general the goals set in this dimension revolve around critical, creative and practical thinking, proposing real scenarios to apply fundamental concepts.
<b>Integration</b>	Learning goals for integration include information, prospects of the courses and their relationship with other areas such as personal, social or work life of students.
<b>Human dimension</b>	In general terms, it lays down what the student may learn from him/herself, about others and/or how to interact with them. Additionally, it intends to answer the question "who am I?"
<b>Caring</b>	It describes the student's responsibilities, commitments and what is to be done in the course. There are no specific feelings, interests or values that are promoted in the courses, as proposed by the guide for their design. Invitation to reflect on the students' values or assessment of new ways of learning is not included either.
<b>Learning how to learn</b>	In the formulation of these goals, what the student must learn, how to be good at the courses and how to become a self-directed student are briefly described. However, the scope of these goals is the course itself, leaving aside the intention of the guide for this dimension, which is to prepare students in a particular topic or issue after the end of the course, managing and understanding their own learning process.

## 5.3 On learning activities

The set of learning activities carried out comprise individual and group work from both learning approaches: active and passive. For active learning, practical workshops and classroom projects where the student has to strive for interacting with their partners and fundamental concepts are laid down.

In addition to traditional "homework," activities to be carried out individually that correspond to the active learning approach make use of games such as crosswords, word search and hangman.

Searches for information or on the Internet outside the classroom are also assigned either to prepare the following sessions or supplement the topics covered. In the component of passive learning activities, the virtual classroom has resources such as videos, written documents, slide presentations, simulations and music, usually based on the teacher's professional experience. The students find such resources useful to "memorize" theoretical concepts, thus they always complete their reading.

An important finding is that all activities planned for the courses are conducted in the virtual setting and that the activities carried out in the classroom or their role in the subject are not clear. In this regard, students consider that additional activities and resources to those in the virtual classroom must be implemented since they consider them insufficient.

Synchronous and asynchronous encounters are also held in the forum and classroom chat, where topics studied in class are discussed, but they are mainly used by the teacher to provide tutorial support. Students suggest planning participation in these communication settings in a more didactic way since it is scarce. It is interesting to find that, in order to justify their low participation in these exercises, students give reasons such as the difference in learning styles.

If the above results are analyzed in light of the holistic perspective of Active Learning, illustrated in Fig. 3 and proposed in the Self-Directed Guide for meaningful learning, it is observed that, although there are no instruments or strategies designed to monitor student activity, reflective dialog is integrated -albeit infrequently- as a teaching strategy in interaction exercises between teachers and students, using the technology tools provided by the virtual environment, as well as other individual reflection activities such as essays, articles, portfolios and surveys. This does not occur in experience activities, because most of those proposed, though active, do not place the student in real action, direct observation of phenomena, case studies, role-playing games, and other tasks suitable for this type of learning.



**Fig. 3.** Holistic view of active learning (Source: A self-directed guide to designing courses for significant learning [9], p. 21)

[Traducción de la imagen: **Experience:** - Doing, Observing – Actual, Simulated – “Rich Learning Experiences” / **Reflective Dialogue:** - Minute Papers, Learning Portfolios, Journaling – About the Subject and/or Learning Process / **Information and Ideas:** - Primary and Secondary Sources – Accessing them in class, out of class, online]

It should be noted that, in any of the courses, learning activities that exploit the differentiating potential of virtual scenarios for teaching-learning processes are not identified since those described herein are generally activities that can also be performed in classroom settings. This is consistent with the students' proposal of integrating other ICT tools in the courses such as social media management systems (SMMS) and providing more training to teachers on the Moodle platform. Some of the students consider that the activities and resources proposed are "dull" and "routine."

#### 5.4 On assessment strategies

The assessment strategies include mid-term exams, self-assessment, co- and hetero-evaluation of the same learning activities and group works. Some efforts to make it anticipatory, constant and with criteria for



students, which are generally behavior, participation and contributions of each student, are observed. However, the share percentage of each assessment activity in the final grade for the course is not clear and, in most cases, there are no assessment rubrics prior to activities, but rather evaluation criteria are revealed in the course of the activity itself.

Feedback exercises that do not provide clear criteria regarding evaluation times and components are carried out, so it can be said that they are not *frequent, immediate, discriminatory and fair*, as proposed in the Self-Directed Guide. This is confirmed by the students inquired, who express that there is little feedback by the teacher in some activities.

## 6 Conclusions

The study showed that the Universidad El Bosque has advanced favorably to meet the challenge of promoting, through its teaching practices, meaningful learning in students. Additionally, as in the classroom modality, it is recognized that teachers have adopted the integrated course design strategy with regard to setting of learning objectives and planning of strategies in the dimensions of *Foundational Knowledge, Application* and, in some cases, *Integration*. The foregoing seems to be related to the way of planning courses that predominates in the university environment and, therefore, the experience of teachers revolves around the appropriation of specific knowledge and its application in various scenarios. In contrasting these results with the background studied, it is confirmed that the same weaknesses of the classroom modality are transferred to the b-learning modality. For education researchers, this poses the challenge of thinking about didactics and ICT integration beyond the setting or modality, planning teaching strategies focused on the learning dimensions that are to be developed [3].

In the same vein and in relation to *Human Dimension, Caring* and *Learning How to Learn*, it was found that teachers find it difficult to orient the didactic planning of their courses to these dimensions, which implies an imperative need to build this capability in the faculty, preparing conceptual frameworks and strategies for building teaching skills necessary for ICT integration and Significant Learning. Given that some international standards governing curriculum planning for Engineering programs [27], [28] consider the skills related to integral human development and self-management of the learning process by engineering students, it is important to further strengthen these dimensions from these Schools.

Moreover, it was evident that although teachers design assessment activities according to the learning dimensions that are to be observed, the grading system of the Academic Program does not record any evidence in this regard. This reduces the monitoring of each student's learning process throughout their studies to obtaining minimum grades and not to observe actual performance for these courses. Regarding the student, failure to receive *frequent, immediate, discriminatory and fair* feedback does not allow to build the skills necessary for self-management of their learning and learning for life [29]. About both findings, there is no evidence that something different happens with other campus-based courses in other programs of the School of Engineering.

New challenges are then posed for Educational Institutions because it is important to monitor students' academic development in a continuous and timely manner. This same challenge is proposed for Curriculum Committees in academic programs, because it must be ensured that the graduate profile of professional corresponds to competencies set out in the context of its pedagogical proposal.

According to the results of the study, it was also found that the characteristics of learners are not ascertained in course planning. This leaves aside one of the most important principles of meaningful learning and learning-oriented teaching models which is to recognize the student's experiences and previous knowledge and orient teaching towards them so that the student is willing to build new knowledge in a conscious and motivated manner. It can be thought that this shortcoming directly influences the success or failure achieved in implementing the modality and ICT integration.



Also related to the above, in the case of this study, it was found that it is assumed by default that students have the skills for self-management and self-regulation necessary for the success of the B-learning modality. It is therefore recommended that, before or at the beginning of courses, both the University and other institutions and educators implement strategies to build these capabilities, in addition to the commitment and motivation of students to participate actively in their learning process.

None of the courses under study showed planning of learning goals, didactic activities or assessment strategies based on the features of ICTs as enhancers of learning processes. In other words, ICT integration merely provides an alternative means of communication, without proposing new relationships and exchanges among actors of the learning process, as evidenced by other studies [30], [31].

After overcoming the aforementioned difficulties in the implementation of the modality, there has been a positive response from students in interacting with virtual environments that accompany the development of courses, supporting the efforts made by teachers in their creation. There is enough evidence to think that, in this particular study case, both teachers and students have the necessary digital skills and that this constitutes a success factor. Notwithstanding the foregoing, the possibility of improving teachers' knowledge and skill regarding LMS Moodle and its potential as a catalyst for B-learning environments should be reviewed. Additionally, the framework of ICT skills for teachers should also include the ability to harmonize the VLEs in a blended training process with a specific pedagogical approach.

From the holistic perspective of active learning, a strength found in the study is that teachers have made progress in a short time in the appropriation of Integrated Course Design for Significant Learning, which is reflected in an increase in the proportion of Experiential and Reflective Dialog learning activities vs. passive learning-oriented activities. It is then evident that educational institutions are responsible for guiding their teachers through course design, following some pedagogical model, and this task constitutes a success factor in the implementation of courses.

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# Analysis of Data Mining Techniques for Constructing a Predictive Model for Academic Performance

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**Abstract.** This paper presents and analyzes the experience of applying certain data mining methods and techniques on 932 Systems Engineering students' data, from El Bosque University in Bogotá, Colombia; effort which has been pursued in order to construct a predictive model for students' academic performance. Previous works were reviewed, related with predictive model construction within academic environments using decision trees, artificial neural networks and other classification techniques. As an iterative discovery and learning process, the experience is analyzed according to the results obtained in each of the process' iterations. Each obtained result is evaluated regarding the results that are expected, the data's input and output characterization, what theory dictates and the pertinence of the model obtained in terms of prediction accuracy. Said pertinence is evaluated taking into account particular details about the population studied, and the specific needs manifested by the institution, such as the accompaniment of students along their learning process, and the taking of timely decisions in order to prevent academic risk and desertion. Lastly, some recommendations and thoughts are laid out for the future development of this work, and for other researchers working on similar studies.

**Keywords:** Data mining · Predictive modeling · Academic risk prevention · Academic performance · Educational data mining

## 1 Introduction

Student desertion -as a phenomenon which impacts heavily on educational processes- has been widely studied and modeled, thus identifying its possible causes in order to find strategies to treat it and prevent it. In Colombia, this phenomenon has been documented via the SPADIES [1], which is an information system developed by the National Education Ministry; it was created to gather and centralize all the necessary information to establish the factors which cause student desertion across the nation. Overall, the Country has progressed in the characterization and diagnosis of this phenomenon, and findings include the fact that the greatest rate of desertion takes place in the first semester of studies. Other interesting results reported by the Ministry states that 20 of the Country's departments (subdivisions with certain degree of autonomy) exhibit desertion rates exceeding 40 %; also the Country's annual desertion average rate is around 10 % for university students.

To counteract these results, the Ministry has modeled student desertion and has designed policies for its diagnosis, monitoring and prevention. This strategy open the way for subsequent publications [2] [3], in which academic risk has been recognized as one of the main factors that influences student desertion in higher education scenarios. Notwithstanding the above, in this context academic risk has not been studied as a phenomenon in itself, but all efforts have been rather directed towards preventing desertion as a direct consequence of this phenomenon. Previous studies have focused on preventing the student's desertion, underestimating the importance of generating preventive strategies that cope with its causes; particularly strategies that deal with academic risk as it is one of desertion's main causes.

Specific programs, projects and strategies have been implemented at El Bosque University in order to follow and accompany the students' learning process. One of the most relevant strategies, regarding academic risk tracking, has to do with the University's Online Academic Management System - SALA [4], where alerts are generated according to the grades the students obtain each period and their historical academic data. These

alerts classify students in three risk-related levels: low, medium and high risk, the later being a trigger for a student's accompaniment and intervention by the University's student support program (PAE).

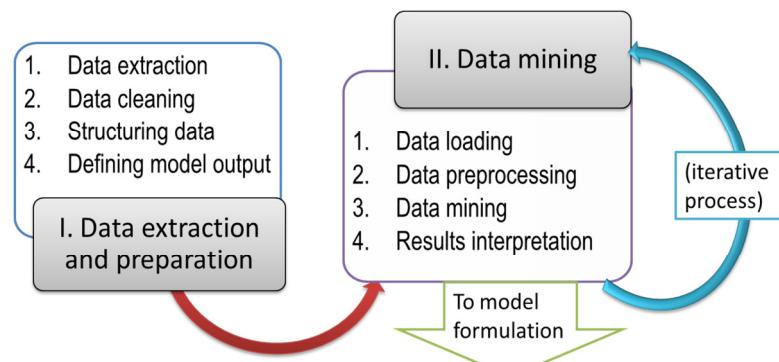
Despite the importance of said strategies, the University lacks a mechanism which acts preventively; one able to identify the causes for academic risk, and act upon these causes before the risk has occurred. This would allow the institution to take timely decisions and design better strategies to prevent academic risk as a phenomenon, and as a consequence, diminish the students' probability of desertion.

Bearing in mind that the University requires a preventive and timely approach towards dealing with student desertion, this work proposes, applies and evaluates certain data mining methods and techniques, in order to take advantage of the information (which had served no similar purpose) that the institution gathers from its students. This practice is known as Educational Data Mining (EDM) [5], which derives from Data Mining, the semiautomatic process of discovering hidden patterns in data [6]. EDM has proven being a useful tool for making predictions in several scenarios [7, 8, 9, 10], and thus will be used to generate a predictive model based on students' academic and demographic data. This model should provide useful insights about the causes for academic risk, in order to empower the Institution in the taking of better decisions and the implementation of stronger strategies regarding student desertion.

The stages of the data mining process, aimed at constructing the predictive model for students' academic performance, are presented and analyzed in the first part of this paper. In the second part, applied techniques and methods, as well as the results are analyzed. The presented conclusions are drawn from these analyses.

## 2 Methodological Development

To build a predictive model for students' performance based on data mining, it's necessary to develop four important stages [6] [10] [11]. Firstly the data that will feed the mining process must be extracted and prepared. Secondly the data mining process itself must be implemented in an iterative fashion: each iteration consisting of data preprocessing, algorithm execution, results -rules- analysis, accuracy interpretation and testing [12]. Thirdly the predictive model formulation must be done by analyzing, selecting and defining the rule set which allows for proper academic performance prediction, regarding the institutional context and the proposed objectives that frame this work. Lastly the predictive model must be validated by applying it to different datasets with similar characteristics to the one utilized during the mining process, and obtaining favorable results. This work presents the development of the first two stages, analyzing the data mining process and its applicability in the building of predictive models regarding educational environments. Fig. 1 illustrates the method.



**Fig.1.** Methodological process aimed to construct the model



## 2.1 Data Extraction and Preparation

**Data extraction.** Being the primary objective to generate a predictive model -out of academic and demographic data- for the students of the Systems Engineering program, the students' information must necessarily fall into these two categories. Also, this data was selected in accordance with results presented in the SPADIES reports giving relevance to socioeconomic variables known to influence desertion rates.

Data mining requires a significant amount of data in order to provide meaningful results. For this study the anonymous records of 932 students were obtained from the University's IT department, which were delivered as four separate spreadsheet files. Performing a process similar to data warehousing, once the data received was loaded into a relational database engine (MySQL), it was normalized to the Third Normal Form [13]; this enabled properly query the information in a consistent and organized way. Further normalization was not considered necessary, due to the static nature of the database.

**Data cleaning.** Being the data then correctly structured, a process defined as *data cleaning* [6] was applied (through SQL queries) in order to check for consistency errors in the data and standardize attribute values. This was a necessary step because a large portion of the data obtained was manually typed into web forms by students at some point in their enrollment. This means typographic errors were present in the data, as well as diverse input formats for a selection of fields, such as home address and city.

Having substantially improved the dataset's quality by making it *cleaner* and more consistent, the data was randomly split into two sets of almost equal size: a set to be mined in order to generate the predictive model, and a control set to verify that the model generated works as expected. This partitioning of the dataset is done in order to assess the classifier model's error rate (product of the data mining process), using a dataset that played no part in the construction of the classifier [6]. This verification portion of the dataset will also allow to evaluate different learning schemes on a fresh dataset to determine which one performs better [6].

**Structuring data.** After defining which data was to be used for mining, the whole dataset was structured as a set of instances [6]. Each instance represents a different student, and each one has values for all the attributes selected for the study. Said attributes are presented in Table 1.

**Table 1.** Defined instances and attributes.

Students' Academic Data Attributes	Students' Demographic Data Attributes
Average ICFES test score, ICFES <sup>3</sup> subject test scores (biology, math, philosophy, physics, history, chemistry, language, geography and English), students' high school, year and period of enrollment, whether the student has received academic incentives, class schedule type (day or night classes), First semester grades (6 subjects) and Second semester grades (6 subjects)	Age, gender, residence distance to University (calculated from home address), City of origin, Social Class (ranked 1-6 according to national legislation), Marital status, job status, whether the student registers a mother, mother's education, mother's job, mother's city of origin, whether the student registers a father, father's job father's education, father's city of origin, number of siblings.

<sup>3</sup> The ICFES test is a test given to graduating high school students to measure their performance along different knowledge areas, and is often required by Universities in Colombia as part of the admittance process. It is comparable to the SAT Test for college admissions in the USA.



**Defining model output.** Being these attributes the information that characterizes the population under study (as input variables), the output variable of our model would be the academic performance, as this is what the model aims to predict. It was necessary to define academic performance according its definition in the institutional context, that is, directly related to academic risk. In accordance to the University's PAE (students' support program) and SALA (institutional academic information system), academic risk appears when a student's grade weighted average<sup>4</sup> is below 3.3/5. So, guided by the above and by the average performance statistically calculated in the sampled data, the output variable academic performance is defined in three types as shown in Table 2.

**Table 2.** Definition of academic performance as output variable

Type of academic performance	Weighted average
Outstanding Performance	from 4.0 to 5.0
Average performance	from 3.3 to 3.9
Academic Risk	below 3.3

The final structure of all instances is presented in Table 3.

**Table 3.** Final structure of instances

Id	Demographic Data	Academic Data	Total grade average
...	...	...	...

Note that in this case, the academic and demographic data are represented by single columns for the sake of visualization.

Finally both data sets (mining and verification), which have been restructured as seen above, were exported as separate text files. Within each file, each instance corresponds to a line of text in which its attributes are separated by commas, and missing values are represented by the ‘?’ character instead of a blank space (requirement for ARFF file conversion) [6]

## 2.2 Data mining

To undertake the task of data mining the *Waikato Environment for Knowledge Analysis* was chosen. The WEKA workbench is a data mining software platform developed at the University of Waikato in New Zealand [6]. It offers an extensive collection of state-of-the-art machine learning algorithms, data preprocessing and visualization tools, all wrapped up in a comprehensive and easy to use common interface. It is licensed and distributed under the GNU General Public License, it's available for free, and runs on all major computer operating systems (Windows, Linux and Mac OS).

As defined previously, data mining as an iterative process comprises a cycle of three main activities: data preprocessing, data mining and results interpretation. Due to WEKA's resourcefulness the fulfillment of such tasks are achieved with great ease.

<sup>4</sup> Weighted average is  $\Sigma[(Sc \cdot Sg)] / [\Sigma(Ct)]$ , where Sc: a subject's amount of credits, Sg: a subject's grade, Ct: total credits taken by a student



Throughout each data mining iteration the following procedures were performed, and on each one, variations of each procedure were implemented -as permitted by the *WEKA Explorer* view-:

- **Data loading:** the data was loaded into *WEKA* so it could be mined; this was done by assembling an ARFF file using the text file containing the mining dataset.
- **Data preprocessing:** the dataset was preprocessed according to which data mining tasks were to be performed over it. *WEKA* allows the filtering and transformation of the loaded dataset in several ways both manually, or using several data mining and sorting algorithms; also, attributes from the loaded dataset can be selectively removed.
- **Data mining:** machine learning algorithms were executed over the dataset. Classification algorithms -which find classification rules that *classify* a particular instance according to the value of its attributes- were chosen to perform the task at hand.
- **Results interpretation:** the resulting output from these algorithms was recorded as individual text files; information present in these -such as classification rates, classification rules and prediction error measurements- was analyzed and interpreted according to bibliography and previous results if applicable. Also, if further iteration was considered necessary, plans for it were laid out in accordance of the results obtained.

**Data loading, preprocessing and mining.** The product results from the data mining process are presented according to the steps previously described, along 4 executed iterations. Table 4, describes how the first two data mining stages were performed (data loading and preprocessing). Similarly, Table 5 exposes the results obtained by executing algorithms J48, PART and Ridor, regarding the amount of rules obtained and the precision of classifications achieved. These three algorithms were chosen due to their similarity in purpose (classification rule induction), but also for their particularly unique ways of achieving this task. Throughout all iterations 10-fold cross-validation was defined as a standard evaluation technique, to ensure the integrity of predictions and results [6]

The iterative process was considered fulfilled as results obtained from the fourth iteration exhibited sufficient and meaningful outcomes in terms of precision and accuracy -measured as classification rates-. Thus, a verification process involving the attempt to classify untrained data (control dataset) was performed in order to assess the data mining process. Aside from certain expected imprecisions in the validation results, it was considered as successful.

**Table 4.** Description of data loading and preprocessing

	Iteration #1	Iteration #2	Iteration #3	Iteration #4
Data loading	467 instances 42 Attributes	467 instances 42 Attributes	467 instances 42 Attributes	467 instances 42 Attributes
Data preprocessing	None	First year subject grades were removed  <b>Resulting data:</b> 467 instances 31 Attributes	First year subject grades were removed  <b>Resulting data:</b> 'Noisy' attributes were removed  <b>Resulting data:</b> 467 Instances 24 Attributes	First year subject grades were removed  <b>Resulting data:</b> 'Noisy' attributes were removed  <b>Filter applied:</b> remove misclassified instances using a J48 decision tree  <b>Resulting data:</b> 179 instances 24 Attributes

**Table 5.** Description of data mining process, according the algorithms executed

	Iteration #1	Iteration #2	Iteration #3	Iteration #4
J48	10 rules found	0 rules found	150 rules found	58 rules found
	231 correctly classified instances	135 correctly classified instances	129 correctly classified instances	153 correctly classified instances
	141 ignored instances	141 ignored instances	141 ignored instances	0 ignored instances
PART	4 rules found	4 rules found	56 rules found	16 rules found
	204 correctly classified instances	137 correctly classified instances	115 correctly classified instances	149 correctly classified instances
	141 ignored instances	141 ignored instances	141 ignored instances	0 ignored instances
Ridor	23 rules found	14 rules found	15 rules found	7 rules found
	233 correctly classified instances	127 correctly classified instances	120 correctly classified instances	100 correctly classified instances
	141 ignored instances	141 ignored instances	141 ignored instances	0 ignored instances

Table 6 shows the results obtained throughout each iteration, concerning classification accuracy for each of the output variables defined for academic performance.

**Table 6.** Accuracy rates obtained by each algorithm

	Iteration # 1	Iteration # 2	Iteration # 3	Iteration # 4
J48	Risk: 81% Average: 62.70% Outstanding: 83.30%	Risk: 27.8% Average: 42.3% Outstanding: 0 %	Risk: 43.2% Average: 42.7% Outstanding: 18.2 %	Risk: 86.8% Average: 85.3% Outstanding: 76.9 %
Part	Risk: 64,7% Average: 57.1% Outstanding: 78.8%	Risk: 16.7% Average: 42.6% Outstanding: 0 %	Risk: 34.8% Average: 40.3% Outstanding: 25.4%	Risk: 85.4% Average: 83.3% Outstanding: 66.7 %
Ridor	Risk: 72,2% Average: 71.8% Outstanding: 69.6%	Risk: 47.9% Average: 40.2% Outstanding: 22.7 %	Risk: 44.5% Average: 37.5% Outstanding: 22.1 %	Risk: 64.9% Average: 55.3% Outstanding: 25%



## Results Interpretation

*About each iteration.* Given the results product from the first iteration, it was observed that the rules obtained were composed exclusively by first-year subject performance averages; such results seem logical because academic performance is a direct consequence of subject average grades. This also relates to the favorable precision results that were obtained. Nevertheless this knowledge is not useful regarding the study's objective, for it is redundant and somehow obvious; therefore such attributes cannot be included as input variables for the predictive model, and were removed in the next iteration.

When the results for the second iteration were obtained, several issues arose. Firstly no rules were obtained by the J48 decision tree classifier. Secondly the decision list generated by PART relied heavily on the fact that a student registers an empty high school name to generate rules -which is rather suspicious-. Lastly RIDOR performed surprisingly well in contrast with the other two algorithms for it included several relevant attributes to generate rules. Sadly it did not perform as well in terms of precision, for it exhibits an inadmissible amount of error -as did the other two-. It was observed that the classification rate diminished considerably in contrast with the last iteration, however this makes sense after removing redundant attributes: the algorithms had less available correlated data to induce rules from. Bearing in mind these observations, certain attributes were chosen to be removed for the next iteration due to their 'noisiness'.

For the third iteration the following attributes were discarded from the dataset because of their large dispersion -which causes 'noise' in the data-: students' high school, year and period of enrollment, whether the student has received academic incentives, mother's job, mother's city of origin, father's job and father's city of origin. As a result of this, the amount of outputted rules rises considerably. Even though rules are composed of relevant attributes, precision is still very low. This is interpreted as an indicator for rules that do not perform too well on the training dataset, which might be caused by instances that are not providing useful data to the algorithms, that in turn allow for proper predictions to be made. Also, it was found that the 141 instances that had been ignored throughout this and previous iterations correspond to instances without defined values for its class attribute. Concerning these observations, it was suspected that a significant portion of the 326 instances that are being utilized to train the algorithms were interfering with proper rule induction mechanisms inside the algorithms. Therefore more elaborate preprocessing was encouraged for the next iteration.

Concerning the fourth and final iteration, a preprocessing filter (*removeMisclassified*) was applied in order to remove misclassified instances product of a classification's algorithm execution. The objective of such task is to enable a better rule induction by using only instances that provide useful data for performance prediction. The chosen algorithm to perform this task was the J48 decision tree learner, because of its good average performance in past iterations and other tests performed on the data. Having done this the number of training instances was greatly reduced (in around 60%), however the algorithms were able extract more valuable and meaningful knowledge from this smaller dataset, while maintaining favorable and tolerable precision levels. By further analyzing the rules product from this iteration, it was noted that they were more generalized than previous exemplars, but managed to describe the dataset in a more accurate fashion. It was also noted that classification rates improved for J48 and PART classifiers. Due to this performance increases and precision prevalence, a verification exercise was considered pertinent to assure these results apply when 'fresh' data is evaluated.

During the proposed verification exercise, the model obtained from iteration number 4 for the J48 algorithm was loaded into WEKA, as was the control dataset (465 instances). Then the control data was adjusted in the same way that the training data was preprocessed in iterations number 2 and 3 (so that the control data's structure matches the training data's). By executing the loaded model over the new data, the control dataset was evaluated using previously defined classification rules, in order to obtain new classification predictions and precision measurements; these new results reveal a slightly lower classification rate for the new data, as well as a small increment in error. In spite of this, the results obtained can be considered as profitable because our previously trained algorithm (J48) managed to correctly classify around 78% of the new instances evaluated.



*Classification Rules Summary.* The rules discovered by the J48 decision tree learner can be summarized as follows. Students whose social class is 2 or undefined are classified within academic risk, while students whose social class is higher than 3 are classified depending on other variables such as marital status. Regarding the latter, whereas students who are ‘single’, depends on additional attributes such as mother’s education and student’s gender to be classified, students who are currently ‘in union’ -but not married- are classified within academic risk by default.

Attention is drawn to the surfacing of attributes such as individual ICFES scores, parent’s education, number of siblings and whether the student registers a mother within the rule set, as influencing factors for academic performance. More interestingly it was found that if a student is not married and his/her social class is 4 it is immediately classified within risk. Also for social classes 5 and 6 (higher classes) most rules defaulted a classification within outstanding performance.

Decision lists generated by the PART algorithm seem to agree with the J48 decision tree, in that students whose social class is 2 are almost defaultly classified within academic risk. Nonetheless students are classified within academic risk if their social class is 3 and they are single or if their social status is 3 and their age is above 24. Concerning a student’s social class being 3, greater variations arise depending on the his/her marital status, parents’ education, gender, age and certain individual ICFES scores. Furthermore students whose social class is 4 and have no siblings are immediately classified within outstanding performance.

Regarding the Ripple-down rule learner -Ridor-, it was discovered that if a student’s social class is 3 most of the times it is classified within average performance. However if the student’s father’s education is undefined and his/her’s english ICFES score is below 50, it is classified within academic risk. Surprisingly for social classes 1, 4 and 5 the defaulting classification is within outstanding performance, but it lies within average performance if the student’s age is below 26.5; if a student’s age is below the latter and his/her mother’s education is undefined the student is classified within academic risk. The default classification for a student’s social class being 2 is within average performance.

*Rules interpretation.* Concerning the classification rules described previously, certain particular features about the dataset’s attributes emerge. For instance, social class seems to be a highly decisive variable regarding characterization of rules that accurately describe the data utilized in this study. It recurrently appears as the first classifying attribute of tree-generated resulting rule sets. Also its defaulting classification for a value of 2 coincides in both the J48 and PART algorithms; this makes sense because PART obtains rules from partial decision trees built using J48. In the case of marital status, it seems to be the second most important classifying attribute; most of the resulting rules revolve around its value ‘single’ and frequently encompass other attributes such as parent’s education. Classifications within academic risk are present for all values of this attribute except for ‘married’ students. Lastly, attributes such as age, gender and selected individual ICFES scores (like biology, philosophy and languages) seem to play a relevant role in conjunction with social class and marital status. Relating to Ridor’s results, students were classified within risk when their age was below 26 alongside with other attribute values such as mother’s education and ICFES scores.

The pertinence of the rules obtained, in relationship with the social and academic context of the studied population is adequate. Particularly the students’ socioeconomical stratum has been perceived as a highly influential variable in their academic performance, as their obtained ICFES scores. Nonetheless, other variables appear as influential, such as age and gender towards which more attention should be drawn.

The obtained results gave way to some important recommendations. Several lessons were learned regarding the data used in this study; primarily the data procured for this kind of work must be as clean and consistent as possible. In case that extensive data preparation is required, no stone must be left unturned; failing in correctly standardizing attribute values can heavily impact data mining precision. Similarly, the input variables defined must be meaningful in order to predict class attributes; irrelevant or obvious correlation between these might result in useless predictions. Concerning the methodological development, time allocated for data preparation and preprocessing must not be underestimated; it could potentially consume great amounts of time [6].



### 3 Conclusions

In accordance with the strategies implemented during the data mining process, it was found that careful data preprocessing can and will have drastic impact over the data mining results; such decisions -like attribute removal, or data discretization - should not be taken lightly. Furthermore, the careful assessment and removal misclassified and ignored instances can profoundly improve success rates when seeking to generate a predictive model.

The rule sets product of the data mining process are found useful to characterize the students' academic performance, for they allow to identify which demographic and academic attributes hold influence over the studied phenomenon. Additionally, having identified these attributes, it is possible to determine if a given student will incur in academic risk along his or her first year of studies. All of the above-mentioned sets base for students' accompaniment and academic risk prevention strategies generation. Bearing all results and conclusions, the formulation for a predictive model based on an iterative data mining process gains feasibility [10].

Regarding the algorithms' performance, not only must their classification accuracy and rule quantity be evaluated, but also - and specially- their quality and pertinence [6]. By the way in which Ridor structures its results and performs generalizations regarding them, this algorithm -in general- did not allow to obtain rules that involved valuable attributes for the consecution of the study's objective; for those rules that might have been relevant, their precision values were significantly low.

It should be noted that the obtained results are strongly related to the institution's characteristics and the objectives of the model to be built. To make useful this study in other institutions is necessary to consider other comparison and evaluation techniques of the algorithms, like statistical tests, applied to large volumes of data[14]

It is necessary to propose and perform studies that consider the academic risk phenomenon as part of academic desertion. Latter phenomenon is frequently studied but separated from risk factors, using techniques and methods such as the analyzed in this research.

Based on the results obtained, the next step to be developed in the study, it is the one which frames this work, is to make further use of the rules obtained by the data mining process, by executing them over several other data sets that belong to the same educational institution. This should be done always minding the pertinence, precision and applicability of said rules in order to formulate a predictive model, which can be validated and proven useful within the institutional context.

Having proved this model as useful, it should be implemented as a software tool, which aids in the decision-making processes, and help to generate stronger strategies for academic accompaniment and risk prevention. Lastly, it is recommended to the academic community to extend the theoretical framework of the Educational Data Mining, adding more studies that identify and analyze the most appropriate techniques according to the diversity of phenomena presented in the post university context [15][16].

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## **Virtual forums as a learning method in Industrial Engineering Organization**

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**Abstract.** This paper describes the experiences of educational improvement and innovation carried out in a multi-cultural environment with students of different nationalities of the Engineering School along 5 years. The experiences in class were based on virtual forums to study problems of Engineering Management. The case of the Harvard Business School (HBS) method, adapted to Industrial Organization Engineering was used. The methodology was applied in several subjects in the Area of Industrial Organization from 2007 to 2012. The objective was to change the classic face-to-face educational model of Industrial Engineering School to a new paradigm based on collaboration. We will focus on the essential problems and peculiarities of the implementation of this particular e-learning educational system in Industrial Organization Engineering.

**Keywords.** Collaborative work - Teaching innovation - Teaching evaluation - Virtual forums - Industrial Management - Case-based Learning Method.

### **1 Introduction**

The principles of Industrial Organization are complex and difficult to explain and understand. On the other hand, certain subjects of Industrial Management require the study of practical and complex situations adapted to the reality of current socio-economic and business environment.

The Industrial Organization Engineering studies the internal aspects of any enterprise: tangible elements, (labor force, means of production, etc.) or intangible ones (patents, logistics, production process, image, brand or technology) and tries to explain their different relationships with the complex economical and industrial environment.

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It is particularly important to get a proper connection between theory and practice, between pure science and applied science, something that is not trivial and constitutes one of the most difficult aspects to explain, especially from the pedagogical point of view.

To solve the dilemma of connecting the industrial reality to the theoretical concepts it was decided to implement the Harvard Business School Case Method, but adapted to the Engineering approach idiosyncrasy. In summary, the Case Study describes a real business-engineering and organizational situation. The students have to analyze the problems or issues and work together in a coordinated manner, analyzing the variables and the context involved in the situation, to finally reach a consensual solution.

The problem consists in resolving the cases in the proper way because teaching in the School of Engineering has been based in traditional lectures and students do not participate in practical cooperative experiences to study such problems and situations. The theoretical and practical traditional classes are usually lectures of one session with basically no group participation.



## 2 Methods

In the following sections we present, in brief, the essential methodological aspects of the e-learning experiences and the distinguishing features of the activities performed.

### 2.1 The context

The study was part of the Innovation and Improvement Program developed under a series of experiences during five successive academic years, from 2007 to-2012 in the five different subjects of Industrial Organization.

### 2.2 The objective

We wish to determine if the usage of a learning method based on virtual debates and deliberations in discussion forums:

- a) It could be a satisfactory means for the resolution of practical business cases.
- b) If in a practical way should represent a new and actual opportunity for collaborative learning and really improve the way of teaching of Industrial Organization.
- c) It is a good method to provide a more flexible and diverse way of learning with a greater role of the student, autonomy, discipline and creativity.

### 2.3 Theoretical aspects

A learning process can be characterized by the existence of a positive synergy of three systems: a learner model, a domain model, and a tutoring model. The tutoring model is based on the pedagogical strategy and the methodology applied, which pillars and foundations were basically two: the theory of Constructivism and the Case Method.

Constructivism was coined by Piaget [1] and Vygotsky [2] authors of the concepts of active learning and social constructivism.

Valeiras and Meneses [3] indicated:

- a) The importance of the concept of mediation and interaction of Vygotsky in constructive learning.
- b) The assimilation process within essential learning proposed by Ausubel et al. [4].
- c) The education for international understanding announced by Gardner [5].

Hernandez [6] declared "constructivism is characterized by creating knowledge through the transmission of information among people. In constructivism, learning is active, not passive".

Alfageme [7] develops one of the best-known cooperative learning methods through class experiences, based on "learning together", term coined by two of the researchers who studied this method from different points of view, Johnson and Johnson [8].

The Case Method is a teaching technique widely used especially in business schools through the description of a specific situation in a given discipline to learn about some aspect through collective analysis and decision making.



Hernández and García [9] mentioned that "in 1870, the new Dean of the Harvard Law School (HLS) decided to replace the lecture by a method of interactive learning based on the Socratic dialogue and the production of a casebook by the students." In 1920, the Harvard Business School (HBS) introduced the Case Method, starting with the subject of Marketing.

The Case Method we have put into practice is the "abstract brief case" as indicated Hernández and García [9] "was proposed by R. Glenn Hubbard, Dean of the Columbia Business School, who began to enter into this school in the fall of 2007". We try to improve the Case Method in two ways: by providing less amount of information to students and giving some clues about possible solutions. This procedure makes the method less complex and more appropriate for the student of the different subjects in Industrial Organization Engineering.

## 2.5 The Tools

The tool used was the "discussion forums" which, for many authors such as Lee [10] and Bourne [11], increase motivation and participation of the students. Aoki and Pogroszewski [12] concluded that the virtual learning in general and the discussion forums in particular are essential tools to evaluate traditional teaching but have to be structured and adapted to the new educational needs.

Can "discussion forums" provide learning in environments in where it is based on deep practice? Could the method proposed be useful to enhance Industrial Organization learning process? - This was our major aim.

Alfageme [7] estimated that forums provide three types of values:

- a) Improvement of social interaction: integration, cohesion, cooperation, solidarity and empathy.
- b) Personal relationships: self-esteem, expectations, self-control, respect, valuation and confidence.
- c) Educational values: productivity, academic performance, construction of knowledge, participation and responsibility.

<b>Time</b>	Asynchronous intervention and lack of control of the duration and frequency of interventions
<b>Proposal</b>	Training of the tutor - Coordinator - moderator in technology and management Good management facilitates the progress of exchanges
<b>Tech</b>	Lack of technical mastery and agility of their use Impersonal nature of the means of communication
<b>Proposal</b>	Graphical interfaces with photographs of students...
<b>Pedagogy</b>	Students are accustomed to compete and not to share information Difficulties to situate each intervention at the right spot Mixing of messages on parallel talks "chat confusion" or communicative disorder Loss of context or difficulty to follow the thread of the conversation Problems of cohesion or coherence between opinions and answers
<b>Proposal</b>	Guidance and coordination of the moderator which should encourage the development of the skills of interpersonal relationship or personal balance and academic and social skills
<b>Communication</b>	Overload of messages and frequent simultaneous sending of many messages by different participants Facilities that prevent "chat confusion"
<b>Proposal</b>	To include "tagged messages" facility automatically
<b>Management</b>	Difficulties to process the results and classify responses
<b>Proposal</b>	To have extensive facilities online for processing the information exchanged

**Fig. 1** Problems, enhancements and solutions of forums according to the authors

The tool used was Virtual Forums of "Aula Global (AG)" a proprietary and closed application and during the final stages "AG2" a more advanced version, lightly more open and partially based on "Moodle".

The development of the series of forums provided a new way of focusing the teaching in Organization Engineering Management subjects (Fig. 2) but at the same time bring a considerable sequence of difficulties to the scenario (Fig. 3).

The tool applied does not classify messages and we had to design a system of classification and arrangement as Chi et al. [13] did in their experiences.

The key point is to differentiate the interactive responses and the contributive ones from the rest of interventions. The interface was also very poor, austere and inflexible.

Thomas [14] expressed the need to improve interaction with graphical interfaces to facilitate it.

Advantages
<p>Greater autonomy to teachers in the design and publication of study materials and in the management of the teaching process</p> <p>Saving time classroom to carry out part of the activities on the own discussion forums</p> <p>Considerable improvement of the information available and the level of knowledge of the students: each member of the team can ask questions and exchange information (may attach documents) in real time</p> <p>Teamwork is built and constitutes the basic an essence of the method</p> <p>The answers are ordered in time and are recorded individually and collectively</p> <p>The teacher has all the essential process of the exchange of information and the progress and can vary the scope of the educational objectives during the development of each phase of the work</p> <p>Speed and agility: the teacher responses must be received quickly speeding up the decision-making towards the final solution</p> <p>Improvement of evaluation: largest and most accurate information available will allow a more fair and accurate student assessment</p> <p>New possibilities and more advanced application environments: problems with simulation of circumstances more complex that even could also vary during the period of the discussions can be addressed</p> <p>It allows adapting the training activities to the new model of continuous assessment of the European Space for Higher Education in which the activity of the student is the epicenter of teaching</p>



**Fig. 2** Advantages of forums in Industrial Organization Engineering

All those issues and difficulties had to be enhanced through a series of appropriate actions and methods that were developed along the whole experiment process. It was therefore necessary to develop rules and standards of conduct, define specific types of interventions and determine certain rules for the use of forums (Fig. 3).

### 3 Results

This work of experimentation, given its diversity and spread, is rich in situations and has brought to us an array of empirical data which has allowed to develop an in-depth analytical study whose extensive description is not feasible to describe here. There were developed 39 different forums (between 8 and 12 students of more than 10 different nationalities per forum).

We use an exhaustive process of time-series clustering analysis and coding, after a previous task of summarizing and classifying messages and conversations. Several patterns and structures of behavior were determined.

Disadvantages, Problems and Advises
Greater commitment and availability: the Professor must almost daily access to verify the information changed and should have the necessary time. The success of a forum depends largely of the moderator. Professor and mediator must continuously check the advance in the objectives and verify if the arguments are the most appropriate
Each teacher must perform a daily monitoring of the development of the discussions with the aim of
1. Redirect a particular situation, when the thread leads to a situation not suitable for the objectives of the debate
2. Provide general comments to particular topics
3. Ask students they summarizing discussions to reach points of agreement
Difficulty of processing of information: problems for classifying responses and to process the information in the absence of tools and facilities
Time consumption is sometimes excessive
Need to re-design study materials, content and teaching activities
Statistical Process Control Tools for the application of statistical methods are specifically required
Teacher training: very specific methodology has to be applied
More training and access to tech tools is indispensable to operate in this environment

**Fig. 3** Disadvantages, Problems and Advises of forums in Industrial Organization Engineering

Forums participation was voluntary and the percentage weight of the qualification of the debates in the final grade of the subjects varied between 10% and 30% depending on the case, kind of practice and subject.

The duration of the discussion is very important according to Johnson et al [15] and in our case the duration debates ranged from 2 to 8 weeks.

### 4 Discussions

The topics for discussion were agreed with the students in most of the cases and the main objective was to have a high level of collaboration among all the participants. In this way, Soller and Lesgold [16] studied the most important aspects of a collaborative participation:



- Participants must share their ideas freely.
- All of them have to be actively involved in the discussions.
- Students should establish and share information and the possible solutions proposed.
- The members of the team should encourage others to justify opinions and explain their points of view.

It is important to distinguish the most suitable motivation type at the Engineering School. Serrano [17] found that the experiences of cooperative learning "tend to increase intrinsic motivation to learning". In that sense we try to strengthen the intrinsic factors in the individual that lead to further motivation, especially in engineering students. In such a way, almost the majority of participants (94, 6%) asserted that they were motivated in some way. What is more, 72.4% answered they were very motivated, 21.3% were quite motivated and only 4.1% of the participants did not feel motivated at all.

## 5 Conclusions

Teaching models of Industrial Organization are not a fixed formula that should be applied in a rigid and inflexible way, on the contrary they must be based on flexibility being carefully applied and arranged according the each particular situation.

Application of the forums in the area of Industrial Organization and in the singular field of Business Administration facilitates the simulation of situations taken from the business reality and allows a widely and deeply study of complex management situations and problems applying conceptual material to real-world. The forums method provides a more practical way to learn managerial skills stimulates students' thinking and encourages discussion.

There are not just problems related to the environment and the external systems and agents but also difficulties in the Organization, the Structure and the Coordination of the debates.

In the different proceedings, practical cases and laboratories of Organization Engineering the professor must be able to introduce, in an easy way, changes in the description and in the significant variables of the case to be studied and even in the objectives to be reached. The instructor must follow and supervise individually and collectively, in a daily basis, the activities of the students, has to be able of analyze the information, to classify and process the records of the conversations and to intervene at the most convenient time. These operations require of one powerful open, easy to use and agile management tool with a broad range of facilities.

The application of the virtual forums technique during the whole period of experiences demonstrated that at least one general classroom meeting to summarize the ideas and present and comment the result and the outcome at the end of the discussions should be necessary. The general meeting obviously could be developed using real time conferencing procedures.

Motivation in 'e-learning' environments is the engine of change and the tutor-moderator should encourage the Group motivation and get students to share the same objectives.

The current applications and e-learning facilities are clearly inefficient. It is necessary that the Education Institutions develop advanced online tools that allow introducing a high level of interactivity in an easy way, to facilitate coordination among the participants and to generate statistical evaluation summaries of activities and interventions, results and ratings.

The put in practice of the study of business cases online in such a way allows flexibility and new facilities and improvements on learning and understanding the complex practical subjects of Industrial Organization.



This research work has allowed us to know and improve the practical knowledge of the concepts of distance learning and the basic characteristics of virtual debates applied to the resolution of business engineering situations through discussion forums and represents:

- A new perspective of Learning Industrial Organization by collaborative learning.
- An analysis of the advantages of the introduction of virtual technologies and discussion forums.
- A new way of understanding and focusing the business administration and Industrial Organization learning processes through qualitative and quantitative methods that facilitate the students the managerial skills that companies and society are demanding.

This work opens the door to further research actions to improve the methodologies of collaborative working and the use of new emerging technologies especially in engineering studies where collaboration among students is a primary requirement.

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## Application of a Learning Analytics tool to a Moodle virtual classroom

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### Abstract

In the last decade Information and Communication Technologies (ICT) emerged and influenced almost all fields: education was not an exception. Their use and development brought with it changes in the learning and teaching processes, but they were oriented towards generation of contents and activities inside traditional or virtual classes. However, an important part was left behind, i.e., all the information that a student can generate. In taking this data, there would be so much information that it would not be possible to analyze it in a simple manner, without high advanced methods of data analysis. Thus, the purpose of making a tool that applies Learning Analytics (LA) techniques, collects data, analyzes it and finds behavior patterns that can be used by the administrators and teachers was born. A platform was created then under the programming language PHP with the database engine MySQL that allows to connect to a virtual classroom designed in Moodle and, based on this, generate statistic graphics about the student's interaction with activities and resources of the course. Graphics are generated for access and presence, use of resources, activities and participation, established communication, traceability in the platform and interaction among people. Each of these allows to make and individual or group analysis by comparing a student to the group progress. Using the LA tool developed, educational processes can be improved because it shows academic progress of students and enables teachers to characterize and monitor students and see in detail their behavior in the virtual classroom. Some aspects are still missing such as prediction and recommendations that the platform must provide to students and teachers.

**Keywords:** Learning Analytics, E-Learning, Moodle

### 1. Introduction

Massive collection of data identifies behavior patterns of users or a specific population for multiple purposes, such as carrying out advertising campaigns, identifying interests of people, etc. Yet, technology is in charge of performing this collection data and intends to facilitate it for, among others, categorization and labeling. Actions to which humans have always tended since the beginning of humanity because it provides access to knowledge of one's self and one's environment.

At this point is where the reason for using learning analytics is structured. This is an emerging science that allows to potentiate and customize educational processes of students and academic institutions based on the measurement, collection and analysis of data sources. These sources are widely contextualized, depending on particular interests, to propose, act and refine the same educational methods, following correlations among variables identified, and thus form more complex qualitative conceptions that frame causalities within learning and virtual pedagogical dynamics.

Then, it is a proactive view of the use of data where they are assigned more than a numerical value and the notion that the student has a passive participation in virtual classrooms is put aside. On the contrary, the student is made a constructive maker of their process based on adjustments made by the tutor, teacher or institution through learning analytics. The objective is then to increase and channel the most appropriate tools for the proposed methodologies or build pedagogies that optimally interrelate according to population, identifying a trajectory, as mentioned, a propensity that can be glimpsed in the data and can predict the success or failure of the suggested programs and the resources made available to the students.



Learning analytics is a multidimensional science that integrates educational reality with the exponential growth of data, producing comprehensive, complex environments for constructing knowledge. Additionally, in identifying patterns in students, teachers and aspects of the platform, teaching-learning processes may be customized, just adjusting the resources to deliver as many aids as necessary to promote the use of activities that increase active student participation and therefore maximize their educational process.

The current research has proposed the creation of a tool to measure and collect six factors that, after analysis and at our sole discretion, will allow to produce specific strategies for customizing students' educational processes, namely: (1) access / presence; (2) use of resources (how many times, what resources, how much time per resource); (3) activity and participation (what to do on the platform); (4) established communication (among students, student-teacher); (5) traceability in the platform (where students start, where they end, what they see) and (6) interaction among people.

Human beings, in their continuous and permanent construction process, are associated with the establishment of bilateral relations and socialization processes that put them in a framework of special features. This is related to what Suarez (2003) stated in correlation to education, which he defines as a social process by nature, as an event that, for being involved in a network of mutual influences, is undoubtedly the most human and humanizing event of all social purposes.

Social issues are indivisible from the notion of human and this from the conception of education. Man is a social being by nature as suggested by Aristotle and, therefore, when speaking of the educational process, it cannot occur in isolation. The educational process runs parallel to self-knowledge in its multiple biopsychosocial aspects (biological, psychological and social) and society, which invigorates and changes demand with specific aspects to be maintained operable and for the common good.

New information technologies set a clear standard in the development of everyday activities within cities. There is an invisible consensus among citizen with respect to their constant and, many times, high use; classic notions of physical normality are modified and everything is virtualized. In educational processes, student participation and learning are sought to be optimized with the use of these technologies.

In Colombia, Law 1341 of July 30, 2009 defines Information and Communication Technology (ICT) as "the set of resources, tools, equipment, software, applications, networks and means for the collection, processing, storage and transfer of information, such as voice, data, text, video and images." The guiding principles of this law are as follows: 1) accessibility and use of ICT, 2) fair competition, 3) efficient use of infrastructure and scarce resources, 4) protection of user rights, 5) promotion of investment, 6) technology neutrality, 7) the right to communication, information, education and basic ICT services, and 8. massification of online Government.

Colombia has a Ministry that regulates all actions of educational plans with ICT, the Ministry of Information and Communication Technology (MINTIC by its Spanish acronym), which works in coordination with the Ministry of National Education (MEN by its Spanish acronym). The latter states that: "ICT not only make available to teachers and students large volumes of information, but also promote the development of abilities and essential skills, such as searching, sorting and processing information as well as autonomous learning. They also expand borders by making new resources available and the way of learning with others, including remote communities." (MEN 2009 p. 49).

Globalization as a worldwide phenomenon, technology growth and innovation, and the philosophy of knowledge societies have not only allowed to bridge the gap and bring educational training to places and people where it was unsustainable before, but increasingly include vulnerable populations. We continue thinking of a clear idea: Educating.

According to Márquez (2012), there are clear indexes for exploiting the methodological invention offered by ICTs, such as the high rate of school failure and the diversity and increase in the number of students per classroom, etc. For the author, ICTs and their proper use will allow for an effective, inclusive school.



For Sanchez et al (2009), the counselor or teacher is the one who mediates between students and their self-learning using ICT, enabling the student to assess information, form a critical personal opinion, and feel the maker of their learning.

Marin (2009) argues that “Training and ICT must be characterized by being personalized, flexible and interactive, enhancing thinking processes from a perspective that combines both the academic view of technology and practice” (p.100).

In that vein, new technologies facilitate learning and teaching, streamlining processes without diminishing education quality. The teacher continues to play a special and crucial role, which is to instruct, provide feedback, guide the student and, in this society of information massification, teach to filter information and form a critical view of their context.

Inclusion of ICT facilitates collaborative learning, but also proposes the creation of new information and digital competencies that teachers and students must have to optimize the process.

According to the Network of University Libraries (2014), there are five basic information competencies: 1) Searching information, which defines the need to know what are the resources where information is available to locate it effectively, 2) assessing information, which proposes to filter the selected information critically, 3) organizing and managing information effectively, 4) using, publishing and disseminating information, respecting ethical and legal standards, and 5) keeping up and sharing information in the network.

Information competencies should be part of frameworks governing educational processes in institutions in order to encourage proper and total use of new technologies and ensure a concrete, dynamic, collaborative interaction not only between teachers and students but among teachers and among students.

It is not uncommon to hear in the halls of universities, read in academic texts, or even attend trainings in business and organizational communities about “knowledge society”.

This term is associated first with information and technology, where the entire industry is developed nowadays. But its scope extends beyond utilization of the technology gear.

Aristotle (undated) stated, referring to societies, that “all associations aim at some good and the most important of all goods must be the subject of the most important association.” This suggests that current macrosociety should have as precept the common good that crosses distances and includes any and all its communities.

Knowledge as a particularity of human beings, is responsible for any and all advances in the history that marks society. Yet, at this specific time, it starts to play a leading role, the primary agent, in an elated and public manner. It is the main topic of world conventions and the ultimate goal, depending on the time.

Alavi and Leidner (2003, p.19 as cited by Flores 2005, p.22) define knowledge as the information the individual has in their mind, personalized and objective, in relation to facts, procedures, concepts, interpretations, ideas, observations, judgments and elements that may or may not be useful, accurate or structurable.

Knowledge is not on a full information plane. Ortega y Gasset (1940 as cited by Adriano 2015) identifies an evolution of knowledge from common sense or popular knowledge to that taught in school, which was of scientific nature. Knowledge, then, can be divided into two: Within a business environment that is often mistakenly transferred to the educational environment, there is tacit knowledge, which expresses what has been learned through personal experience and includes beliefs, own points of view and values; and explicit knowledge, which is expressed through formal language, including grammatical statements, mathematical expressions, specifications, manuals, etc. (Flores, 2005).

Coutin and Perez (2005) argue that information and knowledge are placed as principal elements for obtaining a real competitive advantage in a specific period of time. Materialization of knowledge as a commodity can lead to objectification of the person and it is precisely this vision what education avoids by promoting the opposite: personal identity.



Within the field of education, knowledge is closer to that expressed by Hernandez (2001, p.2) when identified as “the active and interactive apprehension of reality, an activity that is not devoid of an axiological characterization and has historical and social dimensions.” Knowledge is constructed by the human being in society and for the benefit of society and here lies one of the main features of the so-called knowledge society, which will be elaborated on in the following paragraphs.

According to Piaget and Inhelder (1975), there are three types of knowledge: physical, logical-mathematic and social. Physical knowledge refers to empirical abstraction of objects in the natural world (taste, length, hardness, weight, etc.). This is acquired by manipulating objects around the individual's environment. Logical-mathematical knowledge is part of a more complex reflective abstraction. It is knowledge resulting from prior coordination of actions taken by the individual upon objects. As an example, Piaget speaks of seeing three objects, but not seeing the number three anywhere.

Social knowledge, which is a consensus of the immediate context, friends, caregivers, parents and the non-immediate social context and its interpretation.

In addition to the above, not only the immersion of new information technologies, but the comparatively simple manageability they now have with regard to a couple of decades ago, allow to bring knowledge to communities, nations, places where considering the idea was once far-fetched not only in terms of distances, but also because of costs and human resources.

With this notion in sight, it is understandable what a knowledge society is according to Mateo (2006): A knowledge society highlights wisdom and knowledge as the parameters that govern and determine the structure and arrangement of modern society, while also being goods and determinants of welfare and progress of peoples.

Knowledge society is linked to all modifications for humanity, using as main vehicle new technologies that bring geographies together and reduce language gaps, among other particularities. But, prior to knowledge as complex construction of human beings, there is information as raw material. And in this journey of pedagogies and new technologies, there is the term Information Society, which has some key differences that will be briefly explained below.

Therefore, it should be noted that, when describing the age of information, production, reproduction and distribution of information are the founding principle of society (Krüger, 2006). Or as supported by Castell (1999 cited by Trejo 2001), it remarks the work content. It can be affirmed that information society directs its use to employment and production processes in business communities.

It is clear that we currently live in a knowledge society and, although there are shortcomings and weaknesses as seen in developing countries regarding education, optimization is continuously sought. But, when did this change of time and paradigm occur, what supports it and where are its horizons going?

Unesco (2005) describes certain features of the knowledge society. The following lines will briefly describe them.

A knowledge society is a society that thrives on its diversity and capabilities, which means that each society has its various forms of knowledge that should not be relegated but, on the contrary, efforts must be made to involve them in building society.

Knowledge society must ensure shared use of knowledge; this feature is related to the integration of each member, not only in the present but for generations to come. Everyone must have access to knowledge because this is how education is expanded and optimized.

Knowledge societies are not confined to information societies, which denotes that information itself does not form a knowledge society. There must be first equity in their people so that they can interpret this information critically and analytically.

In light of the above, and as a summary, knowledge societies seek comprehensive development, specifically the expansion and optimization of educational processes, and make use of new technologies to do this. It can be said that assertive use of ICTs for this purpose is a social constructivist pedagogical model that, using



concepts such as collaborative learning, can guarantee effective learning in virtual or classroom education means.

With respect to the unstoppable advance of process technologization and a society that reinvents itself day after day, it is necessary to delve into an issue that has gained particular interest in academia in the last decade because of its potential for continuously improving education, i.e. data analysis and learning analytics.

Relevant factors in the knowledge society and its difference with respect to information society have been previously identified. Information as a raw material of knowledge has in turn a source. Information lacks a sense of applicability if not analyzed within an environment or a context that gives it form and substance. The same happens with data if not contextualized, organized, structured and filtered. Their potential was discovered around the 1960s by large organizations that, due to constant monitoring of their customers, obtained in a short time enough data to redirect their marketing strategies and thus increase and position their brands.

According to Han et al (2012), databases and technology information has evolved from primitive system processing files to powerful databases at present.

During the 1990s, the World Wide Web (or WWW) and the technological development of hardware and applications at the virtual level ultimately led to create strategies to have a higher level of information security and repositories became the most protected objects in companies. Therefore, databases became more secure and reliable.

This situation soon became a technological field of information and communication where large amounts of data are handled, causing difficulties in information management, such as capture, storage, search and analysis. This gave rise to the integration of different components and projects that interact together to analyze large amounts of data.

Given the exponential growth of this new force and the urgent need for functional data (turning them into information and then into knowledge), Data Mining (DM) arises to make use of statistical methods in order to find correlations and/or patterns. According to Long & Siemens (2011), DM is the use of mathematical algorithms for the specific recognition of certain factors within large amounts of data, allowing to manage components such as connectivity management, high availability, security, performance optimization, filtering, monitoring, application management, SQL and customized scripts, etc.

Pérez (2008) holds that “data mining tools allow to extract patterns, trends and regularities for predicting standards and/or making strategic decisions” (p. 2). For Talegaon (2014), the analysis of large sets of data allows to discover patterns, unknown correlations and other information that may be useful to make the best decisions.

Then, there is a large amount of data that cannot be processed and/or analyzed by traditional means called big data. Therefore, it can be said that Big Data is the ability of society to level information by employing novel approaches in order to produce knowledge, goods and services of significant value depending on the context.

According to Gutierrez-Priego (2015), expansion of educational technology, implementation of virtual training and use of Internet as a learning tool have provided what is called fingerprints. These, like in the business context, provide data that are increasingly extensive in quantity. Big data in the educational environment are analyzed by educational data mining and/or learning analytics.

Bienkowski et al. (2012) identify a difference between educational data mining (EDM) and learning analytics. For the authors, these two lines complement each other, but their origins have different focuses. EDM develops methods and applies statistical and MD techniques to analyze collected data during teaching and learning.

Learning analytics applies techniques from information science, sociology, statistic psychology, and MD to analyze the data collected during the administration of education, teaching and learning. Learning analytics creates applications that directly influence educational practice.



De Laat & Prinsen (2014) state that SLA is necessary within the educational frameworks developed in social and interaction environments, because it is important to understand the learner's social mobility. If a good analysis of students' activity and connectivity is performed, better opportunities may be provided in learning networks of higher education by, for example, approaching the real needs of these institutions. Instead, LA uses information about learners and learning environments, evaluating, analyzing and proposing real time models for prediction and optimization of the processes of education and educational decision-making (Ifenthaler, 2015 cited by Ifenthaler & Schumacher, 2015).

Learning analytics has the potential to provide learners with substantial feedback to help and improve their understanding and skills. Analytics allows, when introduced deeply into the student learning process, to identify the impact of curriculum and learning strategy, while facilitating individual progress (Macfadyen et al, 2014).

Long and Siemens (2011) state that learning analytics is "the measurement, collection and analysis of information reported on learners and their contexts for the purpose of understanding and optimizing learning processes and environments." The authors hold that this line allows large quantities of information to make sense. Friesen (2013) highlights that the improvements that LA could make (in relation to the optimization of learning processes) relied on the definition of patterns, which in turn is based on the decisions of on-line platform users.

Gewerec et al (2013) claim that through LA tools it is possible to find out what is happening in the "black box of the process conducted by students in the virtual environment of the social network, using friendships and content of the activity logs of students' blogs"(p. 58).

Lukarov et al (2014) refers to the importance of being clear about what is being looked for in the data; giving a sort of context becomes important when looking for correlations or patterns.

Then it is important to monitor and analyze the teaching process, not only because it is a mechanism to give academic, administrative and training guidelines, but also because their results contribute to decision making, using tools that help them adapt to training plans or resources. The tool built contributes to the collection and analysis of data generated in the virtual classroom, defining goals for both the student and the teacher. It also generates the Key Performance Indicator (KPI) to prepare final assessment reports. Based on this, the teacher can choose better the topics that will be covered in the classroom, guided by the learning styles of each student. The use of LA techniques allows to obtain information that facilitates the acquisition of deeper knowledge of students using on-line and/or mobile teaching systems, thus customizing learning and adapting it to the progress of each student (Martinez, 2013).

To improve the tools that measure the degree of knowledge of each student with mechanisms that provide teachers with information on levels of competencies in specific areas and the real situation of each student, a virtual classroom, where the strategy is qualitative assessment, is designed to measure login statistics, study preferences, and topics where greater risks are present.

## 2. Material and methods

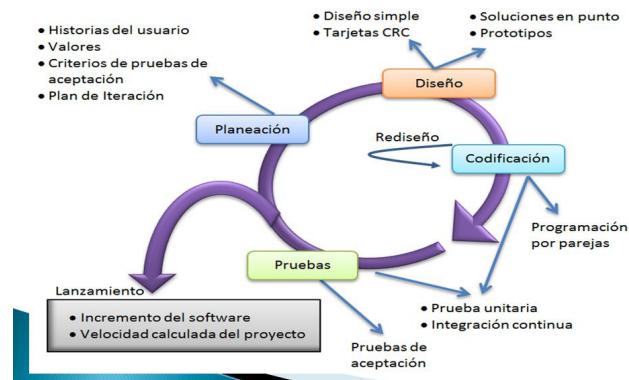
The inclusion of agile methodologies in short projects has brought the benefit of including the user as a more active agent in the development of software, while traditional methodologies emphasized process control through a rigorous definition of roles, activities and artifacts, including modeling and detailed documentation, which is the reason why they are very effective in large projects. However, for changing environments such as those handled today, they are not very useful. Instead, agile methodologies provide a simplification of timelines but preserving practices of traditional methodologies, i.e. without losing quality. For this reason, this project was worked with an agile methodology.

*Extreme programming.* This practice arises from agile methodologies to develop customer-oriented systems. It is based on feedback for programmers, analysts, designers, users and computers; therefore, it is performed

cyclically, these cycles being more rapid and more intense and providing more and more information. The main objectives of this methodology are to create a global system plan, to develop and release the software rapidly, and then to revise it continually to incorporate additional features. Fig. 1 shows the interaction in the process of software development, using the XP methodology.

## XP Aplicado

Metodología XP(Extreme Programming)



**Fig. 1.** XP methodology. Source: González C., 2012.

[Traducción de la imagen: XP aplicado = Applied XP / Metodología XP = XP methodology / Planeación = Planning / Historias del usuario = User stories / Valores = Values / Criterios de pruebas de aceptación = Acceptance test criteria / Plan de iteración = Iteration plan / Diseño = Design / Diseño simple = Simple design/ Tarjetas CRC = CRC cards / Soluciones en punto = Spike solutions / Prototipos = prototypes / Codificación = coding / Rediseño = refactoring / Programación por parejas = pair programming / prueba unitaria = unit test / integración continua = continuous integration / Pruebas = testing / pruebas de aceptación = acceptance testing / lanzamiento = reléase / incremento del software = software increment / velocidad calculada del proyecto = Project velocity computed]

Based on the XP methodology, the application was developed according to the following cyclic stages: Planning, Design, Encoding and Testing.

For the modeling of user requirements, a tool called Enterprise Architect was used, which has large high-end capacities to help manage information, rich on the whole and in features. This makes the tool very suitable for modeling any system and serves as specification, visualization and documentation language of the software.

The application was developed in the programming language PHP as it allows to create dynamic web pages, is easy to connect to the Moodle virtual classroom and was used as MySQL database engine. The interface, on its home page, shows interesting news for teachers and students as well as contact and registration links.

### Application modules

Information. Information of application operation is shown here.



**CATEGORÍES**

- Información
- Acceso/Permanencia
- Uso de los recursos
- Actividad y participación
- Comunicación establecida
- Trayectoria dentro de la plataforma
- Procesos de interacción entre personas
- Ingreso/Modificación/Eliminación Usuarios
- Comentarios
- Cerrar Sesión

**TRAYECTORIA DENTRO DE LA PLATAFORMA**

ESTE INFORME MUESTRA DESDE EL INGRESO DE SESIÓN POR PARTE DEL ESTUDIANTE HASTA LAS INTERACCIONES CON LOS DISTINTOS RECURSOS DEL AULA

SU OBJETIVO PRINCIPAL ES RECONOCER SI EL ESTUDIANTE NO SOLO ESTÁ INGRESANDO EN LA PLATAFORMA, SINO SI INTERACTUA CON LAS DISTINTAS HERRAMIENTAS QUE OFRECE EL AULA

**INGRESE**

**Fig. 2.** Information module. Source: The authors.

Access/Presence. Individual statistical graph by group of time spent by students in the virtual classroom.



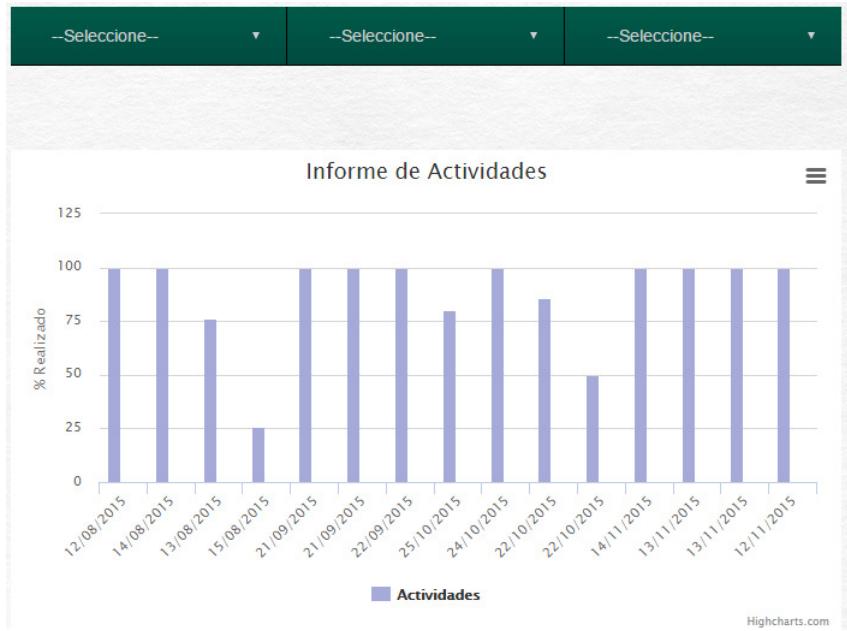
**Fig. 3.** Access/Presence. Source: The authors.

Use of resources. This option displays which resources are consulted by students, individually or by group.



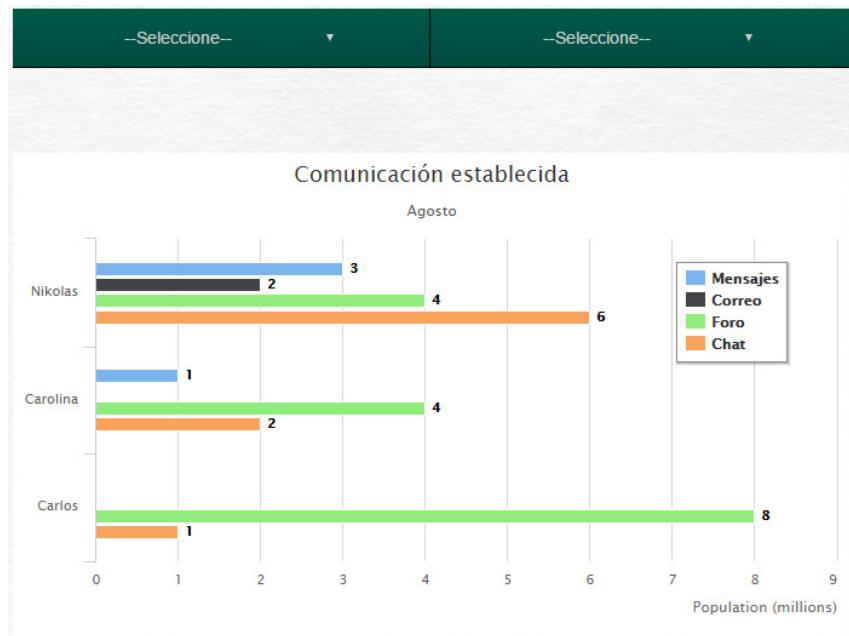
**Fig. 4.** Access/Presence. Source: The authors.

Activity and participation. This page shows activity, percentage completed by the student, date on which it was posted, date on which it was finished, and closing date of the activity.



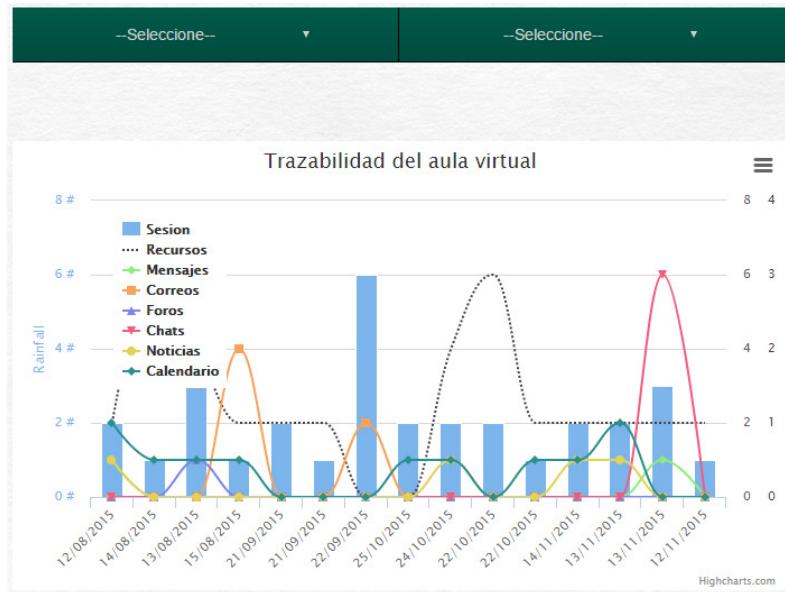
**Fig. 5.** Activity and participation. Source: The authors.

Communication established. This page shows the type of communication established, which can be a message, mail, forum or chat, and whether it was synchronous or asynchronous (one-to-one, one-to-all, all-to-all), date of communication, and number of messages.



**Fig. 6.** Communication established. Source: The authors.

Traceability in the platform. This module shows traceability of the student in the platform, from login to interaction with resources, chats, etc.



**Fig. 7.** Traceability in the platform. Source: The authors.

Interaction among people. This page shows the type of communication established, which can be a message, mail, forum or chat, and whether it was synchronous or asynchronous (one-to-one, one-to-all, all-to-all), date of communication, and number of messages. Unlike the communication page, this specifies the individuals who were involved in the communication.



**Fig. 8.** Interaction among people. Source: The authors.

### 3. Results

Having applied the tool developed on a virtual classroom, the findings were as follows:

- The tool fulfills the initial purpose of learning analytics, i.e. to display data. It presents six items graphically: Access/Presence, Use of Resources, Activity and Participation, Established Communication, Traceability in the Platform and, finally, Interaction among People.
  - Access and presence: This option allows to know what hours are most used by students to connect to the virtual classroom and how many minutes on average they stay connected. It initially shows the total by group, but allows to compare the student with the group and filter data by month.
  - Use of resources: This module allows to see graphically what resources are most consumed by students, which is useful for the teacher to characterize the group he/she has in the virtual classroom.
  - Activity and participation: This module shows in what kind of activities students involve: forums, chat, messages, wikis, glossaries, etc. The purpose of all this information is to help the teacher in charge of the course make decisions geared towards improvement.
  - Established communication: This option shows with whom and by what means the student communicated with his/her peers and whether the student prefers to communicate with their peers through messages, forum or chat.
  - Traceability in the platform: This module allows to see graphically what the student does and where the student goes after logging into the virtual classroom. This module helps identify which section the student visits after entering the virtual classroom: Resources, activities, news, notes, etc.
  - Interaction among people: This module allows to identify with whom the student communicates more, the teacher or a specific classmate.

It should be noted that the tool was used only in one virtual classroom as a test to validate its operation. Therefore, it would be hasty to assert and show some results that maybe in another course will not be as obvious as in the one it was applied.

Clearly, as a resource in the teaching-learning process, the tool offers solutions because it enables teachers to carry out an initial characterization of their students. This information is not directly provided by virtual



classrooms within their report options. Thus, it is useful for teachers to have these graphs that allow them to know the habits of their students and, based on this, develop strategies to improve and strengthen the process.

The tool does not have a feedback process yet that enables communication between teacher and student. Teacher's feedback to students is vital because he/she is in charge of guiding them in their training process.

## Discussion and conclusions

The tool is in the first phase or stage of Learning Analytics. For now that was the purpose, but the authors are clear, and so is stated in the objectives sought by LA, that data alone are not significant. The second stage is oriented towards diagnosis (analyzing the data collected) and prediction (not just limit ourselves to analyze the data but to predict what may happen with a particular student based on this analysis). Finally, the prescription stage (aiming at providing personalized guidance to each student, according to the individual analysis of their data in the virtual classroom).

The tool is useful for both teachers and students; for teachers, because it helps them characterize their students in the virtual classroom and, based on it, take some steps and make corrections to the teaching process; and for students, because it allows them to measure their performance graphically, compare themselves with their peers, assess themselves and use it as a challenge for improvement in the case of low achievers.

The authors are clear that, regarding LA, there are some items that are critical and controversial, such as the ethics of data collection and their analytics. It is understandable that these issues always give rise to discussions about how appropriate it is to collect and analyze data of students in virtual classrooms.

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## Open Educational Resources: initiatives towards culture implementation at a public university

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**Abstract.** This paper presents a Brazilian public university experience in Open Educational Resources – OER development. It discusses the OER concept in a contemporary approach, i.e., as open to anyone, under an open license that permits no-cost access and free reuse, continuous improvement and repurposing for educational purposes. It also discusses open education concept and mobile apps in OER context. It presents the results reached at the researched university with open education in MOOC's format and the development of open mobile application for physics education (M-Labs) and another for the blind and visually impaired. From the methodological point of view, this is an exploratory and descriptive research with a qualitative approach and an experience reporting as a data collection procedure. The paper concludes that both MOOCs and the mobile app developed are relevant initiatives in order to introduce an OER culture at the researched university.

**Keywords:** Open Educational Resources. Open Education. MOOC. Mobile App. Physic Education. Visually impaired.

## 1 Introduction

Open Educational Resources – OER constitute essential tools especially for public higher education institutions operating in developing countries with increasingly reduced budgets, face with limited available public financial resources.

In this scenario, OER assume a decisive role in implementing an education guided on quality criteria and, above all, effectiveness in its teaching and learning processes. Santana, Rossini & Preto [1] help us to reflect on the genesis of REA stating that "(...) is open because they allow other flights and other productions, is open because it allows remixing and, ultimately, is open because they understand the difference as a value to be commended and not simply accepted or considered"(p.13).

The purpose of this paper is to present the experience of a Brazilian public university in the development of OER culture in open education and mobile app context. First, the article discusses the concept of open educational resources in their contemporary approach and, subsequently, it uses the strategy of the experience report to present the results initially obtained by the introduction of OER in the university.

## 2 Theoretical Framework

The “2012 Paris OER Declaration” from World Open Educational Resources (OER) Congress Unesco, held in Paris on 20-22 June 2012 [2], has emphasized that the term Open Educational Resources (OER) designates,



teaching, learning and research materials in any medium, digital or otherwise, that reside in the public domain or have been released under an open license that permits no-cost access, use, adaptation and redistribution by others with no or limited restrictions. Open licensing is built within the existing framework of intellectual property rights as defined by relevant international conventions and respects the authorship of the work [2].

How has the theoretical OER framework improved since 2012? What are the contemporary concepts? Let us see.

## 2.1 OER: contemporary concept

Even considering the OER official definition coined at UNESCO on “2012 Paris OER Declaration”, there are many concepts about OER although, most of them, keep the chiefly ideas assumed on Paris OER Declaration.

The “Guidelines for Open Educational Resources in Higher Education” [3] clarifies that OER is not the same as online learning, eLearning or even mobile learning. In this way, the guidelines state:

OER can include full courses or program, course materials, modules, student guides, teaching notes, textbooks, research articles, videos, assessment tools and instruments, interactive materials such as simulations and role plays, databases, software, apps (including mobile apps) and any other educationally useful materials (p. 5).

According to common definitions [4] used both by CERI - Centre for Educational Research and Innovation; William and Flora Hewlett Foundation and UNESCO, it is also possible to define OER “as teaching, learning and research materials that make use of appropriate tools, such as open licensing, to permit their free reuse, continuous improvement and repurposing by others for educational purposes” (p. 17).

Furthermore, Butcher & Moore [5] present the following OER benefits such as education open to anyone; affordable, in other words, ideally free; students can try the course before signing up; flexible study times not bound by weekly timetables or semester calendars. Besides that, students work at their own pace; available from anywhere and not restricted by access to school or college; access to huge amounts of study materials and the intellectual capital is available for reuse.

## 2.2 Open education

In contemporary society, the conceptual approaches related to open education are varied and, according to Santos conception [6] it is possible to characterize it in terms of their practices, especially in context with the learning system and the historical moment in which they are inserted. The author points out the following main characteristics permeating open education:

- student freedom to decide where to study and may be from home, work or even their own institution and / or learning hubs;
- possibility of studying in modules, credit accumulation or any other means that allow the student to learn in a manner compatible with the necessary rhythm to their lifestyle;
- use of self-instruction with formal or informal validation of learning through optional certification;
- exemption from registration fees, monthly payments and other costs that would be considered a barrier to access to formal education;
- exemption of selecting exams and necessity of presenting previous qualifications, which could constitute a barrier to access formal education;
- accessibility of courses for students with physical disabilities as well as those who have some social disadvantage;
- provision of open educational resources, used both in formal and in non-formal education (p. 72).



The open education idea shows us that education is not limited to the space of the traditional classroom and may occur for lifelong learning in favorable spaces. This continuing education idea is also present in the concept of MOOC, an acronym for Massive Open Online Courses, offered by higher education institutions and which are able to attract a large numbers of people who seek to expand their level of knowledge in a specific subject. With MOOC, all material produced and access to the course is free [7].

Thus, open education constitutes non-formal education in an OER context. However, especially in countries with high educational regulations, the current challenge is validating the studies carried out under open education into the formal education systems. For example, how to validate MOOC certificates into academic credits in formal education? This is an issue that formal educational institutions are actively seeking answers to!

### 2.3 Mobile App

The OER concept refers to the open licensing idea on order to permit their free reuse, continuous improvement and repurposing by others for educational purposes, including mobile apps [4].

With the explosive increase in the use of smartphones and tablets an education process without those devices has become inconceivable. Especially today, the student, as native or resident digital, has assumed that teaching and OER will be available on their mobile devices [8].

In traditional face-to-face education students need to go to a specific location to use specific labs to learn physics, chemistry, math and others fields. However, especially in schools located in development countries, these important experimentation labs really do not exist. With OER mobile apps and the communication capabilities of mobile technology, students can interact with labs experimentation, learning in their own context without expansive financial investment [9].

## 3 Method

This experience report is defined in the context of social research with a qualitative approach. Thus, this is an exploratory and descriptive study using a data triangulation strategy, according to the type of research suggested by Gil [10].

The data triangulation technique featured the report of participant observation, analysis of the institution reports and scientific articles published by the institution researchers on the theme. According to Triviños [11] the data triangulation technique allows to expand the description, explanation and understanding of the study subject, since it is understood that it is impossible to conceive the phenomenon isolated from their social and cultural context.

Thus the OER implemented by the public researched university was analyzed, especially in the context of open education (06 MOOC) and mobile app (03), both of them developed in 2015.

### • OER at a public university: experience reporting

The researched university started lately its distance education programs as part of Brazil Open University – UAB, a consortium or system of 103 Brazilian public institutes and universities in order to provide formal distance education throughout the country.

Besides the formal education, the researched university had also developed several mobile apps in its laboratory of educational technology. In the context of open education, the university started to offer MOOCs



by mean of distance education department. Both the mobile app and the MOOCs are initiatives in OER context and have contributed to the introduction of a new culture at the researched university.

### a. Open education: MOOC

Conscious of the need to improve continuing education, especially in distance education, since 2014 the researched university has conducted several programs with focus on the formation of their teachers and tutors by means of distance education department. However, from 2015 onwards it started to offer MOOCs as an important tool to open education.

They have prepared and offered six new MOOCs during 2015 and all of them were based on a self-learning proposal, through a route of pedagogical learning able to promote the engagement [7] of participants. Among these, two courses are related with continuing teacher education and another four courses were designed in order to attend academic student needs, which presented topics such as reading and academic text production, ABNT style, Prezi basic and Web Conference, as per table 1.

Table 1: MOOCs 2015 – enrolled *versus* approved

MOOC	Enrolled	Approved	Approved (%)
Moodle for Teachers and Tutors	1795	594	33.1%
Planning, Evaluation and Distance Education Framework	1669	598	35.8%
Reading and Academic Text Production	6954	1606	23.1%
ABNT Style	858	417	48.6%
Web Conference	365	22	6%
Prezi Basic	637	21	3.3%
<b>Total</b>	<b>12,278</b>	<b>3,258</b>	<b>26.5%</b>

As recommended by Silva [6], the principal characteristics of the MOOCs offered by the researched university are related to open education concept as OER. In this way, they allow student freedom to decide where and when to study with an intense OER use, such as virtual learning environment in Moodle open source learning platform. There is also a validation of learning through an optional online certification and there are no registration fees or selecting exams.

This initial successful experience had a positive effect on the university professors as many of them felt motivated to use Moodle platform as a support for face-to-face classes as they are also engaged in developing new MOOCs, by supervision of distance education department. In fact, it has begun an OER dissemination culture at this researched university!

### b. M-labs

By means of its laboratory of educational technology, the researched university has also developed the M-labs, which aim to introduce various internal and external sensors (integrated to the tablets and smartphones) for experimental measurements in physics education [12].

M-Lab is an experimentation platform in physics phenomena with tablet and smartphone devices developed with an interface that performs data acquisition of sensors embarked in mobile devices such as accelerometers and magnetometers, which enable the measurement and perception of many physical phenomena related to several areas of physics such as mechanics, dynamics fluids, electromagnetism etc.

These M-labs are designed within a pedagogical proposal that encompasses theoretical grounds, production of experimental measurement plans to begin and motivate students in performing measurements, interactive games,

videos for use in the measurement process and future measurements are listed that the experimenter can perform at any location or context in which the experimenter is inserted [12].

Another relevant point is that M-labs' accurate values are not usually found in current didactical laboratories used in physics education. In this way, M-labs present statistical tools, such as linearizing data and least squares methods, since this allows a real time data processing, optimizing both the interpretation and the assimilation of contents.

In this way, physics education is taken to a new level, since the M-Labs offer a portable laboratory, including plotting graphs and data processing, in which the student and the teacher have free experimentation possibility, at any time and place, from a simple perception occurrence of a physical phenomenon.

According to “Guidelines for Open Educational Resources in Higher Education” [3] mobile apps such as M-Labs are included in OER context. Further, professors and students can interact with lab experimentation, learning in their own context without expansive financial investment [9].

### c. “Quick Voice” app

Mobile devices open new fields for the inclusion of people with disabilities and, fortunately, new researches with mobile technology have been increasing lately in order to include these people

The researched university, by means of its laboratory of educational technology, created a mobile app named “Quick Voice” with the purpose of maximizing the inclusion of the users with visual impairment. This mobile app was especially designed for the blind and visually impaired, helping them to convert bi-dimensional code (QR Code) into text files, either in writing or in audio, assisting mainly people with visual impairment [13].

Without any high-cost equipment and difficulty to use, any person can access a site or software for the creation of tickets in QR Code and transform a text into a ticket, which can be printed in a common printer. From this material another person has the possibility of transcribing the ticket into audio, which would permit the reading of the complete text [13].

“Quick Voice” app is relatively simple to operate, using the camera of the device to capture the QR images and a decoder, which transforms the images generated into text strings, which are read and converted into audio [13]. Thus, “Quick Voice” could be used in many segments, such as magazines, books, didactic material etc., as per Fig. 1.



Fig. 1: Quick Voice App



As part of OER field, ‘Quick Voice’ app is an educationally useful material designed for the visually impaired [5]. An open education characteristic is the accessibility tool for students with physical disabilities as well as those with some social disadvantage [6], as is the purpose of “Quick Voice”.

The open mobile application development in the researched university has contributed to the dissemination of an OER culture among professors and student who are motivated to participate in the expansion of such projects.

## 4 Conclusions

Open Educational Resources - OER permits free reuse and improvement for educational purposes and includes courses, course materials, videos, assessment tools and instruments, interactive materials such as mobile apps and any other educationally useful materials.

In the OER field, the researched public university started open education courses in MOOC’s format and designed several mobile apps such as MLabs and “Quick Voice” to be used as educational tools.

The six MOOCs offered by the researched university reached 12,278 enrollments in 2015 and all of them allow the student freedom to decide when to start, where and when to study. These MOOCs present an intense OER tool, such as virtual learning environment in Moodle open source learning platform. There are no registration fees and the validation of learning is obtained through a free optional evaluation for online certification. This successful experience motivated many professors to use Moodle open platform in their face-to-face classes and they are also engaged in developing new MOOCs, disseminating OER culture through the university!

The researched university has also designed interesting mobile apps as OER tools. For instance, M-Labs is an experimentation platform in physics education with tablet and smartphone devices, in which the student and the professor have the free portable experimentation in physics phenomena, at any time and place, without expansive financial investment in face-to-face laboratories.

“Quick Voice” mobile app was another OER tool designed by the researched university. Especially projected for the blind and visually impaired, “Quick Voice” app is a strong tool to help them to convert bi-dimensional code (QR Code) into text files, either in writing or in audio. M-labs and “Quick Voice” apps have promoted an OER culture among professors and students, motivating them to participate in new OER projects.

The development of Open Educational Resources is quite challenging and requires a multidisciplinary team committed with the results. However, faced with increasingly reduced budgets the public universities need to strengthen the OER culture in order to take account of emerging contemporary educational demands, especially in developing and poor countries.

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## Integral schema for Monitoring and Evaluation of ICT Inclusion, Use and Appropriation in Education

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**Abstract. Problem:** Taking global Frameworks of ICT4E for developing M&E (Monitoring & Evaluation) research: ¿How to compose an integral schema to assess the state of inclusion, use and appropriation of ICT4E in institutions at Tunja, Colombia? **Objective:** Design an integral M&E schema of Inclusion, Use and Appropriation of ICT4E. **Methods:** The Evaluation schema was designed by correlation of Core Indicators of 7 educational Frameworks. The Monitoring scheme is composed of the steps for evolution assessment. Final assessment was performed to the 14 official institutions. **Results and Conclusion:** Public Educational Institutions at the city of Tunja are in the second stage of evolution, called Use. Individual Frameworks' scores supports the data behavior. It's the first time the institutions of the municipality are assessed about their ICT4E skills, so the given information should be taken as a preamble for further assessments; these should line up with national policies and goals.

**Keywords:** ICT4E · M&E · Educational Frameworks · Assessment · Indicators

### 1 Introduction

After more than 30 years of research on the field of integration of ICT in education, we understand that ICT are tools to deliver contents and implement better educational practices [1,2,3,4,5,6,7]. So a main goal for developed countries is the integration of ICT with the technical capabilities of teachers, technical support, maintenance and modernization, pedagogical skills, preferences and capabilities of teachers, availability of resources, skills and motivations of students to build a more dynamic educational environment. This is known as ICT for Education (ICT4E) [8].

Among investigations it's accepted the Technology-Enhanced Learning (TEL) concept [9]. However, other studies argue that only by providing infrastructure and computing resources to the institutes is not enough for a true integration of ICT in school practice [10].

#### a. ICT4E Frameworks

To guide ICT4E practices, organizations like UNESCO and nations such as South Africa, Australia, United States and the Netherlands, have designed Frameworks to set a benchmark of needed skills for its effective implementation, use and appropriation in educational environments [11,12,13,14,15,16].



## b. M&E Schema

In order to assess the state of inclusion, use and appropriation of ICT of the official institutions of primary and secondary education at the municipality of Tunja, it's proposed a Schema of Monitoring and Evaluation (M&E) of ICT4E.

The schema is built from identifying indicators, which are the ways in which each selected framework delivers a state, trend or warning on ICT in the educational environment [17]. The indicators of each studied Framework cover topics such as implementation, monitoring, design plans, policies and custom models. Also are clearly and effectively categorized, so they can be correlated through the Core Indicators to be considered in any study of monitoring and evaluation of ICT for Education [18]. Based on this input the selected frameworks were correlated by their categories and their Stages of Evolution to ensure an effective measurement [19].

The schema is run through the survey *Assessment of the level of inclusion, use and appropriation of ICTs*, applied to the 14 official institutions in the municipality of Tunja.

### • Frameworks and Indicators

In [19], 7 frameworks where identified for possessing outstanding progress reports and status of the implementations. Then they were analyzed based on the *Stages of Evolution* and the *Categories of Indicators*, and their most relevant indicators were extracted.

The selected Frameworks are:

- UNESCO ICT Competency Standards for Teachers, with 63 indicators.
- ICT-enhanced Teacher Standards for Africa, with 48 indicators.
- ISTE: National Educational Technology Standards for Teachers (NETS-T), with 84 indicators.
- Australia: ICT Competency Framework for Teachers, with 58 indicators.
- ICT-tools for a balanced use of ICT in the Netherlands, with 36 indicators.
- Metas Educativas 2021, with 4 indicators.
- Competencias TIC para el desarrollo Profesional Docente, with 45 indicators.

*Metas Educativas 2021* is not really a framework but it is included because it's an unanimously accepted proposal by the Ministers of Education meeting at El Salvador, on the XVIII Ibero-American Conference; a joint commitment to meet the challenges of their people through an education program.

All the Frameworks were analyzed by two proposed factors: *Stages of Evolution* and *Categories of Indicators*. Although other studies as [20,21] developed M&E models, each Framework has its own way to assess and supervise [22,23,24,25,26,28]. So the work took on with the correlation of these factors to develop an integrative result. These proposed definitions determine how is evaluated and monitored the progress:

- The *Stages of Evolution* help to score the evaluated subject or entity at a performance level. Fig. 1 shows how each Framework measures progress. For the integral schema, this work proposed 3 stages: the lowest level was defined as Inclusion, intermediate level as Use and advanced as Appropriation. This allows to set quantitative scores on scales from 0 to 3 or 0 to 4, depending on the Framework.
- The defined *Categories of Indicators*, used to assess the particular approaches.



FRAMEWORK	STAGES OF EVOLUTION		
	Inclusion	Use	Appropriation
1. UNESCO ICT Competency Standards for Teachers	APPROACHES TO TEACHING		
	Technology Literacy	Knowledge Deepening	Knowledge Creation
2. ICT-enhanced Teacher Standards for Africa.	Stages		
	Emerging	Applying	Infusing
3. ISTE: National Educational Technology Standards for Teachers (NETS-T)	RUBRICS		
	Beginner	Medium	Expert
4. Australia: ICT Competency Framework for Teachers	Phases		
	Phase 1	Phase 2	Phase 3
5. ICT-tools for a balanced use Of ICT in the Netherlands	Expertise/Vision		
	Teacher-Driven Learning	Autonomous Learning	Self-Organized Learning
7. ICT Competencies for the Professional Development For Teachers	Levels		
	Exploration	Integration	Innovation

**Fig. 1.** Stages of Evolution of the Frameworks (Source: WOSC 2014, p. 124)

Each Framework is briefly described below:

#### a. Category of Indicators

At the design of the M&E Schema, was proposed a list of 7 *Category of Indicators* to have a general reference among all frameworks: ICT, Learning environments, Teacher Professional Learning / development, Pedagogy Assessment, Curriculum and Educational Policies. The states of evolution are quantified in Table 1.

**Table 1.** Qualification levels by category: Category of Indicators.

Evolution State	Qualification
Inclusion	0 >= 1
Use	1 >= 2
Appropriation	2 >= 3

#### b. UNESCO ICT Competency Standards for Teachers

This UNESCO project provides a comprehensive framework for "capacity building" and "e-learning". Its primary aim is creating inclusive knowledge societies through information and communication [22].

It has 3 stages of evolution called *Approaches for Teaching*, quantified in Table 2. It groups the indicators into 6 categories called aspects of teachers' work: 1. Understanding ICT in Education (UN-1), 2. Curriculum and Assessment (UN-2), 3. Pedagogy (UN-3). 4. ICT (UN-4), 5. Organization and Administration (UN-5), 6. Teacher Professional Learning (UN-6).

**Table 2.** Qualification levels by category: UNESCO ICT Competency Standards for Teachers.

Approaches for Teaching	Qualification
1 Technology Literacy	0 >= 1
2 Knowledge Deepening	1 >= 2
3 Knowledge Creation	2 >= 3



### c. ICT-enhanced Teacher Standards for Africa

ICT e TSA was conceptualized and launched in 2009 by the UNESCO International Institute for Capacity-Building in Africa (IICBA), as one of the strategies for capacity building to strengthen the development of teachers in Africa [23].

It has 4 stages of evolution called *Stages*, quantified in Table 3. It groups the indicators into 6 categories called Areas: 1. Engage in Instructional Design Processes (AF-1), 2. Facilitate And Inspire Student Learning, Innovation And Creativity (AF-2), 3. Create and Manage Effective Learning Environments (AF-3), 4. Engage In Assessment and Communication of Student Learning (AF-4), 5. Engage In Professional Development Model And Ethical Responsibilities (AF-5), 6. Understand Subject Matter For Use in Teaching (AF-6).

**Table 3.** Qualification levels by category: ICT-enhanced Teacher Standards for Africa.

Stages	Qualification
1 Emerging	$0 \geq 1$
2 Applying	$1 \geq 2$
3 Infusing	$2 \geq 3$
4 Transforming	$3 \geq 4$

### d. ISTE: National Educational Technology Standards for Teachers (NETS-T)

The text contains six standards with performance indicators, designed to be appropriate for state, universities or district guidelines. This performance indicators provide specific outcomes that are measured during the development of tools for assessing them [24].

It has 4 stages of evolution called *Rubrics*, quantified in Table 4. It groups the indicators into 6 categories called Standards Areas: 1. Technology Operations and Concepts (NS-1), 2. Planning and Designing Learning Environments and Experiences (NS-2), 3. Teaching, Learning, and the Curriculum (NS-3), 4. Assessment and Evaluation (NS-4), 5. Productivity and Professional Practice (NS-5), 6. Social, Ethical, Legal, and Human Issues (NS-6).

**Table 4.** Qualification levels by category: ISTE: National Educational Technology Standards for Teachers (NETS-T) .

Rubrics	Qualification
1 Beginner	$0 \geq 1$
2 Medium	$1 \geq 2$
3 Expert	$2 \geq 3$
4 Transformer	$3 \geq 4$

### e. Australia: ICT Competency Framework for Teachers

The Framework articulates the competency standards for teachers working in government schools at Western Australia. It defines competency rules to describe the different degrees of effectiveness in which teachers demonstrate efficacy applying their professional knowledge, skills and attributes in the specific teaching context [25].

It has 3 stages of evolution called *Phases*, quantified in Table 5. It groups the indicators into 6 categories called Dimensions of Teachers' Work: 1. Facilitating Student Learning (AU-1), 2. Assessing and Reporting Student Learning Outcomes (AU-2), 3. Engaging in



Professional Learning (AU-3), 4. Participating in Curriculum Policy and Other Program Initiatives in an Outcomes-focused Environment (AU-4), 5. Forming Partnerships within the School Community (AU-5).

**Table 5.** Qualification levels by category: Australia: ICT Competency Framework for Teachers.

Phases	Qualification
1 Phase 1	$0 \geq 1$
2 Phase 2	$1 \geq 2$
3 Phase 3	$2 \geq 3$

#### f. ICT-tools for a balanced use of ICT in the Netherlands

This Framework aims to support the effective and efficient use of ICT in primary and secondary education at institutions of the Netherlands. It was designed by the ICT-OP [26].

It has 3 stages of evolution called *Expertise/Vision*, quantified in Table 6. It groups the indicators into 3 categories called Infrastructure/Content: 1. Instruction and Practice (4B-1), 2. Adaptive Learning Material (4B-2), 3. Personal Learning Environment (4B-3).

**Table 6.** Qualification levels by category: ICT-tools for a balanced use of ICT in the Netherlands.

Expertise/Vision	Qualification
1 Teacher-Driven Learning	$0 \geq 1$
2 Autonomous Learning	$1 \geq 2$
3 Self-Organized Learning	$2 \geq 3$

#### g. Metas Educativas 2021

It is a unanimously welcomed proposal by the Ministers of Education meeting at El Salvador in the XVIII Ibero-American Conference; a joint commitment to meet the challenges of their people future as an update through an educational program leading to a more just society for all [27].

The paper presents indicators to assess progress of the program until 2021. There were identified 4 indicators related to the implementation of technology in education: Indicator 16 (ME-16): Computer's use frequency at school by students for learning tasks, Indicator 20 (ME-20): Ratio of students per computer, Indicator 23 (ME-23):% Design of Technical and Professional Careers, Indicator 24 (ME-24): % Practices at enterprises.

#### h. ICT Competencies for the Professional Development for Teachers

This document is intended to provide guidelines, criteria and parameters for those who design and implement training programs for teachers and practicing managers, and teachers willing to take on the challenge of developing and training on the educational use of ICT. Was designed by the Educational Innovation Office, from the Ministry of Education of Colombia. [28].



It has 3 stages of evolution called *Levels*, quantified in Table 7. Groups the indicators into 5 categories called Competencies: 1. Technological (CP-1), 2. Pedagogical (CP-2), 3. Communicative (CP-3), 4. Management (CP-4), 5. Investigative (CP-5).

**Table 7.** Qualification levels by category: ICT Competencies for the Professional Development for Teachers.

Levels	Qualification
1 Exploration	$0 \geqslant 1$
2 Integration	$1 \geqslant 2$
3 Innovation	$2 \geqslant 3$

#### **• Schema of Monitoring & Evaluation**

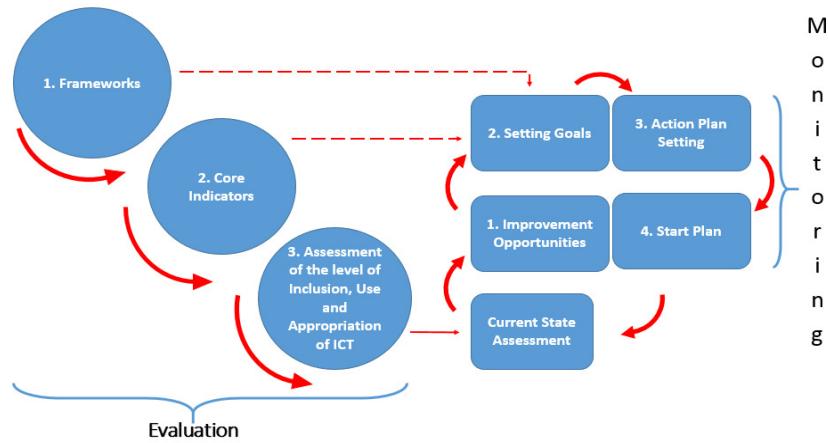
The evaluation scheme is integrated from the correlation of all Frameworks' categories, they will deliver the state scores. This correlation is achieved by extracting the most relevant and immediate indicators for the Implementation, Use and Appropriation of ICT in each case, also is identified their correspondence with the group of *Core Indicators* which it belongs. For such purpose is proposed an integrative frame called Category Indicators, the final correlation is shown in Fig 2.

	Core Indicators	Category of Indicators	Frameworks' Indicators											
Inputs	1. Classroom ICT resources	1. ICT	UN-4	AF-1	NS-1	AU-1, AU-2, AU-3, AU-4, AU-5	4B-2	ME-20	CP-1 CP-3, CP-4, CP-5					
		2. Learning environments	UN-5	AF-3	NS-2		4B-3	N/A						
	2. Teacher training	3. Teacher Professional Learning/development	UN-6	AF-5	NS-1	AU-3	4B-1	ME-16	CP-2, CP-3, CP-5					
				AF-6	NS-5									
Outputs	3. Classroom pedagogy	4. Pedagogy	UN-3	AF-2	NS-3	AU-1	4B-1, 4B-3							
	4. Student knowledge of School subjects	5. Assessment		NS-3,		AU-1, AU-2	4B-1	N/A	CP-4 CP-2, CP-3, CP-4					
				AF-4	NS-4									
	5. Student attitudes			NS-3,		AU-1, AU-2, AU-5								
				AF-2	NS-5									
	6. Student skills			NS-3,		AU-1, AU-2	4B-3	ME-23	CP-4					
	7. Systemic outcomes			NS-4										
	8. Teacher outcomes			AF-1	NS-3	AU-4								
	9. Long-term outcomes	7. Educational Policies	UN-1	AF-5 AF-6	NS-6	AU-4, AU-5 4B-3			CP-4, CP-5					

**Fig. 2.** Indicators of the Frameworks (Source: WOSC 2014, p. 124).

Based on [29,30,31,32], was structured the assessing tool called *Assessment of the level of inclusion, use and appropriation of ICTs*, applied to the 14 official institutions in the municipality of Tunja.

The Monitoring schema was made from the steps to be followed to assess the state of inclusion, use and appropriation of ICTs across time and when is required. This process needs the Current State Assessment to make a quantitative review across time. The tasks in monitoring are: 1. Improvement Opportunities, 2. Setting Goals, 3. Action Plan Setting, and 4. Start Plan. The ideal frequency for measurement is annual due to amount of assessments made by the official institutions on this way, so adding this measurement to the summary of evaluations conducted facilitate its implementation. The scheme can be seen in Fig.3.



**Fig. 3.** M&E Schema (Source: The Authors)

## • Results

The collected results were analyzed around the 7 selected Frameworks, plus the integrator frame *Category of Indicators*. Then, the current state of Inclusion, Use and Appropriation of ICT for Education in the official educational institutions in the municipality of Tunja is presented in Table 8.

**Table 8.** Evaluated Scores.

Framework	Categories	Abreviattion	Score
1 Category of Indicators			
	1.2 ICT		1,4
	1.2 Learning environments		0,9
	1.3 Teacher Professional Learning/development		1,4
	1.4 Pedagogy		1,9
	1.5 Assessment		1,6
	1.6 Curriculum		1,9
	1.7 Educational Policies		1,6
2 UNESCO ICT Competency Standards for Teachers			
	2.1 Understanding ICT in Education	UN-1	1,4
	2.2 Curriculum and Assessment	UN-2	1,8
	2.3 Pedagogy	UN-3	1,9
	2.4 ICT	UN-4	1,2
	2.5 Organization and Administration	UN-5	1,4
	2.6 Teacher Professional Learning	UN-6	1,3



**3 ICT-enhanced  
Teacher Standards for  
Africa**

3.1 Engage In Instructional Design Processes	AF-1	2,1
3.2 Facilitate and Inspire Student Learning, Innovation and Creativity	AF-2	2,6
3.3 Create and Manage Effective Learning Environments	AF-3	2,2
3.4 Engage In Assessment and Communication of Student Learning	AF-4	2,1
3.5 Engage In Professional Development and Model Ethical Responsibilities	AF-5	1,8
3.6 Understand Subject Matter for Use In Teaching	AF-6	2,2

**4 ISTE: National Educational Technology Standards for Teachers (NETS-T)**

4.1 Technology Operations and Concepts	NS-1	1,7
4.2 Planning and Designing Learning Environments and Experiences	NS-2	1,9
4.3 Teaching, Learning, and The Curriculum	NS-3	2,7
4.4 Assessment and Evaluation	NS-4	2,1
4.5 Productivity and Professional Practice	NS-5	2,2
4.6 Social, Ethical, Legal, And Human Issues.	NS-6	2,0

**5 Australia: ICT Competency Framework for Teachers**

5.1 Facilitating Student Learning	AU-1	1,8
5.2 Assessing and Reporting Student Learning Outcomes	AU-2	1,7
5.3 Engaging in Professional Learning	AU-3	1,3
5.4 Participating in Curriculum Policy and Other Program Initiatives in an Outcomes-focused Environment	AU-4	1,7
	AU-5	2,6
5.5 Forming Partnerships within the School Community		



6 ICT-tools for a balanced use of ICT in the Netherlands

6.1 Instruction and Practice	4B-1	1,8
6.2 Adaptive Learning Material	4B-2	1,5
6.3 Personal Learning Environment	4B-3	1,5

7 Metas Educativas 2021, 4 indicators.

7.1 Indicator 16: Computer's use frequency at school by students for learning tasks	ME-16	6.8 Hours
7.2 Indicator 20: Ratio of students per computer	ME-20	1/3 Students per CPU
7.3 Indicator 23: % Design of Technical and Professional Careers	ME-23	64,3%
7.4 Indicator 24: % Practices at enterprises	ME-24	57,1%

8 ICT Competencies for the Professional Development For Teachers

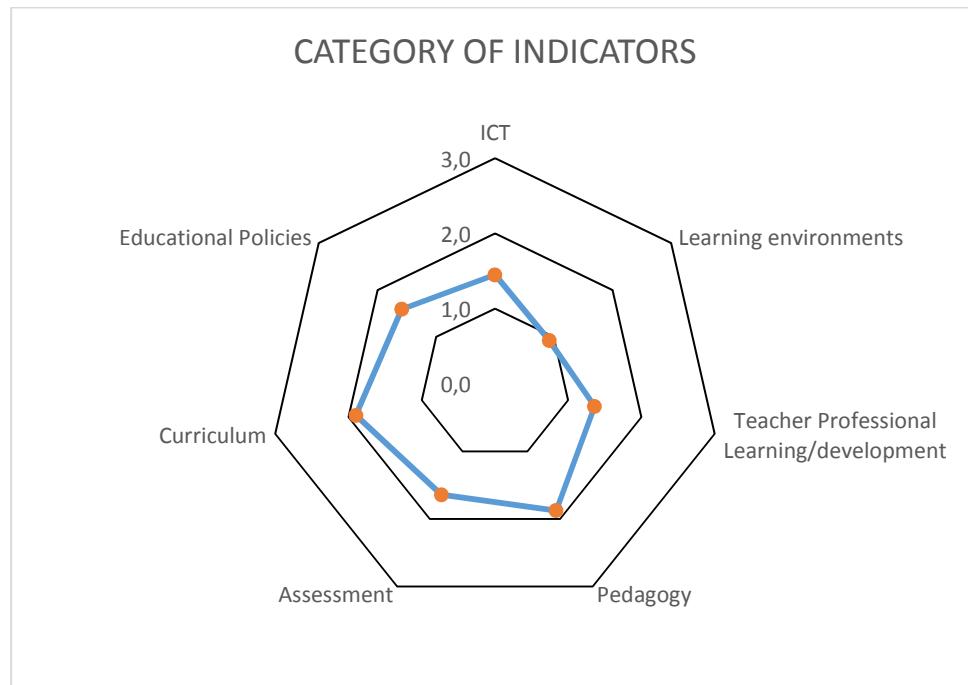
8.1 Technological	CP-1	1,4
8.2 Pedagogical	CP-2	1,8
8.3 Communicative	CP-3	1,5
8.4 Management	CP-4	1,8
8.5 Investigative	CP-5	1,2

## • Findings and Conclusions

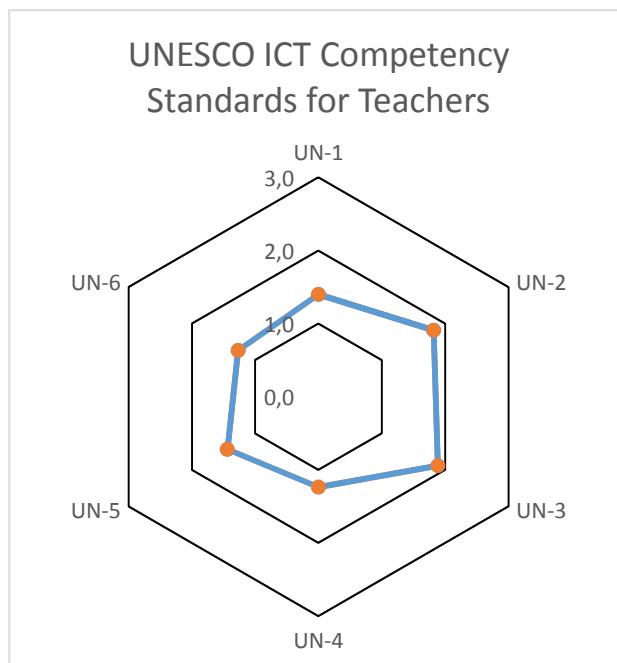
The scores were represented in radar charts to make easy comparative analysis between institutions for a detailed report. Though, the matter of this study was only centered on the general results as a performance metrics. The general results of this study shows that public institutions of primary and secondary education at the municipality of Tunja are in the second stage of evolution, called Use, this is shown in Fig. 4. The scores for each individual Framework were as follow:

- UNESCO ICT Competency Standards for Teachers: At second stage of evolution, called Knowledge Deepening. See Fig. 5.
- ICT-enhanced Teacher Standards for Africa: Reaching the third stage of evolution, known as Infusing. See Fig. 6.
- ISTE: National Educational Technology Standards for Teachers (NETS-T): Going through the transition from the second state of evolution called Medium to the third status, Expert. See Fig. 7.
- Australia: ICT Competency Framework for Teachers: At the second stage of evolution called Phase 2. See Fig. 8.
- ICT-tools for a balanced use of ICT in the Netherlands: At the second stage of evolution, called Autonomous Learning. See Fig. 9.

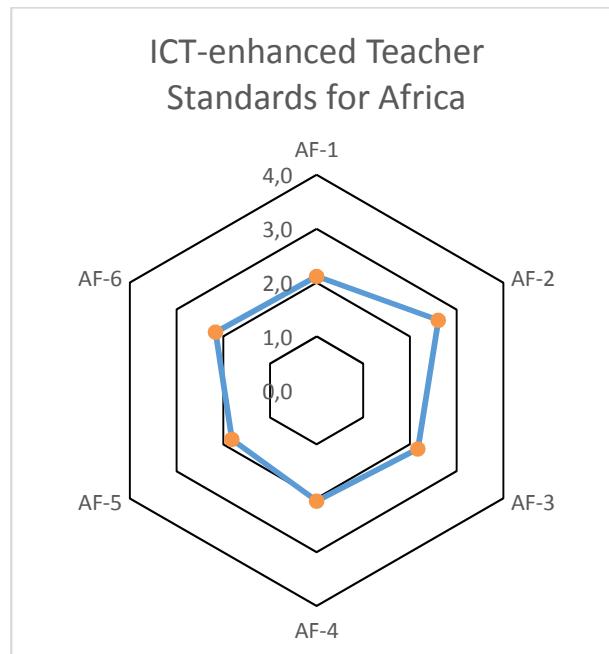
- ICT Competencies for Teacher Professional Development: The scores are distributed at the second stage of evolution, called Integration. See Fig. 10.
- About Metas Educativas 2021: The municipality has successfully accomplished the proposed indicators for 2015.



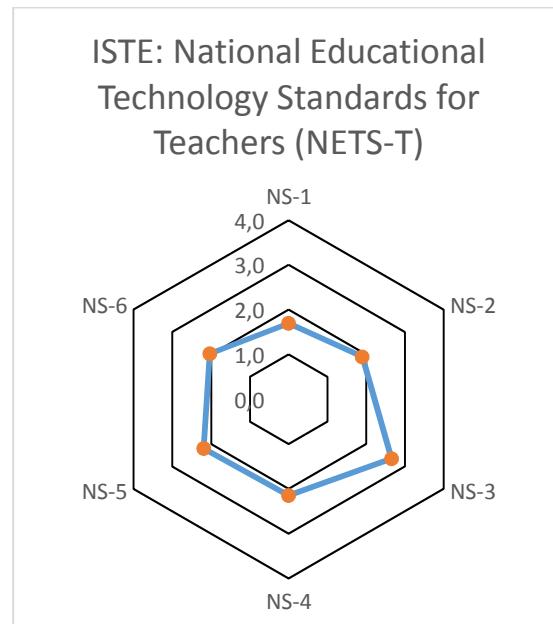
**Fig. 4.** Evaluated state according to Category of Indicators (Source: The Authors).



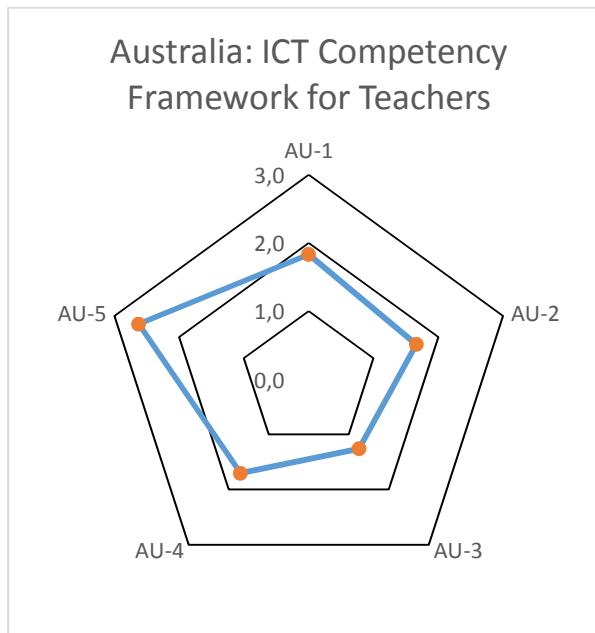
**Fig. 5.** Evaluated state according to UNESCO ICT Competency Standards for Teachers (Source: The Authors).



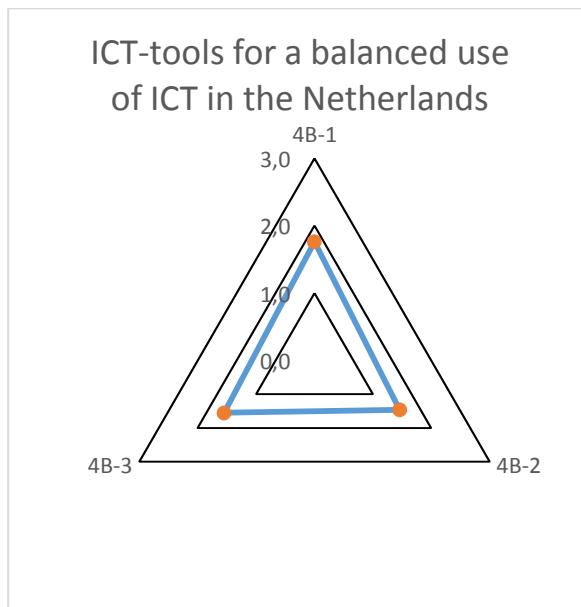
**Fig. 6.** Evaluated state according to ICT-enhanced Teacher Standards for Africa (Source: The Authors).



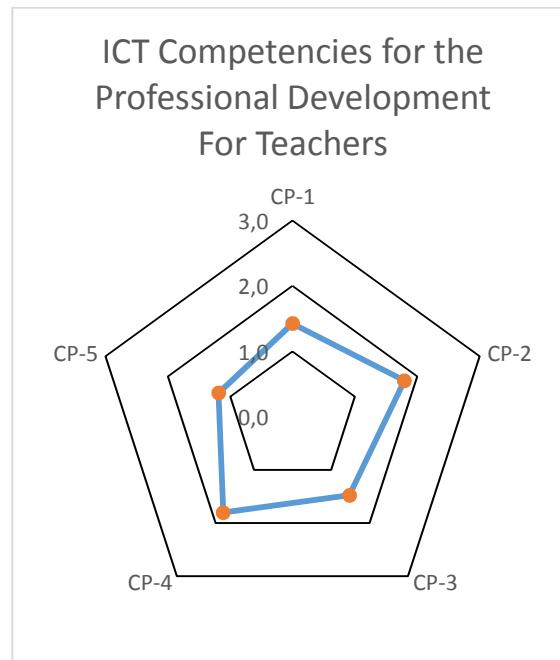
**Fig. 7.** Evaluated state according to ISTE: National Educational Technology Standards for Teachers (NETS-T) (Source: The Authors).



**Fig. 8.** Evaluated state according to Australia: ICT Competency Framework for Teachers (Source: The Authors)



**Fig. 9.** Evaluated state according to ICT-tools for a balanced use of ICT in the Netherlands (Source: The Authors).



**Fig. 10.** Evaluated state according to ICT Competencies for the Professional Development For Teachers (Source: The Authors).

A significant remark of this study, is the capability to evaluate states and show the results according to different frameworks. This provide the institutions with numerous tools to overcome their weaknesses, work on their strengths and continue evolving in the educational exercise supported by ICT.

The second important contribution of the research is the data obtained with the evaluation schema. With the quantification of the state of Inclusion, Use and Appropriation of ICT at education, the Municipal Secretary of Education may establish new action plans, assessing and monitoring of the educational environment for improving it. It's also important to mention that as far as it's known, this study is first on its type at the region.

About the current state of Inclusion, use and appropriation of ICT: The scores show that the institutions of the municipality have strengths in skills such as administrative management, design curriculum, training and making associations of the school community and especially in pedagogy or teaching practice. The achievements in these areas should be used to support areas with more opportunities for improvement, as the development of curriculum policies to foster professional development and the evaluation/reporting of results in learning, making of adaptive resources and personal learning environments, and especially, with deepening on ICT for Education operational concepts and educational research.

### • Implications for Further Research

This is the first time the institutions of the municipality receive an assessment of their skills related to ICT. The given information should be taken as a preamble for a deeper and detailed assessment work. The studies can be done individually for each institution so the M&E can be performed to attain specific interests and goals.

About Monitoring, even though is advised a yearly frequency, it also can be done by half-year or even on shorter terms. The objective is not only taking data, the measured scores must be improved, therefore it would be appropriate to conduct a study focusing on the techniques that can be used to improve the scores over the indicators and validate data using the monitoring and evaluation schema.



Finally, all the results and improvements made must line up with national policies and goals. For example: Newly, during the International Seminar on ICT, organized by Fedesarrollo, the Minister of Education launched the National Observatory of Educational Use of new technologies. This is an innovative tool that will measure the use and impact of ICT at the classroom. The Observatory will realize its work by publishing every year a National Report on Use of ICT in Education [33]. This kind of initiatives can provide new base data, and this schema can also contribute to MEN.

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## Study of the attitude of students towards new technological contexts and neuroscience progress

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### Abstract

Technology and Neuroscience have formed a strong collaboration to improve education. The effective use of information and communication technologies (ITC) in education practice requires that both students and teachers maintain a positive attitude towards these technologies, and develop their use in educational contexts to update teaching methodologies based on educational neuroscience and neuropsychology. Thus, the use of ITC requires a positive attitude when using these tools during the teaching-learning process, as a starting point to improve the quality of the process. The aim of this study is to analyse the student's attitudes towards the use of new technologies in the primary school classroom. We designed a questionnaire and gave it to 1.770 students aged between 1—12 years from 50 CEIP (Infant and Primary schools). In general, the results show that whilst students between 11-12 years do not show a rejection of the use of ITC, a low percentage of these demonstrate that they would prefer to use them in a group. We conclude that an adequate use the use of ITC in the classroom would depend on the predisposition of the students, and the knowledge of the technologies and their use by the teachers and students. Therefore, it is recommended that ITC is implemented in the classroom in order to improve the teaching-learning process and to incorporate new methodologies from neuroscience research.

**Keywords:** Technologies, Information, Communication, Student, Teacher, Innovation, Learning, Neuropsychology

### 1 Introduction

Cognitive neuroscience and technology have, in recent years, been developing in parallel and collaborating closely (Enríquez, Martín-Plasencia, Maestú, Ríos, Periañez & Calvo, 2006). The use of neuronal imaging techniques, along with other types of electrophysiological techniques makes it possible to obtain new scientific knowledge for a better understanding of brain processes. It also allows us to know in which part of the brain (along with when and how) these processes are integrated in order to better perform learning processes (Llinás, 2002). As an example, we can find several studies concerned with global functional connectivity (Stam, C. J. & de Bruin, E. A., 2004), the neural correlates of the action denomination and spatial relationship (Damasio, Grabowski, Tranel, Ponto, Hichwa & Damasio, 2001), or the relationship between the neural substrate related to the sense of touch and object recognition (Reed, Shoham & Halgren, 2004). As research has progressed, some techniques have been used to run a cross validation of several techniques such as electroencephalogram (EEG) and RNMF (magnetocephalography) that allow a better understanding of brain functioning (Martínez-Montes, Valdés-Sosa, Miwakeichi, Goldman & Yamaguchi, 2004). These technological advances favour not only the development of knowledge about brain function, but also an understanding of the complexity of the information processing involved in attention, memory, thinking skills and learning that require the synchronisation of a multiple neuronal network. Access to this information by the teacher opens up the possibility of applying neuropsychological progress to the educational context, including programs to develop multiple intelligence (García & Llamas, 2016), neuropsychology and technology programs to improve language difficulties (Pradas & De la Peña, 2016), or programs applying neuropsychology to schools at



different ages (Martín-Lobo, 2016). Some studies have shown an improvement in processes such as attention, motivation, and memory in university students when technology is used based on neuroscience strategies (Valerio, Caraza, Martínez & Jaramillo (2014).

When referring to attitudes, decision-making and emotions, there are also a number of studies based on the use of technologies. An example of this can be found in the study by Greene, Sommerville, Nystrom, Darley y Cohen (2001), which examined the role of emotion on moral judgement using magnetoencephalography (RNMF).

### Neuropsychology and technology in students aged between 11 and 12 years

The neurofunctional basis of cognitive and emotional learning allows us to have a perspective of the brain as a functional support for learning, and it particularly allows us to apply technological methodologies in the classroom (Pradas, 2016). It is therefore relevant to know the neurodevelopmental characteristics of the students included in this work in order to use technology from the neuropsychological perspective. The development of their brain functionality shows that during this period (11-12 years) they are capable of processing information in different areas of the brain at the same time, in order to integrate and coordinate the information. This complex information processing requires a certain degree of brain development and myelination of neurons, along with an increase of neurotransmitters in the synaptic processes (Bressler, 2002). When observing children of this age using technology, we can appreciate the high degree of interest that this generates, along with the implications of the tasks and multitasking actions that they are required to perform. Further, this is a period involving better comprehension, memorising and organising, for which it is necessary that they develop the frontal lobe areas and integrate information through the hard body that links both hemispheres (Ferré & Ferré, 2013). When technological methodologies are applied considering these facts, this helps the teacher when making decisions regarding the use of technology as an efficient tool for neurodevelopmental progress rather than as mere entertainment. At this age the reading and comprehension speed increases due to binocular reading using both eyes, which allows for higher precision and higher visual, visuo-spatial and visuo-motor skills that are developed between 6 and 11 years of age, and that continue to develop thereafter (Bova, Fazzi, Gionvenzana et al, 2007). A further important aspect worth consideration is attention. Between the ages of 9 and 12 years, children develop attentional control processes that improve selective attention (Goldberg, Maurer, Lewis, 2001), and attentional difficulties are due to a lack of development of the frontostriatal circuit that is responsible for inhibitory control (and that continues to develop during adolescence), rather than due to selective immaturity (Booth, Burman, Meyer, et al. 2003). Technology can facilitate the development of selective attention and focusing when doing homework as well as working memory, given that during this age grey matter increases in parietal and frontal areas that are involved in this type of memory process (Campo, Maestú, Ortiz et al, 2005).

### Neurotechnology

Over the last few years, technology has been incorporated into the classroom, and is now believed to be present in every school. As early as the 1970s, some authors suggested that adaptation to the environment in the digital era entails training and using new technologies in all the subjects in schools (Donaldson, 1970). However, in order to use them correctly we need to know the effects that they can have on the generation of knowledge, and therefore know the relevance of training teachers and understanding the development of knowledge when interacting with technologies. Based on these suggestions, our study aims to incorporate educational neurotechnology into our educational and neuropsychological research. We therefore find a bridge between two relevant areas of study for the educational context: neuropsychology and technology. These areas offer the opportunity to promote a more successful learning experience. Educational neurotechnology focuses on the use of technology in the educational context by also analysing neural processing. It can therefore be regarded as a new science of learning based on the knowledge of the brain and the methodology used when including technology in the classroom context (Pradas, 2016). This methodology focuses more on "how" learning occurs rather than "what" is being learned. In the current context we can find a high diversity of sources of information, news, data and an overabundance of information, and we require a learning approach focused on inquiry, coordination and dynamic articulation processes of knowledge to solve problems rather than simply acquiring fixed knowledge. The key is to know the advantages of using technology for our brain, as well as to discover its drawbacks, in order to develop new strategies. For instance, Small (2009) suggested that whilst the



use of the Internet has a positive impact on brain functioning, it is problematic when overused. Individuals that spend around 10 hours per day using the computer can show a reduced aptitude for interpersonal contact, such as keeping a conversation face to face. Small (2009) also suggested that the Internet has changed not only the way people produce and create content, but also the way they communicate and experience enjoyment. The Internet also alters brain functioning (Small, 2009). We should take into account that when using technology, the effect of stimulus-response takes place at a speed that does not occur in the analogic context. The success achieved when playing videogames, for instance, is due to the decisions we make. Thus, Linehan, Lawson and Doughty (2009) developed a serious game designed to improve behaviour when making collaborative decisions. The game MetaVals aims to develop collective decision-making processes in pairs (Romero, Usart & Almirall, 2011; Usart, Romero & Almirall, 2011). It is critical to understand that with the use of technology we can maximise the sensory information that we receive through multimedia sources. This allows the stimulation and potentiation of the capacities of both hemispheres, stimulating both ways of thinking in order for them to complement each other. This in turn would help to fulfil the great potential of the human brain in a holistic way.

### **Application and development of technology**

In order to use this progress and apply innovative programs, education that uses ITC should offer the conditions required to optimise the teaching-learning process, promote knowledge transfer, and incorporate new skills. Attitude is one important issue that should be taken into account in studies about learning contexts (Collins, 1996). Learning contexts should reflect the anticipated use of new knowledge in order to avoid the acquired knowledge being lost (Bransford, Sherwood, Hasselbring, Kinzer, & Williams, 1990; Duffy & Knuth, 1990). When implementing ITC, the educational context should also be adequate, providing and preserving the links with the context outside the classroom. Moreover, the teachers should promote the student's participation with a positive attitude when using the ITC, and also favour active construction of knowledge. This requires an open learning space instead of a mere transference of facts (Collins, 1996; Hannafin, Hall, Land, & Hill, 1994; Jonassen, Peck & Wilson, 1999). Cooperation and interaction in the classroom are also important to promote the acquisition of learning skills, problem solving skills, and social relations (Bennett & Dunne, 1994; Slavin, 1995; Susman, 1998). Finally, given that we can find differences in skills and perception in the classroom towards the use of ITC, these differences should be considered as key criteria for an effective teaching-learning process in the classroom (Bearne, 1996; Kerry & Kerry, 1997; Wang, 1990). Thus, the responsible authorities should adapt the educational context to the needs and capacities of the individual students.

ITC can contribute towards the creation of powerful learning contexts in various ways. In particular, ITC offers opportunities to access a vast quantity of information through multiple resources, along with various ways to visualise this information from different perspectives. ITC can also make complex problems easier to understand through simulations that promote the creation of an optimum learning context (Llamas-Salguero, 2013). Moreover, ITC can also be an instrument for curricular differentiation, offering opportunities to adapt learning content and tasks to the specific needs and skills of each student, and offering tailored information (Mooij, 1999; Smeets & Mooij, 2001).

However, some studies show that the approach in schools is focused on the use of ITC based on traditional knowledge (Chalkley & Nicholas, 1997; Richardson, 1997; Smeets & Mooij, 2001; Williams, Coles, Wilson, Richardson, & Tuson, 2000). Further, a recent study about the impact of ITC on student performance (including 60 schools) shows that the percentage of lessons that include ITC was generally low. And whilst some links were found between the amount of use of ITC and the student's performance, this relationship was not consistent across all of the different levels.

### **Programs of educational neuropsychology using technology**

Educational neuropsychology programs train visual, auditory and perceptive skills, and sensory integration and lateral development in order for the brain hemisphere to provide good integration and comprehension of incoming information. These programs also improve linguistic, memory, higher thinking skills and creativity that favour neurodevelopment and learning (Martín-Lobo, 2016). All of these processes can be trained with technology using educational neurotechnology programs (Pradas, 2016). Further, the students show an attentional affinity towards technology that facilitates the creation of strategies for accessing information and new neural circuits for learning, which is possible due to the plasticity of the young brain (Small, 2009), and



they also display a profile that has both the necessary skills and interest for using technology (Roca, 2008). This allows the use of neurotechnology to improve school performance from a neuropsychological perspective. Increasing the number of studies in this area will open up new lines of educational and methodological research. A first step in this analysis is to study the attitudes of students towards technology.

## 2 Methodology. Experimental design

The present study aims to analyse the attitude of students towards the use of new technologies in a Primary school classroom. The study made use of a questionnaire methodology, and this questionnaire was given to a sample of 1.770 students (Table 1) between 11-12 years old from 50 different CEIP (Infant and Primary schools). We employed a questionnaire with closed questions and two possible outcomes, "Positive" and "Negative", along several open questions that allowed the participant to provide more detailed information and opinions related to educational contexts and technologies applied to education.

The closed question in the questionnaire was: What do you think of Information and Communication Technologies? This question was also related to other guided open questions to corroborate the perception of the students towards ITC, with the following study indicators: Comprehension of the tools and applications, possibilities to use it as a future working tool; Accessibility for students and teachers, interaction in the classroom, active communication, speed and easiness of use, and educational support.

The questionnaires were given to the students in order to know their attitude, given that, with this information, we could change, modify, or develop different teaching methodologies using ITC as a support to generate new knowledge for the students. The sample analysed in this study was composed of students from the 6<sup>th</sup> grade of Primary School, recruited from various Infant and Primary Schools in Spain.

Table 1. Sample distribution

	Frequency	Percentage
Male	921	52,0
Female	818	46,2
Total	1.739	98,2
Lost data	31	1,8
Total	1.770	100,0

## Statistical analysis

We made use of SPSS 13 (Windows version) package for the statistical analysis. As a preliminary step, we analysed the normality and homogeneity of the variances. In addition, we ran a descriptive analysis of the sample. For each of the analyses, we considered the number of valid cases, excluding cases with lost data. The Frequency tables display the absolute frequency of the valid cases for each of the variables (Frequency), percentage frequency (percentage), percentage frequency of the valid cases, that is, eliminating cases with lost data (valid percentage) and the accumulated percentage frequency (accumulated percentage).

As a measure of the relationship between the variables evaluated in the frequency tables, we used the Chi-square statistical analysis. A  $p < 0.05$  value indicated that the variables were related (for some results we also provide the Likelihood ratio). For each relationship of interest, the statistical analysis is provided, with a significance level predetermined at  $p < 0.05$ . Once the relationship between two nominal variables was obtained, we evaluated the strength of this relationship using the Contingency Coefficient. When appropriate, we compared the mean values - for instance the male and female student's age, using a T Students for independent samples. For all of the cases we adopted a significance level of confidence of 95%, and all cases with lost data were excluded. We applied the Levene (F) test as well as the T (t) statistics, degrees of freedom (df), the bilateral significance, the means differences for each group, and also applied the typical error of the mean difference.

## 3 Results

After analysing the student's responses to the open questions, they were asked to respond to the closed question: "What do you think about the Information and Communication Technologies? It was found that 86.3% (1.527 of 1.770 students) of the sample answered with a generally positive opinion of ITC. Their answers to the open questions included the following comments: "They are important because we learn easily and they are fun", "They allow us to do many things", "They are fun", "They are easy to use", "They provide a higher diversity of activities, and they are useful to gather information easily", "They are quicker", "They are important to communicate with others"; "They support the study process". Apart from the most common answers as seen above, some students pointed out that there are insufficient technological tools in their school or that they are not in use.

The students with negative attitudes to ITC accounted for 5.4% of the total sample (96 of 1.770 students). On the basis of these results, we can conclude that the majority of the students take a positive stance towards ITC. Amongst the negative answers given by the students, some examples included: "We don't know much about them, They can be addictive", "They are OK, but I prefer the text book for some things", "They are a waste of time". These answers are of interest because they show that some students do not have enough knowledge about ITC, given that in some schools ITC tools are not implemented, or if they are implemented, they are not in use or are only used to project video. Under these circumstances, the students would not be expected to be aware of their functionality or potential educational value. One of the answers that is of special interest is "They can be addictive". The students are familiar with the use of ITC in their homes without much control other than that of the family. The teachers, however, can offer some guidance in the classroom about the function and use of the tools by using, for instance, programs for learning how to interact with ITC, guides for internet surfing, social networks, and various types of games. There is a percentage of the sample, 8.2 % (146 of the total 1.770) that did not answer this question.

The attitude of the students obtained from the data in this study is somewhat puzzling, given that not all of the students indicated that they like ITC, whilst some did not understand the use of ITC in the classroom as being something positive. Only 60% of the sample stated that they like to use ITC in the teaching-learning process, are motivated by its use, have a better understanding of concepts, and like to write essays with these tools. These data are surprisingly low, given that ITC technologies appear to be generally welcomed by the schools (Table 2).

Table 2: Student's attitudes towards ICT.

Items	DA%	N%	A%	CA%
I like using ICT as a tool in teaching and learning.	40			60
I don't like to use ICT as a toll in teaching and learning	40	40	10	10
I am very motivated with the use of ICT in teaching and learning	10		20	60
I like to participate in classes when using ICT	30		20	50
I like to present work with ICT in the classroom as they are very easy to use.	30		10	60
With ICT I can understand the concepts more efficiently	20		20	60
When I use ICT increases my attention in class	20	10	20	50

Scale: DA- Disagree N-Neutral A-Agree CA-Completely Agree.

We also analysed gender differences, in an attempt to examine whether they reflect some of the stereotypical views held in society regarding the use of ITC by male and female children - for example that male children like more ITC than female children. A total of 52 % (921 of the total 1770) were male, whereas 46.2% (812 of the total 1770) were female. Table 3 displays the responses according to gender. Subsequent analysis of these differences revealed that there were no significant differences in the general perception of the use of ITC, but there were significant differences regarding the positive or negative value of these technologies (Table 3).

Table 3. Chi-Square Tests.

	VALUE	DF	ASYMP. SIG. (2-SIDED)
Pearson Chi-square	1,685 <sup>a</sup>	2	,431
Likelihood Ratio	1,701	2	,427
Linear-by-Linear Association	1,676	1	,195
N of Valid Cases	1739		

\* 0 cells (,0%) have expected count less than 5. The minimum expected count is 6,92.

## 4 Discussion

The importance that we assign to the use of ITC is of considerable significance (Harrison et al., 2002). Our results show that even in schools that have an equivalent ITC system in place, students perceive these technologies differently in terms of both availability and use of the related tools. In particular, the students can be categorised into two groups according to the type of answer given. Those that say that “The tools in the school are not enough and not used”, and those that perceive that the infrastructure available is adequate and that “The ITC tools are important because we learn easily and have fun”, “They allow us to do many different things”, “We understand them”, “They are easy to use”, “They provide a wider range of activities”, “They support our study”.

The attitude that the students have towards the use of ITC has a significant impact on the learning context, and this attitude is defined by different factors. The skills of teachers in terms of the use of ITC play an important role (Smeets et al., 1999; Veen, 1995). Another aspect that could influence this attitude is the ease with which the students are able to access ITC (Kennewell, Parkinson, & Tanner, 2000; OTA, 1995). This refers not only to the number of computers per student, but also to the positioning of the computer station, for example, the computer room or the classroom. Kennewell et al. (2000) considered that it critical that the computers are placed in the classroom to maximize the opportunities for ITC to be part of the curricular activities. These authors suggested that the number of computers, however, is less important.

Further, the pedagogical perspectives of the teachers and their point of view about how ITC can contribute to the learning context play an important role in the real use of ITC in the classroom (Drenoyanni y Selwood, 1998; Higgins y Moseley, 2001; Hokanson y Hooper, 2000; Niederhauser y Stoddart, 2001). Switching towards a learning context focused on the students, and where teachers create the intellectual learning context is of particular interest. This particularly applies to open learning contexts (Hannafin & Savenye, 1993; Keeler, 1996).

Another factor to take into account is the possibility of a gender difference with regard to the use of ITC. It has been suggested that female children have a less positive attitude towards ITC than male children (e.g., Huber & Schofield, 1998; Makrakis & Sawada, 1996; Volman, 1997). However, we found no significant differences related to gender when analysing the closed question about attitude towards ITC. This could be due to the small differences obtained with young adults (Comber et al, 1997; Durndell, Glissov, & Siann, 1995). The students in our study displayed, in general, positive responses regarding the use of ITC. The students that showed a negative attitude towards the use of ITC accounted for only a low percentage of our sample, particularly with regard to attention, motivation, and a deeper understanding of concepts. We did, however, find a high percentage of respondents with a positive attitude towards the tools and applications, the speed and ease of use of ITC, the confidence of its use at work, the ease of understanding and learning, the interaction in the classroom, or active communication and educational support. This results is surprising if we consider the preference that young students show towards technology Roca (2008). This results could be explained in terms of a higher need of training of the teachers and updating of their knowledge of technological progress and methodological changes that come from neuropsychology and technological research studies. This new



knowledge could be implemented in the classroom context to innovate and improve the educational experience in the classroom.

## 5 Conclusions

We can draw several conclusions from our data with regard to the attitude of students and their perception of the use and influence of ITC in the classroom. All the schools that participated in this study had the same technological facilities, and the pattern of responses was, in general, similar across the schools, regardless of the use of the ITC in the different centres. The opinion of the students towards ITC is, in general, positive, and we found no gender differences in the responses of our participants.

Whilst the attitude of the students towards the technological tools is generally positive in, their evaluation of the use of ITC in the classroom is particularly low. The participants in this study do not regard the use of ITC in the classroom to be adequate, and do not believe that ITC tools could function as a support for improving the understanding of concepts, attention, or the acquisition of knowledge. On the basis of these findings, both educational authorities and teachers should tailor the use of ITC to the individual needs of each technological-educational context when incorporating ITC into the teaching-learning process. The unique requirements of each context would be provided by individualised assessments.

A future perspective could start and focus on developing educational neurotechnology programs for neuropsychological skills training along with programs based on the findings from neurosciences and neuropsychology in order to develop the student's potential. In addition, these should be adapted to the needs of each educational context to improve the quality of the teaching-learning process.

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## Learning platform assessment model LMS

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**Abstract:** Use and appropriation of a LMS by higher education institutions require a decision that should go beyond economic aspects, especially when there is a mimetic institutionalism in most platforms, which offer similar educational, communication, interaction and management services and tools. In this regard, this article makes a proposal to establish a quantitative evaluation system that assesses attributes of LMS platforms, according to institutional requirements.

**Keywords:** LMS Platform, Virtual Environment Assessment, LMS Metric.

### 1 Introduction

Day by day education has been incorporating new Information and Communication Technologies (ICT) into their training processes, thus raising awareness in world population of knowledge society and directing academic institutions, particularly Higher Education Institutions(HEI), to adopt new teaching methodologies, new teacher and student roles and, therefore, new forms of management and administration in academic processes as well as the creation of various means of dissemination, sharing and interaction of information and knowledge.

Regarding this process of implementing and adopting ICT in HEIs, quality criteria, strategies and standards have been defined [1], which have gradually guaranteed the quality and relevance of this training methodology [2] and the acceptance of this alternative training by the academic community [3].

The development of a virtual learning methodology is subject to a number of factors, such as content production, digital resources, content repositories and creation of learning objects and technology platforms - Learning Management System (LMS), where information is exchanged, resources are delivered and learning process is monitored.

In the context of virtual education platforms, countless options are identified; they have similar characteristics, work as content repositories, contain various materials, and provide tools for both synchronous and asynchronous communication and interaction [4]. Therefore, this is the space where information, teaching experience and students' needs converge, promoting synergy and connectivism among actors in the educational process [5, 6]. In addition, recommendation systems are created to help identify resources or information relevant to the student [7].

Furthermore, studies concerning the assessment of virtual education platforms have conducted from a qualitative perspective, considering aspects such as interactivity, flexibility, scalability, usability, functionality, ubiquity, persuadability [4, 8]. Other studies focused on platform type (proprietary, free, multi-language), installation and administration (course management, profiles, and authentication), communication tools, and type of resources. However, the studies are limited to verifying the existence of such options [8, 9]. Other studies identify and compare the features of platforms [10]; a recent study assesses three platforms considering aspects such as user interface, contents system, and platform customization [11].

In relation to the above, this paper presents a metric to guide the team responsible for evaluation and decision-making in choosing the platform to be implemented in HEIs so that they have objective criteria to do so, using a quantitative methodology for assessing and comparing LMS features and attributes.



## 2 Learning environments

Technology and e-learning platforms are considered a factor contributing to the positioning and success of HEIs, which involves changes in many aspects such as administration, teachers, educational processes and, in particular, teaching-learning and access to knowledge methodologies. Additionally, these virtual environments become a strategy for dissemination, institutional recognition, and coverage.

Regarding these developments, different degrees or levels of virtualization of virtual learning environments are promoted, as defined by how ICTs are implemented. VLEs have evolved in many and varied ways of disseminating and sharing information such as LMS (Learning Management System), m-learning models [12-14], 3D educational environments [15] or metaverses [16, 17], Augmented Reality models [18], Gamification strategies [19] and tutorial videos such as Khan Academy [20]. These offer a wide variety of digital resources that could be reused and shared by institutions through shared virtual campuses [21], federation of repositories [22] and, last but not least, resource recommendation systems [7].

In this sense, the paper presented by Lara and Duart (2005) shows the evolution of online learning, along with the creation of standards that ensure quality and interoperability of existing resources and platforms, where complexity of technological developments are related to the benefits for training [4, 23]. It also proposes the creation of content and resource management models within institutions in order to consolidate and capitalize academic media and materials, which are now available in learning platforms.

Therefore, when selecting the platform (LMS) to be implemented in the HEI, technical, economic, support, usability, accessibility and other aspects should be taken into account, as well as aspects related to the type of project (business, educational, state or social).

As for this environment, there is a number of learning platforms ranging from proprietary to open source applications, including student-, teacher- and learning process-oriented platforms. In many cases, this makes HEIs establish which of the existing platforms responds to the pedagogical and communicative model of the institution. However, the studies conducted compare platforms in terms of resources and tools available [4], hindering decision-making with respect to the best LMS to be implemented in the institution and often leading HEIs to have more than one platform available for the development of their virtual courses, without any objective selection criteria beyond being the most recognized and/or supported LMS.

In addition, it is observed that the decision of which platform is more suitable also responds to the interests of engineers or content designers who, by default, make use of the platforms that have managed to position in the educational environment. Adopting platforms that have already been successful in other educational institutions gives rise to a mimesis and ignores the interests of the institution and community that will use the platform.

## 3 Learning Management System

Learning Management Systems or LMS are programs that administer and manage the teaching-learning process through the integrated use of different tools, either for distance training or as an aid for classroom teaching, and where the student is the protagonist of his/her learning process and has the possibility of joining several knowledge networks [24].

They are online education settings designed to offer remote assistance that allow integration of multimedia material and discussion forums. Virtual platforms are based on four major axes: 1) interaction, which allows to establish communication processes among participants; 2) introspection, which seeks to foster critical and creative thinking through the resources offered; 3) innovation, because alternative learning and assessment processes increase; and, finally, 4) integration of communication, collaborative work and administration tools such as those mentioned above: profiles, email, discussion forums, bulletin boards and multimedia resources (video, audio, image).



For Vazquez (2015), a platform essentially meets three conditions: 1) it is a fully developed environment that allows network access and interaction between students and teachers, 2) it has a set of resources and assessment strategies, and 3) it provides activity management. Additionally, the platform should automate processes and administration and have portability and standards [25]. However, the study conducted by the authors argue that, while LMS offer advantages, they cannot be taken for granted, i.e., it is necessary to consider the risks this implies for the student such as student's beliefs and motivations, assessment to the extent that it does not reflect student's progress, simple and user-friendly applications, isolation, type of activities, among others.

A relevant aspect when considering a platform is its design, which must ensure usability so that the development of content and activities is efficient, effective and satisfactory. For this, a type of user assessment is proposed [26].

The main functions of management systems are management of users, resources, materials and activities, monitoring of the learning process, assessment, reporting, and communication services. However, a new generation of service-oriented platforms [27], with interoperable services among LMS, has been started [28].

These learning management systems have evolved since 1960 with a system developed at the University of Illinois (PLATO - <http://www.plato.com/solutions>). In 1970, a project developed by IBM in collaboration with the Stanford University introduced "Coursewriter" where user roles such as instructor, administrator and student are defined.

Furthermore, changes and levels of virtuality have evolved hand in hand with the web and ICTs as these has been the means where different applications have been developed for teaching-learning processes. This situation demands the incorporation of new options in the platforms.

Most LMS allow functions such as learning space management, communication of participants, content management, activity management, and evaluation. The study conducted by Salinas (2005) deals with three components related to platform quality: pedagogical, organizational and technical.

LMS have four independent systems with specific features that are integrated to implement information technologies in the educational process. These systems are identified as contents, exams, assessment, and communication tools [29, 30] and have a set of services in place.

Istanbul (2016) considers that LMS must be designed to facilitate navigation by students while reviewing contents and carrying out the proposed activities. Thus, LMS should take into account the behavior of students, giving way to individualized learning, i.e. the student learns independently by accessing information. This strengthens self-learning because the student is encouraged to construct knowledge [31] and assigned different levels of activities on the platforms.

For Muñoz-Merino (2009), learning platforms in subsequent generations should be service-oriented, defining the following layers (Table 5): 1) Infrastructure, 2) Services, 3) Educational Services, and 4) Educational Applications [28].

As already defined, platforms and resources must be user-friendly, easy to navigate, motivating and intuitive environments [32], so that students accomplish the learning objectives defined by thematic experts or tutoring teachers and/or content authors.

The following lines present the main technical factors of platforms based on the model established for software development and quality, in accordance with ISO/IEC 9126 for websites, and transposes learning platforms.



- Interactivity: The interaction is measured according to student's motivation for e-learning systems and information available through interaction. LMSs are able to capture many details related to student's participation status and data on interaction with the system [33].
- Accessibility: A necessary condition for LMS platforms and virtual education environments is to enable students to participate, access and use digital resources [34]. For these authors, accessibility should also be present in two ways: 1) in education resources and 2) in the LMS platform, including collaborative services, editing services, complementary software services, which must meet the standards set for the WWW Consortium [35].
- Usability: ISO 9241 and 9126 define usability as the extent to which a product can be used by specified users to achieve specific goals effectively, efficiently and satisfactorily in a context of use [36].
- Flexibility: For Nokelainen (2006), under this perspective the student has the opportunity to explore the learning material freely. Flexibility in learning material content means that the material contains various assignments and defines the social organization of learning (face to face, group, individual) along with the source of learning resources (teacher, student, library, Internet) to be used.
- Scalability: In the development of web applications and particularly LMS Platforms, it means that the number of students can be increased exponentially in a short period of time, which can modify the behavior of the application. Scalability intends that the platform be able to operate independently of the number of registered and active users [37].
- Standardization: Virtual education or e-Learning has grown considerable. Aware of this phenomenon, various organizations and companies related to software and education are working on creating standards and specifications for interoperable and accessible platforms, materials and resources, thus allowing reusability [38] and adaptation to learning styles [39].
- Responsiveness: Meanwhile, UNESCO has published a paper on mobile learning and how mobile technology, which is now more accessible, and therefore LMS designs and platforms must exploit these technologies and adapt their resources to the advances made. Thus, UNESCO defines the following settings for online education and, therefore, technology requirements [40]:

## 4 Research methodology and design

The paper presents a proposed metric for the assessment of LMS platforms that allows institutions and the team responsible for the use of LMS to make an objective decision on the platform to be implemented.

For validation of the proposed metric, experts' opinion was taken into account [23] under the Delphi methodology as this allows to evaluate the model without data or actual experiences. Thus, a group of experts who are familiar with LMS was selected. It should be noted that each LMS may be assessed by two or three experts, according to their expertise in LMS, i.e. teachers and tutors will be in charge of academic or pedagogical criteria or features, while technological and administrative features will be evaluated by support engineers and platform experts.

As mentioned, the following procedure is conducted:

- I. Build the model metric based on the review and experience in the field of LMS considering features and attributes of the tools identified in LMS, such as:
  - Content tools
  - Communication tools
  - Assessment and monitoring tools
  - Technical requirements.
- II. Set the expert's competence coefficient in order to ensure expert's knowledge of LMS; for this, the expert's level of knowledge of LMS, experience, education and course development were identified [23]



The coefficient of the said study is obtained by applying the following formula [23]:

$$K = \frac{1}{2(K_c + K_a)} \quad (1)$$

Where:

- $K_c$ : “Knowledge coefficient” and information the expert has about LMS. It is calculated based on the assessment by the expert on a 0 to 10 scale, multiplied by 0.1.
- $K_a$ : “Argumentation coefficient” or rationale of experts’ criteria. This coefficient is obtained from the assignment of a series of scores to different sources of argumentation found by the expert.

Using the final values obtained, experts are classified in three big groups:

- If  $K$  is greater than 0.8, greater than or equal to 1, then there is high influence of all sources.
- If  $K$  is greater than or equal to 0.7, greater or less than 0.8, then there is medium influence of all sources.
- If  $K$  is greater than or equal to 0.5, greater or less than 0.7 or equal to 0.7, then there is low influence of all sources.

### III. Present the model metric to selected experts

Concerning the construction of the metric according to the review of literature and following the model proposed by Olsina (1999) called Web-Site QEM (Web-Site Quality Evaluation Method).

Particularly, for the purpose of this research, three characteristics are established as criteria for constructing the assessment instrument:

- Pedagogical tools or criteria
- Administrative tools or criteria
- Technology tools or criteria.

The first ones refer to elements associated with mediation for learning processes and knowledge, the second ones correspond to actions for managing resources and users as well as tracking elements, and the third alludes to technical and standardization aspects of LMS in order to meet accessibility and usability regulations.

### IV. Finally, the metric receives a total score based on experts’ judgment.

## 5 LMS Assessment Model

In various pieces of research on evaluation and decision-making to identify LMS platforms for an institution, there are no metrics, indicators or assessment models. However, several features they must have are identified based on common criteria and, in many cases, these are defined for specific domains, such as communication tools, content standards, teaching tools, management tools, among others.

Meanwhile, Menendez & Castellanos (2010) suggest that one difficulty in defining and implementing a learning platform is the lack of quality models tailored to the needs of users (teachers, students, administrator) and, therefore, studies are required to identify not only the features of LMS, but also quality with respect to users’ level of satisfaction [41, 42]. Quality in virtual education is understood to the extent that learning is achieved by those who make use of the resources available for this purpose, which means quality content platforms, teachers, and infrastructure [43].

Mueller & Strohmei (2010) set out the conditions that must be considered at the time of designing a learning management system, which is defined as an information system for administrative and teaching support of learning that systematically provides collaboration and communication resources and options.



Moreover, evaluation of LMS is similar to the web site evaluation process. Regarding LMSs, they are also software that must be governed by the principles of quality. Therefore, it is an activity in which numerous factors and features are involved, as well as desirable attributes and increasingly mandatory standards, hence the importance of having a model that enables evaluators to specify these characteristics and attributes in an orderly fashion.

According to the Olsina's model [44] that defines a quantitative and flexible methodology called Web Site Quality Evaluation Method (QEM), it evaluates the quality of centric applications on the web and specifies the desirable and mandatory features and attributes to be evaluate on a more or less complex website. Based on that model, a similar structure for evaluating LMS is presented.

### 5.1 LMS Metrics Model

For the purpose of this work, which is to measure the attributes of LMS and enable institutions to make a decision, a model that includes the preparation of a set of independent metrics focused on the aspects mentioned above, such as teaching tools, administrative tools and technological tools or options, is proposed.

The use of metrics provides quantitative and qualitative criteria for making decisions about which LMS is suitable for training, administrative and technological requirements.

Metrics provide users, evaluators and developers with elements to identify and evaluate quality items of the software product quality and quality management items for future developments and/or adjustments [45].

It should be considered that metrics do not eliminate human judgment in relation to the evaluator's interaction with the LMS. It is desired that the use of metrics within an institution benefit decision-making to the extent that the factors of interest for to the learning process and their relevance to institutional needs are identified.

For the IEEE standard, the metric is defined as a "quantitative measure to the extent that a system, component, or process possesses a given attribute." Metrics can be direct or indirect, internal or external, objective or subjective.

Quality and metrics for an LMS, as mentioned above and according to the reviews and analysis performed, would take into account the following set of features and attributes that meet the requirements of users and institutions to make decisions with respect to LMS.



- Criteria or academic tool metrics: This is the main factor to be considered in a virtual education process because the technology platform LMS must cater to learning needs and facilitate the process of information acquisition, collaborative participation, and mechanisms and strategies for assessment and feedback on students' training progress. The latter includes characteristics associated with pedagogy, communication, content resources and courses, requirements of the student and the teacher, and process of monitoring and progress in the development of the course or learning objects.
- Administrative process metrics: Course management and user management, together with the technical support involved in the implementation of an LMS, are part of one of the characteristics to be evaluated in virtual education platforms. It is very important to have the respective administration to enable resources and contents on platforms.
- Technology metrics: An equally important feature as to the technical and functional requirements supporting the development of courses and modules implemented in LMS. In addition, compliance with standards is part of this feature, providing both accessibility and usability of LMS platforms.

## 5.2 LMS Assessment Tree

In accordance with the above characteristics, attributes have been defined for each of the three characteristics present and necessary on LMS platforms, which are considered relevant at the time of implementation and form the requirement tree shown below:

*Table I presents the features of the academic component, based on academic processes, which in turn have sub-features such as Academic Processes, Web-Based Learning, Collaborative Environment, Evaluations.*

Table I. Academic features

1. Academic features
1.1 Pedagogical
1.1.1 Learning process
1.1.1.1 Pedagogical focus defined
1.1.1.2 Allows to create learning paths according to student profile
1.1.1.3 Oriented to knowledge management
1.1.2 Web-based learning
1.1.2.1 Web 2.0 tools (wiki, blog, RSS, Podcasts)
1.1.2.2 Web 3.0 tools (virtual lab, smart search, virtual world, 3D games)
1.1.2.3 Student portfolio – Personal page
1.1.3 Collaborative environment
1.1.3.1 Social content (student creates contents viewed by others)
1.1.3.2 Role definition (role play)
1.1.3.3 Group and subgroup management
1.1.3.4 Private social network
1.1.4 Assessment
1.1.4.1 Test management
1.1.4.2 Grade book
1.1.4.3 Diagnostic test (previous knowledge)

*Table II presents a feature of the administrative component, which allows to evaluate what is related to LMS help options, user management, LMS technical support by either a community or the existing documentation available.*

Table II. Administrative features

3. Administrative features
3.1 Help tools and online feedback
3.1.1 Help quality
3.1.1.1 Help explains the platform and its services
3.1.1.2 Tutorial videos
3.2 User management
3.2.1 Single authentication system



3.2.1.1 User's level of access
3.2.1.2 Teacher's registration system
3.3 Technical support
3.3.1 Manuals, specifically technical adjustments
3.3.1.1 Help manual for the teacher
3.3.1.2 Help manual for the student
3.3.1.3 Support by academic communities

*Table III presents the technological component, based on the processes associated with the following sub-features of usability, accessibility, interactivity, scalability, standardization, responsiveness and adaptability to future requirements of LMS.*

Using the requirement tree, each attribute is evaluated giving zero (0) if unimportant or irrelevant and ten (10) if very relevant. In this continuum of 0 to 10, there may be intermediate values corresponding to the considerations made by the experts or agents interested in evaluating or making a decision regarding the type of platform to be selected.

According to that score on the scale mentioned, the model defined by Lovelle is taken as a benchmark for evaluating each attribute; therefore, evaluation of the platform (E) is obtained from the combination of several metrics, namely [46]:

$$Ec = C1 * M1 + C2 * M2 + \dots + Cn * Mn \quad (2)$$

Where:

C1 = Weighing factor of the metric

M1 = Metric to be assessed

Therefore, to measure a feature or sub-feature, the weight of each must be weighted with their metrics or assessment by the expert.

Table III. Technology features

2. Technology features
2.1 Usability
2.1.1 Visual design
2.1.1.1 Resource visibility and platform structure
2.1.1.2 User location indicator
2.1.1.3 Texts adapted to the web
2.1.2 Allows different profiles
2.1.2.1 Alternate itineraries
2.1.2.2 Usability perceived by users
2.1.2.3 Multi-user access modes
2.2 Accessibility
2.2.1 Access to the disabled
2.2.1.1 Visual impairment
2.2.1.2 Hearing impairment
2.2.1.3 Physical disability
2.2.2 Interface design
2.2.2.1 Navigability in different operating systems
2.2.2.2 Navigability in different devices
2.2.2.3 Customization by user
2.2.3 Resource design
2.2.3.1 Available and compressible resources
2.2.3.2 Intuitive access to resources
2.2.4 Access to non-graphic browsers
2.3 Interactivity
2.3.1 Information of access to resources
2.3.1.1 Resource access statistics by student or group
2.3.1.2 Time of access to resources
2.3.2 Completion of activities
2.3.2.1 Monitoring of activity completion
2.3.3 Interaction channels
2.3.3.1 Gamification integration

2.3.3.2 Allows augmented reality environments
2.4 Scalability
2.4.1 Management of high volumes of data
2.4.1.1 Manages a high number of user at the same time
2.4.1.2 Manages and organizes users in different groups
2.5 Standardization
2.5.1 Compatibility with known standards
2.5.1.1 SCORM
2.5.1.2 IMS (Enterprise / Metadata / Content)
2.5.2 Platform modularity
2.6 Responsiveness
2.6.1 Adjustment to different devices and formats
2.6.1.1 Adapts to different resolutions
2.6.1.2 Adjustment to screen size
2.6.2 Quality in mobile devices
2.6.2.1 Possibility of adjustment to new devices
2.6.2.2 Simple navigability
2.7 Future requirements
2.7.1 Ability of LMS to endure over time
2.7.2 Possibility of being modified according to new needs

For example, as shown in Table I, the Pedagogical Feature value corresponds to the weighting of the four (4) defined sub-features, namely, 1.1.1 Learning Process, 1.1.2 Web-Based Learning, 1.1.3 Collaborative Environment, and 1.1.4 Evaluations.

Additionally, each feature defines a weight according to the interests and appreciation of the organization. For this work, the weighting of each attribute, sub-feature and feature is consistent with institutional interests.

With respect to that requirement tree and evaluation, each institution can expand features, sub-features and attributes according to its interests and existing standards, which would broaden the spectrum for decision-making. That is to say, they can incorporate both rules and standards such as W3C or NTC5854 (Colombian technical standard), among others or international standards such as AICC, IMS, ADL, and IEEE, for defining the architecture to be considered in such LMS solutions [47]. Likewise weights will be a factor to be discussed and determined by the institution.

## 6 Results

To illustrate the process conducted and consistent with the procedure defined for evaluating platforms, the results obtained for the platform Sakai regarding the technical aspect are presented below (Table IV).

The score obtained by Sakai according to the metric proposed is 1.8, showing a low rating on technical aspects such as responsiveness, accessibility and interactivity, which today has much relevance regarding new online learning models or strategies. However, it is emphasized that the platform is ready to meet new requirements due to its flexibility.

Furthermore, there is a low rating as to how virtual courses are structured, showing difficulty in design and set up of resources and few options for tracking students and collaborative environments.

Table IV. Technical features - Sakai

35%	2.Technology features	1.850	0.6475
8%	2.1 Usability	6.83	0.55
	2.1.1 Visual design	6.67	
	2.1.1.1 Resource visibility and platform structure	9	
	2.1.1.2 User location indicator	5	
	2.1.1.3 Texts adapted to the web	6	
	2.1.2 Allows different profiles	7.00	
	2.1.2.1 Alternate itineraries	7	
	2.1.2.2 Usability perceived by users	6	
	2.1.2.3 Multi-user access modes	8	
6%	2.2 Accessibility	4.42	0.27

	2.2.1 Access to the disabled	5.67	
	2.2.1.1 Visual impairment	7	
	2.2.1.2 Hearing impairment	5	
	2.2.1.3 Physical disability	5	
	2.2.2 Interface design	2.00	
	2.2.2.1 Navigability in different operating systems	2	
	2.2.2.2 Navigability in different devices	3	
	2.2.2.3 Customization by user	1	
	2.2.3 Resource design	5.00	
	2.2.3.1 Available and compressible resources	5	
	2.2.3.2 Intuitive access to resources	5	
	2.2.4 Access to non-graphic browsers	5.00	
7%	2.3 Interactivity	3.83	0.27
	2.3.1 Information of access to resources	6.50	
	2.3.1.1 Resource access statistics by student or group	7	
	2.3.1.2 Time of access to resources	6	
	2.3.2 Completion of activities	4.00	
	2.3.2.1 Monitoring of activity completion	4	
	2.3.3 Interaction channels	1.00	
	2.3.3.1 Gamification integration	1	
	2.3.3.2 Allows augmented reality environments	1	
5%	2.4 Scalability	6.00	0.30
	2.4.1 Management of high volumes of data	6.00	
	2.4.1.1 Manages a high number of users at the same time	6	
	2.4.1.2 Manages and organizes users in different groups	6	
4%	2.5 Standardization	6.50	0.26
	2.5.1 Compatibility with known standards	5.00	
	2.5.1.1 SCORM	8	
	2.5.1.2 IMS (Enterprise / Metadata / Content)	2	
	2.5.2 Platform modularity	8.00	
3%	2.6 Responsiveness	1.00	0.03
	2.6.1 Adjustment to different devices and formats	1.00	
	2.6.1.1 Adapts to different resolutions	1	
	2.6.1.2 Adjustment to screen size	1	
	2.6.2 Quality in mobile devices	1.00	
	2.6.2.1 Possibility of adjustment to new devices	1	
	2.6.2.2 Simple navigability	1	
2%	2.7 Future requirements	9.00	0.18
	2.7.1 Ability of LMS to endure over time	9.00	
	2.7.2 Possibility of being modified according to new needs	9.00	

## Conclusions

The demand for platforms and, in particular, for technological tools assisting the training process has also led developers or communities to create technological, academic and administrative mimics in terms of their development. Therefore, this proposal offers an alternative so that institutions and those responsible for implementing online programs or having LMS to support classroom processes select the platform that best suits their interests and needs. In this regard, it is concluded that:

- Most of LMSs tend to be identical in some aspects, particularly in the design and development of courses.
- It should be noted that a relevant aspect is to have standards not only for the contents but also for the design of online learning environments, which are frequently confused.
- The proposed metric allows institutions to assess and define the weight they deem relevant for the development of virtual education. These criteria should be based on the needs and requirements of the institution, which help select the best platform.
- Using the proposal presented, institutions can define their own weight and start the platform selection process, including other factors defined in different standards.

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## Participation and knowledge through Plickers in high school students and its relationship to creativity

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**Abstract.** This research aims to know the relationship between knowledge, participation and creativity in a sample of 60 students (30 girls and 30 boys), aged 15 and 16 years (15.6 average and standard deviation 0.49) at an American learning center. The instrument used to evaluate creativity was the test CREA (Corbalan et al., 2003) and used to evaluate the participation and knowledge of the students was the Plickers application. The Pearson correlation and a descriptive analysis to find out the average, deviation, maximum and minimum of each variable, were used to know the relationship between the variables. The results indicated that creativity is related to the participation, and this knowledge. Therefore, due to the relationship between the variables, teaching must include factors such as creativity and interaction for more meaningful learning.

**Keywords:** active learning, creativity, knowledge, participation, education, technology

### 1 Introduction

This study has as main purpose to discover new learning mechanisms for schools using new technologies in search of innovate the classroom and collaborate with teachers, schools, parents and people in the community and is part of the new plan of the United States Department of education. All together working as a team, preparing students to live, work and thrive in a multicultural, multilingual world highly connected in the innovation of new technologies that adopt the new science standards of the next generation for the libraries in public schools and education centers in private schools, from primary to grade of secondary grade. Providing an educational environment open to the where the teachers are communicators, guides and motivating students to learn new trends of information technology and communication (ITC). High school students will have the opportunity to thrive in a world of the 21st century, which requires the ability to make personal decisions, use technology with ease, resolve challenges or current and future problems of humanity, and participate wisely in a democratic society. The study of creativity, the creative problem solving, and change leadership allows individuals to expand their capabilities and develop their full potential. The leaders who know how to carry out and manage the change are in demand in all industries around the world.

#### *Active learning and educational methodology*

Can be seen at the active learning as a teaching strategy - apprentice - learning whose design and implementation focuses on students by promoting their participation and reflexion continues through activities that promote dialogue, collaboration, development and construction of knowledge, as well as skills and attitudes. Active learning is an essential principle of the new instruction to what now is usually called "learner-centered" or "learning centered" education of Weimer [1]. If the teachers want a greater part of student learning, then the active learning is an essential component of effective teaching and the result can be masterly to the professors that can inspire their students. It is common that students feel rather disconnected from the content of the teacher have to must make the classroom an environment of participation that there is connection with the students with games in order to draw the attention and producing classes full of motivation. The advantages of a teaching class with learning active allow that teachers are seen as presenters with a sense of the subject as designated by Svnicki and McKeachie [2]. For teachers be viewed as instructors in the classroom has its



advantages: (1) allows the teacher to complement the text of a book and proportioned material of last generation as a learning tool; (2) the teacher gives a status of 'control' in the classroom, students may not disrupt the flow of material and there will be fewer distractions; (3) allows the master of information key to bring learning the material in class more simply and that what has been learned is evoked without problems when considering students; and (4) provides an opportunity for the teacher encourages students inspiration.

Active learning has different definitions that focus on two key co-speakers: "do" and "what it reflects." The most general definition mentioned active learning come from authors Bonwell and Eison [3]: "The participation of students in doing things and thinking about what they are doing" (p.5). The authors emphasize that students must participate in activities that include reading, writing, these research studies that evaluate the performance of the students have shown that many of the strategies that promote active learning are comparable to the conferences to promote the content domain to bring to class discussions to solve problems and can learn from them in order to create the ability of understanding of the issues learned to be independent either by connection of the issue with the reality and what can the student share in the class as a case that will help to students to feel connected with the teacher.

The definition of active learning, promote neuroscience [3], Leamnson [4] says that active learning is different investigation as "stabilizers used repeated times, certain synapses, appropriate and desirables in the brain" (p.5). To which, the synapses of diligent students, may be overshadowed by the way incapacity of members give the educational institution. Active learning has the word "action" as a very important ingredient to which the student perceives what they learned reaching metacognition. The definition by Zull [5] defines education as "lifelong learning based on experience" (p.14), Zull emphasizes "doing" and uses the expression "action", which emphasizes the value of where originates in "what the student perceives about your own actions. The action is a learning test. Zull also uses the term "metacognition" to highlight the importance of the students when they think at the time that they are doing. Metacognition is at the heart of all learning [5]: "the final result of the journey [from the brain to the mind] is to understand our own intelligence" (p.30). Similarly, Ambrose, Puentes, DiPietro, Lovett, y Norman [6] specify the conclusion of action learning and experience as an alternative to the effectiveness of better learning and very similar to the definition of Bonwell and Eison [3], Among other arguments about the learning active presented by Prince [7] "learning is a process that leads to change, which occurs as a result of the experience and increases the potential to improve future performance and the apprenticeship" (p.5). Prince in this investigation taking elements of active learning and the in-body readings as evidence on the activity of improvising with participation in class and as this benefits the peer class work and helps the environmental liabilities of class pass another more active level for best performance of the students in the class.

### 2.1.1 Approach of active learning and educational methodology

Active or significant learning is related to participation and teaching and creative methodology. In fact, authors as Wesseler [8] and Gopalakrishnan and Aravin-dakshan [9] alludes to the importance of the active and significant learning using a creative methodology, through what he calls creative participation, which is characterized by the involvement of knowledge, experiences, feelings, strengthening discovered processes.

This is, to promote a significant and active learning, no doubt through implementing creative and innovative educational methodologies that meet a series of requirements, and move away from the methodologies traditional focused only on the teaching role. Sotelsek and Robin [10] argue that this methodology that promotes meaningful learning facilitates learning based on student prior knowledge of the contents of lessons learned to complement the new concepts of the new class. Without forgetting that priority should be given to reasoning and understanding, stimulate critical thinking of students and content not conceive as a closed set of ideas, but as an open body of knowledge in which there are different perspectives.

### *Benefits of active learning*

The dynamics of teachers trained for the students is important to offer a creative environment study groups to help educators to ensure that learning is motivated to occur significantly at the learning exchange [11] where is dedicated to the "learning spaces that curriculum support focused on the student." and to offer content in a responsible and realistic way to students. Weiman [12] showed that the halls with students with the same level of learning, were able to learn more concepts than the assistant teachers that has trained in the use of interactive teaching methods (small discussion groups, in class test that used response personnel or "response controls", demonstrations in class systems and small session of questions and answers) techniques are offered by the teacher where these students are better trained in topics and were very stimulated to learn new concepts in class



using a focus read-only [13]. These tests identify the learning in the classroom. Purpose of this study is that teachers can learn a set of issues that contribute to active learning in the classroom will be used in the development of creativity which verifies learning environments [14]. The objective of this study was to identify headings behaviors and activities that used active learning in conjunction with creativity in the classroom [15].

The importance of active learning is to achieve the meta-analysis of learning in groups small in science (science, technology, engineering and mathematics, [STEM]) by Springer, Stanne, and Donovan [16] these studies examined the development of academic disciplines and specific criteria. The meta-analysis showed that the different forms of Small Group learning are indicated to promote a high level of performance academic, what motivated attitude of the teacher to students promotes learning, and the greater the persistence among the courses better will be the interpretation of learning according to the study by Springer, Stanne, and Donovan, [17].

#### *Tools and resources for active learning*

This new generation of teachers is concerned about resources that benefit in the classroom for teaching purposes. All of these resources should bear in mind a number of aspects which are essential to be considered as tools that allow: be, mix, share, interact and cooperate [18]. If it fails any of these items may not be considering them as tools that are expected to generate significant changes in a deliberate process that generates evidence, which are substantial results in a process-so formal rules-based and based on scientific literature [19]; [20];[21].

#### *Learning and technology*

In the educational process in the classrooms, it has a series of resources that are with-engine as part of active learning which served for Ramirez [19] to daily activities such as learning tools:

- Blogs. a tool for asynchronous collaboration that teaching level used it as review and expand content for research of an educational way to communicate with students and expose comments of the learned topics, researched. Another way of using blogs is as an instrument of communication in the classroom where the teacher can announce different events, tutoring services, to reflect the evolution of his thought and expertise for a certain period of time in the school year, or to publish their work in the manner of a portfolio and receive comments regarding this.

- Wikis. These mean collaboration that help hierarchical unit directional of learning where extend the space and time of training anywhere with Internet access. It can be used as space of communicate, collaboration, for performing and presenting a topic concerning task.

- Podcast and vodcast. Podcast and vodcast were originally intended as versions audio blogs and are used as an audio file free, that you can download and listen to on your computer or an MP3 player, like an iPod. Distribution is through an rss file, so you can subscribe and use a program to download it and listen to it when the user wants to.

- Social networking and virtual worlds. These forms of communication are often more dynamics. Social networks are making new friendships, virtual, and come from content, interact, create communities of similar interests, readings, games, friendship, relationships, relationships, etc.

Virtual worlds are important for the high educational potential to the in the most real demonstrations.

- Slideshare, Scribd, and concept maps. They are web sites for sharing and exchanging files text, presentations, or create conceptual maps, which then can be compared with others inside or outside the classroom to a space more broad as does the publications on the web.

- Flickr or Picasa. They are web sites to upload and share photographs with different interests because it is family, business, informative way or demographic form.

- Youtube, Ustream... allow us to carry out video or recordings of a short film for the purpose of gain a broad exposure to people from different parts of the world. Many people, educators and professionals use these websites to present interviews, important research topics taught class, a practice with musical instruments or any other activity that we consider **outstanding**.

- Collaborative maps. Google Maps allows us to more quickly find sites and places of interest. As represent geographical maps for information to be able discuss aspects social, political, historical, geographical, centered on a theme or subject in one is collaborative in the classroom.

- Virtual platforms (Moodle) and forums. It allows us to carry out any training (e-learning) mode to Exchange themes between teachers and pupils.

In our competitive times the learning process has to be changed and also demanding to be able to respond to the methodologies in the teaching process - apprentice - je in a positive way.

### *Active learning Neuropsychological bases*

Neuropsychology is the specialty that is in charge of a proper relationship with different medical specialties who study the brain.

It is important to highlight the evolution of brain and cognitive functions in order to know the stages that allow a better understanding of the operations of the brain neuroanatomy.

Active learning helps to provide opportunities to students to talk and listen in a more expressive way, writing, reading and reasoning about the contents, ideas, problems and concerns in an academic subject [22]. Active education integrates the contents of the classes of the students part of the education of learning active to the long-term memory to which these students may use the concepts and theories of the course in a more effective way, less time will be required to review the material and answer questions about content and more time can be used for activities of a higher level of thinking to any other mental through our neurocognitive abilities.

There is no doubt that it is easier to learn about topics that may interest us and provoke us curiosity. To investigate what is happening in the brain in these situations investigation how curiosity (intrinsic motivation to learn) influences the memory and learning using fMRI [23]. The study showed a significant improvement in memory for information in States of high curiosity in meaningful learning and incidental, in comparison with the low curiosity, and that high curiosity, there was more activity in the midbrain and the nucleus accumbens, as well as the midbrain area segments ventral and the hippocampus and the connectivity between these regions.

Processes cognitive according to Piaget [24] the basic processes that allow the improvements and adaptation of the brain are those of assimilation and accommodation. As defending Montessori [25], it is the same environment that educates the child, why give him an absolute importance to educational materials, passing the teacher to an according to plan.

Active learning neuroscience offers us a kind of secular learning than usual which is based on the learning of the students in a way characteristics passive class, which includes listening to lectures and taking notes. On the contrary when carrying out examination of the investigation effectively teaching routine-mind is used as a form of teaching to which they are oriented more towards study-teas that are often grown in a way active for example, through the participation of students in problem solving [26]; [27].

Neuroscience gets a new appreciation of the form of teaching learning methods influence and like these help the improvement of the results of the studies. With the emergence of the neuroimaging techniques in the 1970's and the functional imaging in the 1990s (i.e., fMRI), researchers have contributed how studies the brain processes different types of information from a few years ago. Effective-mind scientists have had a predilection in the study of learning and memory, and in general, these studies show that multimodal or multisensory learning engages in physical changes over the longer term in the brain, and helps to the perfection of the retention of memory and the memory.

Some studies such as the mental image of Kosslyn [28] uses only images mental such for perception of learning to which Pyslyshyn [29] relies on symbolic theory of images, has established strict criteria for the support of the Pro-position theory, saying "to support this point of view, it is important not only to these areas topographic organized to participate in imagery" ", but that his participation is type - the way in which your topographical organization is involved also reflects the spatial properties of the image" (P.175). The main objective of the present study was topic map of mode individual-participate in each of three conditions: perception, imagination, and attention control / perceptual using images of magnetic resonances related (fMRI) to build map of interpretation of the imagine.

For this reason that the mention of neuroimaging techniques is important in the 1970s and the functional imaging in the 1990s (i.e., fMRI), in particular scientists have great appreciation for these studies showing as multimodal or multisensory learning leads to physical changes over the longer term in the brain, and improvement of the evocation of what they learned.

Learning is greater when multiple neural pathways are activated at the same time. This means that participation as many sensory, cognitive, emotional and social processes of students will increase your learning potential.

The problems this active regions of the brain involved in executive functions (for example, the prefrontal cortex) this happen when students learn passively.

Short written works incorporating this tactile stimulation induces [30], help visual processing using imagination [31], and messy activation in the prefrontal regions involved in executive function the use of varied teaching methods. The issues of multiple ways to integrate contents through the activation of a variety of interconnected brain processes as written, listen, talk, interact, movement, etc.



Induce students to empathize with new learning methods using personal experiences this active older memory pathways and support that the new reporting to engage physically with them.

Promoting students to work in pairs or groups, this involves social, emotional, hearing and motor networks. When students work between Yes, cognitive and sensory networks help to involve more in the subject. These processes include talk and listens others, experiencing positive emotions, physical movement, and problem solving. Comparing this active learning with passive learning normally implicated, less use of the parts of the brain, where students can listen and limited competence and not there is storage of learned material.

#### *Relationship between creativity, participation and knowledge*

Principles of creative teaching us wants to expand with the words "creative class" is important for students to teachers. Since you must create development at the mind and creative skills. Objective, teachers can increase activities to develop creativity where generated in a suitable learning environment. Creative teaching needs imagination, flexibility, originality, ability to adapting, and its use in the solution of problems of curriculum. Therefore it is necessary that the assigned person have control of education and that it reconciles the basic principles that are pair - you of the creative potential:

The rule of rating, should be spontaneous creative thinking that is not out of fear of a wrong answer; another rule of flexibility is part of a structure; This want of-cir if we do a task too elaborate, we are not limited to the pen-writing or children; to understand the rules of the patience, the teachers, can be tempted to provide the correct answer to the children or direct their pen-thought processes; learning to be independent to solve answers involves time; Finally the rule to push themselves to achieve the response of the different use - des to the activities that are offered in programs, as well as adapt them and use them as needed to the teacher [32].

Based on commented, the overall objective of this study is to analyze whether there is a statistically significant relationship between creativity, knowledge and participation in classes. Therefore it is essential to check the following specific objectives: know the participation of students in classes, assess the creativity of sample and evaluate the knowledge which has sample.

## **2 Methodology. Experimental design**

This research work is in search of levels of creativity, knowledge; participation and motivation of students in high school education that were part of our research and if there is a relationship between them. For this reason, the initial hypotheses are:

- There is statistically significant and positive relationship between creativity and the knowledge
- There is statistically significant and positive relationship between creativity and the participation
- There is statistically significant and positive relationship between the knowledge and the participation

To do so followed a non-experimental, correlational and descriptive design.

#### *Sample*

The sample used in this research consists of 60 students (30 boys and 30 girls) pair - you 3 ° of ESO with ages of 15 and 16 years of age (average 15.6 and standard deviation 0.49).

In the present study was conducted at the school located in the East of the County of Suffolk, New York at Riverhead district high school. Riverhead district has approximately-high a population of 33.500 whereby this divide between 66.1 percent of whites, 15.8 percentage of African American people and 25.3 percentage corresponds to the Hispanic race. Social class - economic that it influences in this district of Riverhead is varied because in certain areas such as Flanders is an area of lower middle class and the inhabitants of the area are afro American people as most Hispanic people is engaged in agriculture by the great vineyards and work in the service area. Riverhead also boasts a population of people who work in Manhattan and Connecticut that are large pro-force by which class people account medium-high.

#### *Instruments*

To know the levels of creativity used the test creates that has been created by Corbalán, Donolo, Tejerina, Limiñana [33]. Test CREA measuring creative intelligence through cognitive assessment, which carries out the generation of questions in the theoretical context of search and solution of problems.

The use of the test can be used, both individually and collectively, and easier administration. It tends to be applied to children of 6 years, adolescents and adults.



This creates Creative Intelligence Test used with 3 sheets: sheets A and B goes - give to teenagers and adults and sheet C applied to children.

PLICKER is application to stimulate active learning: review of knowledge and pair-participation.

This dependent variable is an application just to keep inter-degree students and motivated in class time. PLICKER is a tool used by the teacher or instructor who has aimed to create an environment where participants earn confidence to answer questions and at the end of each participation the teacher uses the system to register the percentage of correct answers of each student at the end of each session with PLICKER, the master against each of the students and measured how much participation has been carried out during the week. Weekly teacher can measure levels of participating with each student's knowledge. It is very easy to use these cards PLICKER, just visit the website and tighten card free printing button. Each card has letters and 63 cards are which you can distribute to 63 students. The only thing you have to do is questions and your students to take their cards and the will on the side of letters (A, B, C, D) to answer the question. The teacher uses his cell phone, IPHONE or Android download App to your mobile will be a tool that won the attention of students in a way interactive and the result percentage ranges is:

Low: 0 to 50% of shares

High level: 51% to 100% of shares

The most amazing thing of this application class will make anything better assimilated and in addition to class time pass quickly and the use of PLICKER can be supplied individually or in a group.

#### *Procedure*

To conduct this study with a sample of 60 students of high school to carry it out the explanation to the management team and the leader of the center objectives of the investigation, asking permission and its collaboration in this work. I will inform the administrators of the secondary Riverhead Central School District of the days that it would perform tests for a week. Teachers cooperated with the participation of their classes and get parents permits for carrying out the tests.

The observer offers creates Creative Intelligence Test, throughout the study with the teacher and teacher trainer Professor. After consent is requested written authorization from the families of students chosen to be part of the test .

Provided the group creates Test (groups of 30 girls students and 30 guys) made use of the library for the groups of students making a first takes contact with them to foster a preferably relaxed and serene atmosphere. We used the blade B, indicating the instructions to members of each group to develop the test. To perform this test each student had 4 minutes previously making sure that they have understood the instructions and be motivated to start the test.

For PLICKER information gathering is taken at the time formulas your questions and the students respond. Each has letters (A, B, C, D) and the cards are 63 students rotate the card on the side of the letter to answer the questions without fear to respond or make a mistake. Teachers should download the PLICKER App on the Iphone or Droid phone. To collect the questions the teacher raises the cell and students tend the cards with their respective answers cell phone picks up information in a database. Each question creates the participation of students begin to respond whenever formulas a question by creating an atmosphere of motivation and active creativity. Statistical analysis: We made use of Excel and EZAnalyze 3.0.

## **3 Results**

Below is the table 1 show the descriptive statistics of the variable of creativity, participation and knowledge (Table 1).

*Table 1: descriptive results*

Variables	Media	ST	Min	Max
Creativity	9,80	4,25	3	25
Participation	27,47	9,48	3	40
Knowledge	35,15	10,14	5	44

Scale: ST: Standard Deviation. Min: Minimum. Max: Maximum

Continuation displays the correlational results (table 2).

*Table 2* Analysis of correlations

	Pearson	p
<b>Creatividad y conocimiento</b>	.165	.269
<b>Creatividad y participación</b>	.369	.004
<b>Participación y conocimiento</b>	.903	.000
<b>N of Valid Cases</b>	60	

#### 4 Discussions

In terms of the level of creativity, has been used the test of creative intelligence CREA, which highlighted the general level high 8.3 average 4.5 and 4.7 low which is attributed responsible for the creative development where the individual can make a reflection review and evaluating critical - creative [33].

With respect to the knowledge of the active learning the mean was 35. 15 so Stenberg and Lubart [34] discusses the concepts and components that influence creativity and one of the resources is the knowledge. Knowledge influenced among students who participated in the class and showed flexibility in the development of thinking.

In relation to the participation, the average was 27.47 is another resource for the development of the creativity influencing the intellectual challenge that used the effort to lead to creativity.

Regarding the relationship between the variables of creativity and participation, this study has found that there is statistically significant relationship between creativity and the participation are interrelated by motivation which is an essential component in creative learning [35].

Creativity is a conception of ideas that add to the cognitive processes more refined of the human being, detailing each evolutionary, social, and educational experiences and their manifestation in different number of fields. Creativity is set in this work of different forms of inclusion of contextually in tests observed in the moment of each teacher teaches their student, being original and constant in the evolution of a new concept: the newness of concepts and the contributions of students to participate in class to help that the mind to achieve cognitive processes to stimulation personality motivation, emotions that used the affective world, play a singular in this learning process component where we're all creative to a greater or lesser extent as also we can go develop it slowly.

Torrance and Hansen [36], investigated the conduct of the teachers could study how teachers posed questions to their students which could be more or less creative, and observed that creative teachers accepted good shape students ideas and incorporate new ideas in the structure or sequence of the subject to be treated, also used to stimulate their students , instead of teachers-us creative they were more direct and tolerate greater number of periods of silence with less participation and students out of the confusion.

In these approaches the influence of teachers is essential to the production of methodological knowledge in the classroom and as teachers they systematize with the active learning of students who will be influenced by the ongoing contributions, concepts and skills to engage in projects in different subjects to do research that organize students to analyze their work developing modalities to respond objectively process organization and sequence of work solve De Souza [37]. Therefore the teacher methodology is a process of change in search of new approaches for innovation of a new teaching model to improve the educational system in creative, interdisciplinary and contextualized education [38, 39].

One of the keys that complement the new methodologies of active learning is the motivation [40]. The contribution of motivation in students is often expressed through class participation, suggesting questions to teachers of subjects that the attention and causing positive stimuli between teachers and students in better performance in class in use of information technologies and communication, TIC improving knowledge of students and challenging teachers to improve to improve the academic curriculums [42] [43].

Entries have a strategic role in the Organization of the skills of the student, with the participation levels of organization and quick running between the individuals creates a structure of experiences involving the student to improve his attitude to a more functional and cooperative attitude that develops multiple tangible and intangible interrelationships stimulating learning [44].

In the learning process, it is important to take into account two characteristics as: is to manage the paradox and diversity with special clarity of the issues. The creation of change and complexity helps the learning process because teaches the student the ability to change, be flexible and take full advantage of the dynamics to expand their knowledge and motivated students can start to make more competitive and demanding in the form of instruction in each work because they make sense of balance, thoughts - systematic strategic resources and strategic capabilities as it is knowledge which is something intangible [45].

Socialization is a factor in the management of knowledge as it mentions Nonaka and Takeuchi [45].

The knowledge - socialization is important because it is a rewarding form of learning that full teachers such as students with experiences that will provide different ways of thinking to be able to solve specific problem using common sense. Many times the stress, lack of communication, rejection, social factors deprives the student to respond to teachers with better attitude and is made difficult the participation and cooperation in group. These negative factors that greatly influence in the classroom at the time of learning, it is important to discuss the fears of students to inform parents, teachers and psychologists of the schools and facilitate learning to students that cost them participation. Before these positive and negative factors is very important socialization on the part of students and teachers, having success in these cooperative relations between the two sides is fostered individualism and fear will lose share to create an atmosphere where all can succeed is "we won two and win all" and this creates a leadership in the classroom [46,47].

To achieve that leadership in the class all parties have to take into account the elements of the intellect according to Vargas [46] and these are: the Organization, the human, social and technological. This set of elements highlighting the intellectual factor of the members is essential for the Organization to be structured; the technology that members can make new trends in technology and knowhow to integrate it to improve the methodology of the class and know how to take advantage to the use of tools to solve problems; human parties can provide the set of abilities, skills, and attitudes that can incorporate the learned concepts, experiences and join cooperation in an open way.

It is necessary to say that in reality different postures of origin field of education, psychological and social complement is made up of human to which knowledge Delval [47] introduces the elements of constructivism and its multiple variations of capacities of human beings to reflect, learn, anticipate, control of a positive nature and build a culture focused on focus operation and content of the mind in construction of knowledge and conviction of human beings.

The conception of constructivist teaching and learning in different approaches according to Coll [48] where wide on the theories of human development, genetics of intellectual development theory and other theories of development and learning, theory of meaningful verbal learning and socio-cultural development and learning theory, all of these factors influence education in social practice and the socializing where the social nature and socialization processes build personal identity.

Educational intervention contributes to the resolution of divergent psychological problems as: the psychological development of the individual as it is the flat intellectual and as is in its development in the school. Identification and care as it is the need to be motivated in the process - learning. The rethinking of modalities and different kinds of methodologies in school to help the developing learning, the search for new learning strategies, the importance of promoting the interaction of the teacher with the student driving to a cooperative learning environment, the revaluation of the role of the teacher as guide, facilitator, driver and transmitter of concepts to emphasize the student's learning.

One of the aspects of learning is that it has to be a significant learning and therefore significant learning presents situations in the school area, as well as Ausubel has it [49,50] says the first two types of learning is: receptive and discovery. The second learning is: responsive and meaningful. So the situation of learning may become repetitive reception, meaningful reception, repetitive discovery and significant discovery. Not on the other hand however the activities in the classroom have to be responsive driving learning and student can reach advanced stages of learning.

Cognitive structure integrates various knowledge in meaningful learning that are indispensable to coordinate concepts intended to relate them broadly to reach the goals of the reception of concepts interrelate them that are organized hierarchically in a cognitive structure that facilitates the interpretation of material taught in class to the memory.



There are a number of phases in the meaningful learning is connected according to Shuell [51]. Motivational factors are interconnected where it depends on creating, requires it is facilitated by providing information to curricular content teachers for teachers and students, support materials and training further advantages in intrinsic motivation, active participation, understanding and new learning strategies.

These learning processes tend to memorize and interpret schematic knowledge, like looking at global information procedure and review to learn the information. Gradually the students be able to build a picture of mastery of material. The opportunity to reflect on situations and materials and the elaboration of conceptual maps and semantic networks that generates tasks solution metacognitive behavior - problems [51].

It is worth to emphasize that learning should be a way to determine and set up cognitive bridges that influence the reception and the motivational discoveries of each student.

## 5 Conclusions

There is a statistically significant relationship between the variables of studio. Practice the implication of these findings has reflected at the time of put technology in classrooms and to design teaching methodologies that promote creativity, participation and knowledge previous.

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## Automatic generation of virtual machine for security training

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**Abstract.** This paper explores the applicability of configuration management tools to the design and development of practical content challenges in the field of cybersecurity. Using the tools Puppet and Packer, a series of templates have been developed to create a test scenario. Such scenario has been proposed to contain both vulnerable services and already implemented security measures. Based on this scenario, flexibility of the solution and time saving achieved have been assessed. Through this assessment, it has been determined that the use of these tools is a viable option in developing both small scale scenarios focused on teaching and big scenarios used in cybersecurity events.

**Keywords:** cyber exercise, configuration management, Puppet, virtualization.

## 1 Introduction

IT security has currently become one of the main concerns of companies and institutions. The practical component is extremely important as it prepares students to face real situations they will find in their jobs. In teaching, the main problem is the time cost its development implies and, consequently, the scarce variety of scenarios that can be proposed. To this end, virtualized systems allow us to create believable environments where students can interact with the tools and face similar situations to those that may occur in a real environment. This can be achieved through gamification models or Capture The Flag (CTF) competitions where students must pass a series of tests.

The latter is added one more level of competitiveness since the different teams have to face each other. In this type of events, a series of vulnerable servers is delivered to each team. Each must find and fix these vulnerabilities, fending off other teams, while finding and exploiting failures in servers of opposing teams.

Attacking the problem from automation of the process of creating machines and services deployed in them, and preparing the necessary infrastructure to host a CTF type event or cyber exercise is a complex, multidisciplinary task that is to be addressed in this paper, in addition to preparing complex scenarios to install, configure, deploy and monitor a large number of machines from the world of virtualization to create different, dynamic scenarios in each event.

## 2 State of the art

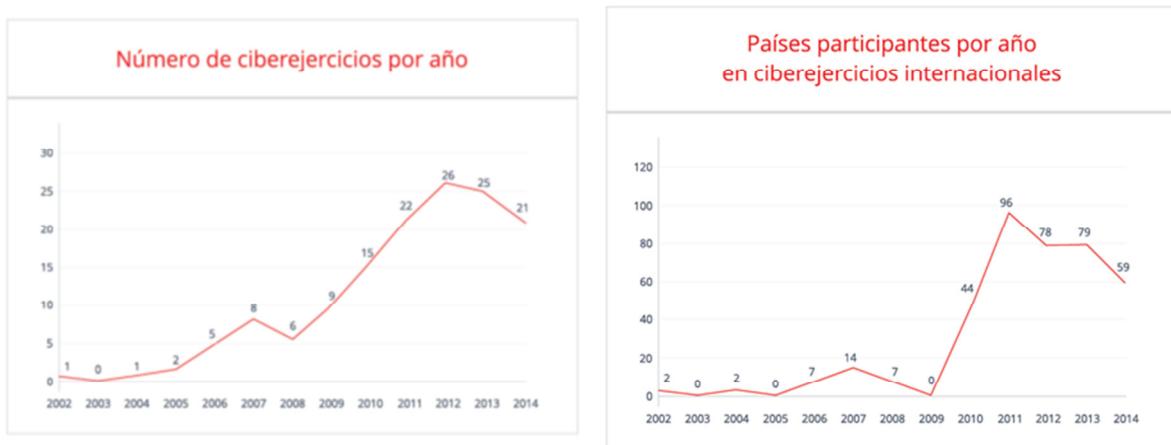
This section presents first the two types of cybersecurity events used as models (cyber exercises and CTF competitions) and the use of the virtualization technique as an indispensable element to carry them out. Finally the DevOps concept that frames the configuration management tools used in this study is introduced.

### a. Cyber exercises

Based on the definitions provided by the glossaries of official bodies such as the Cooperative Cyber Defence Centre of Excellence (CCDCOE) or National Initiative for Cybersecurity Careers and

Studies (NICCS), we could say that a cyber exercise is an event that aims at evaluating and improving defense capabilities in the field of information technology of a particular community (either military or civilian) through recreation in a controlled environment of a confrontation situation within the scope of information networks.

According to cyber exercises taxonomies prepared by INCIBE (Razvan, Adrien, & Panagiotis, 2015) and (Jason Kick, 2014), the number of cyber exercises performed each year has experienced significant growth as shown by Fig. 1.

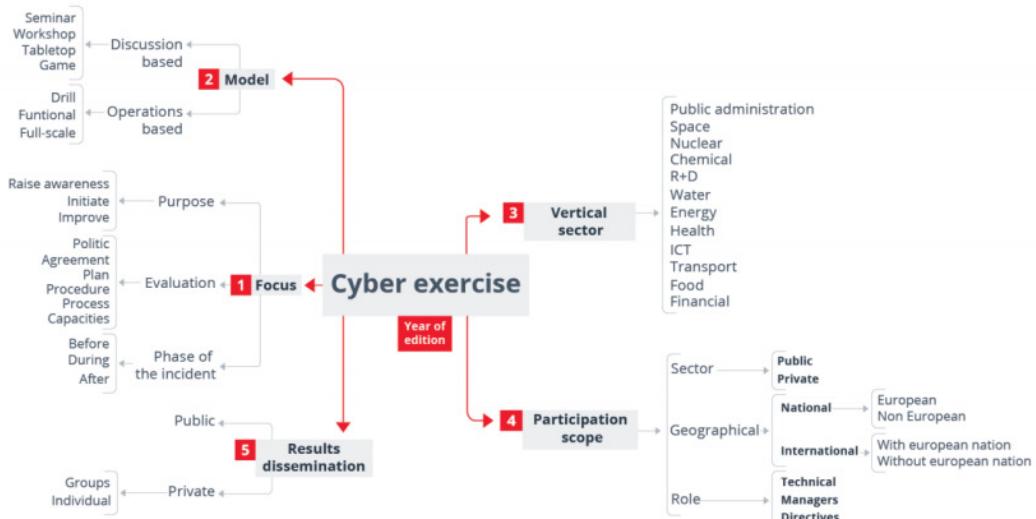


**Fig. 1.** Number of cyber exercises and participants by year (INCIBE, 2015)  
 [Traducción de la imagen: Number of cyber exercises per year / Countries involved in international cyber exercises per year]1

Most cyber exercises reflect the time when the incident occurs, while others also include before and after phases. The before phase may include securitization of a given infrastructure, while the after phase can focus on analyzing digital evidence that has been produced during the incident in the scenario and generate reports on events occurred and actions taken.

Lastly, a common component to most cyber exercises is the number and type of events (injects) introduced in the scenario during its development. These events come to represent the changing, unstable framework surrounding crisis situations in case of an attack.

Upon analyzing the main features that comprise the context surrounding the organization and execution of an event of this kind, we are going to frame the cyber exercises model to which this work intends to contribute, following the taxonomy described, as summarized in Fig. 2.



**Fig. 2.** Cyber exercise taxonomy schema (INCIBE, 2015)

### b. Capture the Flag competitions and their teaching applicability

Such events are characterized by being highly technical and lacking, in the vast majority of occasions, a script or story surrounding testing (unlike cyber exercises), focusing on the pursuit of participants' pure technical skill.

Conferences such as DEFCON have been organizing such competitions for more than two decades (DEFCON, 2016); a controlled environment in which participants can measure their knowledge is created to ensure a level playing field. There, techniques, exploits and tools are shared and it is mandatory to document and publicize the method for solving the challenges posed by the competition.

### 2.3 Virtualization

Virtualization is a technique that allows to create virtual versions of a software or hardware resource. It gives us the advantage of isolating the guest system (the virtual machine) from the host system, flexibility to define hardware features of the system (CPU, RAM, etc.), and the ability to restore through snapshot systems; for example, if we infect one system to analyze the behavior of a sample of malware, we can return the system to its initial state.

## 3 Working methodology

The general objective is to reduce the time needed and make the creation of virtual machines used in the practical section of information security teaching flexible. At the same time, the machine created in the VNX virtualization platform are intended to be integrated in such a way that scenarios can be easily deployed.

The specific objectives are to assess the service deployment platform on virtual machines (e.g. Chef, Puppet and Ansible), integration of the chosen tool with VNX platform, development of templates that allow to install vulnerable services or older versions of CMS e.g. Wordpress, Moodle, etc.), development of templates that



allow to install security services, being these firewalls and IDS as a minimum and, finally, development of a testing scenario that serves as demonstrator of developed templates. For instance, seeing how an IDS protects a machine with outdated Wordpress.

As methodology used to achieve the objectives specified in the preceding paragraph, it should be mentioned that there are two big different parts: the preliminary study of existing alternatives in the DevOps ecosystem and the assessment of its applicability within the teaching environments of a laboratory, as well as the completion of a cyber exercise / CTF.

#### 4 Identification of requirements

To be able to identify the requirements of the software solution to be offered, we must be clear about the use cases to which we want it to be applied. To do this, we are going to differentiate three different use cases to which we want to apply the advantages of these tools.

4.1 Teaching laboratories: Small scale scenarios normally developed by a single person. They usually contain a moderate number of virtual machines (around 4 to 10) and machines with repeated roles are not common. Each machine plays a clearly differentiated role (attacking machine, victim machine, etc.) through the services they contain. In this case, customization of services and portability of the scenario are the most important features sought after. On the one hand, being able to customize scenarios provides the necessary flexibility to teaching, which as a rule is limited to offering scenarios pre-designed with machines containing vulnerable services. This approach does not contribute all the realism that would be desirable since its similarity with a real production environment in a company is poor. On the other hand, virtual machines are heavy resources, occupying several GB each. This represents an obstacle when sharing this scenario with students so that they can deploy it in the personal computers. Thus, configuration management tools set out the alternative to share only templates that are extremely light files so that the student is able to generate the scenario on their computer based on it.

4.2 Cyber exercises: In this case, we are facing scenarios of considerable size (from 100 to 1000 virtual machines) where the capacity to control the deployment prevails. Part of the scenario usually consists of exact copies delivered to different participating teams, thus faithful reproducibility of the scenario designed along those copies is critical. Due to the volume of machines to be managed, scalability is another aspect of high interest. The solution must be compatible with private cloud virtualization environments because these are usually chosen when deploying this type of events. The variety of host systems is another point to be highlighted; the solution must be able to configure systems on a wide range of operating systems. In this type of events, real industrial control or other infrequent systems in the IT ecosystem may be employed. For this reason, and despite the configuration management tools do not include support for this type of system, the greater the number of supported systems, the more flexibility we will obtain in order to minimize manual configuration of the event. Finally, the solution must not interfere with the proper operation of the exercise. This implies that vulnerabilities or information leaks that give advantage to the team discovering them must not be introduced therein.

4.3 CTF competitions: This use case is the most variable of the three because CTF competitions may vary greatly in scale from one event to another. As mentioned in Chapter 2.2, configuration management tools can only provide an improvement in Attack/Defense-type CTF since, in the Jeopardy type, many of the challenges do not require the use of servers. This type of CTF can be seen as a cyber exercise at a small scale. The number of machines to be handled is generally lower, but some of the requirements are shared such as the capacity to manage and monitor deployed machines, reproducibility of the scenario (copies of the scenario are usually delivered to each team too), or the need not to interfere in any way in the behavior of services deployed. In this case, flexibility in design the scenario is also important, but it is undeniable that in order to offer innovative challenges there will always be a craft component when designing them (although this can be incorporated into the workflow introduced by these tools).

After describing the different use cases, the requirements we can extract from them are as follows:

- Managed flexibility:** The platform created must be capable of responding to different challenges but keeping control over the options offered. This means that it must be easy to modify the already designed scenarios to



include new elements or add new challenges to them. At the same time, control must be maintained over the infrastructure so that we can keep track of different versions created for each scenario, develop catalogs or use different variants without incurring added complexity.

- **Scalability:** The solution must be compatible with the creation of scenarios of various sizes. It must be useful for generating laboratories in workshops or subjects related to cybersecurity (4-10 virtual machines). Yet it must also be a significant help to server configuration in more complex architectures aimed at completing a cyber exercise or CTF-type competition.
- **Minimization of tool trace:** It must be avoided that the system used disclose information of network infrastructure or underlying services. At the same time, vulnerabilities that may be exploited in the security event and alter its good operation must not be introduced.
- **Reproducibility:** Performance evaluation of users (whether students or staff of the defense sector) should be conducted on exact copies of environments so as to ensure equality. It may also be interesting for forensic analysis as the exact steps taken by the attacker can be reproduced.
- **Portability:** The scenarios designed must be able to be deployed in different occasions and varied locations. This implies that a heavy system that entails big storage requirements for migration must not be developed.

## 5 Software development

This chapter will detail the process of developing the software solution to the problem presented. The main objective is to reduce the time for configuration of servers and services deployed therein. Thus, this section is divided in a first analysis of different tools that serves as a basis to identify their qualities and choose one of them. Using such tool, we will propose a series of templates to recreate a small scale scenario that serves as concept test and demonstrator.

**5.1 Analysis of DevOps tools.** Below we are going to highlight the principal features of the configuration management tools Puppet, Chef and Ansible as well as the virtual machine generator Packer. We will also comment on their main advantages with respect to generation of the scenarios proposed in the environment of cyber exercises / CTF in order to select one of them.

The three tools share most of their features as well as their mission. Consequently, we are dealing with tools that allow to describe in a template (called manifest, cookbook or playbooks, depending on the tool) the state in which we want to leave a machine at the time of deploying it. In addition to the syntax and semantics contributed by such description, the tool is capable of applying such changes on a variety of architectures and operating systems. In applying such configuration, idempotence is guaranteed to ensure that, regardless of configuration, the result will be the same.

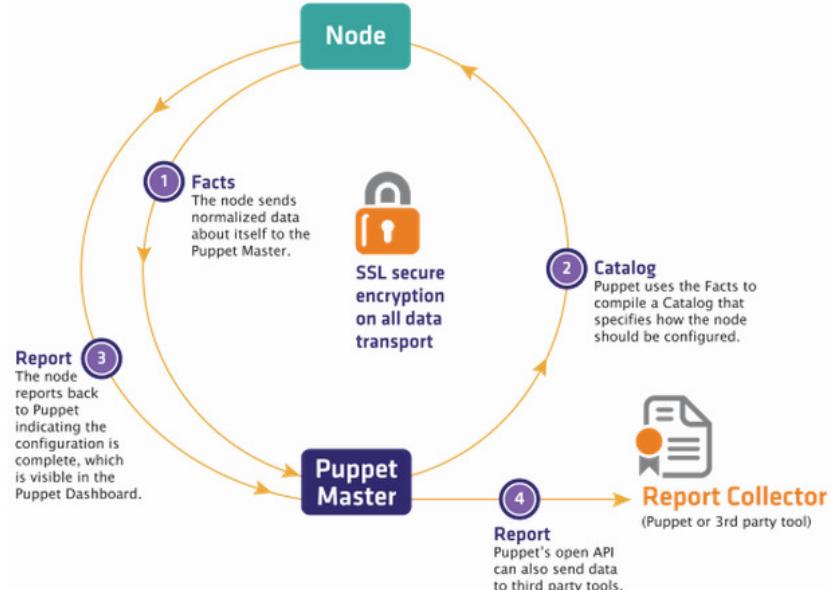
**5.2 Comparison of configuration management tools.** On the one hand, Chef and Puppet need the installation of a software client agent in the host system. Agents play an important role and proper operation of the deployment architecture depends on them. For this reason, both the installation and management of the installed versions of these agents should be part of the action plan when implementing the use of these tools. See Puppet execution cycle in Fig. 3.

On the contrary, Ansible does not operate through a software agent. Instead, Ansible takes advantage of the fact that most of the times machines already have a remote login system (SSH generally). In this manner, commands to be executed by the machine are sent through such protocol, avoiding the use of any added software. This aspect represents a clear advantage with respect to the easy use of Ansible, minimizing the necessary preparation to use it and offering a low entry barrier.

In the case of Chef (see Fig. 4) and Puppet, architecture is composed of a master server that orchestrates configuration deployment to all servers registered against it. This server stores recipes and control the machine inventory it manages. The system administrator only interacts with the master server and never with end-computers. Thus, control can be maintained on a large volume of servers. Generally, recipes are not monolithic

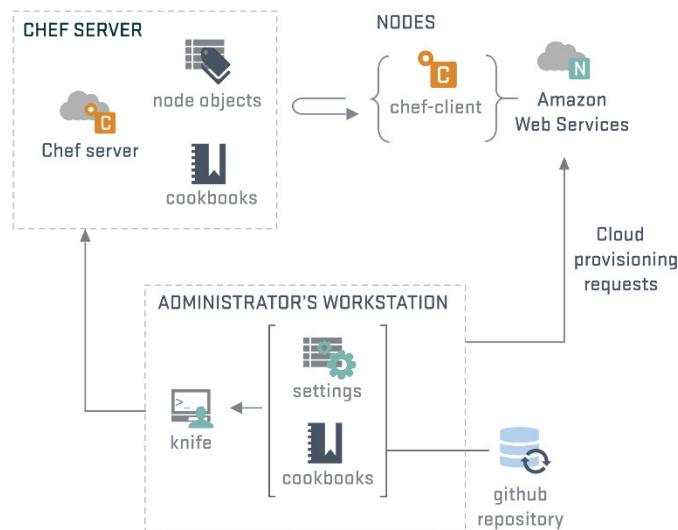


blocks, but fed on other previously designed module recipes. These recipes are generally stored in the master server so that all servers use the same base templates.



**Fig. 3.** Puppet execution cycle

In this way, it is avoided that different system administrators use different templates for common tasks, maintaining homogeneity in the deployment. Inside or next to the master server usually is the database that contains information of architecture supplementing templates. This database contains the information that can be used by templates to complete system configuration (e.g. IP address distribution, credentials, etc.) so that its use can be managed centrally.



**Fig. 4.** Chef architecture

Regardless of architecture, all tools employ safe protocols when exchanging information among nodes.

- Ansible: Deploys pairs of public and private keys for each node so that they can be mutually authenticated and uses the SSH protocol to maintain confidentiality.

- Puppet: Makes use of a public key infrastructure, employing certificates to protect requests made among the architecture components.
- Chef: Uses the HTTPS protocol to protect messages and employs pre-shared secrets between agent and master server.

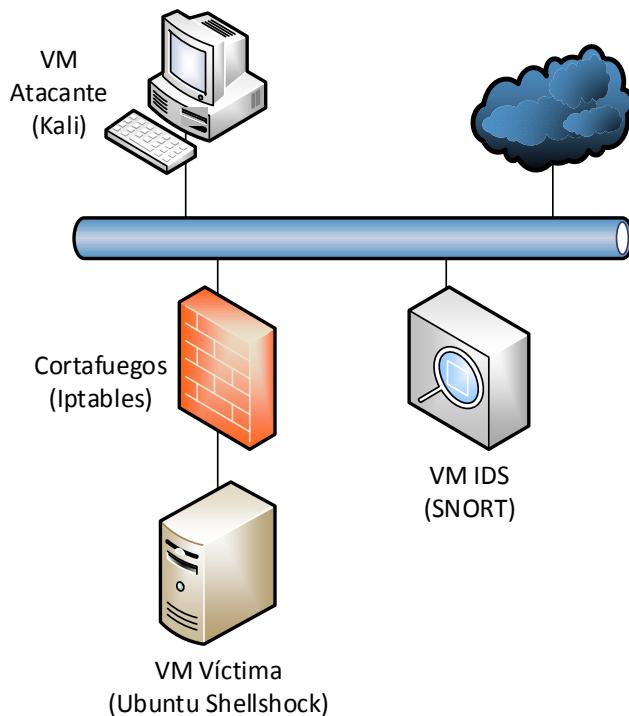
#### Supported platforms

- Chef maintains an updated list of compatible systems, dividing the compatibility of different operating systems into Tier 1 and Tier 2 depending on the degree of support offered. In both Tiers, we find all the most common operating systems (Debian, CentOS, Red Hat, Windows, Ubuntu...) so that incompatible systems are limited to older versions of different operating systems.
- Puppet also documents extensively the platforms it supports and the dependencies it introduces in the system. Like Chef, it supports most of UNIX systems as well as MAC OS X and Windows. Dependencies revolve around the language interpreter Ruby where the tool is developed and a series of binaries that allow it to perform its function properly (base64, md5sum, openssl, syslog, etc.)
- Ansible does not have an exhaustive list of compatible systems, but limits the requirements to the software it needs to operate. Specifically, it needs Python installed and the python-simplejson module. It also needs a way to communicate with the managed node, using ssh, scp or sftp. Windows is also supported from the 1.7 version and has similar requirements to the UNIX environment. The difference is that, in this operating system, communication is achieved through PowerShell remoting.

## 6 Assessment

As a final phase of the project, we will design and create a scenario with the tools we have analyzed in order to assess the level of compliance with the objectives proposed. The objective of this scenario is to capture the result of generating different virtual machines.

Fig. 5 shows a diagram of the proposed scenario.



**Fig. 5.** Diagram of the assessment scenario



[Traducción imagen: Attacking VM (Kali) / Firewall (Iptables) / IDS VM (SNORT) / Victim VM (Ubuntu Shellshock)]

In this scenario, we will simulate an attack from the “Attacking VM” to the “Victim VM” using Shellshock vulnerability. Then we will see how we can mitigate this attack, creating a new scenario containing filtering rules on the firewall that reduce the impact of the vulnerability as well as the detection of such attack from the “IDS VM”.

The scenario will be deployed using the virtualization platform VirtualBox, using the NAT mode to connect the machines we launch. In using this connection mode, we do not need to perform an extra configuration of network interfaces for the machines included in the scenario. In case of deploying the scenario in a laboratory having a range of IP addresses assigned.

Below we describe the process of generating each machine:

- **Victim VM:** We will use the Packet template and the manifest described in the section dedicated to vulnerable services.
- **IDS VM:** We will use the method described in the previous section, being the Packer template identical to that of the victim machine, except for the Ubuntu version used (14.04.03) and that we will allow system updates.
- **Attacking VM:** In this case, by using a Kali machine that needs no further configuration, we can directly use an image already downloaded from the Internet or use a basic Packer template that simply installs the system without any provisioning.

As we have mentioned, most of the time is spent in installing the operating system; despite this, generation of machines can be parallel (if the computer has enough resources to do so) so we can say that the net overall time is 12 minutes. This measure denotes a clear improvement in the use of this type of tools. The manual process of installing the victim machine conducted for preparing the templates took more than two hours. However, once we have the templates prepared, deployment reduces dramatically as we have seen. At the same time, the configuration has been recorded in a versionable text file in such a way that the possibility of making a mistake during configuration is reduced. The students may receive these files from the teacher and generate the scenario in their own computers in a short time, allowing to improve the learning process.

Continuing the evaluation process, if we launch the machines generated in our virtualization environment and we log in the Kali machine, we can start the simulated attack. To do this, we can use Metasploit with a module dedicated to exploit Shellshock but, because of its easy exploitation, we can run a test using basic tools like curl or wget (or even the browser itself with a plugin that allows us to modify headers).

## 7 Conclusions and future work

In this document, we have analyzed the applicability of tools framed within the DevOps philosophy to the generation of security scenarios. We have also evaluated the potential impact of their use in improving the design, management and deployment of CTF competitions and cyber exercises, identifying their strengths and how we can further contribute to their development.

After conducting the assessment process, we have observed that we are capable of generating reproducible scenarios from light files that can be shared. Times for generation and modification of scenarios allow them to be used by students in their computers, thus improving the quality of practical content that can be offered in workshops related to cybersecurity.

We have also managed to integrate development with the virtualization platform VNX in order to create scenarios compatible with such tool. A disadvantage with respect to the use of VNX that has been set out during the performance of this work is the capacity to control the scenario upon deployment. The solution developed on VNX allowed certain interaction with the scenario from the host machine so that the student can introduce events in it. In our case, these tools focus solely on the generation and configuration processes, so we depend on the opportunities provided by the deployment platforms we use.

The project in turn gives rise to multiple future lines of work, given its heterogeneity. The development of templates represents one of these lines, being able to create specific repositories focused on security teaching in order to share a catalog of scenarios. Some particularly interesting templates would be dedicated to operating



systems that emulate the behavior of routers and switches (Vyos / pfSense) that would provide the scenario with greater flexibility in describing complex network topologies.

In the generation of vulnerable services, there is also room for improvement. One of the initial proposals at the beginning of the project was automatic installation of vulnerable versions of applications such as Wordpress or Joomla. Research conducted during the performance of the project has shown that there are templates dedicated to it, but only the process of installing the application is automated. This implies that there is still a manual process when introducing content in the blog (in the case of Wordpress) or installing plugins. Projects focused on deployment management automation in the Wordpress application such as wp-cli, which allow management from a command line have been discovered. The creation of templates that allow to install this type of projects and manage the installation of plugins would add a side to the variety of vulnerable services. Another line to be followed is the use of light virtualization technologies (LXC, Docker) that would reduce the hardware requirements necessary to deploy scenarios with a large number of nodes. This approach would be useful in teaching, even though the isolation capabilities this type of virtualization has should be analyzed in detail to avoid the introduction of vulnerabilities in the scenarios.

Finally, the lack of control over the scenario after deployed is another critical contribution. The possibility to instantiate a master server within the scenario to make hot modifications is a very interesting line to introduce interaction with the scenario.

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## Makerspaces in Libraries: Technology as Catalyst for Better Learning, Better Teaching

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**Abstract.** Across disciplines, the practice of education continues to evolve; supporting organizations such as the library are responding by reworking existing and developing new practices. With roots grounded deeply in constructivist learning theory, the emerging practice of makerspaces in libraries is proving an effective step in that evolution. Examples of associated active learning activity at one such library, an early adopter and first mover among academic libraries in adopting and integrating makerspace in libraries, are presented. The product of leveraging technology as catalyst for active learning and engagement within and beyond the physical commons of the library, a blending of formal and informal learning, accented by increased innovation and entrepreneurship across disciplinary and organizational boundaries, appears a natural result.

**Keywords:** Active Learning · Learning · Makerspace · Maker Space · Libraries · Future of Libraries · Constructivism · Engagement · Innovation · Emerging Technology

### 1 Introduction

Informal learning happens anytime, anywhere. Increasingly, the learning associated with formal academic programs is taking place outside of the classroom, driving an ongoing transformation across the educational landscape.<sup>1</sup> As educational practice continues to move toward a model more appropriate for the post-Industrial Age,<sup>2</sup> librarians and the commons of library are becoming ever more integral to the learning and teaching lives of the communities they support. Blending traditional roles of content provision with support of active and collaborative learning, makerspaces in libraries is a relatively recent phenomenon – a natural adjunct that crosses disciplinary boundaries of educational innovation, integration of formal and informal learning, Science, Technology, Engineering, and Math (STEM) outreach and engagement. Combined with the Arts (STEAM), the resulting overlapping confluence of interest can drive innovation and entrepreneurship across the supported communities.

This paper presents examples of activity from one of the first movers of the makerspaces in libraries movement, the first academic library in the United States to offer 3D printing and scanning as a library service available to all.<sup>3</sup> In addition to presenting examples of both self-directed and collaborative learning, specific actions are detailed that have enabled the organization to more closely realize institutional and administrative goals. Rather than merely supporting learning by rote, in a makerspace learning is driven directly by curiosity and engagement on the part of the end-user, with a resulting integration of formal and informal contexts across learning styles. In such an active learning environment the role of librarian is more akin to the view of learning expressed by Plutarch nearly two thousand years ago: “the mind is not a vessel to be filled, but a fire to be kindled.”<sup>4</sup> The pages following will offer insight into the changing roles of librarians and the library as it further joins forces across the educational enterprise to kindle and nurture the flames of Plutarch’s fire in the minds of learners of today.



## 2 Literature Review

At its heart, the fundamental philosophy connecting makerspace activity with learning is constructivist learning theory. Halverson & Sheridan<sup>5</sup> frame the role of makerspaces in education as simply a natural evolution of constructivist thought, from Dewey and Piaget through Seymour Papert's Constructionism. Ellis & Philips<sup>1</sup> further note that recent decades have witnessed the practice of education evolving away from the traditional teacher-focused "transmission-style of teaching and learning, which were teacher focused, to a variety of *constructivist perspectives which focus on how the learner constructs meaning through active and social learning and personal context* [emphasis added]."<sup>2</sup> Beyond traditional roles of selecting and providing access to shared resources, libraries are increasingly moving toward playing more central roles in the teaching and learning lives of their communities.

Whether in support of active learning on the part of the student, or co-curricular development with teaching faculty, the development and support of the constructivist learning environment is key to effective institutional support of learning. Jonassen<sup>6</sup> articulates design principles and lays the groundwork; Stripling & Hughes-Hassel<sup>7</sup> detail the beginnings of more widespread library adoption and support in the introduction of the more formalized concept of inquiry-based learning and the support of collaborative learning communities. In addition to a thorough backgrounding, Woodard<sup>8</sup> frames library support as a function of teaching information literacy skills — importantly, recognizing that *technology can serve as catalyst* triggering learning, changed teaching practices, and different roles for educators themselves. Tracing the natural evolution, Levy & Roberts<sup>9</sup> recognize the changing roles of librarians in the practice of education, and document the emerging roles of librarian as educator and active partner in educational development.

The introduction and rapid adoption of the Framework for 21<sup>st</sup> Century Learning<sup>10</sup> consolidated the approach and growing support for constructivist and/or problem-based learning approaches by libraries. With mastery of key subjects, such as reading and languages, arts, mathematics, and sciences, at the core, the framework was designed with a vision of ensuring "student success in a world where change is constant and learning never stops." With interdisciplinary themes woven throughout, the framework identifies overarching support for "Learning and Innovation Skills," "Information, Media, and Technology skills," with "Life and Career Skills." Recognizing the role of librarians as vital partners and agents in support of 21<sup>st</sup> century learners, Kuhlthau<sup>11</sup> recognizes the active hybridization of roles in support of inquiry-based learning with constructivist models of learning. Booth<sup>12</sup> established the foundation for the development of library instructors around deeply constructivist roots, providing a legitimate platform for the use of technologies, emerging and otherwise, into standard library practice, with Beagle<sup>13</sup> recognizing constructivist learning support as emergent in the information commons of the academic library.

With growing library adoption and support of constructivist learning, branded variously as "creative collaboration," "cultivating curiosity," or "21<sup>st</sup> century learning," such active learning behavior began to be recognized as "maker" activity. Over the same timeframe, associated makerspaces in libraries began to proliferate to meet the needs of "fundamentally experiential learners, actively engaged and solving problems, posing questions, and making decisions."<sup>14</sup> Resources including Beetham & Sharpe<sup>15</sup> began to arrive on the scene, establishing the connections between formal pedagogy and the types of 21<sup>st</sup> century learning being adopted and supported in libraries worldwide; indeed, a global survey of libraries conducted near the end of 2013 found that fully *seventy-eight percent of respondents either already provide makerspace or were planning to do so in the near future*<sup>16</sup> [emphasis added].

Grounded in learning theory, appropriately framed in terms of 21<sup>st</sup> century learning, and with growing adoption worldwide, there is growing recognition that makerspace in libraries offers an environment in which formal and informal learning can blend naturally. Driven by self-interest, spontaneous and collaborative engagement in makerspace activity can enable members of communities of practice to develop and hone competencies associated with formal academic programs.



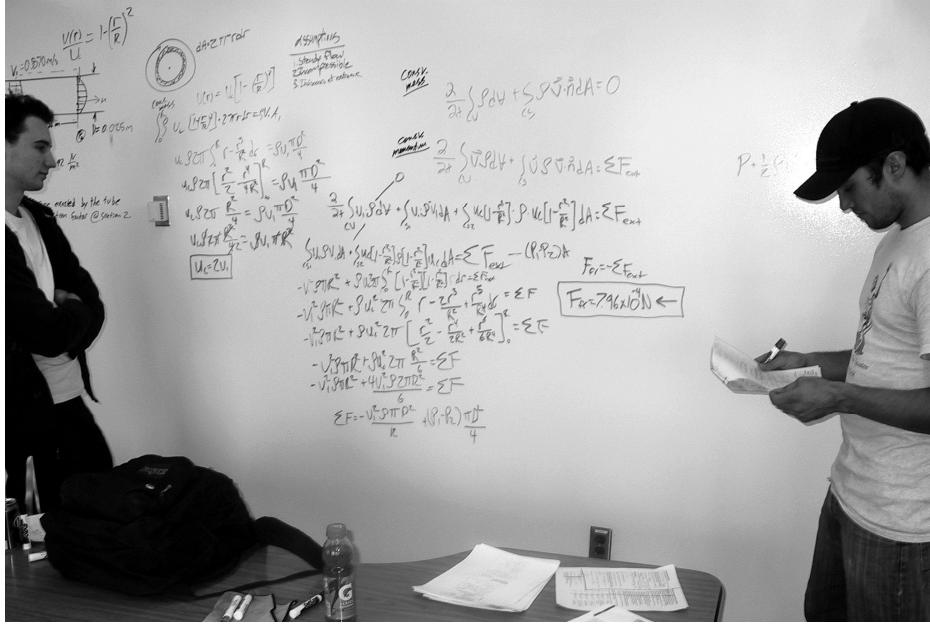
### 3 Active Learning in Practice

Across education, it is widely accepted that much of the learning by students enrolled in academic programs takes place outside of the formal classroom. Even with recent innovations such as flipped classrooms, it is when the learner actively engages with the materials to be learned, whether or not as “home” work, that learning happens. In practice, for a majority of students significant amounts of learning is taking place in a collaborative fashion as students actively engage with one another around the topic of study. Whether school library in K-12, an academic library in higher education, or public library where boundaries cross, the library is one of a small number of places ideal for the activity. Rather than the formality of the classroom, or the informality and relative solitude of home, the library is a “third place;”<sup>17</sup> intrinsically neutral, and dedicated to values of equal access to all, it is a place where learners gather.

Technology has always been a catalyst for learning in the library. Consider the book itself, or codex, a technology that only came into existence in the fifteenth century; prior to that library technology included papyrus scrolls or even stone tablets. Over recent decades, that technology has expanded to include photocopier machines, ICT such as personal computers and laser printers. In a makerspace technology typically expands further, and might range from pipe cleaners and glue guns to 3D printers and laser cutters.

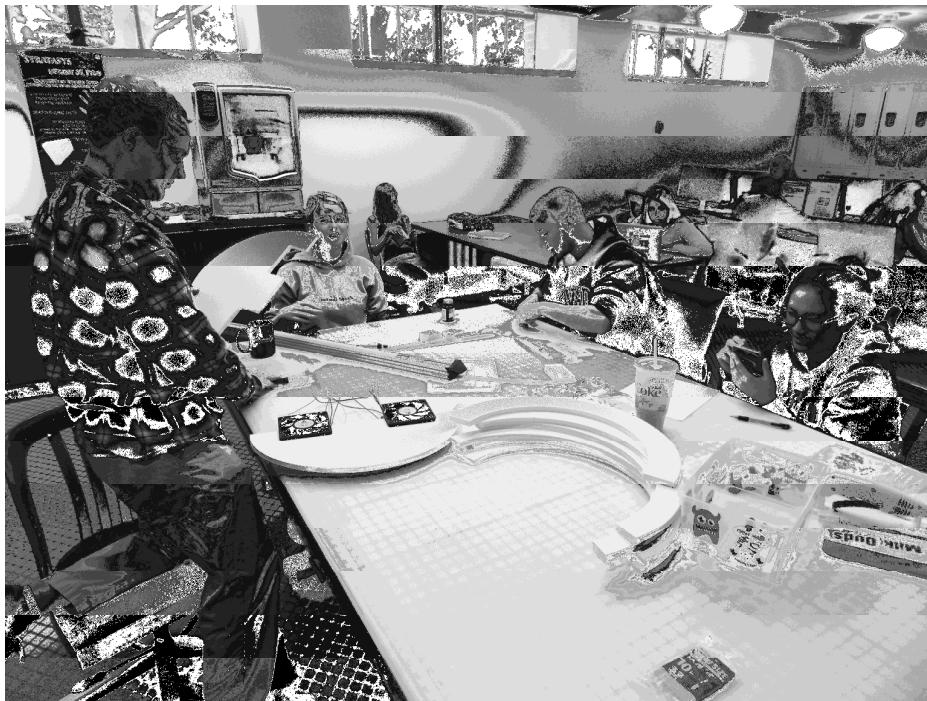
#### a. Active Learning

In any examination of library technology that directly supports teaching and learning across disciplines, obvious things like collaborative study areas are too easily overlooked; conversation areas are powerful tools in support of collaborative learning. The library can leverage and encourage such informal learning behavior simply with the arrangement of furniture and ready availability of resources. In the case of the DeLaMare Science & Engineering Library, non-traditional library technology introduced included whiteboards and markers. In combination with an active encouragement of conversation, and availability of study tables that also lent themselves to use as whiteboard surfaces, ad-hoc study groups began to form throughout the library. In 2010 an initial pilot of two rolling whiteboards with a writeable surface four feet in height and eight feet in width was quickly expanded to a total of six. With heavy use, the library continued to expand the availability of ad-hoc collaboration areas throughout the library by painting entire walls with whiteboard paint.<sup>18</sup> By 2013 the library had over 20,000 square feet of whiteboard writeable space – throughout a space that is roughly 22,500 square feet in total – and there are times in the semester when that is still not enough. The library is alive with formal and informal learning behavior; although predominantly student-driven, faculty regularly leverage the space to hold office hours and review sessions with ready access to space to encourage students to engage directly in moderated problem solving.



**Fig. 1.** Ready availability of writeable “whiteboard” surfaces throughout the library seem to greatly improve the formation of ad-hoc collaborations between students attempting to problem solve and learn formal academic course material.

Driven by requests from the communities supported, novel resources and services added by the library in support of active learning range from 3D printers and scanners, a wide range of lendable technology, laser and vinyl cutters, and even a printed circuit board mill: each is information technology that serves to catalyze both self-directed and collaborative active learning. As an example, at the University of Nevada, Reno, all incoming freshman students enrolled in Engineering are required to pass the ENG 100 introductory course. In that course, students are introduced to basic concepts of engineering by means of group projects that include building robotic hovercraft piloted and controlled by LEGO Mindstorms technology and box fans, powered by a hydrogen fuel cell. In support, the library provisions LEGO Mindstorms robotics toolkits that are available for checkout. Custom parts are regularly designed and 3D printed for new designs, and the laser cutter is regularly busy cutting shapes from Styrofoam and other materials to assemble. Fig. 2 shows a snapshot of one such group actively constructing a prototype within the spaces of the library, with ready access to supporting technology.



**Fig. 2.** Students regularly utilize the spaces and rapid prototyping services of the library to collaboratively develop projects; in this case a team of ENG 100 students are actively engaged in assembling the pieces of their custom robotic hovercraft design on the main floor of the library. Note the structural pieces recently cut from a sheet of Styrofoam by means of laser cutter technology provisioned in the library.

Similarly, for advanced courses such as Statics, the laser cutter is regularly used by students to precision cut designs from balsa wood prior to assembly and testing of designs. In a real sense, the laser cutter is simply another type of “printer,” producing the precise shapes by cutting away the excess material in a subtractive process. The rationale for implementing such a shared service or resource in the library is simple: libraries are fundamentally about sharing and supporting sometimes expensive technology to the benefit of all. The ability to rapidly prototype and test ideas is on the critical path to learning and the creation of new knowledge, and the library is a natural hub.



**Fig. 3.** A team of engineering students assembling a real-world model of a truss bridge from balsa wood structural members precision cut to their design specification; successful designs sustain can static loads far in excess of 300 pounds.

### b. Innovation and Entrepreneurship

With ready access to rapid prototyping equipment, combined with the creative abrasion and intellectual stimulation that comes about naturally in such an active hub, it is not surprising that innovation and entrepreneurship are natural results. One such example is the *hummingdoc*<sup>19</sup> – a stethoscope adapter for earpods that, combined with a similarly developed smartphone app, can enable the user to listen to and analyze heart and lung sounds. Initially conceived to enable expectant parents to hear their as yet unborn child's heartbeat without needing to go to the doctor's office, the product was prototyped with the 3D printing services of the library and members of the supporting community. The product went on to be a product of a separately created limited liability company, Hummingdoc LLC, with product actively being sold and delivered.

Another example of a product conceived and prototyped with support of the library's makerspace equipment and services is the *InfinitByte* flash drive.<sup>20</sup> Designed around the use of microSD cards, the waterproof and ruggedized drive holds two cards yielding a capacity of up to four terabytes operating at speeds of up to 5Gbps. Its inventor, a retired military Blackhawk helicopter pilot instructor, spent a substantial amount of time working with students at the University to develop the part designs to exacting specifications using 3D modeling software in the library. After an initial Kickstarter crowdfunding campaign failed to reach needed funding goals, its designer, and the students he had been working with, learned critical business lessons. In response to feedback from the campaign as to pricing, he reworked his supply manufacturing chain and was able to reduce the anticipated final cost by more than half, to something on the order of a few tens of dollars; a second Kickstarter campaign is currently under development, with an anticipated near-term launch.

Beyond directly enabling innovation and entrepreneurship, the benefit of learning on the part of the students involved in such cases cannot be overstated – the sort of learning that can at best be presented as a theoretical in the classroom environment. Authentic experiential learning, driven by real-world considerations, has repeatedly translated into direct benefit for those involved; beyond knowledge creation, providing skills and experience that is valued in academia as well as in private industry.

### c. Engagement Leading to Outreach

The technology of the library is proving to be a key ingredient in outreach and engagement. In addition to K-12 and academic liaison outreach, the availability of a continuum of lendable technology in support of self-directed learning is proving watershed. Consider a crossover example that combines curiosity, building to full engagement, disciplinary, and career choices, leading directly to entrepreneurship. A student, self-described as “flailing and uncertain,” and without having declared a major by the end of his sophomore year, borrowed an entry-level micro-programmable from the library. After exhausting interest with the Makey-Makey kit,<sup>21</sup> with its ability to control web-based games by means of simple connections, he returned and checked out the next step: a Sparkfun Arduino Inventor kit<sup>22</sup> with associated how-to documentation.

A few weeks later the student renewed the kit, with its wealth of electronic bits and pieces, stepping up to check out a Raspberry Pi, assorted shields, and a soldering iron kit. The following semester, the author heard directly from a faculty member of the robotics lab on campus about a new student who had “mad skills” – he could program, solder, prototype... it was in fact the very same student. Note that the skills that were most valued by the Engineering faculty member were not those that were being taught in the formal classroom, but those that had been learned by the student on his own with access to appropriate and supporting resources through the library. Fig. 4 is a picture of the student in the robotics lab, where he worked for the remainder of his undergraduate term, proudly showing the forearm of a prototype android he had constructed. Even the 3D printed white ABS plastic structure of the forearm and digits was a direct product of engagement with library resources, as he had printed the pieces with the library’s 3D printing and scanning service.

Although one might expect an associated entrepreneurial effort to be associated with robotics, upon graduation this past year the student joined forces with a fellow engineer to create the online company *dringo.org*<sup>23</sup> to connect students with businesses by means of crowdsourcing the search.



**Fig. 4.** Prototype android arm, controlled by logic assembled on the breadboard circuit in the student’s right hand. Note that the structure and enclosure of the forearm and digits is composed of parts fabricated by means of the library’s 3D printing service. Photo credit: Nick Crowl.



## 4 Summary and Conclusion

This paper has touched on only a few of the many examples witnessed in the library over the past year. Reimagined to not only allow for, but encourage active learning, the examples presented in can only hint at the tantalizing possibilities: full engagement with the active learning environment of makerspaces in libraries can be transformative. Motivated by curiosity and self-interest, and supported by the resources of the library, acquisition of 21<sup>st</sup> century skills ranging from information, media, and technology skills to innovation, life, and career skills are a natural outcome of engagement with the resources of the library. In addition to blending traditional roles of content provision with support of active and collaborative learning, opportunities for engagement and creative abrasion across STEAM disciplines are driving innovation and entrepreneurship across the community.

## Acknowledgement

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# The systematic integration of technology enhanced learning for lifelong competence development in a corporate context

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**Abstract.** Digitization causes fundamental shifts in economy and society. These changes will go in line with significant changes of corporate core competencies as well as the skills and capabilities of employees. Due to the increasing pace of technological development in production and service processes as well as the ongoing trend to automation classic educational approaches will no longer suffice to ensure the achievement potential as well as employability of people. Thus the need for workplace learning becomes more and more evident. One central opportunity arising with digitization is the implementation of workplace learning in form of technology enhanced learning. Consequently, this paper gives an overview of the nowadays relevant learning enhancing technologies. In addition to this, it suggests a roadmap to integrate technology enhanced learning into the corporate context as well as the existing competence development.

**Keywords:** digitization · work based learning · learning enhancing work design · vocational training · work design · technology-enhanced learning

## 1 Introduction

The increasing digitization is going to change labor and the roles of humans in industrial production significantly. Physical and monotonous activities and even certain planning and controlling tasks will be performed by computers and machines in the future. People, however, will mainly be responsible for strategic, coordinative and creative tasks as these are the kind of mental tasks machines cannot take over – yet. [1; 2]. These general observations can be underlined with the findings of FREY & OSBORNE from 2013. They analyzed the impact of digitization on the current job profiles in the US labor market and calculated the probability of jobs being replaced by robots or machines. They projected that about 40 % of the current job profiles will disappear in the next twenty years [3]. The study has been adapted by numerous international scientists and applied to the job market of different other countries in the last two years [4; 5]. Based on the work of the American researchers, German scientists calculated that, approx. 59% of current positions in Germany are in danger, too [5]. When analyzing these somehow alarming results, however, it should be noted that these studies do not take into account that at the same time a multitude of new job profiles will develop and possibly equilibrate the expected losses in employment. Consequently, other studies project fundamental gains in productivity and employment due to the digitization of service and production industries [6]. In addition to that, the changes which are to be expected are not an entirely new development - the vanishing and arising of job profiles has a long history in economic development. Up to now the relation between automation and unemployment has not been proven empirically but there seems to be an effect of technological change on frictional unemployment [7; 8]. This could be partially explained by the need and necessary time for requalification of formerly employed people. These findings are emphasized by research about the half-life of professional knowledge, which is broadly found diminishing [9-11].

While results like this need to be backed up by further research in the future, what seems to be clear at the moment is that the increasing speed of technological change, extensively discussed by authors like BRYNJOLFSSON & MCAFEE [12], will severely affect companies' qualification and competence demands as well as education and vocational training. Thus, not only educational institutions need to adapt their offerings but also companies need to ensure opportunities for lifelong learning and to place a higher emphasis on the organizational learning processes. In addition to that the broader availability of technology enhanced learning does constitute a challenge in itself, since applicability and effects of these relatively new learning forms need to be evaluated.



These changes in education due to the availability of technology enhanced learning are also reflected in the rise of learning theories as so-called situated learning [13] or connectivism [11]. To what extent these learning theories are better suited to explain and implement technology enhanced learning needs to be evaluated thoroughly. Nevertheless, it is obvious at the moment that these learning theories could constitute a preliminary foundation for the paradigm shift of educational institutions and companies concerning the technology enhanced learning for the faster and faster ongoing digitization of society and economy.

## 2 Core competencies for a digitized world

The idea of corporate core competencies initiated by PRAHALAD & HAMEL [14] and further developed by TEECE ET AL. [15] under the notion of dynamic capabilities is essential in explaining the success of companies. But what are the main corporate core competencies that will contribute to the success of employees and companies in a digitized world?

### 2.1 Core competencies of companies

Considering the aforementioned changes in society and economy it becomes obvious that these core competencies are more and more about innovation capability and flexibility. Taking into account that nowadays four out of the ten of the companies with the greatest market capitalization did not exist 40 years ago and two of them are not even 20 years old, there seems to be a fundamental change which can be observed in the economy. In addition to that companies like WhatsApp (subsequently bought by Facebook for about 19 billion US\$), Uber, myTaxi and AirBnB did alter and frame the business models in their industries significantly. So what does make these newcomers different from the existing companies in their industries? They even did not invent totally new business ideas but they were able to add value to the customer by combining existing industries and offering a platform based service by outsourcing tasks to their customers. But why were the existing players in the different fields not able to defend their markets?

The main reasons behind this were a higher innovation capability and organizational flexibility of these newcomers [16; 17]. These two qualifications will be important cornerstones for companies in implementing a competitive strategy in a digitized world. Whereas innovation encompasses the development and implementation of ideas, processes and products or services, which are considered as new [18; 19], organizational flexibility addresses the ability of an organization to answer continuously changes in their industry and environment [20; 21]. It has been proven that these relatively broad concepts are able to explain the enduring success of companies and the failure of others - at least partially. However, the gap in relation to organizational learning still persists. Though NONAKA & TAKEUCHI [22] ascribed organizational learning a pivotal role in innovation capability, CROSSAN ET AL. developed a framework for the implementation [23] the research on the success of organizational learning remains still open to interpretation. First reliable studies in this field so far have been undertaken by LORENZ & VALEYRE [24], CALANTONE ET AL. [25] and ALEGRE & CHIVA [26] which point in the direction that learning and especially organizational learning could contribute to innovation capability. But still, the question remains in how far we could train students and employees to foster these core competencies or to convince companies of the need to develop their human resource purposefully in this direction. And even if these development goals are translated into a company strategy it still needs to be decided how they can be translated into an employee development plan.

### 2.2 Core competencies of employees

The aforementioned shifts in the core competencies of companies also can be observed on a micro level considering the key qualifications of employees. The employees' competencies which will be needed to achieve the vision of smart factories as described in the German notion Industrie 4.0 include overview knowledge, digital literacy, skills for interdisciplinary communication and self-organization. But the main



important competence of future employees will be the capability and willingness to lifelong learning. Without it, Industrie 4.0 cannot succeed.

The changes caused by digitization call for innovative solutions in job design, human resources development and corporate governance, as well as the selection and the implementation of suitable technologies. The ongoing automation and digitization of many routine processes could create new opportunities to make better use of human capabilities like creative thinking, deciding and designing. Furthermore, companies' collaboration will increase significantly and demand new management and leadership approaches, also affecting the degree of participation and involvement of employees. Corporate competitive advantages can only be accomplished, if the corresponding innovation capabilities and thus the ability to learn exist in companies. A number of recent publications and studies confirm this, they consistently emphasize the role of learning for overcoming the new challenges due to the increasing complexity of production. A German study found that about 80% of the companies surveyed had an additional qualification need due to the rising demands for flexibility and another 60% saw the need for a systematic skill development [27]. All in all, the development of the necessary skills and capabilities becomes a central challenge.

Therefore, vocational learning processes must be supported more than ever and new concepts for on-the-job training need to be developed [27]. One of the most promising concepts is the so-called workplace learning. It directly combines everyday work with continuous learning. This means that work systems and environments are designed from the beginning on in a learning enhancing way [28].

### 3 Competence development in a digitized world

The digitization of industries and society will also affect the way of learning since a multitude of learning technologies is nowadays available. However, companies still only implement these technologies very slowly. This is due to the lack of future job profiles, inconclusive implementation guidelines, lack of didactic principles and unclear suitability of different learning technologies [29; 30].

#### 3.1 The need for workplace learning

The need to combine learning processes and everyday work tasks is not only based on the changing work environment and the proceeding automation in many different areas, it is also necessary because already established classic forms of learning would not be anymore sufficient to counteract the shifts in the demand of competencies [31]. Estimations for the half-life of knowledge once acquired by education or vocational training show that this knowledge lasts for around ten years, which means it decreased by 50% within the last twenty years [10; 32]. If learning is included into the daily everyday tasks, this loss of knowledge can be prevented. This is crucial, because the employees knowledge is one of the most important assets of a company as well as its one of its keys to success: On a macroeconomic level companies are more and more under pressure to continuously innovate and to be more flexible in order to defend their competitive edge, something which is only possible if their members of staff possess the latest expert knowledge. Digitization offers manifold opportunities to integrate learning into existing work processes. Digital media in form of technology enhanced learning systems can provide totally new opportunities of knowledge dissemination and lifelong learning in companies. For example, internal knowledge exchange and collaboration supported by social software can greatly contribute to employees' task performance and innovativeness [33].

Workplace learning provides the opportunity to endow employees with the necessary competencies to manage the complexity of the arising digital work and production systems. Simultaneously technology enhanced learning concepts can be integrated with management and controlling software and thus deliver a much higher benefit to workplace learning. The integration of learning and working into a sound concept of workplace learning demands the solution of numerous challenges:

It will be important to foster employees' self-organization and capability to make use of the available technologies, to teach the new work tasks and situations as well as to ensure the needed personalization and user friendliness in technology enhanced human resource development [34]. Furthermore, new interactive and

individualized learning forms need to be developed, which combine different forms of individual and organizational learning and are adapted to the cognitive capabilities of their target groups. In addition to that, the design of future work and production systems must not only be learning enhancing but also provide more flexible work organization allowing for higher degree of social permeability [35].

### 3.2 Technology enhanced learning

Since the mid-eighties a multitude of technology enhanced learning forms have arisen. The different development phases are shown in the following figure 1.

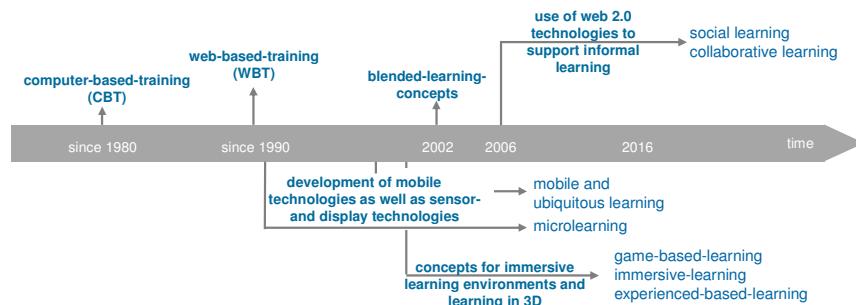


Fig.1. Development of technology enhanced learning (adapted from [36])

The first available technology enhanced learning form was *computer based training* (CBT). Though strongly limited by visualization and calculation speed, many companies experimented with this early learning form. However, CBT was mostly a virtual representation of available textbooks at that time. Nowadays CBT consists to a large part of self-contained, methodically and didactically edited learning units combining text, audio and video files with animations or simulations and it is stored on external devices such as CDs or DVDs [37; 38]. Another learning based technology that does not need any of these storage devices is the so-called *web based training* (WBT). It is internet-based and relies on the online saving of information. By doing so, WBT many times offers more information than traditional CBT because it is not limited to a specific amount of savable data. It also offers communication, interaction and collaboration opportunities as well as the chance to create collective content [39]. Another form of technology based learning is *blended learning*. As its name suggests, it is a combination of different learning techniques and blends traditional classroom training with CBT/WBT concepts. It is, so far, the most prevalent of the three technologies. [40; 41].

The rise of the web 2.0 in the past has caused fundamental developments in learning technologies. Because users can now actively participate in the learning process, they can make use of direct feedback loops and comment on the training they receive. More importantly, they can create joint knowledge and combine what they know with options like company wikis, chats or blogs. In addition to that, new graphical user interfaces (GUIs) make the creation, modification and collaborative development of content easier and further strengthen group trainings based online. Consequently, more and more companies use social software like wikis, weblogs, chats, forums and learning-communities to foster formal and informal learning processes. Because of this, sourcing and filtering solutions for shared knowledge become more and more important, considering the fast rising amount of digital available information. *Social learning* is a web-based learning form that makes use of social media platforms such as the before mentioned wikis or blogs. It stands for informal, self-organized and network-based processes [42]. *Collaborative learning* however is a form of social learning that emphasizes the competence development of groups, the knowledge exchange between its members as well as the joint knowledge generation. Thus, learners are responsible for actively creating, organizing and distributing knowledge [43]. Another influence to the changing learning theories is the development of modern mobile phones and devices. It has led to *mobile and ubiquitous learning* approaches because information can now be created, stored and shared anytime, anywhere [44]. The importance and disruptive nature of these new learning forms become evident given that with connectivism an even new learning theory has been developed [11].

Connectivism does not consider only the knowledge a person possesses but also the knowledge which is reachable within the person's network.

Despite all of these progresses in the area of technology based learning it remains somewhat unclear which of the different techniques is best used for what kind of task/challenge. To change this, an in-depth analysis of the individual companies' internal and external environment is necessary and will help to find the best suitable learning method for each case. How this analysis could look like and how the learning method is implemented best once it has been chosen is demonstrated in the following chapter.

## 4 The integration process of corporate technology enhanced learning

Once a company has decided to integrate technology enhanced learning into its daily tasks, this decision has to be followed by a carefully planned integration process. This paper suggests specific implementation steps for the roll-out of learning concepts.

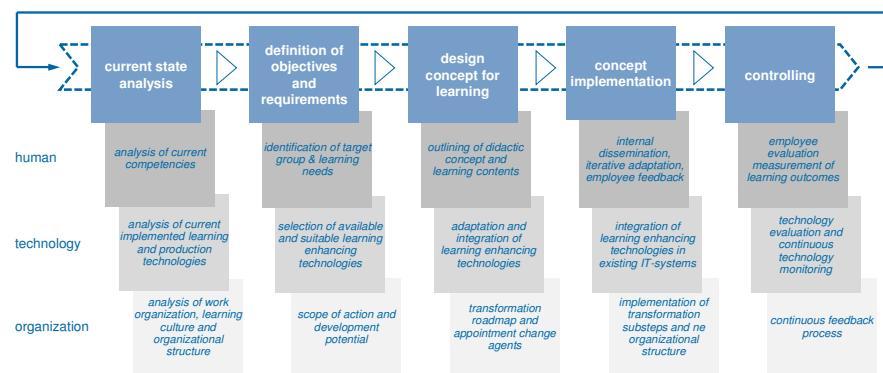


Fig.2. The integration process of corporate technology enhanced learning

One of the most important factor success factors is to establish a project team for the integration of technology enhanced learning solutions consisting of different departments like management, human resource, IT, industrial engineering as well as work council. The addition of work council and employee representation is the only way sufficient participation can be generated. The failure of many corporate knowledge management projects since the beginning of 2000 can be at least partially attributed to insufficient employee participation in its introduction process.

As shown in the model, the analysis of the current state is crucial to the entire implementation and therefore marked as the very first step of the integration process. The three squares attached to the step *current state analysis* show the different sub-steps that are part of this initial analysis and affect different areas of a company: 1) Dark gray areas include measures that affect human resources, 2) medium gray areas show sub-steps that involve the technological aspect of the learning integration and 3) light gray fields show what kind of changes in regard to the overall company organization need to be considered. By taking the three areas human, technology and organization into account, the designed integration model also includes the multilateral approach to analysis of the so-called Mensch-Technik-Organisations-Analysis (MTO, human-technology-organization-analysis) as developed by STROHM & ULLICH [45; 46]. The consideration of the three affected key areas and the differentiation of necessary sub-steps ensures that the process of integrating technology enhanced learning options into a company's work processes does not overlook important factors and is aware of the fact that a change of this kind has consequences for all departments.

The status quo analysis includes a thorough and sound analysis of the current employees' competence levels, the analysis of the already implemented technologies as well as the organizational and especially the learning culture. Competence monitoring should be a continuous process and could be done with the competence matrix



which was developed by HEYSE & ERPENBECK [47]. Implemented technologies like manufacturing execution systems (MES), enterprise resource planning (ERP), service management systems (SMS) communication tools like social software applications as well as technology enhanced learning tools like knowledge management software or dedicated learning tools as mentioned above should be analyzed and evaluated concerning their benefit and compatibility. Finally the organizational structure and its culture play an important role. A tool to analyze the organizational culture is provided by DENISON [48]. Unfortunately the evaluation of corporate learning cultures had much less attention in recent years' research. An idea can provide the contribution of MARSICK & WATKINS [49] or the quite general classification in the four fields discretionary, lean, taylorist and simple applied by LORENZ & VALEYRE in their cross country study of 15 European countries [24].

Once the status quo has been successfully analyzed, the second step of the integration process is the *definition of objectives and requirements*. This step is fundamental because without the identification of the desired target group and the learning needs, a selection of the best suitable learning enhancing technologies and the discussion of the possible development potential the technology implementation lacks clearly defined targets. It is likely that the motivation of members of staff to participate and accept the new learning strategies is affected by this and that it is higher if the implementation ambitions are clearly defined and communicated as such. When choosing a technology enhanced learning form it needs to be taken into account that not every learning technology is suitable for every organization. The decision for a particular work based learning scenario depends on various influencing factors describing the companies' internal and external settings. These influencing factors, which need to be evaluated for the implementation of learning enhancing work designs, are the current human resource development, the existing technical infrastructure, the learning culture, the already existing technology enhanced learning forms, the work tasks of the employees at question, the work organization, the level of experience based knowledge as well as existing organizational learning processes. These parameters are the main factors in learning enhancing work design and influence the selection of suitable technology enhanced learning forms significantly.

After the definition of the target group, the desired goals and the most suitable learning strategies the actual technology enhanced learning concept needs to be designed. This *design of the learning concept* presents step three of the integration model. The technology design has to take motivational incentives as well as didactic teaching methods into account. Furthermore, the design should ensure that the employee receives only relevant information and that this is presented as simple as possible but as detailed as needed. In order to achieve this, the technology enhanced learning system needs to be adapted and personalized for its different users. Consequently, individualized user profiles as well as person related information need to be part of the technology enhanced learning system [50]. Again, this step equally affects the areas members of staff, technology and organization, which is why numerous sub-steps need to be taken. One of the most important ones is the sub-step regarding the overall organization (light gray): transformation roadmap and appointing change agents. A transformation roadmap serves as a guideline during the entire implementation process – it allows to constantly check on the implementation progress, to compare the desired results with the actual milestones achieved and to integrate the learning technology efficiently and focused. To do so, change agents need to be appointed – members of the team who overlook the process and help when needed.

Step four contains the actual *concept implementation*. For this, the employees need to be briefed, the learning technology needs to be fitted to the existing IT-systems (if necessary, changes/updates need to be made) and the before mentioned sub-steps need to be organized and carried out. Here experience has shown that nearly never technology enhanced learning forms can be implemented without any adaptations to the company at hand.

Afterwards, the learning outcomes of the technology enhanced learning system need to be evaluated in a final step of the integration process *Controlling*. The success of the implementation can be evaluated from the perspective of the employees, the information technology department, the industrial engineering as well as the management. The most important influence factor regarding the success of a learning technique is user participation. No learning theory and no learning concept can truly achieve results if the employees do not use it on regular basis. User activity therefore is crucial, regardless of whether or not the implementation process



followed strict guidelines or whether or not the requirements of a learning enhancing work design were taken into account. New technologies can cause significant acceptance problems. This needs to be considered when a learning technique is to be implemented. Hesitations or acceptance issues can be prevented by involving the future users in the actual design of the technology enhanced learning thus offering the chance to eliminate possible sources of irritation before they occur. Especially the security of private data is a common user concern. If the companies' employees are involved in the design of the learning technique and see how their data is stored and encrypted, this issue can be resolved. Nevertheless technology enhanced learning forms offer also manifold opportunities to derive learning outcomes by integrated testing and monitoring. Once a detailed check regarding the success of the integration has been made, it is possible to derive further improvement measures and start the process all over again: A new current state analysis, another definition of objectives etc.. The process of integrating technology enhanced learning concepts into a company's work flow is not necessarily one that is fully completed sooner or later. Moreover, this process is a continuous one and can only benefit from repetitive status analysis and objective adaption.

The introduced implementation model can be exemplified with the help of use-cases carried out in the framework of the project ELIAS, which is funded by the German Federal Ministry of Education and Research. This project, which stands for *Engineering and mainstreaming of learning enhancing industrial work systems for the industry 4.0*, aims to support companies in implementing new learning enhancing work systems and therefore will cover a unique challenge to deal with challenges caused by the digitization of industrial production and services. The FIR – Institute for Industrial Management at RWTH Aachen University accompanied five use cases within the framework of ELIAS. Exemplarily two use cases in the automotive sector were selected for the present paper.

The first case includes HELLA KGaA Hueck & Co., an international active company specializing in innovative light installations and vehicle electronics with 35.000 employees. At the moment, two trends clearly define the company: First, the demand for qualified technical specialists grows further and further because of the rising complexity of machines and the ongoing automation of production and installation processes as well as controlling measures. Second, the average age of employees increases in its main production sites in Germany. The work systems in the area of accelerator pedal sensor production and SMD production that are part of the ELIAS project research are already characterized by a high degree of automation and high product complexity. In order to have better control over operating devices and production processes and take work load off of the technical service, technical specialists receive specific training. This training aims to improve their flexibility, their understanding of the system as well as their decision-making skills. A technology matrix was created with the help of an analysis assessing the need for personnel, current process workflows, information demand and knowledge flow. The matrix demonstrates which competencies are necessary for which production lines. Because of this, so far undetected needs for further qualification were discovered. Based on the results of this analysis and matrix members of staff can be trained systematically. In addition to this, the overall qualification level of employees can be raised as desired or harmonized to a specific degree. The range of tasks of employees can also be gradually extended. This concept of qualification allows for a systematical training of members of staff to so-called high-level specialists in the area of technology. They are characterized by the ability to find solutions for a broad spectrum of tasks. This means that high-level technology specialists as well as the common technology specialists can be appointed for various different areas and take over different trouble-shooting or repair tasks. In addition to that a mobile application for smartphones which enables failure analysis, failure documentation and easier solution finding was developed for learning purposes. Employees were asked concerning their requirements and the idea was to establish a basic tool which in the beginning contains the most important production failures affecting downtime of production facilities. One of the crucial success factors to be determined was to establish feedback processes and give employees the opportunity to improve continuously the instructions. Thus, machine down-time is reduced significantly.

The second use-case includes the FEV GmbH, an internationally active company specialized in engineering solutions. The company constructs and develops engines for all kinds of vehicles and employs approx. 4.000 people. By taking part in the ELIAS project, the FEV GmbH aimed to conceptualize software solutions for



application processes of electronical controlling devices within automobile engines. These software solutions are necessary because electronical controlling devices get more and more complicated nowadays, thus requiring software-supported application tools to collect calibrate and analyze measured data. The duration of training in the area of software applications is approx. 2 years. Shorter development cycles and increasing complexity of electronical control units require a continuous training of engineers. At the same time, FEV GmbH employs more and more personnel in this area, to meet the high demand of statutory requirements. The effective and efficient transfer of knowledge plays an important role when it comes to the training of staff members for new areas and tasks. In the framework of the ELIAS Project, the FEV GmbH develops a concept for a learning enhancing cognitive assistance system for the applying of vehicle engines. By doing so, new members of staff acquire the needed skills for the analysis of data and model-based calibration quicker and long-term members of staff learn easier how to use the software. Based on expert knowledge of lead users, a software tool was created that visualizes processes and can guide personnel step-by-step to the solution of a task. Because of the automation and standardization of routine processes, these tasks can be taken over by new employees in the future.

For the development of these different assistance systems, HELLA KGaA Hueck & Co. and FEV GmbH went through all of the integration steps shown in the model presented in this paper: They analyzed the current situation and the problems that needed to be solved – for all three key areas mentioned before (humans, technology and organization). Afterwards, the companies defined the targeted objectives, designed the actual learning concept and implemented it. A continuous feedback-loop ensures detailed evaluation of the success of the project.

## 5 Conclusion

The implementation of learning processes into the daily tasks of employees will be will be a key concept to ensure employability, productivity and transformation capability of members of staff and the companies they work for in the future. Workplace learning will therefore play an important role in the work routines of tomorrow, in times where economic, technological and demographic changes constitute major challenges for companies and employees. The core competencies needed for the industrial transformation due to digitization will be organizational flexibility and innovation capability. Technology enhanced workplace learning constitutes a viable and promising way to ensure companies' competitive edges as well as long-term employability of people. In the future, lifelong learning will become more and more a prerequisite for companies' success. So far, a variety of different technology based learning concepts exist. They all aim to include learning into the daily work tasks of employees. However, implementing these technologies is not something that can be done fast or taken lightly, because it involves different groups of participating players. The present paper therefore presents an implementation model that shows how to decide what kind of learning method is best suited for specific company goals and how this technique can be implemented step by step.

However, it is only a rough model that focuses on the overall picture of the implementation process and could and should be detailed further in upcoming studies. The main obstacles mentioned in this paper regarding the choice and implementation of technology based learning also need to be researched more. Only if these can be solved, technology based learning concepts can help companies and employees to constantly evolve, learn and grow and thus be qualified to deal with tasks in a highly digitized and competitive working world.

Both cases show possible company reactions to the increasing complexity. They both have in common that digital tools are used to assist during a specific task and that they are also used to address personal and organizational learning. It becomes obvious that learning enhancing technologies need to be adapted to the very different circumstances companies and their departments are acting in. In addition to that the development of any assistance system needs to be coordinated with necessary changes in the work organization to really benefit from workplace learning. Thus work organization should also take into account to provide employees sufficient scope for learning. Finally learning culture will become one of the decisive factors in coping with the ongoing digitization.



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## **Contributions of the Analysis Model as a systematization of the Research Project REDCO Red de Conocimiento: CIER Occidente**

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### **Abstract**

This paper gives an overview of the research work that Research Education and Virtuality Line<sup>5</sup> of GITT Group (Research Group of Terminology and Translation) of University of Antioquia (Colombia), in alliance with Faculty of Education of the same university, conducted from 2014 to 2016, as one of the five universities that participated in the Project CIER Occidente of MEN (Ministry of Education) and Colciencias, through the Macro Project: REDCO Red de Conocimiento (Knowledge Network)<sup>6</sup>.

From the fundamental purpose of REDCO CIER Occidente Project, it seeks the validation of REDCO as a pedagogical methodological matrix from the appropriation of Information and Communications Technology (ICT) in two "Innovative Schools" of two municipalities of department of Antioquia, Colombia: EI León XIII from El Peñol and EI Las Palmas from Envigado, through a virtual environment where multiple and different routes converge, channels, media and languages supported by a strong technological component in its structure defined menus as: Channel News/News, Educational Channel, Campus Virtual GITT, Educational Radio, Channel blogs, Channel videos, forums, chat, video conferencing, among others, supported by a communication model EMIREC, which resizes the formation processes, changing the roles of subjects of knowledge processes through a fluid and continuous interaction, feedback and formative evaluation process and extensive pedagogical mediation given by ICT.

### **Keywords**

Knowledge network, active participation, methodological component, innovative teaching models, collaborative work.

### **1 Introducción**

REDCO is one of the few case studies about knowledge networks that are currently published, in accordance with the detected in the screening done, however, it is important to note that, despite those few studies aimed at understanding these networks, in recent years it can be noticed the presence of increasing them in virtual spaces.

REDCO, then, is interested in listening to these experiences in the academic field, guided by the concern of the contributions that ICT can make to education and knowledge management. Research Education and Virtuality Line, attached to GITT Group, in force since 2011, when was created REDCO to define an analysis model to identify and characterize these knowledge networks, conducting educational processes at all levels and interdisciplinary and multidisciplinary areas in which the development and dynamics are analyzed from the

<sup>5</sup> <http://linea.comunidadredco.com/index.php/bienvenida>

<sup>6</sup> <http://comunidadredco.com/>



field of Educommunication, according to this interdisciplinary field that can offer educational innovation in the Knowledge Society.

The research project in question, developed by the University of Antioquia in the call of MEN Colciencias, Pedagogical Appropriation of ICT in Innovative Schools of CIER Occidente: Validation of a Methodology Matrix for education of researchers educational agents with the use of ICT through REDCO Red de Conocimiento as an educational innovation. Subcommunity University of Antioquia showed what historical moment the appropriation of educational ICT is as a national policy, and while the sample was minimal, can provide, with the help of initial diagnosis delivered by the MEN at five universities participating in the project, and the theoretical basis for the formulation of the research project, the shortcomings and gaps that have the implementation of this field of knowledge, made visible in the Project CIER REDCO Occidente, Subcommunity U. of A., and denotes the need to reassess the methodology and vision for this policy to have a social impact on improving the quality of education in the country. We believe it is the right time for the results of the investigation within CIER Occidente, along with the MEN Colciencias in its systematization, define national approaches to the appropriation of ICT as educational policy, combining theory, research and practice so that promotes leadership in this field, from the innovation observatories, and promote upgraders actions towards quality education at all levels, using ICT as a methodological factor supported and integrated into institutional educational and teaching models.

Invoking this, Albornoz, Mario and Alfaraz, Claudio (2006: 7), agree with "networking is the result of the adoption of flexible and participatory forms of organization, implemented at the time to create and apply knowledge to problem solving. Indeed, knowledge networks are the configurations that combine many of the features mentioned: in them, actors from diverse backgrounds relate to address specific problems and propose solutions, staking its capabilities and seek, hereby complement".

REDCO CIER Occidente, with the component Educommunication has taken educational work, through a knowledge network, as a continuum of communication that ensures socialization of academic and cultural groups to collaborative work, focusing concern in proposing knowledge networks as educational environments where subjects are formed and transformed through their interaction.

Therefore, REDCO as case is considered a valuable knowledge network; as is being developed is seen that from this experience subjects assume the roles to manage useful knowledge, and if this becomes, according to Freire (2005): "True education is praxis, reflection and action of man on the world to transform." It is recognized, then, that as far as educational projects, that allow the construction of knowledge and the formation of critical and capable individuals to function in their environment as social and political subjects, it contributes to improving the welfare and quality of life of the population, which is important to fulfill the fundamental rights of humans.

## Theoretical framework

Due to the rapid evolution experienced the new Information and Communications Technologies, society in general has been rewarded with major changes in their thinking, perceiving and approaching the world. Thanks to the obvious technological revolution have enabled countless commercial, social, organizational and legal innovations that respond to the particular characteristics of virtuality and digital.

As a result, education is part of this permeate context, mediated and affected by ICT; concepts such as e-learning, multimedia education, multimedia literacy, educational knowledge networks, social networks, among



others, today, are quite familiar to REDCO CIER Occidente, perhaps because education itself has been transformed and complementing to address what many authors insist on calling "Information Society" and "Knowledge Society" which, although they are not symmetrical, they share the characteristic of building the "network society" (Castells, M.: 1996).

It is necessary, then, think the new technologies as teaching tools that can assist subjects in the construction of their own knowledge. "... For this, besides the subject that "builds", "materials" or information (images, ideas, etc.), and tools that ease the task are needed; task from own knowledge schemes (Gutierrez, Alfonso: 1991). In this regard, it is important to mention that the term technology in the field of education is not necessarily limited to an instrumentalization of the educational process, but support in new technologies is linked to guide, support and apply knowledge to other situations». (Ramirez, Eugenia. 2003).

In this perspective, REDCO CIER Occidente<sup>7</sup> is defined as a Educational Community formed for all the participating members from two Innovative Schools (subcommunities) with students and co-research teachers, researchers (U of A) and other involved actors in the research project.

**Fig. 1.** CIER Occidente Community <http://blog.comunidadredco.com/>

<sup>7</sup> <http://blog.comunidadredco.com/>



**CIER Occidente, Medellín**

**Proyecto: Validación de una matriz metodológica para formación de agentes educativos investigadores con el uso de TIC a través de Redco**  
**-Red de Conocimiento- como innovación educativa.**

**Red de Conocimiento REDCO\***

**UNIVERSIDAD DE ANTIOQUIA**  
**FACULTAD DE EDUCACIÓN, DEPARTAMENTO DE EXTENSIÓN**  
**GRUPO DE INVESTIGACIÓN EN TERMINOLOGÍA Y TRADUCCIÓN GITT**  
**LÍNEA DE EDUCACIÓN Y VIRTUALIDAD - GITT**

\* El proyecto REDCO, UdeA, es un prototipo que da cuenta de la matriz metodológica para el CIER Occidente en los cinco proyectos de investigación que las universidades desarrollan en las diez instituciones educativas (I.E.) REDCO.  
[http://www.campusvirtualgitt.com/campus\\_linea/images/stories/documentos/publicaciones/Conferencia\\_TICAL2011\[1\].pdf](http://www.campusvirtualgitt.com/campus_linea/images/stories/documentos/publicaciones/Conferencia_TICAL2011[1].pdf)

**Fig. 2.** CIER Occidente's Presentation [http://blog.comunidadadredco.com/wp-content/uploads/2015/08/REDCO\\_Presentacion\\_2014.pdf](http://blog.comunidadadredco.com/wp-content/uploads/2015/08/REDCO_Presentacion_2014.pdf)

**Fig. 3.** REDCO Red de Conocimiento's Web Page <http://comunidadadredco.com>

## 2 Metodology

### Focus

Comprehensive qualitative research from participatory research-action that places the subject and object of knowledge construction in a horizontal place and emphasizes participation as a guiding principle of such processes. Conceived social practices, including education, as environments continuous construction of knowledge, and their systematization as a set of steps that can generate awareness and knowledge about daily tasks.



Participatory research-action is presented as a research methodology oriented educational change and is characterized, among other things, as a process (Bausela E., 2005: 02). The research-action can retrieve information from the participants, their perceptions, progress and interactions, as well as evidence gathered by the participants themselves (...) as applied to students tests, interviews, documents generated, pictures and other audiovisual evidence (Paredes, J. 2011).

From teachers' observation of the reality and educational institution community, it seeks to generate reflection and analysis of their practice, research concocted from the communicative dynamics and the constant interaction through REDCO Red de Conocimiento through partnerships, links and nodes to advance the use and appropriation of ICT as virtual learning environments, construction and transfer of knowledge, in order to strengthen collaboration among peers inside and outside the institution, in institutional and inter-institutional, interdisciplinary and multidisciplinary frameworks, leading to the systematization of experiences through active participation in the network, looking for the improve its research practices, teachers and professionals in their immediate contexts.

### **Strategy**

This research leads to an understanding of the phenomenon of virtual knowledge networks as communication and education environments, from deep, organized and systematized study of practices REDCO CIER Occidente, as knowledge production processes that contribute to the development of educational, social and cultural environments, to contribute to the understanding of new ways to communicate, manage and transfer knowledge at all educational levels; highlighting the role of ICT as educational innovations for sustainable development for more intense cooperation between academic and cultural peers in different local and international stages.

In this sense, from the dynamics and development of REDCO CIER Occidente to the interpretation and analysis of educational and organizational processes within it, including the experiences oriented collaborative work among peer through virtual environments, promote the awareness, motivation and ownership of socio-cultural agents of the educational institution and its members in the development, production and participation in ICT environments (virtual environments) to analyze and evaluate the collective experiences and then collating systematize developments management and transfer of knowledge, use and appropriation of TIC, communication processes, information, interaction, participation, innovation and cooperation.

Conclusions and recommendations should contribute to the improvement and consolidation of REDCO as a methodological matrix to the management and transfer of knowledge through the use of ICT and virtual environments and subsequently to the establishment of other similar pilot experiences in other educational, social and cultural fields for the region and the country. "Research allows linking the study of problems in a given context" (Vidal, M. & Rivera, N. 2007) that is brewing from the involvement and participation in the Knowledge Network for all educational and socio-cultural agents of the educational community of "collective introspective research by participants in social situations" (Kemmis, S. & McTaggar, R. 1988) of their immediate contexts and individuals, interacting with everyday practical problems experienced by teachers, students and other members of the community, looking for a powerful and immediate change for the transformation of education and socio-cultural processes.

The project articulates in action-research, virtual ethnography as a way to understand and analyze interactions and materials that occur within the REDCO CIER Occidente, to get to establish practices that take place there, in relation to knowledge management, from three basic components: education, communication and



participation (Collaborative Work/Communities). This requires understanding the virtual ethnography as a way of life experiences of Internet users, at the same time, which means the Internet as culture and cultural artifact (Hine, C 2000). Complementing the participatory action-research by each of the members of the educational institution, at first development project (Diagnosis: 3 months) was also applied, in addition, the German methodology of Metaplan in order to allow them to analyze the development of processes under investigation and make proposals organized as solution to their difficulties in working with ICT. The Metaplan is assumed as workshop facilitation for integration from the individual to the collective construction.

### **Population**

Education sector in general, teachers at all education levels, higher education, researchers teachers, government and non-governmental organizations.

## **3 Conclusions**

Virtual Knowledge Networks can be understood as favorable environments for education and knowledge management, taking into account the possibilities of forming heterogeneous and interdisciplinary groups and the possibilities of working together on common objectives through flexible and horizontal communication processes.

The new Information and Communications Technology (ICT) offer tools that facilitate communication and participation generating high levels of interactivity, but the dynamics of this type of cooperative work depend on the participation of the subjects involved and therefore a specific profile, a participatory methodology and an interactive platform.

The participation in Virtual Knowledge Networks is limited by issues that relate to the technological infrastructure of the network, but also for the methodology used to carry out processes and the participant's profile. Beyond that the platform provide the right tools to communicate and share information, the methodology should allow the use of such tools and generating discussion spaces, socialization and feedback enabling Knowledge Management. However, although the infrastructure and methodology allow the generation of these spaces, the subject involved must serve as an active agent that not only leverages other constructions but also produces and shares.

Conducting educational virtual processes or Knowledge Management involving high levels of cooperative work, participation, content generation, etc. need a clear and specific profile of its participants. It is important to note that in order not to create an environment more of exclusion for those who are not prepared to accept them, it's necessary to generate learning processes that enable them to integrate into these dynamics. It is important to have dissemination channels that allow disseminating knowledge generated from processes carried out in the Networks.

Globally, they highlight aspects which touch on possible outcomes and difficulties in the development of the Research Project as:

1. Limitations for execution of the project, given the inconsistencies in resource planning, timing and availability of human talent of innovative schools, for non-compliance in time and adequate space by those responsible for CIER Occidente Project. 2. Need to work consistency between the requirements for the development of the Research Project and the availability of commitment of the actors involved in the research process. 3. Limitations in the development of the educative phase, highlighting:

a. Definition of a culture of collaborative work among peers. b. Greater emphasis on ICT skills both methodological and technological level by co-researchers teachers and administrative personal. c. Assurance operation in development of information management, communication, agendas and schedules for the actors



involved in the research process. d. Ensuring continuous education of teachers in discursive skills (review the state of the art process of argumentation, reading and writing), also on variables such as autonomy, self-management and participation. e. Lack of a solid conceptual framework of ICT as an object of study, as teacher education prevails in the instrumental aspect, therefore it is proposed to strengthen a permanent policy of teacher education in this field of educational innovation. f. Advance a positioning of a management and socialization of knowledge culture from the same Laws of Science, Technology and Innovation.

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## Navigation and Visualization of Knowledge Organization Systems using Virtual Reality Glasses: first insights

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**Abstract.** Given the great reception given to the use of mobile devices in recent years, and development of virtual-reality applications to access information, there has been a high demand for consumption of resources on the Internet. However within an educational environment, there are few studies that relate effective methods of navigation for access to resources, and even more for the association of cognitive level concepts. This article presents a proposal for a navigation system in virtual-reality based on Knowledge Organization System (KOS) in a zoo. The main goal is to analyze the association of concepts in a 3D navigation structure, and basic usability aspects through the use of mobile devices on a population of children aged 10 to 12 years.

**Keywords:** KOS, visualization, navigation, education, virtual reality, glasses.

## 1 Introduction

The basis of a Knowledge Organization Systems (KOS) is a set of terms which are linked through some kind of semantic relation. This makes possible to represent KOS terms and relations and not only visualize and also enable interaction mechanisms to navigate through them.

Knowledge Organization Systems' (KOS) visualization and navigation has been a long discussed topic in the past years [1, 2, 3]. Several authors have proposed different kind of interfaces and interaction options in order to make them more usable, attending to different purposes, context of use and users [4, 5].

Digital repositories frequently make use of some kind of KOS as them are helpful tools to organize resources and to assist users to better find and locate resources, providing valuable additional information [6].

Focusing on the educational context, it is amply demonstrated that the use of visualization techniques such as diagrams are highly valuable tools for learning purposes [7, 8].

Visualizing and navigating through KOS could be not only useful for resources' location and indexing, but also a learning experience itself [5, 7]. Fig. 1 depicts different mental processes which could occur while pupils are exploring a thesaurus about mammals, based on similar experiences gathered from previous experiments [references omitted for blind review process].

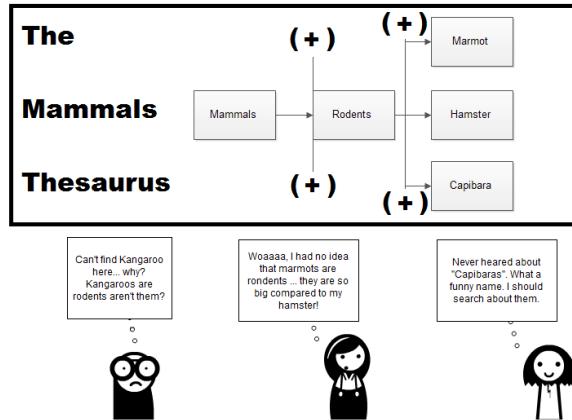


Fig. 1. Navigating through a mammals' thesaurus.

The possibility of acquiring virtual reality (VR) devices has spread through initiatives which could transform a smartphone into VR glasses for an extremely low cost like Google Cardboard<sup>8</sup> or even free as Mc Donald's<sup>9</sup> and Coca-Cola<sup>10</sup> initiatives. This initiative makes possible to everyone having a suitable smartphone to interact with VR interfaces.

Our paper aims to study the possibilities of using this VR interfaces for KOS visualization and navigation, providing first insights of their possible use in an educational context.

## 2 Background

Authors like [9] have proposed models which allow to connect data dynamically with visualization to quickly create visualizations of RDF data. This facilitates both users and data analysts to obtain an overview, explore and conduct a detailed analysis of the Linked Data cloud. Another proposal made by [10] presents an approach for creating visualizations on top of Linked Data using a Wizard Viewing Linked Data, based on an assessment of usability testing by potential users, as web developers and experts on semantic web.

Authors like [11] introduced ways to represent different ontologies through a structure according to "what" you want to represent (information in tabular form) and how (a structure defined ontology). The proposed approach allowed to represent the information of the ontology in different ways: i) a set of data from multiple ontologies: is displayed as nodes organized by different sections such as education, agriculture, health, etc; ii) an ontology of multiple datasets: display multiple Web pages of banks, and iii) visualization of a consultative relations: it shows how to visualize a warehouse inventory of printers showing the amount of each type utilizing a directed graph.

<sup>8</sup> <https://www.google.com/get/cardboard/> [Last consulted: 4 April 2016]

<sup>9</sup> <https://www.geektopia.es/es/technology/2016/03/01/noticias/en-suecia-la-caja-del-happy-meal-se-convierte-en-gafas-de-realidad-virtual.html> [Last consulted: 4 April 2016]

<sup>10</sup> <https://www.geektopia.es/es/technology/2016/03/04/noticias/coca-cola-tambien-quiere-que-uses-sus-cajas-para-hacer-gafas-de-realidad-virtual.html> [Last consulted: 4 April 2016]



Regarding the use of this techniques in immersive environments [12] proposed to display an ontology in a 3D environment simulation as a tool for managing variables and parameters. The simulation where the tests were performed consisted on a model of hypovolemic shock, this is when the heart fails to pump enough blood to the body. The authors constructed an ontology on arterial connections that are involved in hypovolemic shock so the ontology could be used to specify and manage all the variables involved in the simulation model.

Authors like [13] address the issue of creating virtual environments or scenarios through the use of ontologies. Define the problem of generating 3D environments manually. The authors propose the creation of scenarios using schemes for the definition of environment (UML, RDF and OWL), first define all the rules, objects and animations that must have the virtual environment to generate and then by inference functions a package that allows display the 3D world is designed based on designed schemes GEDA-3D is a project of 2D and 3D engine for the representation of knowledge structures. Basically generate 3D environments using an ontology, similar to the form generation software using UML diagrams and structure.

From the framework's viewpoint [14] proposed the creation of 3D scenes using an architecture divided into three layers. Each layer would have ontologies describing a part of the 3D world to be created. These layers are distributed as follows: i) Layer Scene: has ontologies containing the proportions designed for stage and all objects that are within such a scenario, for example the size of the table, floor length, etc; ii) layer spatial relationships: contains ontologies that describe the position of objects in the scene you want to model, for example if a book is above or below where it is located a chair, bed, etc., iii) layer application restrictions: describes all the rules that will govern the 3D scene, for example gravity or what if a glass breaks.

An approach in the educational area is proposed by [15], where the author presents the use of ontologies for knowledge organization and academic resources such as graphics, audio, video images arises, etc. These ontologies are divided by areas of knowledge such as philosophy, engineering or economics. The system was conceived to connect resources in repositories and display them to students and teachers. The way to visualize the information is not explicit but presented a kind of schematic showing how ontologies for educational resources would be created. Another study proposed by [16] presents a combination of Augmented Reality (AR) and Semantic Web technologies in order to enhance the existing mobile Augmented Reality browsers using Semantic Web technologies.

There is a limited literature regarding KOS visualization in 3D environments and most of them is focused on 3D ontology visualizations involving highly specific applications. We were unable to find previous usability studies linking the visualization of KOS using virtual reality in the learning environment. Therefore the following article takes the first step to analyze the possibilities of visual search interface using virtual reality tools to conduct immersive navigation mechanisms on children, using a thesaurus based on a real zoo animals as a use case.

### 3 Materials and Methods

#### a. Development of the KOS

The application was developed as a videogame using unity 3D engine, the idea was using 3D objects of a videogame scene to represent the KOS structure of de Bioparc as a node parent-child frame. For this purpose the Google Cardboard API was used for input touch events and the head motion tracking also for generate the connection between nodes some scripts were built, the class diagram shown below illustrates de design of these scripts. Fig. 1, presents a representation of classes used in the 3D environment.

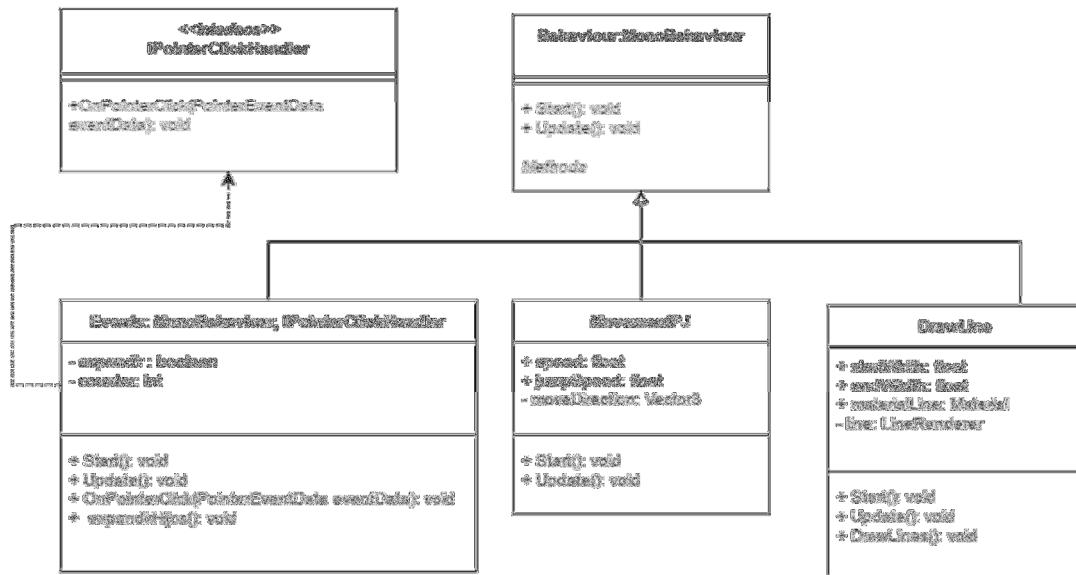


Fig. 1. Class diagram of scripts used on application.

#### *Classes Description:*

- `IPointerClickHandler`: It's an interface of Unity that allows to detect a touch or click input event, it's useful to perceive when a node want to be expanded.
- `MonoBehaviour`: Unity class that allows to manage the entire scene, their methods start and update allows initialize components and update them in time.
- `Events`: This script was created and implements the `IPointerClickHandler` interface and extends from `MonoBehaviour`, with this script seeks detect when a sphere (node) is selected and trigger the event of expand the node.
- `MovementPJ`: the Script controls the movement in the scene therefore the user can navigate in the KOS structure in an immersive way.
- `DrawLine`: it is a simple script that draw the lines between nodes.

#### *App interplay:*

On the other hand for the interaction process with the application its important give to user some immersion and free navigation into the KOS. For this reason has been decided to connect the computer keyboard with the application in this way the users can use it to navigate into the KOS space. For this process we use the tool named Putty that uses a Telnet protocol to connect the mobile device with the computer and detect which keys are tipping on the keyboard.

The interaction with de APP shows below in the figure 2, the user with de Putty application on his computer connects with the KOS application developed when this is done its time to use the Google Cardboard and the keyboard keys to navigate into the KOS space.

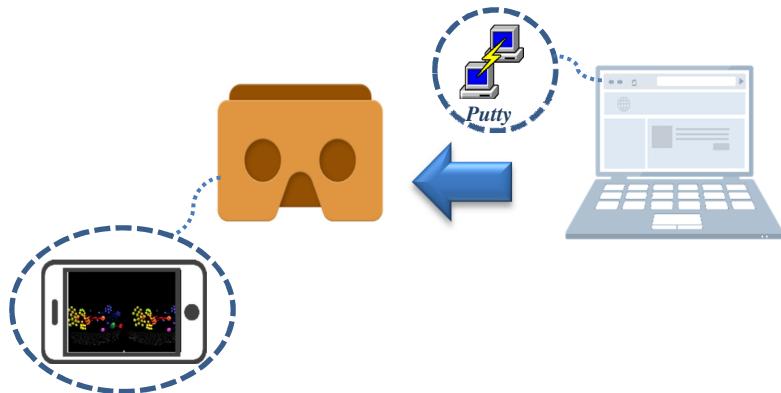


Fig. 2. Interaction between the mobile device inside Google Cardboard and the computer with the Putty application.

Using visualization techniques to represent and navigate through knowledge classification schemes could be a very helpful tool for learning purposes, however, to reach this goal an important effort on the usability side must be done during its implementation. This includes the use of a proper knowledge organization schema [7], built up considering the users' profiles, objectives and context of use.

In order to avoid problems arising from the use of existing KOS, which were not built according to these principles, we decided to create a simple KOS, aiming to ensure the use of a proper sample for the experiment. This KOS was constructed to represent the animals in Bioparc Fuengirola Zoo (Málaga, Spain), which allowed us to construct a thesaurus, where the broader / narrower relation was established according to the animal's habitat. Table 1 present a representation of concepts used to develop navigational interface.

**Table 1.** Concepts used to develop KOS navigation

Concept	Description
Animal	Living organism that can move and reproduce.
Species	Group of similar organisms that can interbreed.
Genus	Group of related species.
Family	Group of related genera.
Order	Group of related families.
Class	Group of related orders.
Phylum	Group of related classes.
Kingdom	Group of related phyla.

AFRICA ECUATORIAL	SUDESTE ASIÁTICO	ISLAS INDO-PACÍFICO
HUMEDALES		RUINAS DEL TEMPLO
COCODRILO DEL NILO		DRAGÓN DE KOMODO
FLAMENCO ROSA		CIERVO MOTEADO DE FILIPINAS
FLAMENCO ENANO		TORTUGA GIGANTE DE LAS GALÁPAGOS
ESPÁTULA AFRICANA	TAPIR MALAYO	IGUANA RINOCERONTE
ALCARAVÁN DEL CABO	BINTURONG	ESTORNIOS DE BALI
GRULLA CORONADA	MUNTJAC CHINO	CÁLAO DE LAS BISAYAS
TÁNTALO AFRICANO	NUTRIA CHICA	URRACA PIQUIRROJA
SITATUNGA	TOMISTOMA	FAISAN NOBLE DE BORNEO
CERCETA DEL CABO	CASUARIO COMUN	ESPOLONERO DE PALAWAN
CERCETA HOTTENTOTA	SUIRIRI CARIBLANCO	
ANADE PICOLIMON	CORMORAN PÍO	
PATO CRESTUDO	TORTUGA GIGANTE MALAYA	CENTRO INTERPRETATIVO
CIGÜEÑA DE ABDIM	GANSO URRACO	
TORTUGA DE CONCHA BLANDA AFRICANA	TARRO RAJÁ	CAMALEÓN PANTERA
ANADE MALGACHE	PORRON MOÑUDO	PITON RETICULADA
	SUIRIRI BICOLOR	VARANO AZUL
<b>TRONCO CAÍDO</b>		VARANO ESMERALDA
		VARANO DE PAPÚA
ESCORPIÓN IMPERIAL	<b>DOSEL DEL BOSQUE</b>	PITON DIAMANTINA DE LA JUNGLA
CUCARACHA SILBADORA MALGACHE		
GECKO DIURNO MALGACHE	ARDILLA TRICOLOR	
MILPIES GIGANTE AFRICANO	GIBON DE MEJILLAS DORADAS	
PITÓN REAL	ORANGUTAN DE BORNEO	
CARACOL GIGANTE AFRICANO		

The interface was built using Unity 3D engine, figures 3 and 4 show different views of the thesaurus. Fig. 3 shows the different animals that can be found in the location of "Humedales" (wetland) in the Bioparc. This structure can be obtained from the catalog of species provided by the park. Humedales is a child node from Africa zone, in this way we can deduce that all species In Humedales belongs to Africa and can be found in a determinate context.

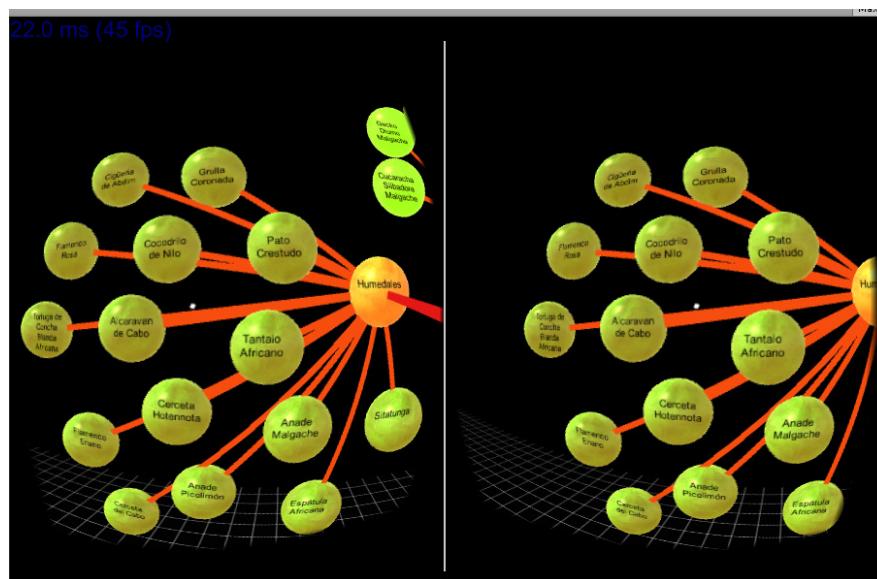


Fig. 3. Bioparc's thesaurus, user is centered in the "Humedales" (wetland) node.

Fig. 4 shows all KOS structure expanded and the camera that follows the navigation process in the application. On the other hand the figure shows the colors of the structure, each zone has its own color and their children have a similar color scale that indicates its linkage with the parent.

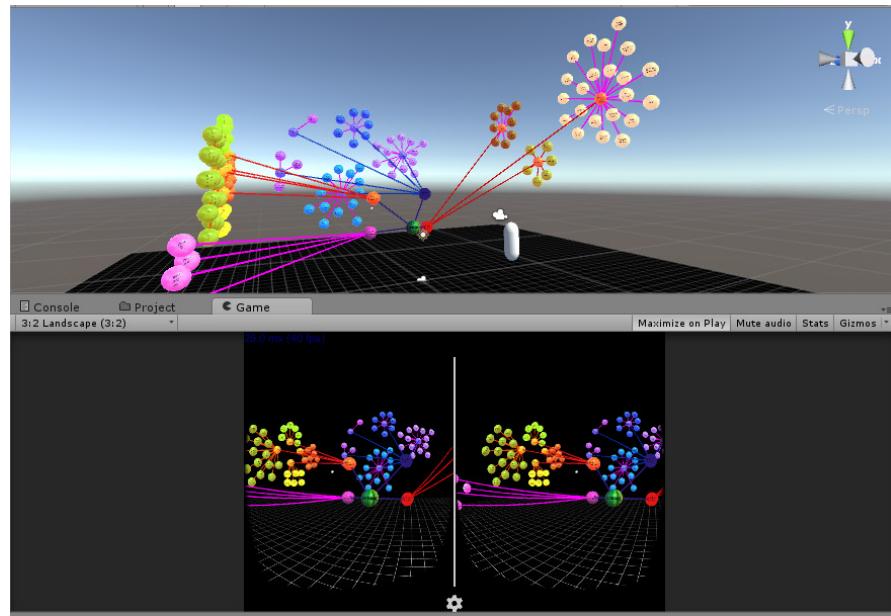


Fig. 4. A broader view of Bioparc's thesaurus – Unity SDK

Fig. 5 present an overview of the KOS implemented in 3D.

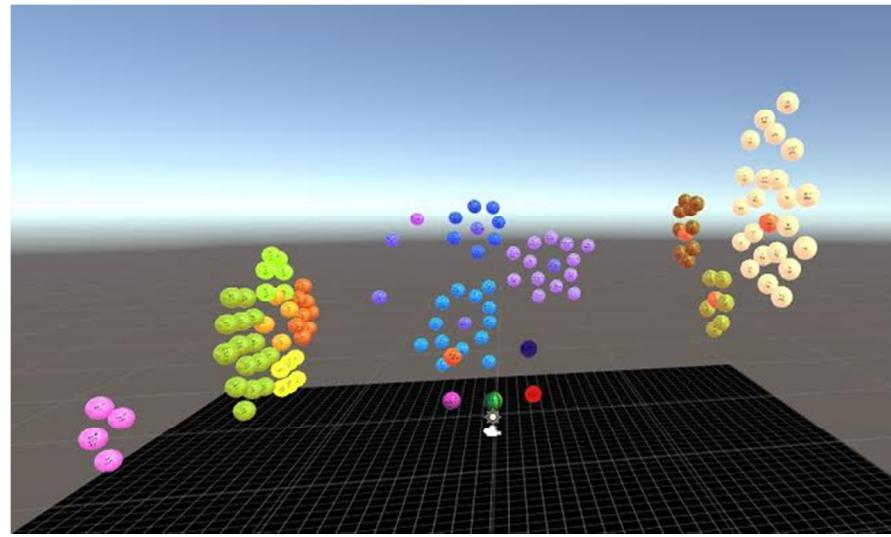


Fig. 5. An overview of KOS implemented

Finally in figure 6 and 7, we present a preliminary representation of the Bioparc zoo.

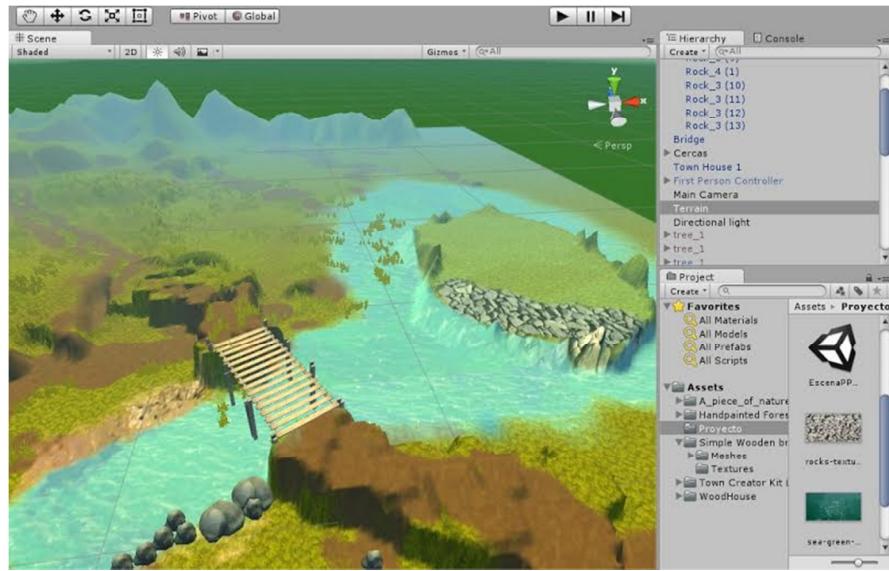


Fig. 6. 3D representation of Bioparc zoo.

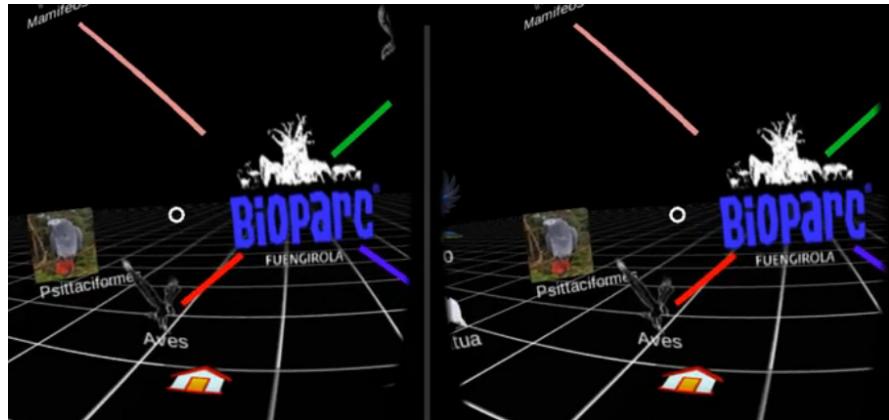


Fig. 7. Preliminary method of navigation using Google cardboard.

### b. Evaluation methodology

The evaluation of the prototype was carried out by the use of the System Usability Scale (SUS) [16] supplemented with personal interviews in order to extract additional qualitative data about the interface and the knowledge extracted by the users while navigating through the KOS, related to perception assessment.

SUS is a widely used and freely distributed questionnaire consisting of 10 items which are scored using a five-point scale ranging from “Strongly Agree” to “Strongly Disagree”. It’s considered to be a quick, easy, reliable [17] and technology agnostic, making it suitable to be used by a broad group of usability practitioners to evaluate almost any type of user interface tool [18] either for small and big samples [17][18].



We introduced some minor changes to the original SUS following the recommendations stated by Finstad [19] regarding the problems while using this scale with non-native English speakers, the change of the word “system” for “interface”, the inclusion of a short set of instructions [20] and other minor modifications in order to facilitate the understanding of the questions to the users, according to their age. The final set of statements were the following:

- 1.I think that I would like to use this visual tool frequently.
- 2.I found the visual tool unnecessarily complex.
- 3.I thought the visual tool was easy to use.
- 4.I think that I would need help to be able to use this visual tool.
- 5.I found the options in the visual tool to be well integrated.
- 6.I thought there was too much inconsistency in this visual tool.
- 7.I imagine that most people would learn to use this visual tool very quickly.
- 8.I found the visual tool very awkward to use.
- 9.I felt very confident using the visual tool.
- 10.I need to learn a lot of things before I could get going with this visual tool.

Participants were 13 kids ranging from 10 to 12 years who were invited to test the interface for fifteen minutes, allowing them first to freely navigate through the KOS without providing any additional information about it, just asking them to learn as much as possible from the information they could find on it. After this, participants used the system to reply a set of questions which could be answered just by extracting the information from the KOS. The set of questions was:

- 1.What does the KOS represent? (*Animals in a zoo and their habitats*)
- 2.What kind of habitats are represented? (*All of them are jungle-type*)
- 3.What was your favourite animal? (*Open answer*)
- 4.Where does he lives? (*Open answer*)
- 5.What is the name of the habitat were Lemurs live? (*Madagascar*)
- 6.Only there? (Yes)
- 7.What is the habitat with more animals? (*Mangrove Swamp, Indo-Pacific*)
- 8.What kind of animals live there? (*Mostly fishes*)
- 9.Find an habitat where there is only one animal living. (*The tiger at the Ankor temple*)
10. Did you feel dizzy or any other sickness while navigating through the diagram? (*We use the term diagram instead of KOS for better users' understanding*)

For questions from 1 to 9 we collected data regarding effectiveness – Was the answer correct? – and efficiency – How long did the participant take to reply? Did the participant need help?

## 4 Preliminary results

Several authors like [21], employ statements 4 and 10 from the questionnaire as representative of learnability, while the rest of the statements are representative of the construct usability. However when trying to analyze aspects of learning about children, it took majority of the questions associated with learning, and only one aspect (10) based on the physical conditions (dizziness), that may affect the conditions of navigation by the 3D interface. We considered learnability as an essential factor for the acceptance of the interface, so we took this approach in our analysis. Fig. 8 shows these results by participant.

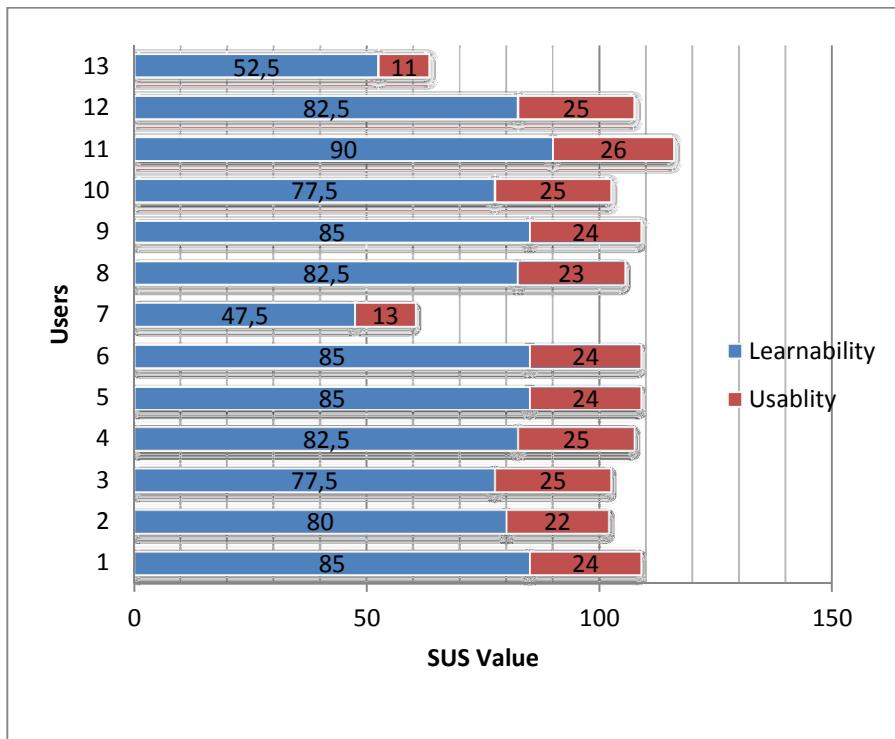


Fig. 8. Measure for SUS scale in 3D interface.

Based on the results on figure 7, the evaluation of the learnability shows that the concepts related in 3D navigational structure has a mean score of 74,45 ( $SD = 6,85$ ), which is above the average established by SUS ( $SUS > 68$ ). The average of usability score was 21,46, although there were participants with a rating below average, in general this aspect was highly valued despite two participants scored below the average in usability aspects, which felt dizziness in the test. The construct learnability average score was 75,57. These results mean that majority of participants in test identified animals and relationships with the habitat, and category of animal selected according to the classification of KOS defined for the zoo. Table 2 presents these results in a detailed statistical description.

Table 2. Statistical description of learnability.

	N	Mean	SD	Error
<b>Task 1</b>	13	3,000	0,226	0,816
<b>Task 2</b>	13	4,307	0,174	0,630
<b>Task 5</b>	13	3,384	0,140	0,506
<b>Task 6</b>	13	4,230	0,520	1,877
<b>Task 7</b>	13	4,230	0,520	1,877
<b>Task 8</b>	13	3,692	0,364	1,315
<b>Task 9</b>	13	3,923	0,177	0,640

Table 2 details the maximum and minimum results of three aspects of learnability that participants valued negatively when using search interface. This aspect was related to the complexity of the tool (Mean=3,000; SD=0,226). However, three aspects of learnability were highly valued related whit concepts used in KOS interface (Mean=4,307; SD=0,174), the location of animals in habitat (Mean 4,230; SD=0,520) and issues

related to ease of learning to potential users in different knowledge areas (Mean 4,230; SD=0,520). Finally in figure 9 we present a summary of task by user satisfaction.

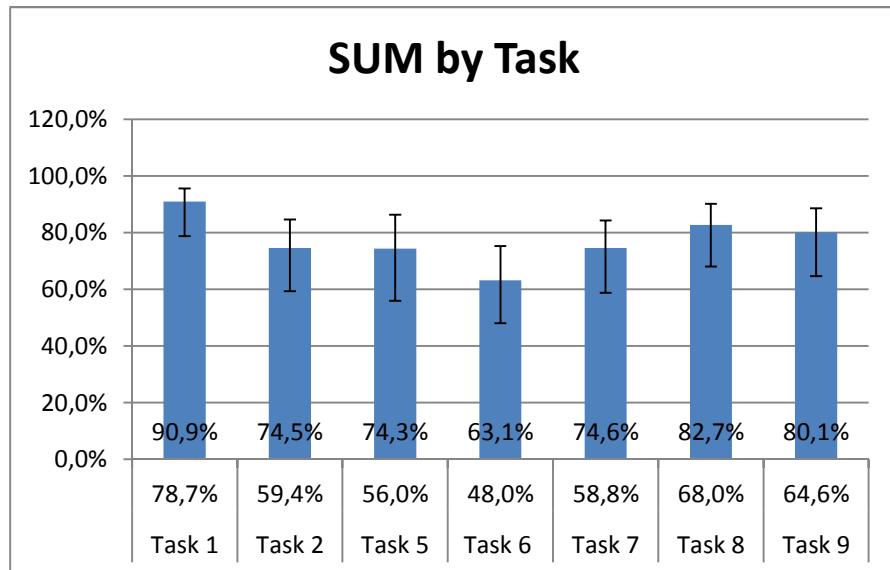


Fig. 9. Summary of user satisfaction by task.

As showed in figure 9, task 1 was the best activity evaluated, and task 6 presented a low satisfaction of all activities by children's. However task 1 was the activity most high evaluated.

## 5 Conclusions and future work

We carried out a mechanism for navigation through a simple knowledge representation scheme KOS, based on the definition of a thesaurus of animals in a zoo. Their representation has allowed us to analyze some aspects related to learnability and usability. However, one of the key aspects that pursued our analysis was to identify whether the participants (children between 10 and 12 years) provided them processes of navigation-concepts through 3D technologies, and most important, if not generate problems of dizziness using google cardboard glasses.

According to the results of the study associated with learnability aspects, the representation of knowledge schemes KOS in navigation mechanisms is possible using techniques of virtual-reality insofar as there aspects like: i) the use of simple navigation schemes where few levels deep are used, ii) few relationships between concepts, iii) use of concepts that did not involve association with other concepts in different levels of navigation.

It is important to mention that there are still relevant usability aspects to explore, to perform navigation tasks on taxonomies. Therefore, it is necessary to have more accurate enabled devices when interacting navigation 3D environments. The above, because we do not delve on some aspects that were found, such as: i) problems associated with dizziness when surfing more than two levels deep, ii) headache when interacting with the navigation scheme, and iii) difficulty to access nodes using google cardboard.



Future work is projected to have a navigation system, using augmented reality, and the use of navigation structures with a higher level of utility, in terms of aid associated with: i) search method controlled by voice, ii) aid menus to visualize the selected concept related resources, and iii) use more specific usability methods for analyzing user behavior when using the tool.

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