Contents

List of Figures

List of Tables

Chapter 1

Introduction

The purpose of this research is to contribute in the diverse forms of use of the interactive learning environments by proposing a learning environment, we based the content management with an adaptive hypermedia approach and with the development of a new type of learning object to be adapted to the learning environment. This environment use various devices that were capable of running a web browser, non-relational data bases for information exchange and some sensors like cameras and Kinect 2 were used. In addition we implemented a way to predict the level of user attention which it was compared against information obtained by a video taken from the user doing the activity.

1.1 Motivation

There are many types of learning environments starting from the most basic that exist almost from the beginning of civilization where a person is able to learn based on their current context. For example the first humans who needed to hunt them could take decisions and adapt to the situation and perform the task that was to hunt an animal to obtain food, in more recent times we can relate to the classrooms of schools, and currently including technology these Environments can be configurable and adapt to a particular context (the user).When a user uses learning environments the themes are usually flat and have the same content for everyone. In addition, users think and assimilate information in a different way which makes it more attractive to have a learning environment that adapts to the learning styles of the users and why not to the user preferences.

Nowadays most interactive museums work stations or exhibits like we see on the figure 1.1, where users come to the station to interact with or receive information by reversing some time on it until it passes to the next station, where the display will probably showed relevant information for the person but if this information is not shown to digestible way (processed so that it is attractive to the user) the user will probably spend less time or not time at all at the station. This expose the lack of adaptation of the exhibits in some interactive museums or standard museums. in order to ensure that the information and how is presented to the user is broadly engaging. Intelligent learning environments can be used as exhibitors in museums

Figure 1.1: A museum interactive station

they use embedded systems, sensors, information and communication technologies that are becoming invisible to the user as they are being integrated into physical objects, infrastructure, the environment in which we live, work and many other environments. This idea provides a good way of bridging the gap between human users and computing systems, and this motivates related research into Computing. Some of these systems use learning resources called learning objects. For the exchange of learning objects between systems standardization initiatives have been developed and there are some implementations and repositories that manage the content using these standards.

1.2 Learning Environment

Learning environment refers to the diverse physical locations, contexts, and cultures in which students learn. Since students may learn in a wide variety of settings, such as outside-of-school locations and outdoor environments, the term is often used as a more accurate or preferred alternative to classroom, which has more limited and traditional connotationsa room with rows of desks and a chalkboard, for example. The term also encompasses the culture of a school or classits presiding ethos and characteristics, including how individuals interact with and treat one anotheras well as the ways in which teachers may organize an educational setting to facilitate learninge.g., by conducting classes in relevant natural ecosystems, grouping desks in specific ways, decorating the walls with learning materials, or utilizing audio, visual, and digital technologies. And because the qualities and characteristics of a learning environment are determined by a wide variety of factors, school policies, governance structures, and other features may also be considered elements of a learning environment.

Educators may also argue that learning environments have both a direct and indirect influence on student learning, including their engagement in what is being taught, their motivation to learn, and their sense of well-being, belonging, and personal safety. For example, learning environments filled with sunlight and stimulating educational materials would likely be considered more conducive to learning than drab spaces without windows or decoration, as would schools with fewer incidences of misbehavior, disorder, bullying, and illegal activity. How adults interact with students and how students interact with one another may also be considered aspects of a learning environment, and phrases such as positive learning environment or negative learning environment are commonly used in reference to the social and emotional dimensions of a school or class.

The Learning Environment (LE) corresponds to the spaces in which the learning activities are developed, can be of three types: aulic, real and virtual. In the first it is the whole environment surrounding the student, in the context of the classroom, which focuses not only on the student, but also on the content, so the interaction with the environment will develop an interaction with the student that can be positive or negative depending the place. And has the following characteristics:

- The educator is the one who has to look for the models appropriate to their materials and the conditions of their group.
- They help to relate the content in an experimental and experiential way.
- It can be given a dynamic spatial distribution, changing as the group and the teacher consider it necessary.

The real Teaching-Learning activities are developed in the classroom, the real environment can be a laboratory, a company, clinic, library, green areas, etc. Real scenarios where you can see the application of knowledge and skills acquired, as well as the practice of attitudes and values.

Virtual environments are those created through the use of Information and Communication Technologies, in order to provide learners with resources that facilitate their learning process, within these TICs can be cited the computer, cannon, a classroom Virtual, the use of internet where they can have access to blogs, discussion forums, chat, specialized pages where young people find fun activities, stories like solution to crosswords, puzzles, etc., that well employees contribute greatly in:

- Acquisition of learning by the student.
- Understand the nature and philosophy of distance education.
- Identify the characteristics of students in remote locations.
- Design and develop interactive materials that are adapted to the technology to be used, to the content, strategies and to facilitate independent study.

Learning environments are important in the day-to-day lives of people because we are in contact with them all the time in accordance with Phillips[19] a Learning Environment is a place where resources, time and reasons are available for a group of people to nurture, support and value the learning of a limited set of information. The LE are social places even when only one person is found there.

One of the challenges facing the design of learning environments is human complexity, because each person thinks and assimilate information in different ways making it difficult to identify which resources are adequate for everyone. Intelligent learning environments (ILE) are a new type of intelligent educational system, which combines characteristics of traditional intelligent tutoring systems (ITS)[16] and learning environments. According to Self[20] ITS are learning systems based on computers that try to adapt to the needs of the learner.

Figure 1.2: A kid using and intelligent chalk-board

According to the literature, providing effective support or guidance by identifying the knowledge levels and learning difficulties of students in learning programming languages could be the key to the improvement in students learning performance. Researchers have indicated the important role of assessment in identifying the learning status of individual students in providing effective learning guidance[12] [13] [21]. Researchers have further argued that assessment could be used as a learning strategy to improve students learning performance[4] [8] . For example, Hauswirth and Adamoli[10] proposed a pedagogical approach aligned with this aspect that allows students to learn from their mistakes by answering a series of questions. On the other hand, researchers have also indicated that assessing students programming knowledge and skills as well as identifying their learning difficulties remains a challenging issue, implying the need to develop effective strategies or tools to identify students status and provide learning support in programming language courses[23].

In the past decade, various teaching strategies and learning activities have been applied to computer-programming courses for beginners[9]. For example, Machanick[18] proposed the idea of abstraction-first teaching by hiding details until students are ready for them. In addition, Emurian, Holden, and Abarbanel[6] employed a peer-tutoring approach, and Hwang, Shadiev, Wang, and Huang[14] proposed a web-based programming-assisted system to provide learning support for programming courses. In the meantime, researchers have indicated that problem-based learning (PBL) could be a promising approach for programming language learning[17]. For example, Glvez, Guzmn, and Conejo[8] reported a problem-solving environment to diagnose students knowledge levels and to generate feedback and hints to help students understand and overcome their misconceptions in learning programming languages.

1.3 Learnign Objects.

A Learning object is defined by Wayne Hodgins[11] as "a collection of content items, practice items, and assessment items that are combined based on a single learning objective". When he created a working group in 1994 though the concept was first described by Gerard in 1967[7]. Learning objects go by many names, including content objects, educational objects, information objects, intelligent objects, knowledge bits, knowledge objects, learning components, media objects, reusable curriculum components, nuggets, reusable information objects, reusable learning objects, testable reusable units of cognition, training components, and units of learning. The Institute of Electrical and Electronics Engineers (IEEE)[15] defines a learning object as "any entity, digital or non-digital, that may be used for learning, education or training", Chiappe[3] defined Learning Objects as: "A digital self-contained and reusable entity, with a clear educational purpose, with at least three internal and editable components: content, learning activities and elements of context. The learning objects must have an external structure of information to facilitate their identification, storage and retrieval: the metadata.". Learning Objects and Metadata Based on the object-oriented paradigm, learning objects are typically defined as components of instruction material, which can be reused in multiple contexts. Instruction designers can create and maintain these components, independent of each other and share them over the Internet [5].

Since many studies generated about in recent years, some authors organize these objects at different levels, regardless of the many groups that, according to the fields of descriptors, we could set up. In the case of structuring levels, the first one would refer to the tiniest units that could be assigned the name of learning objects: a digital image (graphic, photo, diagram, map, chart, ...), a table, phrase, or sound formula (bell, telephone, storm, animal, ...), etc. The following levels are assuming units increasingly complex and, logically, less adaptable to other contexts or learning contents. According to the fields, areas of knowledge, dimensions or other taxonomic forms, the organization of objects can take many forms. For this organization, these objects, in addition to their reuse characteristics, must have the possibility of being updated, combined, separated, referenced and systematized. In this way, they are classified or cataloged and labeled to be located in the corresponding warehouses or repositories of contents or objects, so that later they can be located for reuse or, if necessary, modification or re-elaboration, through the corresponding contrast, comparison strategies , Relationship and criticism of the information obtained. That is why it obviates the need for powerful learning object repositories. Hence, the object and the repository are two complementary entities. An object that does not have the necessary characteristics to be able to integrate in a repository, loses all its virtualities and, at the same time, a repository that does not have a good base of objects, stops being interesting and operative. There are institutional repositories, training companies, associations, consortium, organizations, etc. The Web itself could be considered as a large repository, provided that we apply the strategies of search, processing, selection and cataloging through metadata schemes. The metadata structure implies having a detailed textual structure, describing attributes, properties and characteristics distributed in different fields that clearly identify the object, so that it can be found, assembled, and used.

So it is very important for the learning environments to have a good administration and dustribucion of learning objects.

1.4 Aim's.

Learning environments have been extensively used physically, virtual and for various purposes such as training, entertainment, demonstration, etc. But the problem remains of how to present the information, more specifically how to adapt the content to the user or users of these environments. Using new technologies improves these environments by allowing them to display information across devices by labeling them as learning objects, a good set of learning objects displayed can enhance learning against traditional learning[2].

The aim of this thesis is to create an adaptive learning environment, reduce implementation costs of the learning environment using any device compatible with a web browser, define new type of learning object that we call Environmental learning object, develop a learning environment that can use devices that do not require special installation and are compatible between themselves and the environment. Using e-learnign combined with the simple sequencing standard, learning objects, sensors to analyze if the user likes what they are observing and a technique to distribute the learning objects in the environment and thus adapting the environment to the user in each of the activities performed in the environment until the sequence ends or decides to stop performing the activity. To achieve this, a learning sequence is established, which is previously configured based on the learning context, the user navigates through the sequence thanks to a fuzzy system that allows to semi-automate the course of the learning sequence or waiting for the User performs an action that affects the path of the sequence, at the same time a sensor that measures the level of attention of the user allowing to study and measure if the content shown is optimal for the user.

The contribution of this thesis is the new adaptive learning environment which includes a new type of learning object and a method to measure the level of attention of the user. It provides learning environments suitable for users. As an extra, this environment has characteristics that allow it to adapt to diverse contexts such as entertainment, advertising, museum exhibit, training, etc. Several particular aims were done in order to support the achievement of contributions:

- Elaborate an analysis about the state of the art in the eld of intelligent learning environments and learning objects through the revision of the relevant literature. State of the art helps to dene the tendency of currents intelligent learning environments, the recent improves and helps to understand what is the relevance of the proposed method as well as the feasibility and how we can make an important contribution to the intelligent learning environments.

- Design and conduct several experiments with the proposed LE. The experiments were based on experiments made by other similar methods. The metric implemented to measure the experiments results was compare each others and survey the users.

- Selection of learning environments(including normal and intelligent LE) that are representative of the alternatives for this problem domain in order to compare their performance. There are not enough papers including all the problems attacked in this work to make a consensus about what is that we want from each one.

- Propose an intelligent learning environment to use the new learning object and apply it in a case of study where the environment and the user are involved.

- Develop a prototype of an adaptive intelligent learning environment using the learning object proposed. Using several technologies to deploy the learning objects in the environment. This prototype lets users interact with the environment and allows us to analyze their behavior.

- To evaluate the proposed method we develop a method to evaluate the level of attention or engagement as it is called in literature of the users, using the environment. Results are explained in a posterior chapter.

1.5 Outline.

The rest of this thesis is organized as follows:

- **Chapter 2**, describes a study and background of current and related work, presenting a general overview of learning environments and their improvement in recent years. This study includes intelligent learning environments, their classification, the technologies they use and their techniques. As well as the challenges of these systems. The types of learning objects that exist as well as where and how they have been used and their contributions in the environments. Also the affective computation and how it affects the configuration of the learning environment. And finally describes the adaptive learning environments with an analysis of its advantages and disadvantages when using the adaptive techniques in interactive learning environments.

- **Chapter 3**, describe the concepts that complement the bases of the method proposed in this thesis.

- **Chapter 4**, presents the model of the adaptive learning environment, the proposed method involves the paradigm of configuring or contextualizing a learning environment adapting it to a user or group of users. This chapter includes the overall explanation of data models and the functionality, as well as its components for this case of study.

- **Chapter 5**, the results of the different experiments are presented. . This chapter also details the results for each experiment from a point of view of scientic results.

- **Chapter 6**, after the development of the learning environment, the impact of content in LE was evaluated. This chapter describes the tests that were applied by surveys and sensors in order to evaluate the level of engagements of the users. Details of the environment and the characteristics of the tests are described, as well as the results of each one.

- **Chapter 7**, this chapter concludes with a summary of its contributions and limitations. Final conclusions are drawn and also proposals for future work are presented.

Chapter 2

Art State

In this section the state of the art in intelligent learning environments, e-learning and context are presented. The learning environments have been (Falta aqui)

2.1 E-learnign

Aprendizaje colaborativo basado en recursos adaptativos.

This work consists of an Adaptive Hypermedia System[?], this work is focused on semi-automatic sequencing of educational resources. It builds on information that can be subjective; for example, the user's knowledge, learning style, their predilections and even evaluation; they are perceived differently depending on the context. Sequenced personalized teaching materials; using fuzzy rules and attributes to treat subjective information, involved in the learning process. I n a hypermedia system, such as the Web (W3C, 2008), users surf by a network of resources for information or to perform some task. In the case of a student, navigation can be part of a complex learning activity; an activity may consist of: search some information, discuss the findings with other students (online), and then make a presentation where resources of different formats and sources are integrated. In this paper propose: the architecture for a learning environment based on reusable resources, using techniques such as Adaptive Hypermedia and engine adaptation an extension to Simple Sequencing specification where a particular system of fuzzy inference. In include the use of systems fuzzy inference can facilitate the damnation of rules by the instructors, because in the learning process involved usually fuzzy variables.

2.2 Learning Environments

2.3 Context

PCULS Personalized context-aware ubiquitous learning system for supporting effective English vocabulary learning [Chen 2010]. This work consists of a system that supports students in English using a situational approach to learning based on the location of the learner. Detected by wireless positioning techniques, learning time, individual skills of students in English and free time, which enables students to fit your learning content to effectively support the learning of English in a school environment generating vocabulary appropriate to the situation and presenting textual information via mobile phones. When only text information shown this lack of context that was trying to capture in the vocabulary.

Procedure system operations: In Step 1: The learner enters the system through the user interface where the system checks the user's account and free time available to the user. In Step 2: After the apprentice enters the system, the student agent location automatically determines its location using a location technique based on neural networks. In step 3 and 4: Based on the location of the learner, the context analyzer agent receives contextual information database user and context. Therefore appropriate agent finder English vocabulary seeks the context of the learner according to the analytical results of context analysis agent fits. In step 5: Content delivery agent organizes the English learning materials discovered by the search agent material learning English as appropriate content and transmits it to the device of the learner. In step 6: The message delivery agent transmits the learning content to the learner PDA as a web page or in the form of short message to the cell apprentice. then the trainee returns to step 2 to start the next learning cycle or exit the system, completed the learning process. The application was tested with two sets of users. they applied a test for each user group with these results.

Display-based services through identification: An approach in a conference context. This work combines ubiquitous computing, context, information display and [Hervas 2006] devices, to provide services to the user implicitly, with little or no user intervention feeding context information provided by sensors embedded in devices the environment. Its primary objective is to obtain service information display adaptable to changes in context, providing the same information. They base their research on the identification of users, knowing their profile, their situation in a given underlying information and much other time. Which results in a system that identifies users through RFID cards, and after analyzing generated user information service based on the information display. The whole operation of the service information display is divided into three distinct modules: Context Analysis, generation module mosaics and Composer module. The contextual model represented by an ontology proposed by the authors. The following figure shows the outline of the project is shown.

Every moment is available context information filtered according to the ontology and obtained from the system database and embedded sensors in the context (in principle RFID antennas and RFID tags information). The context analysis module is responsible for deciding when a change in the context must lead to changes in display devices. It is also responsible for the system database maintains the consistency of information on these changes. mosaics are generated after an analysis of the background information so that the appropriate and optimal environmental conditions to display information. The generator module provides an XML description of the Mosaic module compounder. From the description of the specific information to be displayed and the mosaic is generated is obtained, publishing through the devices of the environment and taking into account their differences.

Chapter 3

Theory and Background

This chapter overviews the background and main definitions and basic concepts, useful to the development of this investigation work.

3.1 Learning environment

Learning environment refers to the diverse physical locations, contexts, and cultures in which students learn. Since students may learn in a wide variety of settings, such as outside-of-school locations and outdoor environments, the term is often used as a more accurate or preferred alternative to classroom, which has more limited and traditional connotationsa room with rows of desks and a chalkboard, for example. The term also encompasses the culture of a school or classits presiding ethos and characteristics, including how individuals interact with and treat one anotheras well as the ways in which teachers may organize an educational setting to facilitate learninge.g., by conducting classes in relevant natural ecosystems, grouping desks in specific ways, decorating the walls with learning materials, or utilizing audio, visual, and digital technologies. And because the qualities and characteristics of a learning environment are determined by a wide variety of factors, school policies, governance structures, and other features may also be considered elements of a learning environment. Educators may also argue that learning environments have both a direct and indirect influence on student learning, including their engagement in what is being taught, their motivation to learn, and their sense of well-being, belonging, and personal safety. For example, learning environments filled with sunlight and stimulating educational materials would likely be considered more conducive to learning than drab spaces without windows or decoration, as would schools with fewer incidences of misbehavior, disorder, bullying, and illegal activity. How adults interact with students and how students interact with one another may also be considered aspects of a learning environment, and phrases such as positive learning environment or negative learning environment are commonly used in reference to the social and emotional dimensions of a school or class.

3.2 Interactive learning environment

Interactive learning is a pedagogical approach that incorporates social networking and urban computing into course design and delivery. Interactive Learning has evolved out of the hyper-growth in the use of digital technology and virtual communication, particularly by students. The use of interactive technology in learning for these students is as natural as using a pencil and paper were to past generations. The Net Generation or Generation Y is the first generation to grow up in constant contact with digital media. Also known as digital natives, their techno-social, community bonds to their naturalized use of technology in every aspect of learning, to their ability to learn in new ways outside the classroom, this generation of students is pushing the boundaries of education. The use of digital media in education has led to an increase in the use of and reliance on interactive learning, which in turn has led to a revolution in the fundamental process of education. Increasingly, students and teachers rely on each other to access sources of knowledge and share their information, expanding the general scope of the educational process to include not just instruction, but the expansion of knowledge. The role change from keeper of knowledge to facilitator of learning presents a challenge and an opportunity for educators to dramatically change the way their students learn. The boundaries between teacher and student have less meaning with interactive learning.

3.3 Intelligent Tutoring System

An intelligent tutoring system (ITS) is a computer system that aims to provide immediate and customized instruction or feedback to its learners during a task,[joseph p]without intervention from humans. ITSs have maintained the common goal of enabling learners to acquire information in a meaningful and effective manner by employing tools from a range of different technologies to direct the task at hand. There are numerous examples of ITSs being used in both education and professional settings since the mid-1920s. As a result, there is a strong relationship between ITSs, cognitive learning theories and instructional design. As with any mechanism for learning, ITSs have experienced its share of successes and limitations with continuous research investigating the best approach to addressing the dialogues and affective responses to learning. Research in ITS organizes the "problem" in [1] knowledge about a domain, [2] knowledge about the learner, and [3] pedagogy (knowledge of teaching strategies). The major components of a typical ITS are an expert (or domain) model, student model and tutoring model. The expert model should be able to solve the problems the tutoring module submits to the students. The tutor module controls the interaction with the student, based on its teaching knowledge and comparisons between the student model and the domain knowledge. The student model reflects what the machine can infer about the student's cognitive state

3.4 Intelligent learning environment

An intelligent learning environment is a new kind of intelligent educational system, which combines the features of traditional Intelligent Tutoring Systems (ITS) and learning environments. An intelligent learning environment (ILE) includes special component to support student-driven learning, the environment module. The term environment is used to refer to that part of the system specifying or supporting the activities that the student does and the methods available to the student to do those activities [8]. Some recent ITS and ILE include also a special component called manual which provides an access to structured instructional material. The student can work with the manual via help requests or via special browsing tools exploring the instructional material on her own. An integrated ILE, which includes the environment and the manual components in addition to regular tutoring component, can support learning both procedural and declarative knowledge and provide both system-controlled and student-driven styles of learning.

3.5 Fuzzy Logic

Zadeh introduced the term fuzzy logic in his work fuzzy sets, where he described the mathematics of the fuzzy set theory in 1965. Fuzzy logic gives the opportunity to model conditions that are defined with imprecision. The tolerance of the fuzzy in the process of human rezoning suggests that most of the logic behind the human rezoning is not the traditional bi-valued logic, or even the multi-valued, but the logic with fuzzy values, with fuzzy connections and fuzzy rules or inferences.

3.5.1 Fuzzy sets

Fuzzy sets are an extension of the classic set theory and, as it name implies it, it is a set with boundaries not well defined, this means that the transition of belonging or not belonging to certain set is gradual, and this smooth transition is characterized by grades of membership that gives the fuzzy sets flexibility in modeling linguistic expressions commonly used, such as the weather is cold or Gustavo is tall.

Figure 2.1.Key-Value example.

3.5.2 Fuzzy logic controller

Fuzzy control is a control method based on fuzzy logic. Just as fuzzy logic can be described simply as computing with words rather than numbers fuzzy control can be described simply as control with sentences rather than equations. The collection of rules is called a rule base. The rules are in the familiar if-then format, and formally the if side is called the antecedent and the then side is called the consequent. Fuzzy controllers are being used in various control schemes; the most used is the direct control, where the fuzzy controller is in the forward path in a feedback control system. The process output is compares with a reference, and if there is a deviation, the controller takes action according to the control strategy. In a feed forward control a measurable disturbance is being compensated, it requires a good model, but if a mathematical model is difficult or expensive to obtain, a fuzzy model may be useful. Fuzzy rules are also used to correct tuning parameters. If a nonlinear plant changes operating point it may be possible to change the parameters of the controller according to each operating point. His is called gain scheduling since it was originally used to change process gains. A gain scheduling controller contains a linear controller whose parameters are changed as a function of the operating point in a preprogrammed way. It requires thorough knowledge of the plant, but it is often a good way to compensate for nonlinearities and parameter variations. Sensor measurements are used as scheduling variables that govern the change of the controller parameters, often by means of a table look-up.

3.6 Learning object

Learning object design raises issues of portability, and of the object's relation to a broader learning management system. Learning objects are the basic elements of current Learning Management Systems (LMS) and are the focus of standardization initiatives whose goal is defining open technical standards and their characteristic metadata [6]. The most important initiatives are the Advanced Distributed Learning Initiative (ADL-SCORM) [7], the Instructional Management System Project (IMS) [8], the Alliance of Remote Instructional Authoring Distribution Networks of Europe (ARIADNE) [9], and the IEEE Learning Technology Standards Committee [10]. The main objective of these open standards is to enable the interoperability of learning objects between different LMSs and Learning Objects Repositories (LORS). Basic metadata schema specifications for learning objects include: Learning Object Metadata (LOM). Based on the Dublin Core metadata [11] this specification defines a set of meta- data elements that can be used to describe learning resources. LOM Includes educational, relation, technical, and classification elements [7]. Content Aggregation Model (CAM). CAM defines a package for the aggregation, distribution, management, and deployment of learning objects. Defines an organization element which contains information about one particular, passive organization of the material, the organization for now is limited to a tree structure [8]. Learner Information (LI). A collection of information about a learner or a producer of learning content, the elements are based upon accessibilities; activities; affiliations; competencies; goals; identifications; interests; qualifications, certifications and licenses; relationship; security keys; and transcripts [8]. Sequence and Navigation (SN). SN defines a method for representing the intended behavior of an authored learning experience such that any Learning Technology system (LTS) can sequence discrete learning activities in a consistent way. Provides a rule based sequencing of behaviors [7]. These standards have been the basis for various research projects in eLearning [11] and also extensions to support adaptability have been proposed [13], [14], [15]. Certain limitations of these specification initiatives have been noticed mainly regarding their weak support for the instructional design of the educational resources and pedagogy [16].

3.7 NoSQL

In computing, NoSQL (sometimes called "not only SQL") is a broad class of systems management databases that differ from the classical model of relational database management system (RDBMS) in important aspects, the most prominent is that they are not using SQL as the primary query language. The stored data do not require fixed structures such as tables, typically do not support JOIN operations, not fully guarantee ACID (atomicity, consistency, isolation and durability), and usually scale well horizontally. The NoSQL systems are sometimes called "not only SQL" to underline the fact that they can also support query languages like SQL. The NoSQL databases Systems grew with major Internet companies like Google, Amazon, Twitter and Facebook. These had to face challenges with data processing than traditional RDBMS not solved. With the growth of the web in real time there was a need to provide processed information from large volumes of data that had more or less similar horizontal structures. These companies realized that the performance and real-time properties were more important than consistency, in which the traditional relational data bases devoted a lot of processing time. In that sense, often, NoSQL databases are highly optimized for operations retrieve and add, and usually do not offer much more than the functionality of store records (eg key-value storage) that we can see on figure 4.2. The loss of flexibility at run time compared to conventional systems SQL, is offset by significant gains in scalability and performance when it comes to certain data models.

3.7.1 Key-Value example

Typically the modern relational data bases have shown little efficiency in certain applications that use data intensively, including indexing of a large number of documents, presentation pages sites with high traffic, and sites audiovisual streaming. Typical implementations of RDBMS have tuned either for a small but frequent reads and writes or a large set of transactions that have few write accesses amount. On the other hand it can serve NoSQL lot of load of reads and writes.

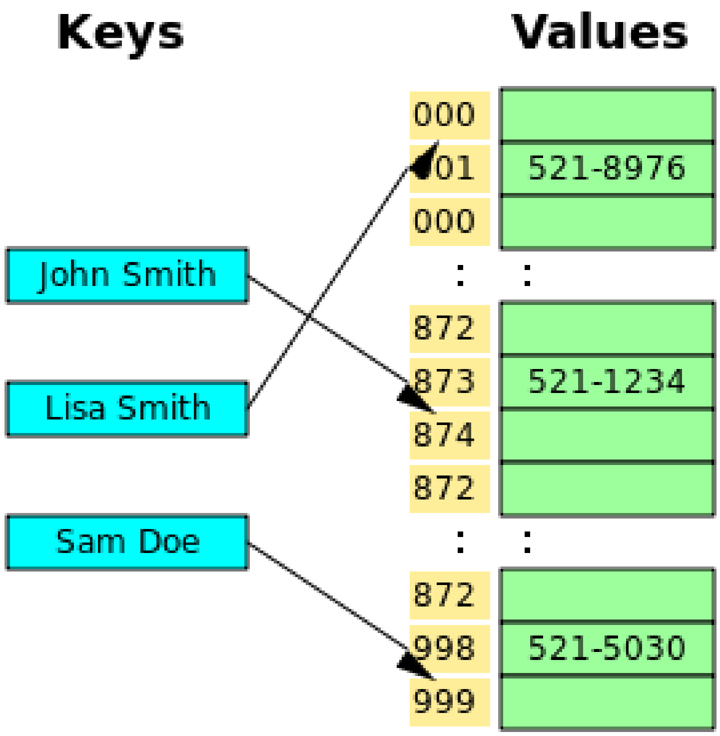


Figure 3.1: Key-Value Storage

3.7.2 Advantages of NoSQL systems

This way of storing information provides certain advantages over relational models. Between the most significant advantages can include: They are executed in machines with limited resources: These systems, unlike based systems SQL, not just require computer, so they can be mounted on machines of a lower cost. Horizontal Scalability: To improve the performance of these systems is achieved simply adding more nodes, with the only operation of the system indicate which nodes are available. Can handle large amounts of data: This is because it uses a distributed structure, Hash many cases using tables. Do not generate bottlenecks: The main problem with SQL systems is that they need to transcribe each sentence to be executed, and each complex sentence also requires a level even more complex implementation, which is an entry point in common, that before many requests can slow down the system.

3.7.3 Main differences with SQL databases

Some of the most remarkable differences we can find between NoSQL systems and SQL systems are: Do not use SQL as a query language. Most NoSQL databases avoid using this kind of language or use it as a language support. To give some examples, Cassandra uses CQL language, MongoDB uses JSON or BigTable uses GQL. Not use fixed structures as tables for storing data. Let you use other types of storage models as key-value systems, objects or graphs. Tend not allow JOIN operations. By having a data volume so extremely large is often desirable to avoid the JOIN. This is because, when the operation is not the search for a key, the overhead can become very costly. The most straightforward solutions consist of denormalising data or perform the JOIN by software in the layer application. Distributed architecture. The relational databases are typically centralized in a single machine or in a master-slave structure, however in cases NoSQL information it can be shared across multiple machines through mechanisms of distributed hash tables.

3.7.4 Types of NoSQL databases

Depending on how you store the information, we can find various types other than NoSQL databases. Consider the most commonly used types. Key-Value Database: They are the base model popular NoSQL data, besides being the simplest in terms of functionality. In this type of system, each element is identified by a unique key, allowing the retrieval of information very quickly, which is usually stored information as a binary large object (BLOB). They are characterized by being very efficient for both readings and for scriptures. Examples of this type are Cassandra, HBase or BigTable.

Document databases: They are the base model popular NoSQL data, besides being the simplest in terms of functionality. In this type of system, each element is identified by a unique key, allowing the retrieval of information very quickly, which is usually stored information as a binary large object (BLOB). They are characterized by being very efficient for both readings and for scriptures we can see an example of this kind of data base on the figure 2.3. Examples of this type are Cassandra, HBase or BigTable.

Graph databases: In this type of databases, information is represented as nodes of a graph and its relations with the edges thereof (Figure 2.4), so that you can make use of graph theory to cover it. To remove the most of this type of database, its

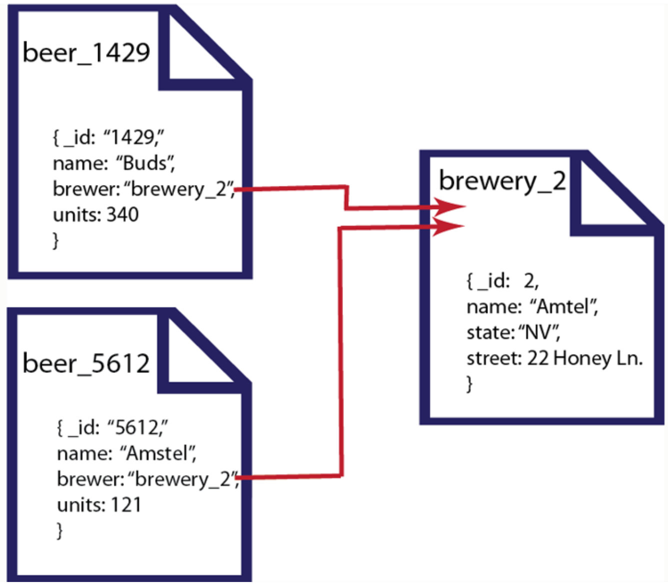


Figure 3.2: Document Database Example

structure must be fully normalized, of so that each table has a single column and each relationship both. This type of database provides a more efficient navigation between relationships vs a relational model. Examples of this type are Neo4j, InfoGrid or Virtuoso.

3.7.5 Examples of NoSQL databases

Here are some examples of the most commonly used nosql databases.

Cassandra: This is a database created by Apache key-value type. It has its own language for CQL (Cassandra Query Language) queries. Cassandra is a Java application so it can run on any platform that has the Java Virtual Machine.

MongoDB: This is a database created by 10gen document-oriented type, Free

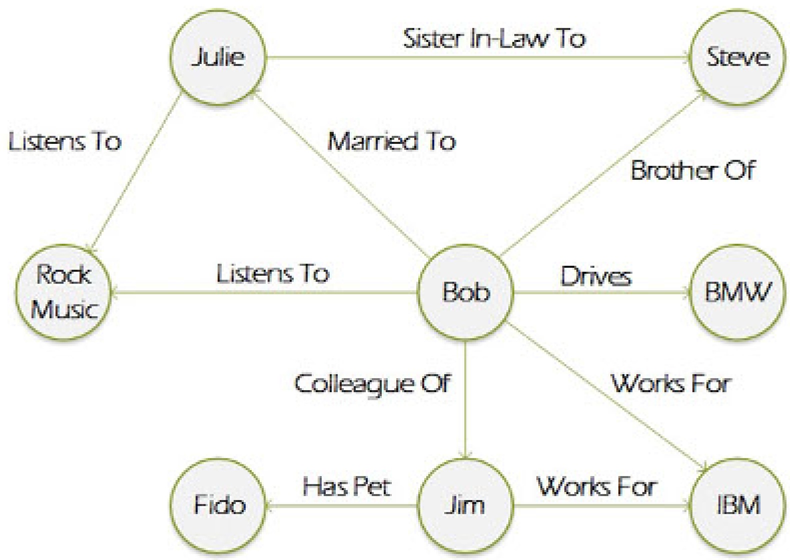


Figure 3.3: Graph Database Example

cassandra

Figure 3.4: Nosql Database Cassandra

scheme is meaning that each input can have a different data schema that has nothing to do with the rest stored records. It's pretty quick to run its operations as it is written in C ++ language. For information storage, uses a proprietary system known document with the BSON name, which is an evolution of the popular JSON but with the peculiarity that can store binary data. Soon, MongoDB has become one of the bases of popular NoSQL data by developers.

Figure 3.5: Nosql Database MongoDB

CouchDB: It is a system created by Apache and written in Erlang language that works in most POSIX systems, including GNU / Linux and OSX, but not in Windows systems. The most important features include the use of Restfull HTTP API as an interface and JavaScript as the main language of interaction. For storage of data files used JSON.Allows creation of views, which are the mechanism that allows the combination of documents return values of several documents, ie, CouchDB allows performing operations JOIN Typical SQL.

Figure 3.6: Nosql Database CouchDB

Chapter 4

The Proposed Method

In this chapter, an architecture for developing interactive learning environments is proposed. The architecture allows the use of techniques of adaptive hypermedia systems and use in interactive environments. This architecture has as resources environmental learning objects, which are presented to users through the various devices that can be part of this environment and are organized by a sequence based on Simple Sequencing. Also a new method to automate the measurement of the level of attention of the user without using invasive methods. In Figure **??** we can observe the components of this architecture. As this environment has multiple configurations of use, sometimes it can help a fuzzy inference system to adapt the information presented by the environment to users. The components of the architecture are described in detail.

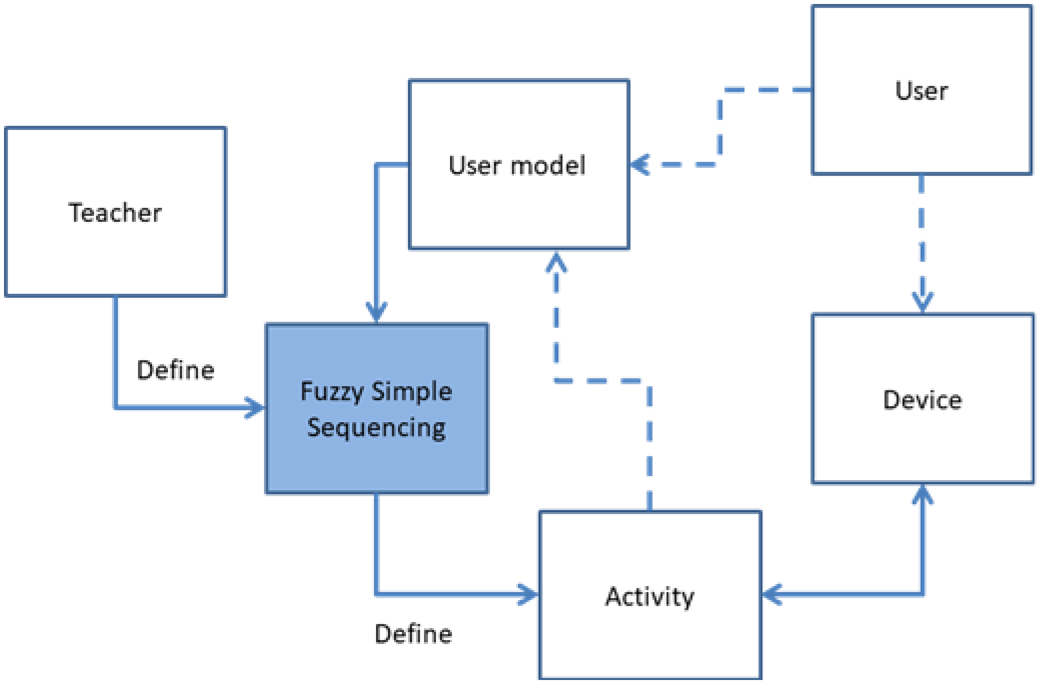


Figure 4.1: Adaptive Learning Environment Architecture

4.1 Environment

Intelligent environments are spaces with embedded systems, sensors and information and communication technologies that are becoming imperceptible to the average user that are being integrated into physical objects, infrastructures, the environment in which we live, work and many other environments. Intelligent interactive environments provide tools with which users can interact, which makes this space interactive so that the computer is closer to the user. There are other types of environments such as e-learning that are virtual learning environments where a user learns individually certain topics from learning objects. The work in this type of learning environments has used different techniques to sequence and select learning objects to cover the learning needs of the individual such as simple sequencing (referencia a la tesis del profe).

Figure 4.2: E-Learning

The problem we notice is that most of them focus on a single solution, either oriented to learning, modify the environment, that handle only one user at a time. In reviewing the literature we realized that by combining certain standards there is an improvement in the user's learning experience. Currently there are certain limitations with intelligent environments such as:

- Learning environments are designed so that learning objects are used by one user at a time.
- Contextual information is sometimes not considered.
- Usually the environment can not be taken to other places without having to make modifications.
- Some works with environments use devices that are not as advanced as they are now, and have become more accessible economically.

We propose to generate an environment that thanks to a web service is capable of attacking all the limitations that we observe in the current learning environments. Thanks to the web services we can create repositories that can be available as long as there is an internet connection. But what about those places where there is no such connection? For these cases you can take a repository that serves as a local to be able to obtain learning objects or content. In addition the environment is focused to serve a group of users.

The proposed learning environment has several uses, the first of them and obviously as a learning environment, as a museum exhibitor, training, entertainment, advertising, games. And this is possible thanks to the web service that allows to use different learning objects and of different types in any device that is able to run a web browser and that it is available. Then we will be concerned with the learning part, the modification of the environment and the user resulting in a learning environment that can be manipulated or adjusted to the needs of the users. In order to carry out this, we propose a new learning object methodology, which we will call "Environmental Learning Object", this object will be used in a learning environment where users can interact with it. We will speak more specifically about this proposal later.

4.2 ELO

They are self-contained. Each learning object can be used independently. Are reusable. A learning object can be used in different contexts, for multiple purposes. Can be added. Learning objects can be grouped into collections, after being presented with a traditional course structure. Are labeled with metadata. Each learning object has associated certain in-formation that describes it. This facilitates reuse by automatic means. We propose a learning environment that uses a new type of learning object which we call "Environmental Learning Object" (ELO) these objects include additional metadata that can be used to identify and manage content for their use in ubiquitous devices: we considered input and output devices e.g. interactive tables, wall projections, monitors, tablets, cameras, microphones and speakers. By tagging through the metadata we can make a selection of learning objects to create and manage different contexts when applied to a learning environment as we can note in Figure. Where each learning object is selected and routed to a device that operates its utility like a sound file that cant be used on a monitor maybe on a Smartphone or a tablet pc, these are the types of problems that can occur when using these learning objects. Also this ELO will give contextual information for feedback.

Objeto de Aprendizaje Ambiental (OAA) es un objeto de aprendizaje que permite la distribucin de contenido a diversos dispositivos con la condicin de que deben estar disponibles y ser compatibles en un ambiente de aprendizaje interactivo. Un objeto de aprendizaje ambiental (OAA) se determina por la tupla ¡O,D¿ donde O es un conjunto de objetos de aprendizaje y D es un conjunto de Dispositivos. OOA=((O,D),D)

Donde un objeto de aprendizaje o ? O objetos de aprendizaje como entidades, digitales o no digitales, que pueden ser utilizadas para promover el aprendizaje, educacin o entrenamiento. Y un dispositivo d ? D dispositivos con la condicin de que deben estar disponibles y ser compatibles en un ambiente de aprendizaje interactivo.

4.3 Fuzzy simple sequencing

Simple sequencing standard[18] [19], which allows sequencing of this type of learning objects. First an activity tree with n number of activities is determined by the teacher, selecting the learning objects to be used per activity and adding fuzzy precondition rules that consider the context and user model to determine the sequence, for example: IF Context.Temperature is HIGH and Session.Activity.Place is OUTSIDE THEN this.Precondition. = SKIP. Then context information is obtained from users using the sensors mentioned above, each activity will have 1 or more environmental learning objects, thanks to the metadata included in the learning objects will be displayed in the appropriate device for example if we have a web page can be displayed on a monitor, a questionnaire on a tablet, a video projected on a wall, sound on speakers, an interactive game on the table as we can see in Figure 3. The main components of the Simple Sequencing standard are the Learning Activities and the Activity Tree. A Learning Activity is defined as a pedagogically neutral unit of instruction, knowledge, evaluation, etc. Learning Activities can have nested sub-activities arbitrary depth. There is an implicit hierarchy of containers in the tree. Depending on the application concept labels can be applied to learning activities. Only leaf nodes can be associated with Resources Activity (the equivalent of Learning Objects).An example of the configuration obtained by sequencing can be observed in Figure 3.2. The tree is traversed as follows from the root there is the General activity (can be any subject in particular) with 2 nodes in it, we see that has the attribute "forwardOnly" on true, this means they have to be traveled sequentially by users, the first activity is a pre-evaluation, which is associated with a learning object in this case a test that contains a rule that makes the activity is carried out or otherwise will not advance to the next activity, as specified in the Pre_condition rule. When a learning sequence is generated learning activities are established and they not change, what changes is the action as if you skip, performed, jump, hide, repeat or show an activity, this decision is taken by the rules of precondition. In this paper we seek to generate diversity of resources displayed in the activities adapting the resources of the activity to the user, for example we have an introductory activity of a particular subject and 2 users of different ages perform the activity, the first user of 25 years will be shown more detailed and textual information, while the second user of 6 years of age is in a very early stage of learning resources that show you are easier to understand and have more audio-visual content. With fuzzy logic generate inputs for use in the precondition rules for example: fuzzy rule if user.age is low and user.academic_level is low then user.level is begginer.

On the precondition rule we will use the output of the fuzzy rule will use the output of that fuzzy rule as follows if user=begginer then pre_condition = show. Thus a set of resources is obtained for a novice user and these are shown on the right devices for each resource through a web browser running in this device as we can see on the figure 1.

4.4 Devices

4.5 Master / User

4.6 Engagement

The other way to obtain user information was by Kinect Sensor and is a bit more complex because the sensor provides enough information the sensor detects a user can give: engage looking away happy left eye closed right eye closed mouth open mouth moved wearing glasses yaw pitch and roll of the face Each of these data the sensor assigned one of the following Yes, No, Maybe and Unknown values; unknown data were discarded since in the sensor documentation was saying that this data could benot sensing and therefore not considered valid data. Only in the face position was a numerical data, the sensor generated an average of 14 records per second of these values sometimes less for a short time when the sensor lost sight of the user but was usually between 1 to 10 seconds. Full activity was carried out in 4 minutes 10 seconds so if the sensor not loses sight of the user throughout the activity it generates about 3500 records. From the above list of data we decided to use only engage, looking away happy and others are captured but used as they are not relevant to what we are measuring. To get textual results perform a normalization by a count of each event every 10 seconds since the data generated by the sensor are textual normalized by assigning numbers to strings for example Yes = 2, Maybe = 1 and No = 0 then for every 10 seconds of activity the Yes, No and Maybe was counted. As the activity lasted 4:10 we decided to count the sensor event every 10 seconds, at the end we gained an average of 140 records for each period of 10 seconds. Here I was a problem, as the number of records varied by user we had to think about how to normalize this data, as records were recorded and distributed yes, maybe, no the solution was to take a percentage of each of the records obtained by which thus we could handle and sensor data.

Chapter 5

Case of Study

5.1 Experiments

In this chapter we present the relevant experiments that were done to test the proposed method. Subsequently, it shows the implementation of the method in a adaptive learning environment used as case of study, deployed in different places. A wide explanation of the system interfaces and its functionality is explained also.

In this particular experimental scenario, we propose some guidelines and follows some guidelines from related work like the work of Hervas[1], Chen[2], Garcia-Valdez[22], and they are briey explained next.

- Hypothesis: before running the experiment we must form an hypothesis. It is important to be concise and restrictive about this hypothesis, and design an experiment that tests the hypothesis. For example, an hypothesis can be that adaptive environment A adapts and presents better learning objects to the user and the user likes and learn more than the environment B. In that case,the experiment should test the acceptance and assimilation of the environment including content, ease of use etc.

- Controlling variables: when comparing a few learning environments on a certain hypothesis, it is important that all variables that are not tested will stay fixed. For example, suppose that we wish to compare the acceptance and assimilation of the environment A and environment B, that both use different technologies.

- Generalization power: when drawing conclusions from experiments, we may desire that our conclusions generalize beyond the immediate context of the experiments. When choosing an environment for a real application, we may want our conclusions to hold on the deployed system.

The next sections show a comprehensive description of the experimental setup for experiments, as well as results obtained in the experiments. Each method was tested using different topics and context. This chapter ends with the description of the functionality of the prototype used to validate the method utilized in the experiments.

5.2 Adaptive Learning Environment topic 1

In earlier implementations of the adaptive environment several experiments were done to test the behavior and the performance. For the experiment the proposed hypothesis is The acceptance and accuracy of the content showed in the adaptive learning environment. The first experiment presents and adaptive learning environment used to teach the topic "El himno nacional Mexicano". Held in the Technological Institute of Tijuana.

5.2.1 Devices

The devices used in this experiment are described below. It takes a server to handle the requests, store the learning objects, generate the learning sequence and keep the web service active. In this case the server was a Gateway fx6850 computer which has 12gb ram and second generation intel i7 processor. Were used 3 monitors of different resolutions the first of 1440x900 pixels, the second of 1600x900 and the third of 1980x1080 pixels. This generated a problem when displaying images or videos but measures were taken to adapt the content to different resolutions. A tablet nexus7 with which the user could control the navigation between activities and answer some questionnaires. And headphones for sound.

Figure 5.1: Configuration of the first adaptive environment

5.2.2 Topic/Content

We selected the theme of the Mexican national anthem for the reason that it seemed to us a subject of general interest and therefore digestible for different ages and people. It began with a brief history of the national anthem involving its authors both music and lyrics and a brief synopsis of each of them in the figure 5.2 we can observe an image with the 2 characters but we show 2 images of each of the authors, depending on the user profile is shown one or another image.

As mentioned above, 3 types of users are managed based on their age. Based on the old rando a fuzzy system chooses which content to display to the user. In the

Figure 5.2: 2 learning objects.

previous image 5.2 The images of the authors of the national anthem are shown but for the type of user 2 and 3. depending on the type of user each one of the activities can change and become a little more digestible, for example for the user 3 that assumes a user More methodical and that has in the majority has better acceptance of complex information is shown more text, graphs and tables that maybe are harder to understand for users 1 and perhaps user 2. then it is the same learning activity but with small changes with respect to different users.

5.2.3 Users

The users for this experiment was a sample of laboratory colleagues, teachers, friends and children of co-workers, a group of users 10 with different profiles the prototype of the environment was used to determine the impression they had to perform a learning activity and obtain Feedback from them. This environment is intended for use in large areas but in this case a small space is used for testing. For this case

Table 5.1: List of users participating in the experiment.

User	Age	Academic level
1	6	1
2	48	19
3	23	17
4	23	18
5	23	18
6	24	17
7	31	19
8	35	20
9	45	21
10	29	19

only the age and academic level were taken, which ranges from 1 to 21 where 1 is the first year of primary school and 21 has a doctor's degree as we can see in the table 5.1.

5.2.4 Survey

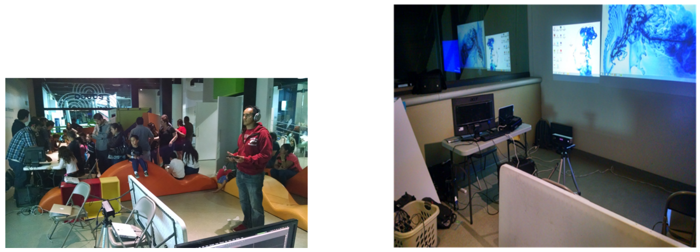
When users finished using the environment they were given a small survey, this survey consisted of 5 questions about their experience using the environment questions as if they were difficult to use or if they liked the resources shown, in order to obtain Feedback from users to make future improvements and modifications shown in the table **??**.

Table 5.2: List of users participating in the experiment.

Question	Answers
1.From 1-10 how easy it was use the environment?	1-10[ ]
2.From 1-10, how was your satisfaction about the information displayed in the environment?	1-10[ ]
3.Did you like the idea of using various visual elements?	1. Yes 2.No
4.Was necessary technical assistance to use the environment?	1. Yes 2.No
5.Would you recommend the use of this environment to others?	1. Yes 2.No

5.3 Adaptive Learning Environment topic 2

For this part of the study users immersed in an exhibitor that gave them visual and aural information as shown in Figure 5.3 on a topic selected based on various criteria, such as the location of the study on this occasion was a interactive museum and the festival of childrens day approaching we try to use a simple theme and it will bring awareness so we decided to use the theme of water where information was displayed as the uses of the same, its cycle, forms of energy that could generate, health, and the importance of it for the planet. Each of users are generating an account on the system to register their activity, after that we were made a brief explanation of how it worked the exhibitor others based on observation no longer required this explanation. The user took a tablet that was the how the user interacted with the exhibitor, with which had control of the ow of information, as the information was a sequence at the end of the last activity was a questionnaire on the information received besides a survey.



(a) User interacting with the environment.

(b) Front view of the equipt.

Figure 5.3: The environment.

5.3.1 Devices

The devices used in this experiment are described below. It takes a server to handle the requests, store the learning objects, generate the learning sequence and keep the web service active. In this case the server was a Mac Pro 2014 computer which has 12gb ram and intel xeon processor. 3 projectors of the same resolutions were used at different sizes organized as can be seen in the figure 5.4. An additional computer that performed various tasks such as displaying the contents of 2 projectors and playing the audio, a laptop to display content on the third projector and a laptop to get the data from the kinect sensor. A tablet nexus7 with which the user could control the navigation between activities and answer some questionnaires. And headphones for sound. In addition to the kinekt 2 sensor to sensing data from the user.

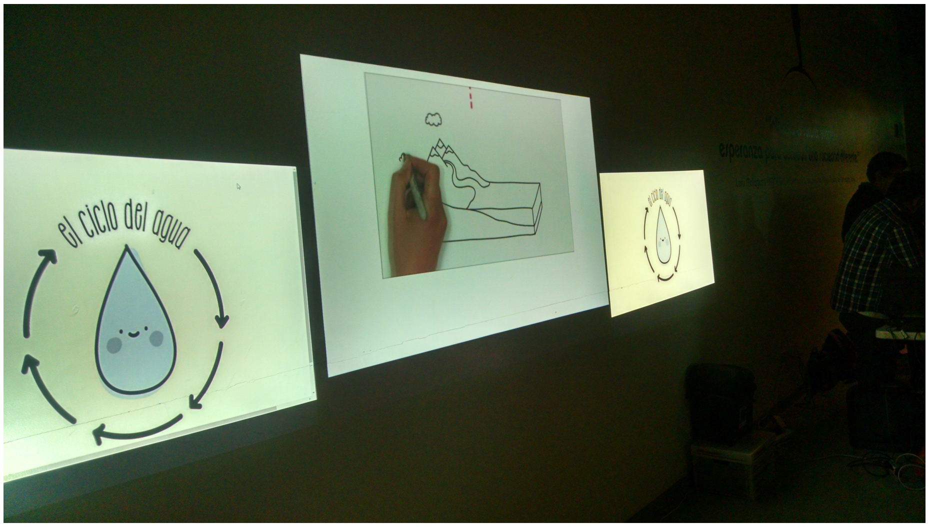


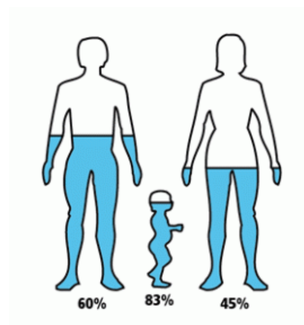
Figure 5.4: Front view of the environment.

5.3.2 Topic/Content

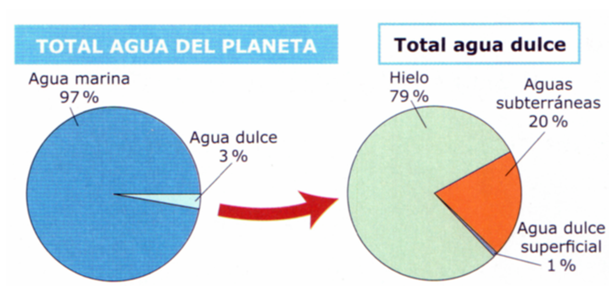
For this experiment the choice of the theme was influenced by the place and date where it would take place, the place was the interactive museum the trompe de tijuana a few days from the holiday "El dia del Nio" so we decided to choose a subject that is digestible and that makes people aware. The chosen theme was "Water Care" where they were collected around 23 different images, 8 audios, 1 video in the figure 5.5.

The information shown by the activity was from the water cycle, its importance for our health, the energy produced by it, besides the care that must be taken with it and how to avoid contamination. The activity could be completed between 8 and 10 minutes depending on the resources shown to the different users as we can see in

(a) water percent of the body



(b) ciclio del agua



(c) total de agua en el planeta

Figure 5.5: imagenes usadas en la secuencia de aprendizaje.

the figure 5.6.

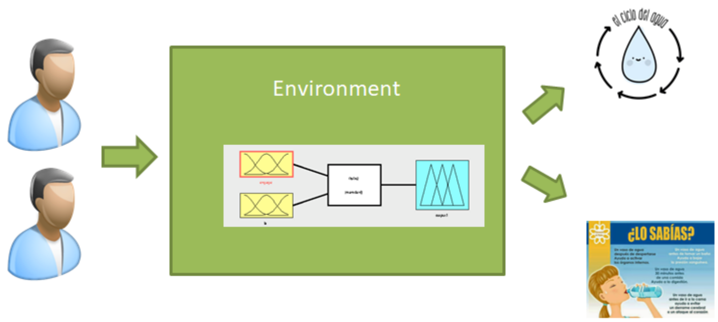


Figure 5.6: How to choose content to show.

5.3.3 Users

his experiment was conducted with visitors of the museums "El trompo" where 21 users divided into 2 groups participated, the rst has 10 users between 6 and 11 years 50% men and 50% women and the second group consisted of 11 users over 11 years old 66% men 44% women in the table 5.3 and in table 5.4 you can see some additional data of the 2 groups of users, additional note some users did not want to reveal their age or name, we respect their decision And they were left with the sign of? And the minority spoke another language which tested the content since it was totally in Spanish although the users still participated.

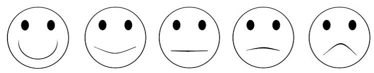
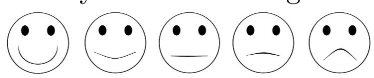
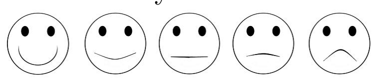
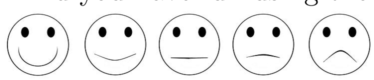
Table 5.3: List of users participating in the experiment group 1.

User	Name	Age
1	Jose	?
2	Mariof	?
3	Jaqueline	?
4	?	10
5	Alondra	38
6	Josue	10
7	Mario	14
8	Cinthya	30
9	Brisa	11
10	Hector	37
11	Enrique	12

Table 5.4: List of users participating in the experiment group 2.

User	Name	Age
1	Josue	8
2	Kevin	9
3	Monserrat	7
4	Evelin	9
5	Armando	8
6	Jorge	7
7	Gemma	8
8	Perla	8
9	Quetzal	7
10	?	6

Table 5.5: Survey to the user group 1.

Question
1.Did you like what you saw in the activity you just did? 
2.Did you like watching different pictures and videos? 
3.Was it easy to use the station? 
4.Did you have fun using the station? 

5.3.4 Survey

When the users finished using the environment they were given a small survey, depending on the user, we applied one or another survey that we can observe in the table 5.1 and the table 5.7 respectively.

5.4 Adaptive Learning Environment topic 3

This experiment was carried out in the technological facilities of tijuana, adjusting our prototype with the feedback of the second experiment. To be able to attend more users in this occasion the activities were the same for all this allowed a better reading of data to the users and minimized the time of use of each user in the activity.

Table 5.6: Survey to the user group 2.

Question
1.I found useful for my learning this station? 1 2 3 4 5
2.Using this station allowed me to learn more things faster? 1 2 3 4 5
3.The use of several images increased my understanding of the subject? 1 2 3 4 5
4.It was easy for me to use the station? 1 2 3 4 5
5.I can explain to someone how to use the station? 1 2 3 4 5
6.Using this station allowed me to learn more things faster? 1 2 3 4 5
7.I think that including this station in the museum was a good idea 1 2 3 4 5
8.I liked to use the station 1 2 3 4 5

This study was very similar to the last one that had some small modications and additions, now the user no longer had control ow only observe and also to observe the user now will take video and sensor, the theme of the exhibition were video games and lm as the age of the users would go for almost 17 years and older could be topics of their interest. In the same way as in the rst part each user had an account to record the activity only this occasion the data produced by the sensor and videos captured by the camera would be recorded, and in the same way as in the rst part at the end we surveyed the users. For the rst part of the study we get data from the survey conducted at the end, in the second they are collected and used data from sensors, this data were a bit more complex, rst we need an observer to evaluate the user manually, where the observer determined whether the user was putting attention to what he saw or distracted and based on that assigned a level of attention on a scale of 1 to 3 where 1 is little attention 2 average attention and 3 very attentive.

5.4.1 Devices

The devices used in this experiment are described below. It takes a server to handle the requests, store the learning objects, generate the learning sequence and keep the web service active. In this case the server was a Mac Pro 2014 computer which has 12gb ram and intel xeon processor. 2 projectors of the same resolutions were used at different sizes organized as can be seen in the figure 5.7. An additional computer that performed various tasks such as displaying the contents of 2 projectors and playing the audio and a laptop to get the data from the kinect sensor.

5.4.2 Topic/Content

To choose the theme to show in the environment we decided to opt for subjects of interest to the population of users who were video games and the cinema. The video about the video games was about the video game league of legends and the movie video was an explanation of the trilogy of starwars in 2 minutes with legos as we can see in the figure ref fig: legolol. The reason for choosing these topics

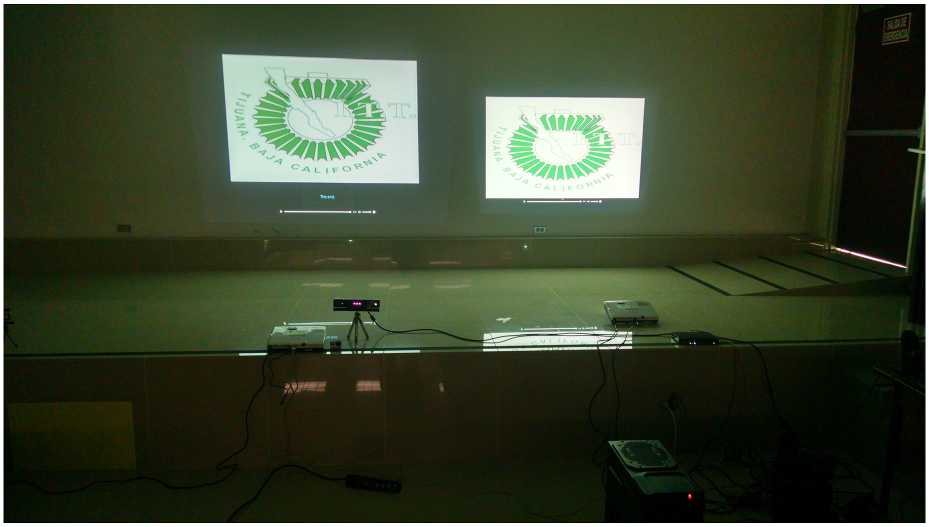


Figure 5.7: Configuration of the last adaptive environment

was the population of users who would use the environment in this experiment the vast majority of the same ages. The first video showed a story and the second was a video tutorial.

(a) StarWars Lego. (b) League of Legends.

Figure 5.8: The environment.

5.4.3 Users

Participaron un total de 41 users of the Technological Institute of Tijuana were used aged between 18 and 50 years 66 % men 34 % women.

5.4.4 Survey

When the users finished using the environment they were surveyed to know the tastes of the users and tie the results of the survey with the results of the experiment, which we will observe in more detail later. Below is the table with survey questions.

Table 5.7: Survey to the user group.

Age:____________ Video 1
1.How much did you like the video 1? 1 2 3 4 5
2.How much did you like the main video? 1 2 3 4 5
3.How much did you like the complementary video? 1 2 3 4 5
Video 2
1.How much did you like the video 1? 1 2 3 4 5
2.How much did you like the main video? 1 2 3 4 5
3.How much did you like the complementary video? 1 2 3 4 5
How often do you use video games? 1 2 3 4 5
How often do you go to the cinema? 1 2 3 4 5
To play you like
6.Using this station allowed me to learn more things faster? Phone 1 2 3 4 5
Tablet 1 2 3 4 5
PC 1 2 3 4 5
Console 1 2 3 4 5
Mention 2 of your favorite video games.
1.How much did you like Star Wars? 1 2 3 4 5
2.How much did you like Legos? 1 2 3 4 5
3.Did you like the way the information was presented? 1 2 3 4 5

Chapter 6

Environment Evaluation

In order to evaluate the performance of the environment we will have to separate the results obtained between the 3 experiments since each of them means different things or different situations. For the first experiment we focused on the acceptance of the environment among the first users who could use the environment as we will remember the users of that experiment taking the results of the survey, in the second experiment was expected to evaluate the analysis of the level of attention of the users with the kinect sensor in the section of experiment 2 will discuss why these data were not used, leaving us with surveys to evaluate users. Finally in the third experiment we used a survey to evaluate user acceptance and preferences, determine their level of attention manually through a video and determine their level of attention automatically with the kinect sensor.

Table 6.1: Survey part 1.

Question	Mean
From 1-10 how easy it was use the environment?	9
From 1-10, how was your satisfaction about the information displayed in the environment?	9

6.1 Results experiment 1

When users finished using the environment they were given a small survey, this survey consisted of 5 questions about their experience using the environment questions as if they were difficult to use or if they liked the resources shown, in order to obtain Feedback from users to make future improvements and modifications. The evaluation of the first prototype that we remembered was a learning activity of the Mexican national anthem with the participation of 10 users, the 10 users concluded the activity to the end and answered the survey that was presented in the table 5.1.

As we can see the results on a scale of 1 to 10 users rated with an average of 9 how easy it was to use the environment, while for so satisfactory information we got a 9 on average on the other hand we got an average of 8 As far as content acceptance is concerned, none of us need assistance with using the environment and 100% users would recommend others to use that kind of environment. It is noteworthy that

Table 6.2: Survey part 2.

Questions	Answer	Frequency
Did you like the idea of using various visual elements?	Yes	8
	No	2
Was necessary technical assistance to use the environment?	Yes	0
	No	10
Would you recommend the use of this environment to others?	Yes	10
	No	0

there were positive behaviors not expected by users when using the environment, for example the smallest of users was so immersed in content that the activity where the lyrics of the national anthem is taught I sing it if I realize that many adults They were watching them when perhaps many of us would restrain ourselves by having public through other people were surprised to see the content and learn details of the national anthem of their country that they did not know and others were very excited to see content that reminded them of things they lived in the past.

6.2 Results experiment 2

For the results of this experiment we will remember that the learning theme was modified and adjusted to the aforementioned parameters, the participating users were 21 and the evaluation used to measure the level of acceptance was with a survey and although the first prototype was used to analyze The level of attention of the users the information collected by this was not enough mind enough to get something from it even so later some details of the data will be shown and explained because we consider that they were not significant for the experiment. Then the results of the surveys can be seen in the tables 6.3 and 6.4.

Table 6.3: List of users participating in the experiment 2 group 1.

User	q1	q2	q3	q4	q5	q6	q7	q8
1	5	5	3	2	5	5	5	5
2	5	5	5	4	4	5	5	5
3	4	4	4	5	5	5	4	4
4	5	4	5	3	5	5	5	5
5	5	4	5	4	3	5	4	5
6	5	5	4	5	5	5	5	5
7	4	5	3	5	5	3	4	5
8	5	4	5	5	5	5	5	5
9	5	5	5	5	5	5	4	5
10	4	3	5	4	4	4	3	3
11	4	5	5	5	3	5	5	5
EST. DEV.	0.50	0.69	0.82	1.01	0.82	0.65	0.69	0.65
MEAN	4.64	4.45	4.45	4.27	4.45	4.73	4.45	4.73

Table 6.4: List of users participating in the experiment 2 group 1.

User	q1	q2	q3	q4
1	2	4	5	3
2	5	5	5	5
3	5	4	5	5
4	4	5	5	3
5	5	5	4	5
6	5	5	5	4
7	4	5	4	4
8	5	5	4	5
9	5	4	5	5
10	5	5	5	5
DESV.EST.	0.97	0.48	0.48	0.84
PROMEDIO	4.5	4.7	4.7	4.4

The results of the surveys show a good acceptance of the way information is presented, the information displayed and the devices used. We obtained 90.8 % acceptance in general. Now the results of the kinect sensor recalling the data that we showed in previous chapters we decided to take "Engage", "Happy" and "Looking Away" and automatically forecast the level of interest of the user. A sample of the data can be found in the table ref tab: kinect1. In addition to the data thrown by the sensor we took a measure of time and marked the activity that was being performed at that time.

The values of 1 and 0 meant yes or no the problem in this case was that the sensor reading was set to throw one data per second giving a very poor reading to our consideration. In this experiment the population was very interested in the

Table 6.5: Sample of data provided by the sensor kinect.

Activity	Engage	Happy	Away	time
/activity/Agua	1	0	0	1430088646
/activity/Agua	1	0	0	1430088647
/activity/Agua	1	0	0	1430088648
/activity/Agua	1	0	0	1430088649
/activity/Agua	1	0	0	1430088650
/activity/Agua	1	0	0	1430088651
/activity/Agua	1	0	0	1430088652
/activity/Agua	1	0	0	1430088653
/activity/Agua	1	0	0	1430088654
/activity/Agua	1	0	0	1430088655

topics shown we detected some inconveniences in addition to the aforementioned with the kinect sensor, some users voted poorly thematic but very well the devices and the reason was because they did not understand what they heard or read by Not dominate the Spanish language, even so they were encouraged to use the environment, another detail is that the activity lasted more than 10 minutes for certain users what seemed a long time.

6.3 Results experiment 3

With the experience gained from the 2 previous experiments and the new environment readjusted here the results of the last experiment are shown. First we analyzed the video of each of the participants and every 10 seconds we assigned a level of attention to obtain data to compare from low, medium or high. In the table 6.6 we

Table 6.6: Sample of data provided by the video footage.

User	02:10	02:00	01:50	01:40
a3	High	High	High	High
a4	High	High	High	High
a5	High	High	High	High
a6	Mid	High	Mid	High
a7	High	High	High	High
a9	High	High	High	High
a14	High	High	High	High
a15	High	High	High	High
a17	High	High	High	High
a18	High	High	High	High
a19	High	High	High	High
a20	High	High	High	High
a25	High	High	High	High
a26	Low	Mid	High	High
a27	Mid	High	High	High
a28	Mid	Low	Low	Low
a31	High	High	High	High

can see a sample of analyzed data of the video. We developed a fuzzy classifier to classify the level of attention that took the data provided by the sensor in the figure 6.1 with 3 input variables Yes, Maybe and No to give the level of attention between high, medium and low.

The results of classification were quite low giving a 59 % of pressure as we can see in the figure 6.2 adjustments were made to the classifier but we did not exceed that percentage so we chose to use other classifiers. The results obtained with different classifiers are shown below.

All classifiers were configured basically and none is optimized so that all the

Table 6.7: Desicion tree

	true Low	true Mid	true High	class precision
pred. Low	141	25	2	83.93%
pred. Mid	14	77	16	71.96%
pred. High	3	11	325	95.87%
class recall	89.24%	68.14%	94.75%	

accuracy: 88.42% +/- 5.17% (mikro: 88.44%) kappa: 0.803 +/- 0.088 (mikro: 0.804)

Table 6.8: KNN

	true Low	true Mid	true High	class precision
pred. Low	133	19	3	85.81%
pred. Mid	22	78	12	69.64%
pred. High	3	16	328	94.52%
class recall	84.18%	69.03%	95.63%	

accuracy: 87.77% +/- 4.13% (mikro: 87.79%) kappa: 0.792 +/- 0.069 (mikro: 0.791)

Table 6.9: Bayes

	true Low	true Mid	true High	class precision
pred. Low	123	13	2	89.13%
pred. Mid	13	64	14	70.33%
pred. High	22	36	327	84.94%
class recall	77.85%	56.64%	95.34%	

accuracy: 83.69% +/- 4.57% (mikro: 83.71%) kappa: 0.712 +/- 0.079 (mikro: 0.712)

Table 6.10: Neural Network

	true Low	true Mid	true High	class precision
pred. Low	144	11	3	91.14%
pred. Mid	12	88	13	77.88%
pred. High	2	14	327	95.34%
class recall	91.14%	77.88%	95.34%	

accuracy: 91.03% +/- 3.68% (mikro: 91.04%)

Table 6.11: SVM High and Low

	true High	true Low	class precision
pred. High	331	29	91.94%
pred. Low	12	129	91.49%
class recall	96.50%	81.65%	

accuracy: 91.82% +/- 3.27%
(mikro: 92.11%)

Table 6.12: SVM High and Low

	true High	true Mid	class precision
pred. High	336	29	92.05%
pred. Mid	7	84	92.31%
class recall	97.96%	74.34%	

accuracy: 92.11% +/- 3.27%
(mikro: 92.11%)

Table 6.13: SVM Mid and Low

	true Mid	true Low	class precision
pred. Low	149	31	82.78%
pred. Mid	8	82	91.11%
class recall	94.90%	72.57%	

accuracy: 85.56% +/- 3.27%
(mikro: 85.56%)

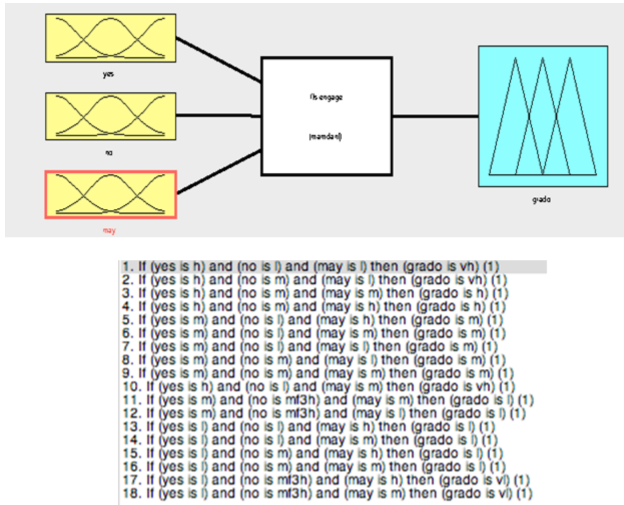
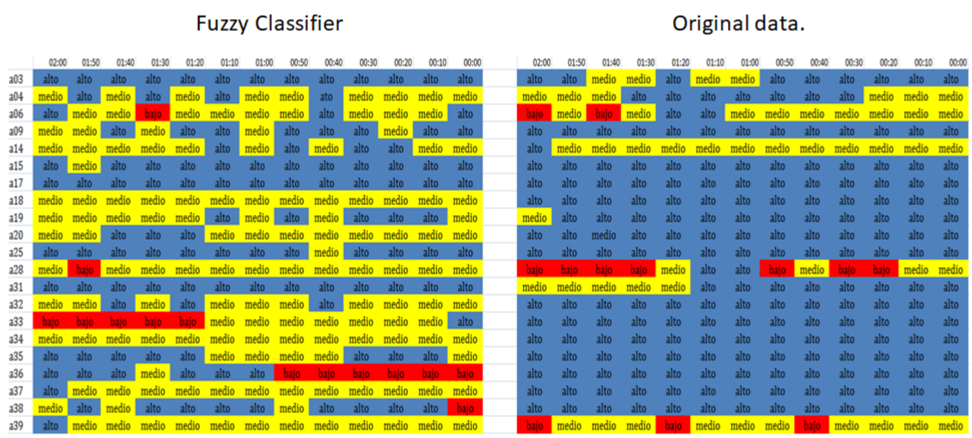


Figure 6.1: Fuzzy Classifier Setup.



Fuzzy Classifier

	02:00	01:50	01:40	01:30	01:20	01:10	01:00	00:50	00:40	00:30	00:20	00:10	00:00
a03	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto
a04	medio	alto	medio	alto	medio	alto	medio	medio	ato	medio	medio	medio	medio
a06	alto	medio	medio	bajo	medio	medio	medio	medio	alto	medio	medio	medio	alto
a09	medio	medio	alto	medio	alto	alto	medio	alto	alto	alto	medio	alto	alto
a14	medio	medio	medio	medio	medio	alto	medio	alto	medio	alto	alto	medio	medio
a15	alto	medio	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto
a17	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto
a18	medio	medio	medio	medio	medio	medio	medio	medio	medio	medio	medio	medio	medio
a19	medio	medio	medio	medio	medio	alto	medio	alto	medio	alto	alto	alto	medio
a20	medio	medio	alto	alto	alto	medio	medio	medio	medio	medio	medio	medio	medio
a25	alto	alto	alto	alto	alto	alto	alto	alto	medio	alto	alto	alto	alto
a28	medio	bajo	medio	medio	medio	medio	medio	medio	medio	medio	medio	medio	medio
a31	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto
a32	medio	medio	alto	medio	alto	medio	medio	medio	alto	medio	medio	medio	medio
a33	bajo	bajo	bajo	bajo	bajo	medio	medio	medio	medio	medio	medio	medio	alto
a34	medio	medio	medio	medio	medio	medio	medio	medio	medio	medio	medio	medio	medio
a35	alto	alto	alto	alto	alto	medio	medio	medio	medio	alto	alto	alto	medio
a36	alto	alto	alto	medio	alto	alto	alto	bajo	bajo	bajo	bajo	bajo	bajo
a37	alto	medio	medio	medio	medio	medio	medio	medio	medio	medio	medio	medio	medio
a38	medio	alto	medio	alto	alto	alto	alto	medio	alto	alto	alto	alto	bajo
a39	alto	medio	medio	medio	medio	medio	medio	medio	medio	medio	medio	medio	medio

Original data.

	02:00	01:50	01:40	01:30	01:20	01:10	01:00	00:50	00:40	00:30	00:20	00:10	00:00
	alto	alto	medio	medio	alto	medio	medio	alto	alto	alto	alto	alto	alto
	medio	medio	medio	alto	alto	alto	alto	alto	alto	alto	medio	medio	medio
	bajo	medio	bajo	medio	alto	alto	medio	medio	medio	medio	medio	medio	medio
	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto
	alto	medio	medio	medio	medio	medio	medio	medio	medio	medio	medio	medio	medio
	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto
	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto
	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto
	medio	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto
	alto	alto	medio	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto
	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto
	bajo	bajo	bajo	bajo	medio	alto	alto	bajo	medio	bajo	bajo	medio	medio
	medio	medio	medio	medio	medio	alto	alto	alto	alto	alto	alto	alto	alto
	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto
	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto
	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto
	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto
	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto
	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto
	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto	alto
	bajo	medio	medio	medio	bajo	medio	medio	medio	bajo	medio	medio	medio	medio

Figure 6.2: Fuzzy Classifier results vs Original Classifier.

results can be improved now the classifier that best result tube was the neural network with a 91.03% of pressure in terms of the classification of the level of attention of users , To reinforce these results additionally we survey the users to get an idea if the tastes of the users are consistent with their level of attention in table 6.15 we can observe this data.

Table 6.14: Results of all the classifiers used.

Classifier	Accuracy
Decision Tree	88.42% +/- 5.17%
KNN	87.77% +/- 4.13%
Bayes	83.69% +/- 4.57%
Neural Network	91.03% +/- 3.68%
SVM1	89.83%

Table 6.15: Sample of data provided by the video footage.

User	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Gender	Age
a0	5	4	2	1	5	1	2	2	1	1	5	2	2	3	4	Male	19
a1	4	5	3	5	5	4	2	1	5	5	5	4	4	3	4	Male	19
a2	3	4	3	5	5	5	4	3	4	2	4	5	5	3	5	Male	21
a3	3	2	2	4	5	2	3	4	5	3	2	5	4	4	5	Female	20
a4	5	5	5	5	5	5	5	3	4	4	5	5	4	1	5	Male	25
a5	5	5	3	5	5	2	5	4	3	3	5	4	5	5	5	Male	19
a6	3	3	2	4	3	3	3	1	4	2	4	3	3	4	4	Female	20
a7	2	4	4	5	5	3	1	4	5	3	4	4	1	2	3	Male	22
a8	1	3	3	5	5	4	5	5	4	1	5	1	4	5	3	Male	25
a9	5	5	3	3	4	3	2	4	5	1	3	5	5	1	4	Male	21
a10	4	4	4	5	4	5	3	2	2	2	4	5	4	4	5	Male	25
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
a35	5	5	5	5	5	5	4	4	5	1	5	5	1	4	5	Female	25
a36	4	5	4	4	4	3	3	2	3	4	5	5	3	5	5	Female	22
a37	4	4	4	5	4	4	4	3	3	2	4	5	3	3	4	Male	22
a38	2	2	1	4	3	2	2	2	1	5	1	1	1	2	3	Female	32
a39	4	5	3	5	5	3	5	3	2	2	5	3	5	4	5	Male	30
a40	4	4	1	3	3	1	2	2	3	5	2	5	4	1	4	Male	38

Chapter 7

Conclusions and future work

In this research work, an interactive learning environment was developed with multiple uses as a museum exhibitor, entertainment, advertising, etc. The main feature of this learning environment is that it has a special learning object that when combined with the environment allows it to be what was mentioned before. The performance of this environment is measured in several tests with real users, the environment in its early versions was tested with ”local users” (Users within the scope of the laboratory) to measure the acceptance of this type of technology and how easy it was to use The environment in which we had good results.

In the second version we moved to the interactive museum in Tijuana The spinning wheel where the objective of the test was to use it with users of different ages and to observe the reactions of these same ones from this version we used the sensor of Kinect 2 to observe the user but the obtained information Was not good enough to use it, this time the environment with information given by the user was able to modify the information shown in an attempt to adapt the information and be more attractive to the user. When we could not use the information given by the sensor we chose to keep the surveys we applied to the users, which showed very good acceptance in the majority, the few who did not agree were children under 6 years old who showed little interest and A level of distraction a little high we attribute this to the children were foreigners and did not have very little Spanish language that was the language that managed the environment.

In the last version of the environment was used in the technological institute of Tijuana using a more homogeneous group of users who were students and some teachers of the school, in this test users in addition to being observed by the sensor were also taken video for Analyze it and have a reference for the results of the classification of data given by the sensor also applied a survey to users to identify the tastes in terms of information and devices used by users. Each of the tests the environment evolved thanks to the information provided by users to go from something very simple like just showing pictures to show videos, play audio. After some modifications we were able to manipulate content and sequence it.

Appendix A

Technical support of installation

Dependencies of the application

- Django framework 1.3-1.7.

  Url: https://www.djangoproject.com/download/

- Redis.

  Url: https://redis.io/

- CouchDB.

  Url: http://couchdb.apache.org/

- SQlite

  Url: https://www.sqlite.org/

- Visual Studio 2015.

  Url: https://www.visualstudio.com/downloads/

- PostgreSQL database.

  Url: http://www.postgresql.org/

- Psycopg2 connection to database.

  Url: http://initd.org/psycopg/docs/install.html

- Kinect for Windows SDK Url:https://www.microsoft.com/en-us/download/details.aspx?id=44561

Bibliography

[1] José Bravo, Ramón Hervás, G Chavira, S Nava, and Jorge Sanz. Display-based services through identification: An approach in a conference context. *Ubiquitous Computing & Ambient Intelligence (UCAmI05). Thomson. ISBN*, pages 84–9732, 2005.

[2] C. M. Chen, Y. L. Li, and M. C. Chen. Personalized Context-Aware Ubiquitous Learning System for Supporting Effectively English Vocabulary Learning. In *Seventh IEEE International Conference on Advanced Learning Technologies (ICALT 2007)*, pages 628–630, July 2007. doi: 10.1109/ICALT.2007.202.

[3] Andrés Chiappe Laverde, Yasbley Segovia Cifuentes, and Helda Yadira Rincón Rodríguez. Toward an instructional design model based on learning objects. *Educational Technology Research and Development*, 55(6):671–681, Dec 2007. ISSN 1556-6501. doi: 10.1007/s11423-007-9059-0. URL http://dx.doi.org/10.1007/s11423-007-9059-0.

[4] Hui-Chun Chu, Gwo-Jen Hwang, Chin-Chung Tsai, and Judy C.R. Tseng. A two-tier test approach to developing location-aware mobile learning systems for natural science courses. *Computers & Education*, 55(4):1618 – 1627, 2010. ISSN 0360-1315. doi: http://dx.doi.org/10.1016/j.compedu.2010.07.004. URL http://www.sciencedirect.com/science/article/pii/S0360131510001879.

[5] A. Dattolo and V. Loia. A fuzzy approach to adaptive hypermedia. In *Knowledge-Based Intelligent Engineering Systems and Allied Technologies, 2000. Proceedings. Fourth International Conference on.*, volume 2, pages 700–703 vol.2, 2000. doi: 10.1109/KES.2000.884142.

[6] Henry H. Emurian, Heather K. Holden, and Rachel A. Abarbanel. Managing programmed instruction and collaborative peer tutoring in the classroom: Applications in teaching Java. *Computers in Human Behavior*, 24 (2):576 – 614, 2008. ISSN 0747-5632. doi: http://dx.doi.org/10.1016/j.chb.2007.02.007. URL http://www.sciencedirect.com/science/article/pii/S0747563207000532. Part Special Issue: Cognition and Exploratory Learning in Digital Age.

[7] R. Gerard. Shaping the mind: Computers in education. *Applied Science and Technological Progress: A Report to the Committee on Science and Astronautics*, 1967.

[8] Jaime Glvez, Eduardo Guzmn, and Ricardo Conejo. A blended E-learning experience in a course of object oriented programming fundamentals. *Knowledge-Based Systems*, 22(4):279 – 286, 2009. ISSN 0950-7051. doi: http://dx.doi.org/10.1016/j.knosys.2009.01.004. URL http://www.sciencedirect.com/science/article/pii/S0950705109000203. Artificial Intelligence (AI) in Blended Learning.

[9] Irene Govender. The learning context: Influence on learning to program. *Computers & Education*, 53(4):1218 – 1230, 2009. ISSN 0360-1315. doi: http://dx.doi.org/10.1016/j.compedu.2009.06.005. URL http://www.sciencedirect.com/science/article/pii/S0360131509001523. Learning with ICT: New perspectives on help seeking and information searching.

[10] Matthias Hauswirth and Andrea Adamoli. Teaching Java programming with the Informa clicker system. *Science of Computer Programming*, 78(5): 499 – 520, 2013. ISSN 0167-6423. doi: http://dx.doi.org/10.1016/j.scico.2011.06.006. URL http://www.sciencedirect.com/science/article/pii/S0167642311001468. Special section: Principles and Practice of Programming in Java 2009/2010 & Special section: Self-Organizing Coordination.

[11] H. Wayne Hodgins. The Future of Learning Objects. *e-Technologies in Engineering Education: Learning Outcomes Providing Future Possibilities*, 2002.

[12] Gwo-Jen Hwang. A conceptual map model for developing intelligent tutoring systems. *Computers & Education*, 40(3):217 – 235, 2003. ISSN 0360-1315. doi: http://dx.doi.org/10.1016/S0360-1315(02)00121-5. URL http://www.sciencedirect.com/science/article/pii/S0360131502001215.

[13] Gwo-Jen Hwang, Patcharin Panjaburee, Wannapong Triampo, and Bo-Ying Shih. A group decision approach to developing concepteffect models for diagnosing student learning problems in mathematics. *British Journal of Educational Technology*, 44(3):453–468, 2013. ISSN 1467-8535. doi: 10.1111/j.1467-8535.2012.01319.x. URL http://dx.doi.org/10.1111/j.1467-8535.2012.01319.x.

[14] Wu-Yuin Hwang, Rustam Shadiev, Chin-Yu Wang, and Zhi-Hua Huang. A pilot study of cooperative programming learning behavior and its relationship with students' learning performance. *Computers & Education*, 58(4):1267 – 1281, 2012. ISSN 0360-1315. doi: http://dx.doi.org/10.1016/j.compedu.2011.12.009. URL http://www.sciencedirect.com/science/article/pii/S0360131511003253.

[15] IEEE. Draft Standard for Learning Object Metadata, 2002.

[16] W. Lewis Johnson. Intelligent Tutoring Systems: Lessons Learned. *Artif. Intell.*, 48(1):125–134, 1991.

[17] Maria Kordaki. A drawing and multi-representational computer environment for beginners learning of programming using C: Design and pilot formative evaluation. *Computers & Education*, 54(1):69 – 87, 2010. ISSN 0360-1315. doi: http://dx.doi.org/10.1016/j.compedu.2009.07.012. URL http://www.sciencedirect.com/science/article/pii/S0360131509001845.

[18] Philip Machanick. Teaching Java backwards. *Computers & Education*, 48(3): 396 – 408, 2007. ISSN 0360-1315. doi: http://dx.doi.org/10.1016/j.compedu.2005.01.009. URL http://www.sciencedirect.com/science/article/pii/S0360131505000205.

[19] Rob Phillips, Carmel McNaught, and Gregor Kennedy. Towards a generalised conceptual framework for learning: the Learning Environment, Learning Processes and Learning Outcomes (LEPO) framework. In Jan Herrington and Craig Montgomerie, editors, *Proceedings of EdMedia: World Conference on Educational Media and Technology 2010*, pages 2495–2504, Toronto, Canada, June 2010. Association for the Advancement of Computing in Education (AACE). URL https://www.learntechlib.org/p/34989.

[20] John Self. The defining characteristics of intelligent tutoring systems research: ITSs care, precisely. *International Journal of Artificial Intelligence in Education (IJAIED)*, 10:350–364, 1998. URL https://telearn.archives-ouvertes.

fr/hal-00197346. The following papers are extended versions of some of the invited papers presented at ITS 98.

[21] Judy C.R. Tseng, Hui-Chun Chu, Gwo-Jen Hwang, and Chin-Chung Tsai. Development of an adaptive learning system with two sources of personalization information. *Computers & Education*, 51(2):776 – 786, 2008. ISSN 0360-1315. doi: http://dx.doi.org/10.1016/j.compedu.2007.08.002. URL http://www.sciencedirect.com/science/article/pii/S0360131507000966.

[22] Jose Mario Garcia Valdez. *Aprendizaje colaborativo basado en recursos adaptativos*. PhD thesis, Universidad Autonoma de Baja California, 2008.

[] Mario García Valdez, Guillermo Licea Sandoval, Oscar Castillo, and Arnulfo Alanis Garza. *A Fuzzy Approach for the Sequencing of Didactic Resources in Educational Adaptive Hypermedia Systems*, chapter Theoretical Advances and Applications of Fuzzy Logic and Soft Computing, pages 885–892. Springer Berlin Heidelberg, Berlin, Heidelberg, 2007. ISBN 978-3-540-72434-6. doi: 10.1007/978-3-540-72434-6_90. URL http://dx.doi.org/10.1007/978-3-540-72434-6_90.

[23] Yanqing Wang, Hang Li, Yuqiang Feng, Yu Jiang, and Ying Liu. Assessment of programming language learning based on peer code review model: Implementation and experience report. *Computers & Education*, 59(2):412

– 422, 2012. ISSN 0360-1315. doi: http://dx.doi.org/10.1016/j.compedu.2012.01.007. URL http://www.sciencedirect.com/science/article/pii/S0360131512000085.