Intelligent Learning Environments

Research in Computing Science

Series Editorial Board

Research in Computing Science es una publicación trimestral, de circulación internacional, editada por el Centro de Investigación en Computación del IPN, para dar a conocer los avances de investigación científica y desarrollo tecnológico de la comunidad científica internacional. **Volumen 129,** diciembre 2016. Tiraje: 500 ejemplares. *Certificado de Reserva de Derechos al Uso Exclusivo del Título* No. : 04-2005-121611550100-102, expedido por el Instituto Nacional de Derecho de Autor. *Certificado de Licitud de Título* No. 12897, *Certificado de licitud de Contenido* No. 10470, expedidos por la Comisión Calificadora de Publicaciones y Revistas Ilustradas. El contenido de los artículos es responsabilidad exclusiva de sus respectivos autores. Impreso en la Ciudad de México, en los Talleres Gráficos del IPN – Dirección de Publicaciones, Tres Guerras 27, Centro Histórico, México, D.F. Distribuida por el Centro de Investigación en Computación, Av. Juan de Dios Bátiz S/N, Esq. Av. Miguel Othón de Mendizábal, Col. Nueva Industrial Vallejo, C.P. 07738, México, D.F. Tel. 57 29 60 00, ext. 56571.

Editor responsable: *Grigori Sidorov, RFC SIGR651028L69*

Research in Computing Science is published by the Center for Computing Research of IPN. **Volume 129**, December 2016. Printing 500. The authors are responsible for the contents of their articles. Printed in Mexico City, in the IPN Graphic Workshop – Publication Office.

Intelligent Learning Environments

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Instituto Politécnico Nacional, Centro de Investigación en Computación
México 2016

ISSN: 1870-4069

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http://www.rcs.cic.ipn.mx
http://www.ipn.mx
http://www.cic.ipn.mx

Indexed in LATINDEX, DBLP and Periodica

Printing: 500

Printed in Mexico

ISSN 1870-4069

Editorial

Education has evolved over the last years incorporating new technologies to fulfill users' needs. New educational environments use modern artificial intelligence (AI) techniques to provide features that enhance learning experience. AI techniques can be applied in learning environments to support human learning, including several aspects of the educational process like affect recognition, student modeling, game-based learning, etc.

The growing usage of computers in education offers an excellent opportunity for exploring new ways of applying AI techniques to education. It also delivers huge amounts of information in need of intelligent management, and poses big challenges to the field on topics such as web-based intelligent tutoring systems, intelligent learning management systems, authoring tools, Student modeling, Applications of cognitive science, etc.

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

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

We appreciate the work done by members of Mexican Society for Artificial Intelligence (Sociedad Mexicana de Inteligencia Artificial), and Instituto Tecnológico de Cancún (Quintana Roo, Mexico) for their support during preparation of this volume.

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Guest Editors
November 2016

ISSN 1870-4069

Table of Contents

Page

ISSN 1870-4069

TURET2.0: Thesis Writing Tutor Aimed on Lexical Richness in Students' Texts

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Abstract. Writing thesis is a process of constant interaction between the student and academic advisor, but writing correctly is a complex task for students even if they have the support of a teacher. The elaboration of the thesis document requires the implementation of a methodology and procedures, which constitute the elements of the format and structure in the thesis. This work shows an intelligent tutoring system (TURET2.0) designed in a web platform and which provides a customized tutoring for students in drafting their writings, specifically to evaluate the lexical richness of seven sections of the thesis. Moreover, as a way to motivate students to achieve their goals, some gamification techniques were implemented. The measures used to assess the lexical richness are lexical variety, lexical density and sophistication.

Keywords: E-learning, natural language processing, intelligent tutoring system, lexical richness, gamification.

1 Introduction

Writing a thesis is not easy for undergraduate students and even more for academic reviewers, since the document requires several revisions to achieve the essential points stated in most institutional guidelines. This work aims to help undergraduate students to improve the document drafting in terms of Lexical Richness through a tutoring system. TURET2.0[1] includes two game attributes in order to motivate students to use the system. TURET is an updated version of a tutoring system tool previously [1].

[1] In Spanish: TURET: Tutor para la Redacción de Tesis.

One essential factor affecting writing is lexical competence, i.e. the writer ability to use properly the vocabulary, leading to considering it a basic reference point for measuring the quality of writing [2]. Universities in Canada take into account the results obtained by students in proficiency exams of different areas. One of them refers to the domain of English; other refers to the domain of mathematics. A study at the University of Calgary for Non-Native English Speaking (NNES) students, aimed to relate the academic success of students with lexical richness [3]. One of their research questions was to compare the lexical richness of NS (Native English Speaking) and NNES (Non Native English Speaking) students with their academic performance. The authors conclude that the results suggest that students with appropriate vocabulary, varied and accurate, have excelled in their studies, while students with a general vocabulary, repetitive, and an uncontrolled set of vocabulary showed a decreased academic performance. This conclusion supports our efforts aimed to improve the writing of students in their research drafts.

Advances in intelligent tutoring systems (ITS) include the use of natural language technologies to analyze student writing and provide feedback as presented in the article by McNamara [4]. Writing Pal (WPal) is an ITS that offers a strategy instruction, practice, and feedback for developing writers. There are also intelligent virtual agents, which are able to answer questions for the student related to an academic subject [5]. A dialogue-based ITS called Guru was proposed in [6], which has an animated tutor agent engaging the student in a collaborative conversation that references a hypermedia workspace, displaying and animating images significant to the conversation. Similarly, our work presented in this document includes the use of Natural Language, but adding two attributes of gamification.

The gamification approach could motivate students to get involved, focus and strive to engage in activities that seem boring, reaching a better performance. The main activities of the game include: information search, selection of information, strategy development, conflict resolution, decision-making exercises, and negotiation [7]. In the work of [8], an intelligent tutor for solving linear equations with elements of gamification is combined with a reward system. Students who used the tutor, were granted with a reward. In subsequent tests (when re-practicing problems), the performance was lower compared to students who did not obtain a reward. In contrast, students who solved new problems to re-practice their skills had better performance. Also, the authors conducted a comparison of the performance of students who used the tutor and a commercial tool. The students that used the commercial tool achieved a lower result in learning.

TURET2.0 is a tutoring system that seeks to support students close to graduating from universities with the need to write a thesis or research project. The document drafting is a difficult activity for the students, as this requires a methodology and procedures to comply properly with the structure that conforms the thesis. TURET2.0 differs from previous version because, it includes elements of gamification with the idea of maintaining student motivation. In addition, we evaluate seven sections of the thesis; in previous work only four sections were assessed. With this version, we seek to support students in the area of IT in Spanish language.

This tutor includes a module for assessing the lexical richness, which is done in terms of lexical density, lexical variety, and sophistication. There are a variety of methods to evaluate the use of vocabulary (lexicon) in text. One of them is to measure the sophistication of some papers using text word lists.

Our proposed system intends to assist the work of the instructor and to facilitate and guide students through this process. The paper is organized as follows. Section 2 describes the lexical richness model, while section 3 details the tutor with examples of draft evaluations. We conclude in section 4, discussing additionally further work.

2 Lexical Richness Model

To evaluate the seven elements contained in a thesis, we propose a computational model that will include three lexical dimensions. The first step in the model considers the preprocessing of each element. Each section in this module is processed with the Freeling[2] tool to obtain the word stems, converting the analyzed word in its singular form, grouping similar terms, and allowing a fast lexical analysis.

Another step in the preprocessing of the text was filtering and removing stop words from a list of 325 words provided by the Natural Language Toolkit (Snowball). Stop words include prepositions, conjunctions, articles, and pronouns. After this step, only content words remained, which allowed the calculation of the three dimensions.

Table 1. Measures to compute lexical richness.

Dimension descriptions		
Dimension	Labels	Computed as
Variety	LV	Tlex/Nlex
Density	LD	Tlex/N
Sophistication	LS	NSlex/Nlex
Tlex: Unique lexical terms		
Nlex: Total lexical terms		
Nslex: Words out of a list of common terms (SRA)		
N: Total tokens		

The first procedure is computing the lexical variety which seeks to measure student ability to write their ideas with a varied vocabulary. This function is calculated by dividing the unique lexical types (Tlex) between all lexical types (Nlex).

The second module refers to the computation of the lexical density, whose goal is to reflect the proportion of content words with respect to all the words employed, i.e. if the text has a good level of content. This dimension is obtained by dividing the unique lexical types or content words (Tlex) by the total words of the evaluated text (N) i.e. the number of words before removing stop words (see Table 1).

[2] http://nlp.lsi.upc.edu/freeling/

Finally, the sophistication method attempts to reveal the knowledge of the tech-nical subject and it is estimated as the proportion of "advanced" words employed. This measure is computed as the percentage of words out of a list of common words (in our case, the 1000 common words, according to SRA).

Each of the measures takes values between 0 and 1, where 1 indicates an acceptable lexical value, and values close to zero mean a poor value of the lexicon of the evaluated section. Together, the three dimensions aim to identify the level of lexical richness of the student writing. The sophistication would be a plus for undergraduate students.

TURET2.0 uses the results computed by the Lexical Richness model to display them to the student, and adding feedback depending on the evaluation result.

3 TURET2.0

The results of a pilot test (prior version of tutor) with students of a public university showed positive results. Students who used the tutor had better results when writing their thesis (in terms of Lexical Richness) compared to those who did not use the tutor. The results were detailed in [1].

TURET2.0 was developed under the Python environment, the previous version used PHP and MySQL with XAMPP package to have web access. However, the response time was not as expected because calls were being made to the operating system to use the Freeling tool and Python from PHP.

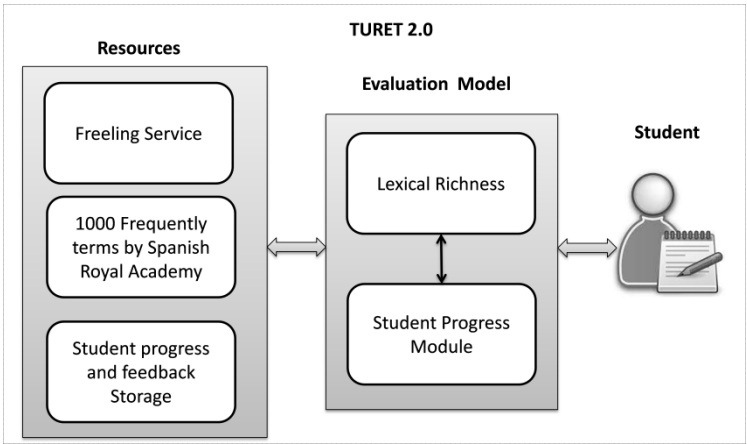

Fig. 1. TURET Scheme System.

Under the Python environment, a Web framework "Django + HTML5" was used to display the interface and results to the student. The use of this environment avoided writing files, system calls and allowed to work in the data memory. Similarly, the open-source relational database management system "MySQL" was used to store the results of each evaluation of students. Finally, Freeling tool was installed as a server, such that

the lemmatization process was performed under the scheme of services, i. e., when a student requests an evaluation in the tutor, the system uses the lemmatization service of Freeling. In Figure 1, we present the system scheme.

The results of the lexical analysis are sent to the Student Progress Module (SPM) to update the student knowledge state. SPM records the student progress in a network. When the student completes the exercises with the Lexical Analyzer, the corresponding node is updated and the SPM estimates the student progress for the parent node using the weights assigned to the measure in turn. Weights were assigned to each node based on instructor's experience. In Table 2, we show the percentages achieved by the student, in case he gets a high score in each of the lexical dimensions. It is worth mentioning that the percentages for each lexical dimension are divided into three equal parts (each part is equal to 1/3). For example, if a student gets high score in all three dimensions in the objective section, he will get 1/3 + 1/3 + 1/3 = 1, which means he has reached 15% of progress. This 15% of progress is the total assigned by the tutor to the objective section.

Table 2. Progress percentages for each section of a thesis.

Thesis structure[3]	
Elements	%
Problem statement	15
Objective	15
Justification	15
Methodology	15
Hypothesis	12
Research Questions	13
Conclusion	15

In Figure 2, we can observe the student work environment in TURET2.0. The elements evaluated by the tutoring system are: hypothesis, justification, objectives, problem statement, research questions, methodology, and conclusion. In this section, the student can review his overall progress and observe a section with the overall results of the remaining students who also are using the tutoring system. The aim is that the student is interested in getting the top ranking, similar to a video game. After several iterations of evaluation of the text in the tutor, we expect that its lexical richness improves.

Also we can notice the progress in the objectives section with 68% achieved, since is the only section that the user has been assessed. In this screen, the user can review his last advance, where a progress bar is used to present this progress, this is a feature of games which indicates that for each stage there exists an advancement. Progress bars belong to the category of "Games tasks and challenges" [7].

In the tutor's home page, we provide a description of the Lexical Richness, with this the student can understand the results of the tutor. The levels used to determine the

[3] Suggested by the authors of research methodology books.

assessment are High, Medium and Low; this scale was defined based on the analysis of the corpus of thesis and research proposals [1]. The student can click on one of the sections to write or paste the desired text to evaluate. The tutoring system will produce the result of the analysis in the three dimensions: density, variety and sophistication.

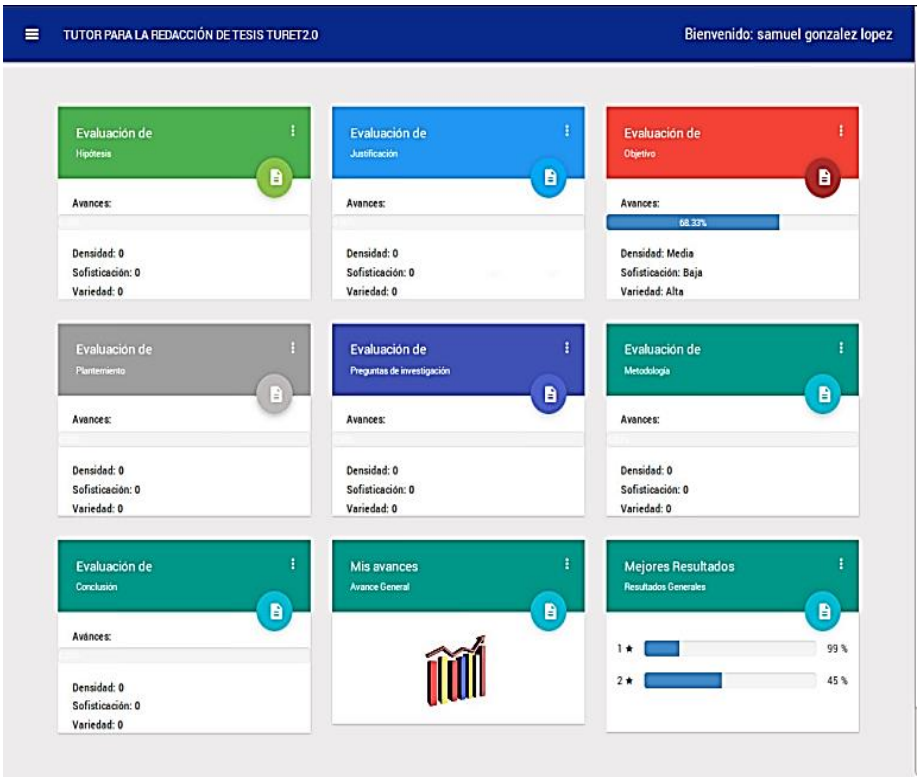

Fig. 2. Main evaluation sections in TURET2.0.

The section where the student can perform the text analysis is presented in Figure 3. Here we can also observe the feedback provided to the student. It can be noticed that two words are marked in red (e.g. “seguridad” in Spanish) in the section of variety assessment. This implies that a content word has been repeated which affects the level of variety.

Textual feedback is also provided, which for now is static. This feedback is de-fined depending on the level achieved by the student. In Figure 3, we observe a medium level of variety assessment, with a textual recommendation for the student to improve his writing (e.g. “Buen trabajo, pero aun nos falta corregir más nuestro texto” in Spanish).

In Figure 4, individual student progress is shown, globally depicting the level reached by the student in all three dimensions, i.e., the student can view the lexical richness of his entire thesis.

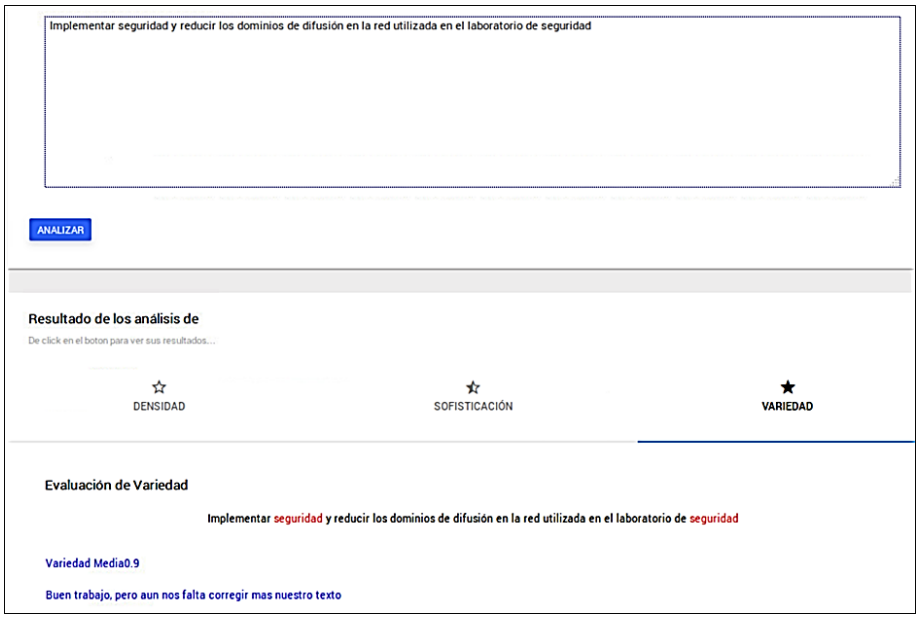

Fig. 3. Text evaluation sections in TURET2.0.

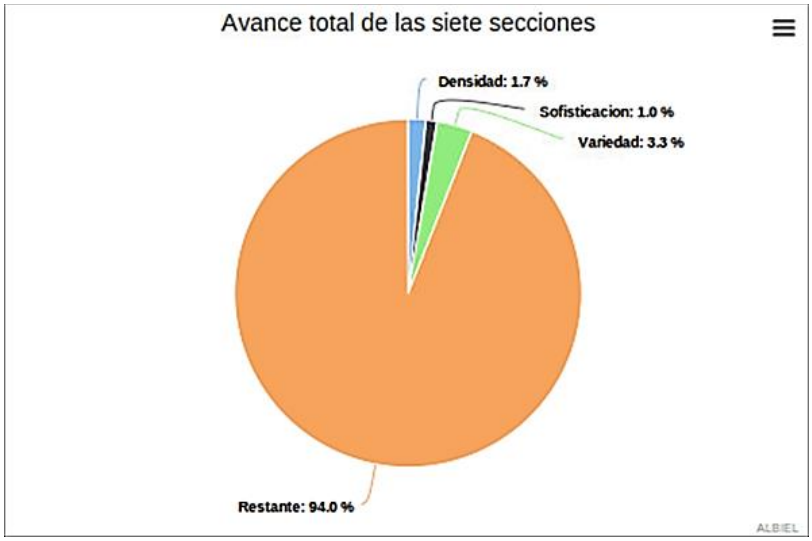

Fig. 4. Individual Global Advance.

Another attribute of gamification considered in TURET2.0 is the score among students using this tool. In Figure 5 we can observe the total score of each student using the tutoring system. The goal is to motivate a competition among them, but also cooperation. This attribute belongs to the category of "Games of collaboration and competition" [7].

Fig. 5. Best results report.

4 Conclusions

The tool presented in this paper aims to support students to improve their writing in terms of lexical richness, with the possibility of improving the quality of the final document. With this, it would allow the academic advisor to focus on analyzing a higher proportion the content of the thesis rather than vocabulary or structure. TURET2.0 is a tool that aims to support to student and motivate to use it, that is, not just another tool to fulfill a requirement of writing.

We plan to gradually incorporate additional features to assess in the student texts such as coherence or argumentation, adhering to same idea of motivating its use.

In future work, as performed with the previous version of the tutoring system, we seek to pilot test it at different universities. In a first stage as a trial to analyze results and implement improvements, then in a second stage as a released tool.

It is also planned that TURET2.0 can be customized by the student to assess only the sections that he is required to write, since some universities do not ask for all sections, omitting for instance research question or hypotheses. Finally, we will take this tool to the mobile devices field for a higher coverage with students.

Acknowledgements. Second author was partially supported by SNI, México, while third author was supported by Conacyt México through scholarship 357381. We thank Jesús Carlos Cardenas Piñuelas and Erwin Alexander Villegas Tun for their collaboration as application developers.

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ISSN 1870-4069

Android App Based on Gamification Techniques for Learning Reading, Support for Education and Illiteracy

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Abstract. According to international and national indicators in Mexico are more than four million of people who cannot read and write. Moreover, reports of Standouts, such as United Nations Educational, Scientific and Cultural Organization (UNESCO) and World Economic Forum (WEF) make suggestions to improve use levels of Information and communications technology (ICT) in order to collaborate to solve these problems so the aim of this investigation is develop a mobile application (APP) with Gamification techniques (game based learning), which will help people to improve their reading skills. This software is constructed with Scrum methodology and it consists in three phases: 1) pregame (planning), 2) game (construction and testing), 3) postgame (deployment), in addition, this APP contains digital material such as audio, images and some tests are included to measure progress over time increase.

Keywords: Gamification, app, android, learning, reading.

1 Introduction

1.1 Technology Issues in Mexico

Several authors mention that the world is involve in a new kind of culture defined as society of knowledge and information, where ICT and its development heads the future of the majority of economies [1]. This sort of society is characterized by take advantage of the ICT to solve old and new problems, create, disseminate and transmit new knowledge [2]. According to these definitions the WEF [3] suggests working in the development of ICT, and making strategies to implement them. As well, it offers many solutions and examples of policies to help countries to improve the use of ICT in different sectors such as government, education, and business [3]. Although different international organizations indicate that ICT is a crucial component to achieve development objectives of societies in those sectors [4], the technological development in Mexico is not optimal according to official international reports.

In 2015 the average development in the 143 countries evaluated by WEF [3] in the Global Information Report 2015, Mexico was 4.07 points, in a scale from 1 to 7; the top ten of economies such as Finland, and Sweden, are located on 1.6 points above average. However, Mexico got 4.0 points with only 0.7 points below. In 2014, Mexico was 79th in this ranking, by 2015 raises ten places, located in number 69th. With this information, Mexico had an apparently improvement in this ranking, but analyzing the numbers, it is concluding that Mexico has been improved, but not to overcome others economies, the real reason is because from 2014 to 2015 five countries got out from the list. In 2014, 148 economies were evaluated and in 2015 this number were reduced to 143, which immediately makes changes in the positions.

This problematic not only was exposes by the WEF, also the International Telecommunication Union (ITU) who in its Development Index Technology, emphasizes that Mexico has a problem in the use of ICT in all sectors include the educational, due to in 2015 edition of IDI the country has dropped 9 sites from the place number 86 to the place number 95 [5, 6].

It has become manifest the importance and the great impact of ICT in the new era of information society and knowledge. Despite this fact which is recognized internationally, by various institutions, Mexico is lagging considerably behind of other countries. The use of ICT is an infallible part for the creation, operation and growth of societies.

1.2 Illiteracy in Mexico

The use of ICT is one of the biggest issues that Mexico should solve quickly; other important topic is the problem of Illiteracy in the country. Nowadays according to National Institute of Statistic and Geography (INEGI) [7], Mexico has approximately 5.48% of people aged 15 and over in illiteracy. That percentage is equivalent to 4,749,057 millions of people who doesn´t know how to write and read.

UNESCO [8] also believe that the literacy faces huge problem, and one of the main challenges of Mexico about this issue is reduce illiteracy.

México is aware of its weaknesses in these two important topics; therefore, in the National Development Plan 2013 – 2018 [9] , are proposed strategies to face those problems. Barbera Cebolla [10] confirms the importance of the ICT to innovate and improve quality in the education, and finally, UNESCO [11] suggests the use of ICT in the education sector as a key point to increase literacy, as a result is appropriate to create a mobile application in one of the most used operative system (Android) for smart devices, this app include Gamification – Game based Learning so that the benefit from doing that, involve giving motivation to the user, and creating a good environment where is possible to improve gradually the reading skills.

1.3 Gamification- Game Based in Learning Works with Reading Skills

Zichermann & Cunningham [12] define Gamification as “Use game mechanics to engaged users, and solve problems” in the context of game based in learning. This technique is useful because follows the pillars of Skinner [13] who says that trough

reinforcements and emotions, in a positive or negative way, can change the behavior of a person, and create and habit.

As said by these authors we can implement Gamification to solve the problem of ICT and illiteracy in México, motivating the user to keep in the game trough reinforcements that can help the users to improve their reading skills constantly, give them something more than knowledge. The game provides a complete experience to the user, but it has to follow some topics that are infallible to create a successful Gamification strategy.

One of the essential parts of Gamification is the mechanic, this part of the game determines how the user interacts, wins or loses, and this is the part where the experience takes place [14]. The Dynamic is as important as mechanics due to the rules of the game, the dynamic and emotions animate the experience and motivate the user to change the behavior [15]. It can be identified three levels of benefactors with Gamification based – learning according to Prensky [16] 1) a business executive, school administrator 2) trainer or teacher 3) user, student or trainee.

Now the benefits of Gamification and ICT are manifested, such as, engagement, loyalty, motivation, and the growth of societies. Make a strategy that include these both topics is the opportunity of solve problems with ICT and illiteracy in Mexico. Finally, Hernández Salazar [17] mentions that virtual learning programs are conducive to include or generate knowledge with different types of message: visual (images), audio, join to Freire's methodology [18] what also say that the education requires three components: 1) a critical method, 2) a change of curriculum content and 3) specific techniques to encode and decode messages, these elements are "focused on the present, creating a context in which develop technological literacy tools to generate a kind of pedagogical highly functional and contextual knowledge" [19].

2 Methodology

The kind of methodology that has been used is "applied" which consists in three phases 1) Investigating the problem of illiteracy in various international and national organizations, to have evidence about the necessity to propose a technology development. After observing the statistics of people in situations of illiteracy is now built a prototype mobile application, constructed with the recommendations of Hernandez Salazar, Paulo Freire and Pallarès Piquer [17, 18, 19] and also with Gamification 2) alpha test with illiterate people, 3) Measure performance and find improvement points.

The mobile app is designed in a way that the user can use series of audio instructions; selecting colors and images, in addition the lessons are based on the teaching materials of the National Institute for Adult Education (INEA).

2.1 Gamification Methodology

The game is divided into 4 categories of player 1) Basic, 2) Intermediate, 3) Advance and 4) Upper, all these categories have 110 lessons in total. To complete all the lessons,

the user needs to unlock levels, achievements, medals and in the final of the whole program the user will get some extrinsic incentives.

2.2 Scrum Methodology

The mobile app is developed under the Scrum methodology, which are used to obtain quality results in an optimum time. This methodology has a control mechanism which is used to manage the unpredictability and control the risk. Flexibility, responsiveness, and reliability are the results [20]. Below are described the phases which are applied to develop the software.

Pregame

Planning: At this point, many functional and nonfunctional requirements were defined and obtained by information gathering Techniques Such as surveys, questionnaires, oral conversation and interviews. All of them were answered by illiterate people, furthermore observations and comparisons helped to identify what end user really need. Some of the most important functional requirements which were identified are:

- Users who wish to use the system, must be registered to keep track of scores.
- It is necessary for the user to answer a test which will define user learning.
- Punctuation needs to be stored in a database associated with the corresponding user.

Some of the most important nonfunctional requirements which were identified are:

- Availability: The system needs to be available when the user requires
- Data Control: data generated by the system must be reliable
- Time of development: total time for development and deployment of the application must be less to 5 months
- Implement a system in which hearing can hear the instructions for each exercise or navigation between screens.

Architecture: It consists in design how the requirements which will be Implemented, to do that was necessary to represent each functional or not functional requirements in user cases, sequence diagrams, and data modeling which includes Entity relationship diagram among others. It allowed to identify processes and actors which interact with the system for example:

Entity: user: It refers to the end user who will use the application, so its principals' actions are: login, listen to audios, solve tests, and practice. Entity: Support staff: Its main function is to register the new who will use the App, Entity: Database: It interacts with the system, its main function to save user data such as personal data, and scores.

Game

Development Sprints: This phase Focuses on the development of new features Considering the time, quality, cost and requirements, this phase has multiple development sprints Which have a mean interval time (10 days) when a sprint begin, a meeting team work is carried out in order to plan the development of it, define and

objective and it`s functionality. After that, all developers must be get together 20 minutes to synchronize activities and get a plan for the next 72 hours to develop. When the software is being programed and the sprint are underway, it must ensure that changes are not affecting the Sprint`s target.

Sprint Review: The development team discusses what was successful and what problems were and how they were solved.

Postgame

Closure: In a period of three months is expected to start the closure. This will include documentation such as the user manual and the technical manual, and some performance tests are also necessary to identify a possibility of software maintenance.

User manual: It will content. A section Installation and Configuration, A guide to using at least the main functions of the system, i.e. its basic functions, A troubleshooting section detailing any errors or problems that may arise, along with ways to fix them, A FAQ section. Technical manual: It will contain. General diagram (Entity relationship diagram), User cases, Data Dictionary, Sequence diagrams, Relational diagram, Definition of environment variables and libraries, Restrictions or limits programming.

3 Results

As a final result, it was obtained an APP in phase two which means that the APP is ready for an alpha test in a national institution INEA. The Fig. 1 is showed some screens on the app. Due the fact these screens are prototypes; they could have a different look later in the final version of the project.

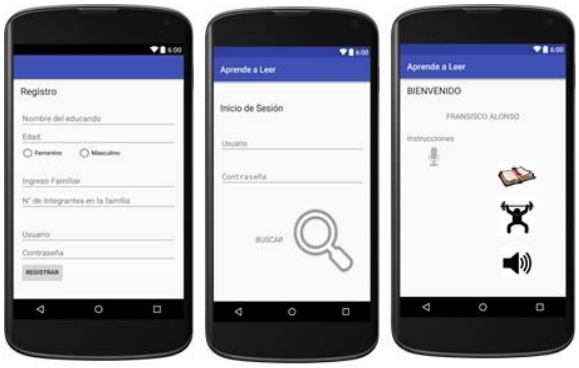

Fig. 1. Registration screens, login, and welcome /main.

Registration Screen: This screen is used to save user data and is a way in which the user can monitor their progress while using the application. Login Screen: With the development of this screen is only granted access to enter the security key (username, password). With the purpose of preventing the user's progress will be modified by

another person. Welcome/Main Screen: This screen shows an example in which the user is logged and can select from a number of options (content and exercises).

3.1 Exercise Screens

The app has a several number of exercises which help the user to identify sounds, pronunciations, and words. Also the app can evaluate the answers given with a number of stars. Fig 2 Show some of these screenshot examples in three different exercises. The user has the opportunity to get from one to five stars, being five stars the equivalent of a 10 and one star the equivalent of 6. The user can do the same activity only three times, in order to pass or improve the average already obtain, after three times the software save the highest level obtained and lock the activity.

Fig. 2. Exercises to identify sounds, syllables, and images, and ranking screen.

Only if the user completes the whole lessons with a minimum grade of 8, can unblock the next level (intermediate, advance or upper) respectively. To finish the whole course, the user has to pass all the levels with the minimum average score (stars). At this moment the application is in "Alpha mode" with no problems of execution neither manipulation, in the next phase is necessary to measure performance and find improvement points through intrinsic reinforcements, such a special point if the user get the highest average in the first attempt, in fact the game will have temporal modifications in special seasons as Christmas or Halloween with some extra exercises to improve the level of the user.

3.2 Reinforcements

The user can have access to his personal information in the game where can notice the status of his level, obtain special missions, and also can see the progress in a level bar in the top of this section and with different medals Gold, Platinum, Titanium, Silver and Steel, which means that the user have more than 10, 9, 8, 7 as a general grade. In

the whole game the motivation is intrinsic on every exercise, but in the final mission the reinforcement could be extrinsic if the user has an excellent performance which means the user have to get 10 or more than 10 in the final grade.

4 Discussion

The alpha mode shows that the interaction with the app has no problems to understand or the mechanic of the mobile phone or tablet, so according to UIT [4] and WEF [3] is real that ICT is a good mechanism to increase the competitively of society, also is a great support to people to achieve basic objectives that have a direct impact of the illiteracy problem in Mexico. This problematic can be supported with a simple game into the app that motivate people to learn using the intrinsic and extrinsic reinforcement. Showing the problem of illiteracy and ICT as a game, could give a new perspective and meaning to the word learn. Prensky [16] people need to stop perceive the process of learning as a boring, and Gamification is an excellent way to do this real. The propose of game include all of the characteristics that Zinchermann [12] proposes which give the student the opportunity to learn and try to do better more than one time. This software also has resources recommended by Pallares [19] like images, and sounds. So far the app has been test with a group of 20 people between 30 and 45 years old, who improve their reading skills in a basic level (sounds, identification of syllables and vowels), the test will continue with a bigger and mixed group, and the current students have been monitoring in order to introduce the game into the app, to analyze the behavior.

5 Conclusion

The benefits of Gamification and ICT were exposed in this paper, now is possible to confirm the advantages from apply this technology in areas that need this support so it is expected that this App would help areas in Mexico where people's illiteracy are located. Finally, is demonstrated that whit different techniques and methodologies is possible to contribute in the development of our country.

Acknowledgements. We thank Instituto Politécnico Nacional, Unidad Profesional Interdisciplinaria de Ingeniería y Ciencias Sociales y Administrativas and SIP 20161046 Project "Computing Skills of Human Capital as a Source of Economic Growth".

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ISSN 1870-4069

Analyzing Proprietary Games Engines for Developing Educational and Serious Games

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Abstract. Gamification is the use of game design elements to enhance the teaching-learning process; with gamification it is possible to make a routine non-game activity such into a game that is engaging and fun. Also serious games are proposed as a more efficient and enjoyable way to carry out cognitive assessment, the serious games combine a serious intention with game's rules and targets. This paper presents an analysis of the most used proprietary games engines in order to identify games and learning attributes supported for developing educational and serious games.

Keywords: Gamification, proprietary games engines, serious games.

1 Introduction

Gamification is the use of game mechanics and experience design to digitally engage and motivate people to achieve their goals [1]. Through gamification we can not only create a mindset that encourages students to try new things, to not be afraid of failing [2], but also can enable students to engage in enjoyable experiences for the purpose of learning. The gamification of learning is an educational approach to motivate students to learn by using video game design and game elements in learning environments. The gamification is today considered as an essential driver of innovation in this domain. Therefore, it is important to understand how Serious Games can best be designed and used as an environment for organizational learning [3]. Serious games are aimed at a population that is familiar with online games, particularly Generation Y, who are more playful, outgoing, are major consumers of training and coaching, and cannot be recruited in the same way as previous generations [4, 5]. The advantage of serious games as a tool for learning is mainly based on the ability to balance entertainment, interactivity and replay ability of the typical games with the learning objectives of a specific educational goal.

Proprietary game engines allow developing Web-based applications, native mobile and hybrid applications by using game strategies and techniques [6], There are several proprietary games engines and the selection process is a very difficult task, therefore the objective of this work is to provide support on the selection process of proprietary games engines depending on the educational activities to be considered in the development of an application. This paper presents an analysis of proprietary games engines by considering learning activities in order to provide a reference for choosing the most suitable games engine for the development of educational applications, serious games or both.

2 State of the Art

In recent years, several studies have been proposed with the aim of improving the development of educational games. Most of these research works have been focused on the use of gamification in a variety of contexts. In this section, we present a set of related works focused on the use of educational games, serious games and both. These works have been grouped according to the kind of application to be developed: 1) gamification applications, 2) serious games.

2.1 Use of Gamification Techniques on Educational Applications

Henzi & Alt [7] applied gamification to leverage the use of information for information-intensive business tasks in the context of corporate intranets. It presents the results of an online experiment, which was conducted in the banking industry. Matallaoui, Herzig & Zarnekow [8] proposed the Gamification Modeling Language initially as a formal language adhering to a context-free grammar and is based on the current consensus of game design elements that can be found in the gamification. Hamari, Koivisto & Sarsa [9] defined gamification as an emerged means of supporting customer engagement and enhancing positive patterns in user service by using game mechanics in serious contexts. Ibañez, Di-Serio & Delgado-Kloos [10] evaluated the learning effectiveness and engagement appeal of a gamified learning activity targeted at the learning of C-programming language. The results of the evaluation show positive effects on the engagement of students toward the gamified learning activities and a moderate improvement in learning outcomes. Marti-Parreño, Segui-Mas & Segui-Mas [11] carried out an exploratory study aims to gain a better knowledge of teachers' serving in higher education institutions attitude towards gamification. Actual use of gamification is also explored. Results show no differences in use of gamification by age, gender or type of institution (public or private). Long [12] designed and integrated gamification with an ITS to support students' learning of actionable rules for making problem selection decisions based on their learning status afforded by the Open Learner Model (OLM), while enhancing both their enjoyment and domain level learning with the ITS. González, Mora & Toledo [13] presented a conceptual architecture proposal for an Intelligent Tutorial System (ITS) known as EMATIC (Mathematics Education through ICT) that includes gamification elements as key components of the system. Dermeval [14] the main challenge of this project was contributed to the actively participation of teachers in the use of gamified intelligent tutoring systems.

2.2 Use of Serious Games on Educational Applications

Boughzala, Michel & De-Freitas [15] defined that a Serious Game combines a serious intention with a game's rules and targets. Serious game often considered to be technological applications that use games to engage individuals in an experience through which a learning or professional training aim can be explored. Matallaoui, Herzig, & Zarnekow [8] introduced a model-driven architecture for designing as well as generating building blocks for serious games. Sorensen & Meyer [16] defined Serious Games as digital games that educate, train, and inform. These games are designed for a primary purpose other than entertainment, enjoyment or fun. The initial intention of serious games is to combine the serious aspects (learning, instruction, etc) with the playing aspect of digital games. Sorensen, b.H. & Meyer [17] used the Serious games in language learning and teaching a theoretical perspective. On the other hand, Fong-Ling, Rong-Chang & Sheng-Chin [18] designed the hands-on OS game to introduce learners the common problems associated with the operating system of the computer. The main goal of this game is to enhance the proficiency of the learner in certain skills related to computer's operating system. Martins, Carvalho & Soares [19] proposed that one way to help both, professionals and patients, can be found in the development of serious games oriented to motor rehabilitation in physical therapy sessions. This work to present a modular system of Back Office, for centralized management of one or more games targeted for physical therapy.

3 Proprietary Games Engines for Developing Educational and Serious Games

A proprietary game engine is a software framework designed for the creation and development of video games. Currently, there are different games engines that allow the development of games able to be applied in a wide range of browsers and platforms from a single development in some cases [20]. The most commons proprietary game engines are:

- **Unity** is a games engine can handle, from a massively-multi player online game all the way down to a simple kart racer [21].
- **CryEngine** is a powerful real-time game development [22].
- **Unreal engine 4** is a complete suite that offers a new workflow features and a deep toolset empower with a complete C++ source code [23].
- **Cocos2D** is an open source cross-platform game framework written in C++/Javascript/Lua. [24].
- **Blender** is a fast, powerful, and free 3D graphics and animation tool. [25].
- **BigWorld** is used by developers to develop game logic and AI and is based on the Python scripting language. [26].
- **Leadwerks** is the easiest game engine to make 3D games powered by OpenGL 4.0 [27].
- **HeroEngine** is a 3D game engine and server technology platform for building MMO-style games [28].

4 Learning Activities on Educational and Serious Games

Gamification is the use of game mechanics and experience design to digitally engage and motivate people to achieve their goals. The application of gamification to real life tasks to influence behavior, improve motivation and enhance engagement [34]. From the innovation perspective, concepts such as serious gaming and gamification are the most interesting and valuable in this domain.

Lameras et al. [35] proposed a serious games classification based on the design features and learning properties learning of the game. The study provides guidance and support to teachers, trainers and game designers to design plan and use serious games for a topic or complete module. Lameras et al. [35] proposed the learning design as a fundamental mode in architecture game design. Learning attributes are proposed as collaborative learning, individual transmission of information and discussion and argument.

Based on the game attributes, Lameras [35] classified the games depending on their relevant attributes. Lameras realized an attempt to assign games categories understanding game attributes in the game that are used for creating instances of games attributes in the educational practice; for example, rules are made by scoring. Lameras proposed this classification because there was not a taxonomy to classify the attributes of the game in specific categories, the classification was done with the aim of helping game designers and instruction. The category, presented by Lameras, is described in the table 1, which is based according to the identification of the attributes of each kind of game:

Table 1. Game categories and associated game attributes.

Game Cathegory	Game Attribute	
Rules	• Scoring • Moving • Timers levels	• Progress bars • Game instructions including victory conditions
Goals and Choices	• Game journal • Missions • Objective cards • Storytelling	• Nested dialogues • Puzzles • NPCs / avatars
Tasks / challenges	• NPC-based task description • Progress bars • Multiple choices to select • Major tasks	• Puzzles • Research points • Study • Requirements • Branch tasks
Collaboration and competition	• Role-playing • Community collaboration • Epic meaning • Bonuses • Contest	• Timers • Coins • Inventories • Leader boards • Communal discovery • Scoring
Feedback / assessment	• Game hints, NPCs • Game levels • Gaining/loosing lives • Progress bars • Dashboards	• Lives/virtual currencies to be used for buying game items from an online inventory • Progress trees

5 Analysis of Proprietary Games Engines for Developing Educational and Serious Games

An analysis of proprietary games engines for game development is presented in this section. In order to validate the aforementioned analysis, we have selected ten proprietary games engines. Proprietary games engines selected allow developing Web application, mobile applications and hybrid applications in some cases. The proprietary games engines selected were: Unity, CryEngine, Unreal engine 4, cocos2D, Blender, BigWorld, Leadwerks and HeroEngine. There are the most popular proprietary games engines in use by developers, because every proprietary games engine selected provide a suite of visual development tools, in addition to reusable software components. At the end of the analysis process, we have determined the importance of the game attributes for the educational context and the availability of each game attributes on a game categories according to the selected proprietary games engines. Nonetheless, it is possible that, according to the type of educational game and the academic level to which this educational game is aimed, some other attributes can be required that they may have been omitted in this evaluation.

Table 2. Analysis of proprietary games engines.

	Game Attribute				
Game engines	**Rules**	**Goals and Choices**	**Task / Challenges**	**Collaboration and competition**	**Feedback / Assessment**
Unity	-Scoring -Moving -Timers levels -Progress bars -Game instructions including victory conditions	-Game journal -Missions -Objective cards -Storytelling -nested dialogues -Puzzles -NPCs	-Progress bars -Multiple choices to select -Major taks -Branch task -Puzzles -Research points - Requirements	-Role playing -Community collaboration -Bonuses -Contest -Scoring -Timers -Coins -Inventories -Leader boards	-Game hints -NPCs -Game levels -Gaining/ loosing lives -Progress bars -Dashboards -Lives.
Cryengine	-Moving -Timers levels -Progress bars -Game instructions including victory conditions	-Missions -Objective cards -Puzzles -NPCs/ Avatars	-Progress bars -Multiple choices to select -Puzzles - Requirements	-Bonuses -Contest -Scoring -Timers -Coins -Leader boards	-Game hints -NPCs -Game levels -Progress bars -Dashboards
Unreal Engine 4	-Scoring -Moving -Timers levels -Progress bars -Games instructions	-Game journal -Missins -Objective cards -Storytelling -Puzzles	-Progress bars -Multiple choices to select -Major tasks -Branch task -Puzzles	-Role playing -Community collaboration -Bonuses -Contest -Scoring -Timers -Coins	-Game hints -NPCs -Game levels -Gaining/ loosing lives -Progress bars

	Game Attribute				
Game engines	**Rules**	**Goals and Choices**	**Task / Challenges**	**Collaboration and competition**	**Feedback / Assessment**
	including victory conditions.	-NPCs/ Avatars	-Research points - Requirements	-Inventories -Leader boards -Communal discovery.	-Progress trees.
Cocos2d	-Scoring -Moving -Timers levels -Progress bars -Game instructions including victory	-Game journal -Missions -Objective cards -Puzzles -NPCs/ avatars	-NPCs-based tasks description -Multiple choices to select -Major tasks -Branch tasks -Puzzles -Research points -Requiremets	-Role playing -Community collaboration -Bonuses -Contest -Scoring -Timers -Coins -Inventories -Leader boards.	-Game hints -NPCs -Game levels -Gaining/ loosing lives -Progress bars -Dashboards -Progress trees.
Blender	-Scoring -Moving -Timers levels -Progress bars -Game instructions. Including victory	-Missions -Objective cards -NPCs/ avatars.	-Progress bars -Major tasks -Branch tasks -Puzzles	-Bonuses -Contest -Scoring -Timers -Coins -Leader boards	-Game hints -NPCs -Game levels -Progress bars -Dashboards -Progress trees
BigWorld	-Scoring -Moving -Timers levels -Progress bars -Game instructions including victory conditions.	-Game journal -Missions -Objective cards -Puzzles -NPCs/ avatars.	-NPCs-based task description -Progress bars -Multiple choices to select -Major tasks -Branch tasks -Puzzles -Research points - Requirements	-Role-playing -Community collaboration -Bonuses -Contest -Scoring -Timers -Coins -Inventories -leader boards.	-Game hints -NPCs -Gaining/ loosing lives -Progress bars -Dashboards -Progress trees.
Leadwerks	-Scoring -Moving -Timers levels -Progress bars.	-Game journal -Missions -Puzzles -NPCs/ avatars	-Progress bars -Multiple choices to select -Major tasks -Branch tasks -Puzzles.	-Role-playing -Community collaboration -Bonuses -Scoring -Timers -Coins -Inventories -Leader boards	-Game hints -NPCs -Game levels -Gaining/ loosing lives -Progress bars -Dashboards.
HeroEngine	-Scoring -Moving -Timers levels	-Game journal -Missions	-Progress bars -Major tasks -Branch tasks -Puzzles	-Role playing -Bonuses -Scoring -Timers	-Game hints -NPCs -Game levels

	Game Attribute				
Game engines	**Rules**	**Goals and Choices**	**Task / Challenges**	**Collaboration and competition**	**Feedback / Assessment**
	-Progress bars	-Objective cards -Puzzles -NPC	-Requirements.	-Coins -Inventories -Leader boards.	-Progress bars -Dashboards -Progress trees.

The goal of the analysis is to provide a reference for choosing the most suitable games engine for the development of educational or serious games considering learning activities and the game attributes that can be present in the application.

6 Conclusions and Future Directions

Gamification is the use of gaming principles in the field of education in order to get students involved, engaged, and excited about learning. Gamification is used in several different contexts, this work demonstrates the utility and importance of the game attribute in the educational environment as well. Meanwhile, Serious games are virtual environments explicitly intended to educate or train, there are designed for a primary purpose other than pure entertainment. As future direction, the inclusion of additional framework such as Cube, adventure game studio, to mention but a few, will be considered. Also we will consider the inclusion or approach of a methodology to analysis of games engines for educational and serious games.

Acknowledgments. This work was supported and sponsored by the Tecnológico Nacional de México (TecNM), National Council of Science and Technology (CONACYT) and the Public Education Secretary (SEP) through PRODEP.

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ISSN 1870-4069

Exploring Digital and Manual Modalities in Educational Activities for Children with ADHD

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Abstract. Planning and conducting educational activities for children with ADHD represents a methodical and precise endeavor. Teachers plan the educational activities but also have to adapt each educational session based on the child's emotional state. Digital technologies are often suggested as a means to provide engaging learning resources and to help children with their academic achievements. Therefore, we developed a supportive software based on an educational activity where we aim to help children reinforce learning abilities. We conducted a controlled study to compare the manual and digital modalities of the educational activity. Our analysis reveals sentiment findings when new technology is introduced. Our findings suggest that using educational activities enhanced with digital technology has potential benefits and may allow teachers and children achieve academic goals yet providing a ludic educational experience for children.

Keywords: Ludic experiences, affective states, attention deficit disorder, learning difficulties.

1 Introduction

Attention deficit hyperactivity disorder (ADHD) is the most common neurobehavioral disorder diagnosed in U.S. children. In 2011–2013, 13.3% of boys and 5.6% of girls aged 4–17 had ever been diagnosed with ADHD [1]. Prior research [2, 3] have found similar prevalence percentages worldwide suggesting geographic location plays a limited role in ADHD prevalence. Particularly, the Mexican Psychiatric Services Office estimates 3.5% of Mexican children have been diagnosed with ADHD [4].

Children diagnosed with ADHD experience a wide range of challenges with daily life and their education, compromising the expectations from parents and teachers according to skills presented in neurotypical children of the same age [5]. For instance, they face problems identifying individual graphemes or words while constructing meaningful sentences related to reading assignment. Furthermore, short term memory

issues may arise and contribute to dyslexia or dysgraphia diagnosis [6], leading to low average grades, failed grades, expulsions, or increased school dropout rates. Along with learning challenges these children have issues while interacting with others peers due to inattention to what is happening around them or what others are saying [7]. Therefore, there seems to be a need to support the efforts teachers have to do to implement strategies and approaches to engage children in educational and social activities.

Digital technologies have been suggested as a means to provide creative, intuitive and engaging learning experiences, which can help teachers better planning their students' educational goals [8]. However, designing technological yet instructional content for children with ADHD is challenging. In this paper we present the findings of an initial technological approach, where children are encourage to play with digital-educational resources. We argue that with our digital instructional resource, children can practice memory, attention and reasoning skills while the activities' design and technology keeps them engaged. Furthermore, the design and implementation of these kinds of technologies might be an alternative to physicians who often rely on pharmacological interventions as initial and/or sole treatment for children with ADHD [9].

2 Related Work

Digital technologies are conceived as a vehicle to deliver instructional educational content [10]. Especially during early childhood, playing positively influences important psychological, sociological, and intellectual developments. For instance, by means of video games researchers have studied how seven-years-old children make connections around mythology assignments. Users confront problems and make use of their expertise to solve puzzles before moving to the next challenge, and this engaging activity would never stops because of the ludic approach to deliver learning content [11]. Technology is also seen as a mediator for teaching cognitively demanding tasks. An example of these are educational tools that support the teaching of mathematics skills such as the manipulation of fraction equivalence [12].

The use of these and other technology-based instructional resources offer new options for children with ADHD. For instance, effective instruction might be reached using graphics, words and sounds, given that the recreation of real world scenarios is possible. Computers also allow repeated trials and let instructors organize content into smaller chunks of information [13]. The review offered by this author indicates that technology could create highly stimulating instructional environment, could envisage a promising approach for helping students gain self-control over their behaviors, or provide biofeedback training so that both students and therapists' are informed about brain activity.

Nevertheless one of the main symptoms exposed by children with ADHD is their short attention span, which leads to poor academic performance. For therapists the measuring of this neurobiological condition is commonly based on a subjective observational approach. Assistive technologies can help therapists make the inattentive

behavior assessment easier given that current gaze tracking devices localize the focus of attention on a display. In [14] authors, explored the design of a system aiming to evaluate a gaze-based attentive user interface that monitors the child eyes. Such a system could be used to manage educational content based on the level of attention the child keeps with the instructional material. A more robust technology-based approach is proposed by [15] to detect divided attention in reading activities. While children were reading the environment was fueled with distractors in the format of multitasking instructions or environmental noise.

3 Technological Solution

During period of four months we conducted a case study using user centered design techniques to design and implement an educational software tool for children diagnosed with ADHD at the Instituto José David in Chihuahua, México. The software was designed as a ludic experience with educational tasks aimed to reinforce learning abilities such as: attention, cognition, memory, and visuospatial memory. The software, for example, uses iconic cards to stimulate short term memory. Cards are presented to the player during a few seconds and the child has to select the previously shown cards immediately after cards disappear. Cards are in an unordered and larger set of cards to evaluate short term memory (see Figure 1a). In addition, visuospatial memory is reinforced when children have to summarize and recall information about the spatial location of objects on a grid (see Figure 1b).

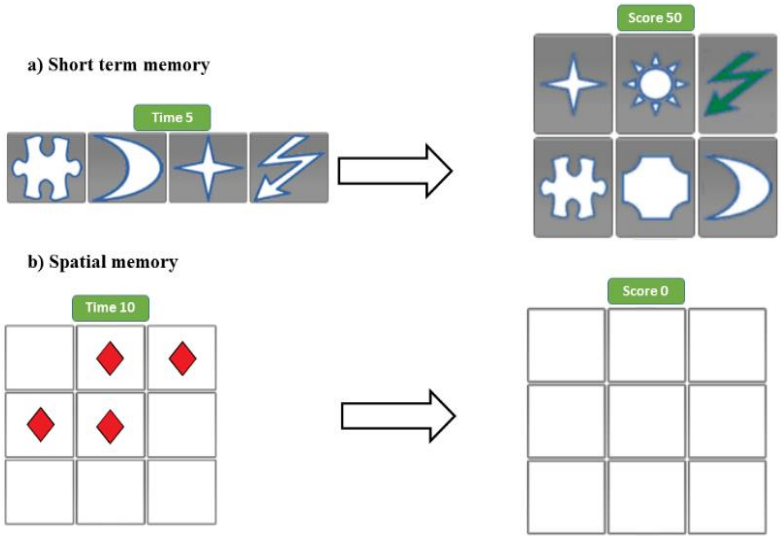

Fig. 1. Software's games: a) memory and b) visuospatial.

4 Methods and Evaluation

Researchers conducted a controlled between subjects experiment to evaluate children's attention and frustration levels while conducting one short term memory activity. Participants (N=15) were students between 8 and 11 years old (6 female). Students were recruited from among ADHD patients at Instituto José David in Chihuahua, México and consent was obtained from their parents. Evaluation consisted in four phases: 1) playing session with a digital game modality, 2) answer a questionnaire about the game, 3) play with the manual modality, and 4) answer a questionnaire about the game.

Participants were taken to Gesell room and assigned to start either with the digital or physical version of the game. A therapist on language and learning explained to each participant the dynamics of the game and how to play it during each playing session. Based on the child's excitement level, each child was given a specific time (avg. 5 min) to calm down and understand how to play and short after the therapist initiated the game. The digital modality was played with the Leap Motion[1] device and the manual modality was played with tangible game cards.

All playing sessions were video recorded with a webcam and a video camera and observed by a psychologist who analyzed each session independently. Furthermore, we used the Emotiv EEG device to track and generate real time reports on children affective state. EEG data was additionally analyzed in order to understand frustration (FM, FD), excitement (EM, ED), and engagement (EBM, EBD). Children were moved to a waiting area after each playing session and one researcher applied a questionnaire to assess each game modality.

The questionnaire evaluates user experience on attention and satisfaction for both manual and digital. It consisted on 9 questions for each modality and each question had a Likert scale with answers from "never" to "very frequently". Children played with both modalities of the educational activity (N Sessions = 60, Total of Questionnaires = 60). Questionnaire's data was analyzed using median values to understand satisfaction and attention levels between manual (AM) and digital (AD) modalities. We conducted Wilcoxon signed-rank test due to the non-normal distribution of data.

Table 1. Wilcoxon signed rank test of FD and FM.

		N	Mean Rank	Sum of Ranks
FD-FM	Negative Ranks	1[a]	2.50	2.50
	Positive Ranks	11[b]	6.86	75.50
	Ties	3[c]		
	Total	15		
Z	-2.915[d]			
Asymp. Sig. (2-tailed)	.004			

a. FD < FM; b. FD > FM; c. FD = FM; d. Base on negative ranks

[1] https://www.leapmotion.com/

5 Findings

Developing educational tools entails aspects from supporting teachers to creating engaging, yet educational, activities for children. In this section we present an overview of how current technology can be used for educational purposes based on sentiments.

5.1 Sentiment Analysis

During our study, children with ADHD showed important levels of frustration while playing the educational game in digital mode. Our findings indicate notorious differences on medians of frustration levels on both modalities. The Leap Motion modality has a higher frustration median than the manual activity (FM=2.0 and FD=4.0). This difference is further validated with the Wilcoxon signed rank test that indicates to what extent frustration levels with the Leap Motion interaction are statistically significant higher than the frustration levels with the manual activity (see Table 1, $Z = -2.915$, $p < 0.004$). To our knowledge, frustration has not been related with learning performance. Nevertheless, it may leads to children unwillingness to perform the educational activity. Frustration might arise due to the novelty of technology. During our study, this was the first time children used the Leap Motion technology and at times the Leap Motion did not perform as children would had expected, thus creating these significant levels of frustration. Even with these levels of frustration, we observed how there is also a significant difference between the digital (ED) and manual (EM) excitement levels (Medians: ED=4.0, EM=2.0). The Wilcoxon signed rank test indicates to what extent excitement levels are significantly higher with the Leap Motion technology than excitement levels with the manual activity (see Table 2, $Z= -2.004$, $p < 0.045$). This entails an interesting scenario where children feel frustrated with the new digital learning activities but also are more excited and motivated to complete them.

Table 2. Wilcoxon signed rank test of ED and EM.

		N	Mean Rank	Sum of Ranks
ED-EM	Negative Ranks	4[a]	3.5	14.00
	Positive Ranks	8[b]	8.00	64.00
	Ties	3[c]		
	Total	15		
Z	-2.004[d]			
Asymp. Sig. (2-tailed)	.045			

a. ED < FM; b. ED > EM; c. ED = EM; d. Base on negative ranks

In this regard, we believe that children might adapt to the technology interaction mode over time and with dynamic learning activities we might sustain excitement levels. Therefore, we can expect lower levels of frustration across a longitudinal study. In sum, a digital version with ludic excitement interactions might be the best option for educational and digital processes.

5.2 Digital Modality or Manual Preference

Although children presented significant levels of excitement over digital learning activity, we did not find a clear preference over the manual modality. Analyzing satisfaction data we observed how median satisfaction for manual activity was 5.0 as it was for the median satisfaction for the digital activity. We can infer that ludic learning activities provide a positive affective state since both modalities had the highest satisfaction level from our survey. In addition, both ludic modalities present high median attention level (AD = 5.0, AM = 5.0). Nonetheless children diagnosed with ADHD are characterized with inattention during learning activities, our participants were satisfied while playing both modalities and were attentive to the dynamics of the game despite the frustration levels due to digital technology. Median levels for the engagement state show how children were enthusiastic players (EBD = 4.0, EBM = 4.0) with few instances of boredom while playing. Regardless of these sentiment findings, there is not a clear children's preference over one modality of the learning activity. Further research is needed to monitor attention and satisfaction levels across time and exploit the benefits of using game-based learning technologies to promote excitement while learning.

6 Discussion

While prior work has highlighted the importance of technologically enriching classrooms or learning therapy sessions, our analysis focuses on identifying opportunities to support ludic learning activities with emergent technology. Technology provides important information around children's sentiments that can be used to enrich the learning experience. Nonetheless, abstract concepts such as attention can be difficult to monitor or infer. Therefore there is the opportunity to design and develop robust solutions to create intelligent learning management systems supported by sentiment analysis. In the next sections, we describe current limitations as opportunities of improvement but also alternative technologies to create more robust solutions.

6.1 EEG Limitations & Complementary Technologies

Teachers plan ahead the learning activities according the children' ADHD diagnosis but also make adjustments on daily basis based on the emotional state of each child. Adapting the learning activities might be troublesome since teachers might not be exactly certain how the emotional state of the child is. Teachers have to react when they observe the child presents a negative attitude (e.g. inattention). Throughout our analysis we observed how current EEG technology allows to analyze and determine the emotional state of the child while conducting certain educational activity. Providing this information to teachers in real time might alleviate or reassure the emotional assessment conducted during therapy or educational sessions. Nonetheless, current mobile EEG technology can be somewhat invasive or inaccurate for complex cognitive processes (e.g. attention). During our study, children were asked to wear a headset in

order to conduct our EEG data gathering, this is somewhat intrusive and not transparent for the children with the risk of inducing the sentiment of feeling observed or evaluated. Furthermore, identifying complex cognitive processes with the EEG data was challenging since identifying the sensory brain signals generated by such processes is still an open problem. Even for experienced psychologists this represents a challenging endeavor, for example, the psychologist involved in our participants' sessions stated how difficult is to determine if children were attentive to the learning activity or just their eyes were fixed on the activity but not paying attention to it. Therefore, current educational activities might benefit from incorporating complementary technologies to enhance accuracy detection of emotional states. Biometrics technology (e.g. eye-tracking or facial recognition) can be introduced to supplement emotional information and help detect when children are frustrated or are losing focus on the educational activity. Providing robust and less invasive mechanisms to infer emotional states on children have the potential benefits of conducting meaningful educational activities where children diagnosed with ADHD can be engaged and attentive.

6.2 Tradeoffs of New Technology vs ADHD

Children diagnosed with ADHD have been socially considered vulnerable since they might be subject to disadvantages compared with neurotypical children. In our study we decided to focus our efforts to empower and support learning activities for this population. Our findings showed higher frustration levels when using technology than those with the manual activity. Although these preliminary findings might suggest manual activities should be preferred over a digital one, we argue that these frustration levels were due to the novelty of the technology, and once the novelty wears off children will get accustomed to interact with such interfaces. Nevertheless, enriching learning environments with technology also conveys additional benefits to improve educational sessions. First, our findings illustrate how children experienced significant levels of excitement while using the digital modality of the educational activity. This experienced enjoyment alleviates the teacher's concerns of keeping children engaged on the learning activity and motivates students to keep assisting to the Institute. Furthermore, through sentiment analysis, intelligent learning management systems can be implemented to adequate the learning activity based on the emotional state of each child. For example, our system can log the emotional state over time and adapt dynamically the activity based on the emotions to keep the child engaged with the memory activity. Future learning management systems might also have a user input to avoid uncertainty when the teacher can disagree with the evaluation made by the system and input new values based on their expertise. Even with the high levels of frustration, we believe future learning systems should take into account the integration of different mechanisms to identify emotional state of the child and dynamically adequate digital learning activities which could help alleviate the teachers' burden.

7 Conclusion

Planning and executing educational activities for children with ADHD is a challenging endeavor. Developing ludic and digital tools to support teachers on their daily sessions

uncovers new challenges but also provides benefits. We acknowledge the length of the study as a limitation; nevertheless our findings suggest potential benefits of enriching educational activities with technology. Future learning systems can adapt educational activities with machine learning algorithms by analyzing emotional states to reduce the levels of frustration and maintain children engaged with the activities. Nevertheless, teachers are employing ludic activities to instruct children diagnosed with ADHD.

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ISSN 1870-4069

Building a Corpus of Facial Expressions for Learning-Centered Emotions

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Abstract. Recognizing emotions in software interfaces is very important today and even more in the educational field where the students can, through their emotions, reveal affective states related or not to the learning process. An educational software with the capability to recognize emotions will allow the students to receive appropriate feedback to their personal cognitive needs. In this paper a method is presented for the construction of an image database of facial expressions, in which, through the detection of EGG signals corresponding to affective states focused on education (engagement, bored, frustrated and meditation), detects and registers spontaneous facial expressions. We also show experiments with the obtained results.

Keywords: Face expression recognition, affective computing, EEG recognition, face expression database.

1 Introduction

The emotional state of a person is important because it enables or restricts the performance of its actions to achieve different goals. The study of emotions and the affective states had become increasingly popular over the last 20 years including them on the computing systems that we use nowadays. In the educational area, the emotions of the individuals are transcendental to the learning process. Several research works [1, 2, 3] had been developed to study the existing relation between the affective state of the student and the cognitive processes through the use of intelligent systems of learning. Some of the most important affective states focused on education are bored, confused, frustrated and engagement [4].

The purpose of this work was to build an image database of spontaneous facial expressions that corresponds to affective states focused on education. The main purpose was to use the corpus in different Intelligent Tutoring Systems (ITS). The main motivation of this work emerges from the need of having an image database of spontaneous facial expressions corresponding to affective states focused on education, since the existent data bases have issues such as: they only contain

images from people with posed facial expressions to represent an emotion and the images are from people with physiological features different from our community.

For the creation of the corpus, we needed to capture the images and label them with the emotion that they represent. The Emotiv EPOC headset, was used to perform the reading of EGG signals in persons participating in the experiment; this device allows to detect affective states focused on education using the affective suite. Additionally, to capture the image of the facial expression corresponding to the affective state of the person, a camera C920 Logitech HD Pro Webcam was used.

This paper is organized as follows: in the second section the related work is described; a description of the technology used to build the corpus is presented in the third section; in the fourth section the methodology for the development of the corpus is shown; the experiment and the obtained results are described in the fifth section; finally in the sixth section we present the conclusions.

2 Related Work

In this section some important works related to databases of facial expressions are presented and discussed.

Radboud Faces Database (RaFD) is a database that contains photographs of a group of 67 models, formed by Caucasians adults and children. Each model was trained to show 8 different facial expressions (anger, disgust, fear, happiness, sadness, contempt and neutral) and each emotion is shown with three different gaze directions where all photographs were taken from 5 different camera angles simultaneously in a highly controlled environment [5].

JAFFE Database is a database of facial expressions acted by Japanese women. The database contains facial expressions of over 60 women and each one of them presents 3 to 4 expressions of the following emotions: neutral, happy, anger, disgust, fear, sadness and surprise. The database contains a total of 219 images on grey scale [5]. In figure 2 two participants can be observed showing the seven expressions previously mentioned.

Database for Emotion Analysis using Physiological Signals (DEAP), is a multimodal database which presents a data set for the analysis of human affective states based on the basic emotions proposed by Ekman (fear, anger, happy, sadness, disgust and surprise). In this database EGG and physiological signals of 32 participants were recorded as each watched 40 one-minute long excerpts of music videos. Participants rated each video in terms of levels of arousal, valence, like/dislike, dominance and familiarity. For 22 of the 32 participants frontal face video was also recorded. The correlation between EGG signals and the participant ratings was investigated. The data set is publicly available so it can be used on investigations regarding estimation methods of affective states [6].

NVIE Database is a Natural Visible and Infrared Facial Expression Database that contains both posed and spontaneous expressions performed by 215 students (157 men and 58 women). The evaluated emotions were: happiness, sadness, surprise, fear, anger and disgust. The spontaneous emotions were induced by

screening deliberately emotional videos. Besides of capturing the facial expressions the goal was to analyze the relation between facial temperature and the emotion through a statistical analysis [7].

Cohn-Kanade dataset is a database that contains images of 100 college students between 18 and 35 years old. From this population, 65% are women, 15% are Africa-Americans, and only 3% are Asian or Spanish. All of the subjects were recorded acting a total of 23 facial expressions corresponding to seven emotions (neutral, anger, disgust, fear, joy, sadness and surprise) [8] using a video camera. This database was released in order to promote investigation on the individual automatic recognition of facial expressions, since then it has become the database of facial expressions more used in the development of algorithms and assessments of this kind [9].

The database of facial expressions that is presented in this paper distinguishes itself from the previous mentioned works in that the registered emotions are focused specifically in the learning process.

3 Technology

Emotiv EPOC is a brain-computer interface, created by Emotiv Systems. It is used in researching applications and contains three components named "suites" to process the signals: Expressive suite, Cognitive suite, and Affective suite.

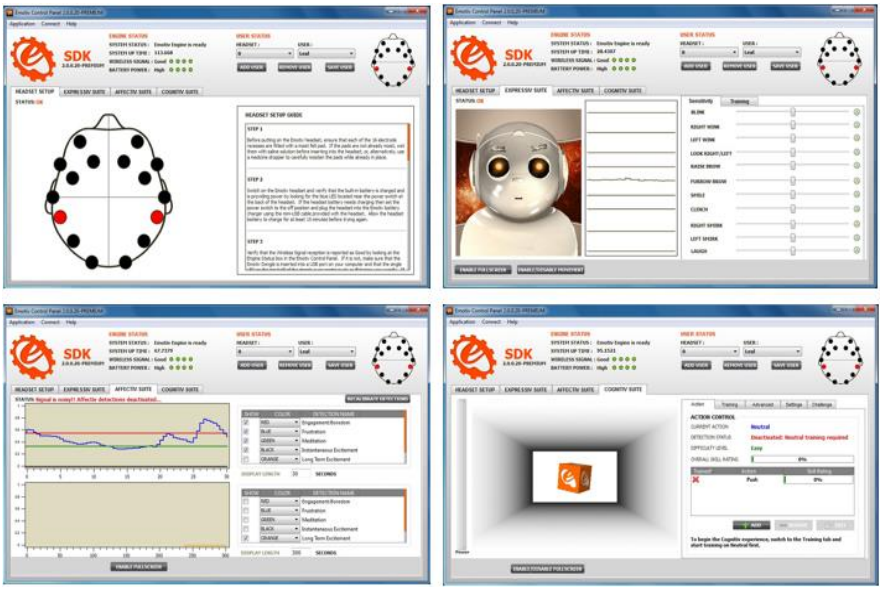

Fig. 1. Emotiv EPOC suite's interfaces.

The expressive Suite determines the facial expressions in real time according to the signals received by the interface. An avatar appears in the computer's screen

imitating the user's facial expressions. This action make possible a natural interaction. The cognitive suite interprets the user's thinking and intentions. The affective suite monitors the user's affective states in real time. Figure 1 shows the Emotiv interfaces.

The Emotiv EPOC headset has two support electrodes. They are set behind each ear in the skull's protuberant zone and are considered as points of reference to guide the correct placement of the rest of the electrodes. With the Control panel included in the kit, it is possible a graphic visualization of the electrodes' status to be able to know if the electrodes are positioned correctly or the electrodes need an adjustment. There is also the TestBench application to visualize the EGG signals in real time.

4 Application Development to Build the Database

The affective states detected by Emotiv EPOC considered in the creation of the facial expressions database are: *engagement, boring, frustration and meditation.* A Java application was implemented in order to create the facial image database considering the affective state when using the Emotiv headset. Emocomposer was required to emulate the headset operation. Figure 2 shows the environment and components of the application. The environment of the application consist of different components around the Emotiv's SDK and the Emotiv EPOC headset. The Java program running in the PC was implemented with the NetBeans IDE development environment. A jna.jar library was needed to make possible the interaction of the application and Emotiv EPOC headset. The open source OpenCV library was incorporated to perform the capture of the images using a Web Cam.

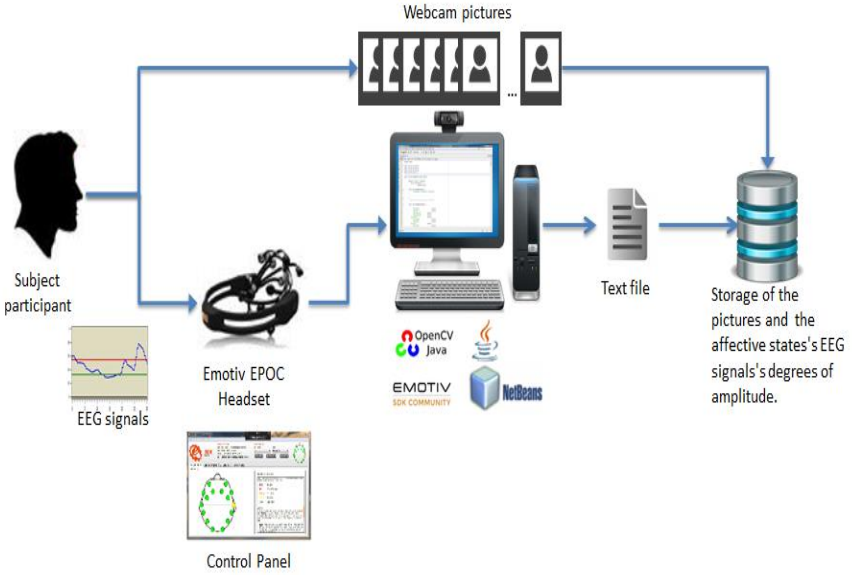

Fig. 2. Environment to create the facial expression database.

4.1 Testing the Environment

Some situations were detected and solved: lighting troubles which were solved using two extra white light lamps in addition to the experimentation room illumination. Figure 3 shows the general experiment environment, where the participant, as can be appreciated, is in front of the monitor, the position of the illumination lamps, a web cam, and the Emotiv EPOC headset.

4.2 Important Points in the Final Experiment

In the Final Experiment phase, the captured images were stored to feed the facial expressions database, using a partially controlled environment in which aspects like illumination, background, and acoustic were considered, to allow the participant express his/her emotions in a natural manner. Next, each experiment phase is described.

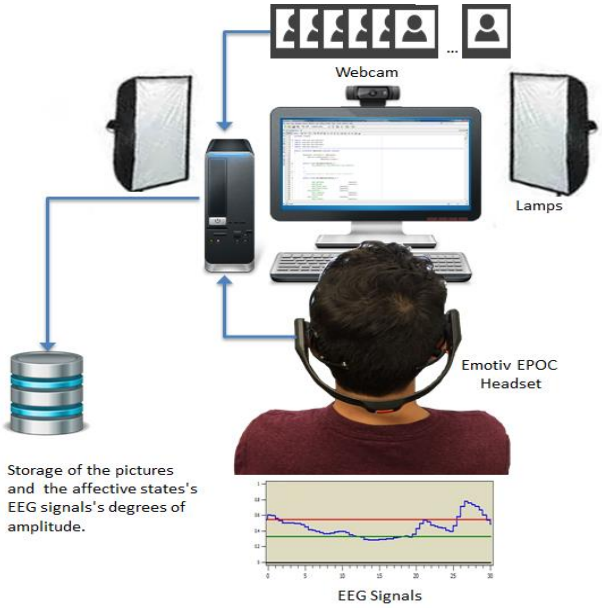

Fig. 3. Experiment environment.

A group of Master degree students from Instituto Tecnológico de Culiacán was chosen to participate in the final experiment. It was conformed of 8 students (5 men and 3 women), ages from 24 to 47. Intending to homologate the initial states of the subjects, they were instructed to follow the next recommendations: Sleep at least 8 hours the day before the experiment, had a good breakfast, do not consume coffee or energy drinks, do not consume substances that affect the nervous system, do not use gel or hair spray the day of experiment, do not wear glasses and wear dark clothes the day of the experiment.

The materials used in the experiment were: The Emotiv SDK Kit; a Laptop with Windows 7 Professional 64-bit operating system, Intel (R) Core (TM) i3-2310M and 4.00 GB RAM; the development environment NetBeans 8.1; Open CV library to capture the images; Java platform: Standard Edition Development Kit (JDK ™) to 32 bits; Logitech Webcam C920 HD Pro; Java application EmoStateLog Emotiv SDK and application implemented for the experiment; the Emotiv EPOC headset.

Some examples of programming exercises on Java that were provided to the subject participant to perform cognitive activities for 30 minutes were:

a) Hello World program
b) A program that reads name and date of birth of a person and get the number of days he has lived
c) A program that accepts as input 10 numbers and outputs their sum and average.

Experiment Execution Protocol

Our application captures an image every four seconds; to classify the image we take the amplitude value of emotions with greater intensity of the EEG signals and store it in a specific directory in the appropriate folder according to the student emotion. The directory contains four folders, one for each emotion (Engagement, Boredom, Frustration and Excitement). Additionally we recorded the name of the image and the amplitude values of the signals in a text file.

This process is performed individually with each of the eight participants, during the morning using the Master of Science laboratory from the Instituto Tecnológico de Culiacán, registering an average of 450 photographs by participant.

Debugging of Facial Expressions Database

We eliminate the photographs that had some type of facial obstruction, closed eyes, or have no frontal posture. The images were cut massively to reduce the margin of the image and emphasize the subject's face. At the end we had a total of 730 photographs. Figure 4 shows some photographs stored in our corpus.

5 Evaluation, Results, and Conclusions

Next to the creation of the corpus, we evaluate it with an application for emotion recognition for facial expressions using the technique local binary patterns (LBP). The recognizer working with 118 photographs had an accuracy of 86.95%. Due to the positive results in the evaluation, the use of this method for the preparation of a spontaneous learning-centered facial expressions database is considered feasible. For future work, we will perform the final experiment in a highly controlled environment and with improved lighting equipment, increasing the number of subjects, and taking into account the emotion *meditation*.

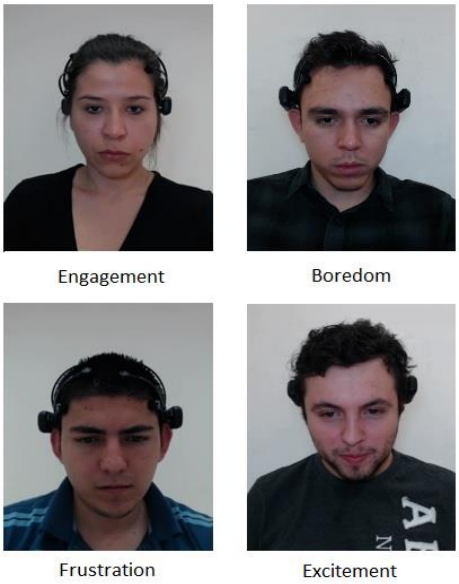

Fig. 4. Examples of facial expressions stored in the corpus.

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ISSN 1870-4069

A Fuzzy Control System for Improving Learning

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Abstract. It has been shown that the emotional state of students has an important relationship with learning; for instance, engaged concentration is positively correlated with learning. This paper proposes the Fuzzy Control for Improving Learning (FCIL), the proposed technique induces emotions in the player for supporting the learning process. The fuzzy system analyzes the players' emotional state for controlling the aesthetic content of an educational video game. A total of 13 subjects played a video game designed to practice basic math skills; for each trial, a student plays two times in a row the same game but each time the game was controlled by one of two approaches: FCIL or random. Results show that when the proposed approach is used, participants showed more engagement, i.e., they were in pleasant-high states more frequently. The proposed approach is a promising alternative for improving the learning effectiveness through detection and stimulation of positive emotions.

Keywords: Fuzzy control, educational video games, emotion induction.

1 Introduction

An educational videogame is a computer game that induces user engagement while promoting cognitive learning and social skills. In general, a successful educational game requires that its *mechanics* (game components), *dynamics* (behavior as responses of the players inputs), and *aesthetics* (environment shapes, animations, sound, etc.) fulfill the expectations of the target population. Each player has specific characteristics, e.g., preferences, abilities, emotions, and the game must adjust its dynamics and aesthetics accordingly.

In general, there are two approaches to adjust the game content: Dynamic Difficulty Adjustment (DDA) methods, aka dynamic game balancing, automatically change parameters, scenarios, and behaviors in a video game in real-time, based on the player's

ability; on the other hand, Emotionally Adaptive (EA) methods consider that by maintaining a high level of engagement, the game experience could lead to psychological benefits, such as a sense of efficacy and power over one's environment, as well as improvements in learning.

The main contribution of this paper is a fuzzy-logic-based method for changing the aesthetics of an educative video game. The aim of this approach is to select the aesthetic content for promoting learning. We believe that some multimedia content can: (i) alleviate some negative emotional states that are common in the constructive learning process (e.g., frustration), (ii) activate students that are in states that prevent learning (e.g., boredom or tiredness), and (iii) keep students in states that favor learning (e.g., happiness). The fuzzy rules were designed to consider many of these cases, it is important to avoid unlearning states for long periods; e.g., it is worthwhile to use unpleasant sounds to stimulate a bored student that cannot be activated by using harder difficulty level nor using pleasant sounds.

The rest of this paper, is organized as follows: section 2 reviews alternative approaches proposed to adjust the content of an educational video game, section 2 introduces the proposed approach, section 4 describes the empirical study, section 5 presents and discusses the results, and section 6 provides some conclusions together with perspectives for future work.

2 Related Work

There are many studies that focus on providing instructional objects at the correct level of difficulty for the student. A common approach consists of planning the curriculum sequence, i.e. providing the student with the most suitable sequence of knowledge units and learning tasks (examples, questions, problems, etc.) [3]. This approach solves the problem of finding an optimal path through the learning material.

Few studies have investigated how to improve the game--based learning performance by adapting the instructional material according to the learner's current developmental and individual particularities; e.g., the way of thinking, feeling, behaving, and relating to others; for instance, some approaches [7, 5] identify the learning style for providing personalized learning materials – learning styles group common ways that people learn [6].

Emotionally Adaptive methods require knowing the emotional state to take decisions. These decisions can only consider specific emotional feature; e.g., the mental work load [17] the anxiety level [15, 10] or the arousal [13].

Emotions can be defined as biologically based action dispositions that have an important role in the determination of behavior [9]. Emotional response can be measured by different approaches: affective reports, overt behavioral, and physiological reactivity [8]. Affective reports require that an observer (someone or the user himself) determines the user's emotional state; many instruments aiming to support the evaluation process have been proposed – e.g., adjective checklists, physiological techniques, photo decks [12]. In this paper, a simplified version of the Self-Assessment Manikin (SAM) [12] was used to assess the user's emotional state. SAM is a non-verbal pictorial assessment technique that uses a graphic figure depicting values along each of

three dimensions (pleasure, arousal, and dominance). The simplified version used in this paper only uses two dimensions (pleasure and arousal).

A closed related work is that of Liu et al. [10] where the player's physiological signals are analyzed to infer his or her probable anxiety level and the game difficulty level is automatically adjusted in real time as a function of the player's affective state. They use a finite state machine to model affection-based dynamic difficulty adjustment; but, their approach does not adjust the game contents.

3 Fuzzy Control

The inputs for the fuzzy control are: $(\underline{V}, \underline{A})$, the current player's emotional state; and (V_{k-1}, A_{k-1}), the nominal emotion induced by the aesthetics used in the previous stage, where V is the valence and A is the arousal. The fuzzy control output is the aesthetic (V_{k-1}, A_{k-1}) for stage k.

3.1 Membership Functions

We need to define the linguistic terms that input/output variables can take on. Along with each linguistic term, we need to define their membership functions. Although most of the work that deals with fuzzy inference and control, uses an odd number of linguistic terms, that is not a requirement. As shown in Fig. 1, the variables we use in performing fuzzy inference are defined with 2, 3, 4, or 5 linguistic terms; the number of them and their labels were taken from the application domain [14]. Another important design decision about the fuzzy inference system is the shape of the membership functions for the linguistic terms of the involved variables. Gaussian functions were chosen to represent fuzzy set membership.

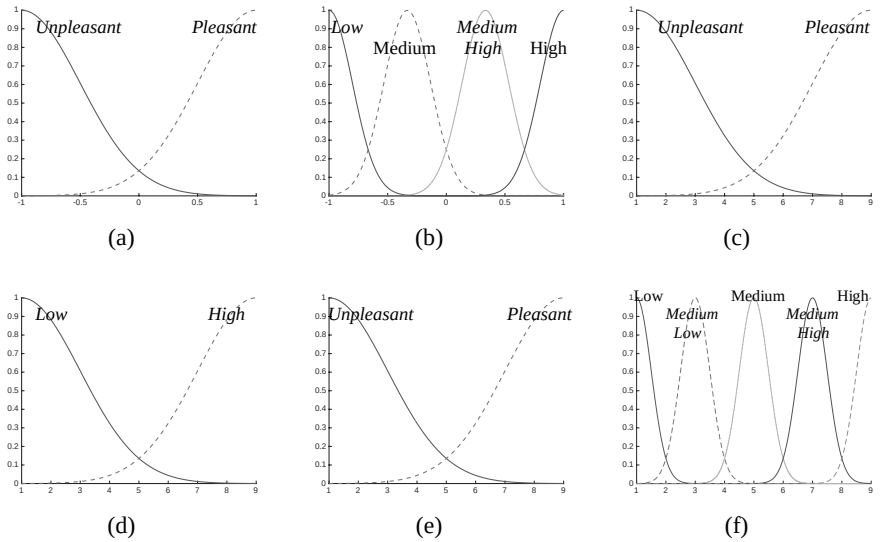


Fig. 1. Membership functions. (a)$\underline{V}$ (b) $\underline{A}$ (c)V_{k-1} (d) A_{k-1} (e) V_k (f) A_k.

3.2 Fuzzy Rules

To induce emotions in the player, the current implementation only change sounds, but the results can be generalized to other aesthetics. To induce emotions, the IADS-2 International Affective Digitized Sounds [2] data set was used. The IADS was developed to provide a set of normative emotional stimuli for experimental investigations of emotion and attention.

Table 1 Fuzzy Rules for the next stage aesthetics by considering the player emotional state and the previous aesthetics used. The notation (Valence, Arousal Level) represents the state. The subscript in each cell indicates the rule number. Pleasant emotions are represented as +, and Unpleasant as −.

		Previous Aesthetics		
		(+, Low)	**(+, High)**	**(-, High)**
Player State	**(+, Low)**	R_1: (+, Very High)	R_2: (-, High)	R_3: (+, Very High)
	(+, Medium)	R_4: (+, High)	R_5: (+, High)	R_6: (+, High)
	(+, Medium-high)	R_7: (+, Medium)	R_8: (+, Medium)	R_9: (-, Medium)
	(+, High)	R_{10}: (+, Medium)	R_{11}: (+, Medium)	R_{12}: (-, Medium)
	(-, Low)	R_{13}: (+, Very High)	R_{14}: (-, High)	R_{15}: (+, Very High)
	(-, Medium)	R_{16}: (+, High)	R_{17}: (-, High)	R_{18}: (+, High)
	(-, Medium-high)	R_{19}:(+, Medium Low)	R_{20}: (+, Medium Low)	R_{21}: (+, Medium Low)
	(-, Medium-high)	R_{22}: (+, Low)	R_{23}: (+, Low)	R_{24}: (+, Low)

The fuzzy rules for aesthetics, shown in Table 1, were selected by applying the following theories and facts:

1. Russell [16] asserts that the emotional state is a biological product of evolution and therefore it likely has a function. Russell suggests a general principle of congruence: pleasant states facilitate attention to positive material (and vice-versa).
2. Pleasant-high emotions are associated to engaged concentration, which is positively correlated to learning [16] hence, each rule of *{R_1, R_3 … R_6, R_{13}, R_{15}, R_{16}, R_{18}}* selects aesthetics that induce pleasant-high emotions. The rules in this set aim to activate students.
3. Unpleasant-high emotions (e.g., frustration or confusion) may be natural and unavoidable when learning a difficult material [1] such is the case of conditions required for rules *{R_{19} … R_{24}}*. Aiming to reduce the arousal, these rules apply aesthetics that evoke pleasant-low emotions (e.g., calm).
4. Baker et al. [1] suggest that boredom must be detected and quickly managed. Boredom conditions are in rules *{R_{13} … R_{18}}*; hence, these rules suggest arousing aesthetics aiming to elevate the student arousal.
5. For the same reasons stated in the preceding point, the proposed rules avoid inducing unpleasant-low emotions; furthermore, these aesthetics are never used and Table 1 does not have a column labeled as '(-, Low)'.

3.2 Fuzzification and Defuzzification

The fuzzification transforms the inputs into fuzzy sets in such a way that they can be used by the fuzzy system; for this aim, a simple singleton fuzzifier was used. A number of deffuzzification strategies exist, each provides a means to choose a single output based on the implied fuzzy sets. A typical *Center Of Gravity* (COG) strategy was used [14].

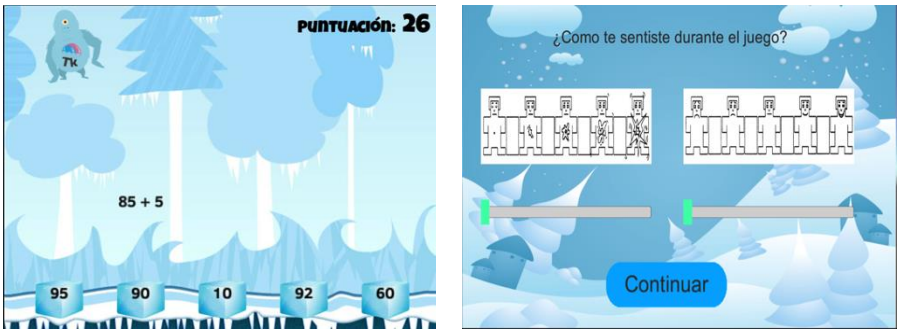
4 Materials and Methods

This study investigates the pertinence of the proposed method in terms of players' enjoyment, and performance. The following sections describe the video game, participants and metrics used in this study.

4.1 Videogame

A game to practice basic math skills was designed for this study. Two versions of this game were used for the test, they have the same mechanics and dynamics – e.g., both have the same game elements, states, and rules for selecting the difficulty – but different aesthetics, as explained below.

Dynamics. Each stage is composed of two scenes that interact with the player. In the first scene (Fig 2a), a character throws 10 arithmetic operations of two numeric quantities. For each operation, the player must choose the right answer by moving the falling object (using left and right keys); the fall can also be speeded up (using the down key). To obtain points, the falling object (the sum) must be introduced into the correct container (the answer) before it reaches the bottom of the screen. The game plays the selected sound each time a new sum operation is shown. The second scene (Fig 2b) is aimed to obtain the user's emotional state; the user introduces his/her emotional state by using a simplified SAM version [12] that only has two sliders (arousal/valence).



(a) (b)

Fig. 2. Game Dynamics: (a) The playing scene, the user must introduce the falling object into the correct container to earn points, (b) SAM scene, the self-report is used to introduce arousal and activation values.

Difficulty Level. For testing purposes, games use a simple linear DDA algorithm to select the next difficulty level. The change factor is calculated as

$$F = S + 0.5;$$

where S is the Score Ratio obtained in the previous stage. The new difficulty level, D_k is calculated as

$$D_k = F \bullet D_{k-1}.$$

where D_{k-1} is the difficulty of the previous stage.

Aesthetics. The two games differ in the strategy employed for generating the next scene content (aesthetic):

Game A. The aesthetics (sound) is selected randomly from the database.
Game B. It uses the FCIL approach proposed in this paper. The aesthetic selector chooses the closest sound to the suggested. For both games, a random content is generated at the beginning and an initial difficulty is selected.

4.2 Participants and Procedure

A total of 13 participants in secondary school from the "Colegio del Centro" Secondary School in Zacatecas, Mexico participated in this study. Participants played two consecutive 10-minute play sessions separated by a 5-minute resting period. Each participant played 'Game A' for one session and 'Game B' for the other —the order of playing these sessions was assigned randomly. In total, six participants played first the 'Game A' and then the 'Game B' (and the other seven participants first played the 'Game B').

4.3 Metrics

For each participant/play session the following metrics were obtained:

Percentage of stages by emotional state. This metric is calculated as:

$$e = \frac{\sum_{\forall p} p_e}{\sum_{\forall p} p_t} \cdot 100 \quad ,$$

where p_e, is the number of stages that participant p exhibited emotion e and, p_t is the number of stages completed by participant p in the play session.

Emotional Transitions. Let e, e' be two emotional states, the percentage of transitions between e and e' is:

$$\text{tran}(e, e') = \frac{\sum_{\forall p} p_{e \mapsto e'}}{\sum_{\forall p} p_e} \quad ,$$

where $p_{e \mapsto e'}$ is the number of times that participant *p* exhibited the emotion *e* immediately followed by emotion *e'*. Note that

$$\sum_{\forall e_i} \text{tran}(e, e_i) = 1 \ .$$

Last Score. To compare the performance of participants, video games save data log of scores. Let $S_n = \langle s_{ni} \mid i = 1 \ldots N \rangle$ be the scores of each stage obtained by the *n*-th participant, where s_{ni} is the score at the end of the *i*-th completed stage. The last score is

$$\text{last}(S_n) = s_{nN}.$$

4.4 Statistical Analysis

Data are represented as mean ± S.D. and the significance was assessed by Student's t-test for paired data. Differences between values were considered significant when $p < 0.05$.

5 Results

The overall comparison of the proportion of stages by emotional group is shown in Fig. 3. The proportion of pleasant-high states is higher for FCIL (55.21%) than for random selection (40.95%). Besides, the overall proportion of unpleasant-high states is lower for FCIL (18.75%) than for random selection (20.95%).

Table 2. Comparison of emotional state transitions. As shown in bold, transitions to pleasant-high are higher for the proposed approach than for random selection.

			Random				FCIL			
			(Emotional state)$_{k+1}$				(Emotional state)$_{k+1}$			
			Pleasant		Unpleasant		Pleasant		Unpleasant	
			Low	High	Low	High	Low	High	Low	High
(Emotional state)$_k$	Pleasant	Low	0.633	0.200	0.100	0.067	0.278	**0.500**	0.056	0.167
		High	0.128	0.564	0.026	0.282	0.130	**0.696**	0.022	0.152
	Unpleasant	Low	0.600	0.200	0.200	0.000	0.167	**0.500**	0.167	0.167
		High	0.056	0.444	0.056	0.444	0.000	0.308	0.231	0.462

As shown in Table 2 transitions to pleasant-high are higher for the proposed approach than for random selection (except for unpleasant-high states). It means that participants change to pleasant states more easily by using the proposed approach. Furthermore, unpleasant-high emotional states not always require remediation [11] since such states (e.g., frustration or confusion) are related to learning and are linked to learning gains [1].

Finally, there was not a statistical difference in the last score for FCIL and random approaches, $t(13)=-1.30$, $p=0.217$. It means that results shown in Fig. 3 and Table 2

was not driven by the difficulty level; hence, the aesthetics are playing a crucial role to change the emotional state of the player.

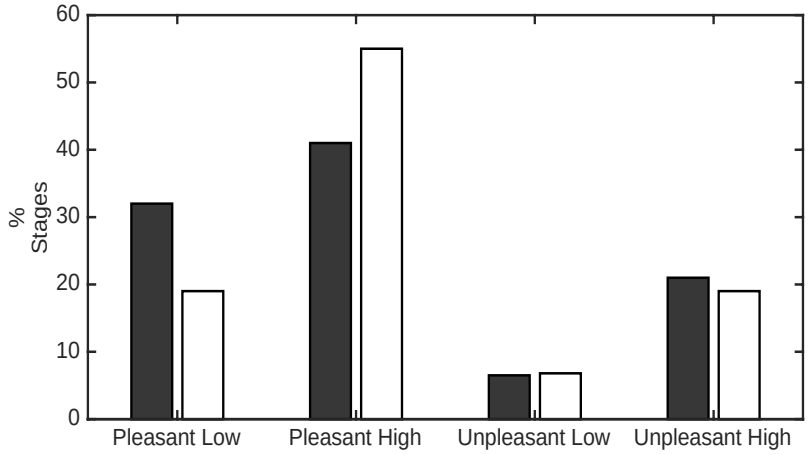


Fig. 3. Overall comparison of percentage of stages by emotional state of the player (dark – random selection, white – proposed approach).

6 Conclusions and Further Work

The proposed technique induces emotions in the player for supporting the learning process. The overall results show that in comparison to random content generation, the proposed approach increases the proportion of stages were the students experience pleasant-high emotions and reduces their Unpleasant-low stages. The unpleasant—tlow is considered an unlearning state; hence it must be avoided because it can make it difficult for students to complete some tasks. Currently, we are working on a systemic approach that controls the difficulty, the mechanics, dynamics and aesthetics of learning materials. Introducing a difficulty control into the proposed FCIL could help students to smoothly reach their "flow zone" [4] and once reached, it can help to keep students in flow. Besides, we are working on replacing the self-reporting by a physiological assessment.

Acknowledgments. We are in debt to the staff members and students of the secondary school "Juan Bosco" from Zacatecas, Mexico. This research was funded by the National Council of Science and Technology of Mexico (CONACyT) through the project CATEDRAS-3163.

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ISSN 1870-4069

Architecture of an Intelligent Training System based on Virtual Environments for Electricity Distribution Substations

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Abstract. In the electrical domain, qualified electricians are required since it involves danger. Training has been based on classroom courses and practice in the real installations, but it takes a long time and is costly. We propose to complement traditional training with an intelligent training system based on virtual environments in such a way that a blended training model is composed. We are looking for adaptive and innovative training; therefore we are including the characteristics and states of the student to adapt the instruction. We are developing a system to teach novice student how an electrical substation works as well as its individual compounding equipment. The proposed architecture for the intelligent training system and the development progress of the virtual environment are presented.

Keywords: Adaptive training, electrical distribution, learning environment, learning styles, virtual reality.

1 Introduction

Training is very important for every productive process, since if personnel are not well trained, accidents and losses could occur. In energy sector, training becomes a strategic aspect because accidents prevent the energy provision, which in turn affects industry and services sectors. Additionally, accidents could injure people. In most areas of electrical domain, the training takes a long time and is a costly process, because personnel have to move in order to practice in the actual installations. The substations are not always available because they are in operation in a regular basis. Additionally, very often there are not enough instructors available for the training demand.

We have composed a blended model with the aim of improving electrical training. The model includes the aspects of traditional training: instruction in a classroom with a certified instructor and practice in real installations; and the novel component is conformed by intelligent training systems with virtual environments which allow

learning the electricity topics and practicing the maneuvers before practicing in real world. The systems provide virtual representations of the electrical installations. To date, we have developed several virtual reality systems for learning maneuvers in domains such as electrical tests in substations [1] and energized lines [2].

Now, we are developing a system to teach about the individual equipment composing a distribution substation, in order to teach novice electricians how they work and how they contribute to the whole process of the substation. The system presents the lessons with textual and auditory explanations in a virtual environment, and we are including elements of augmented reality.

There are diverse advantages of the virtual reality, one of them strives in that it allows to visit places which are difficult to get or physically impossible to visit. On the other hand, the augmented reality, allows having information which are not explicitly present in the real environment. We are trying to integrate these features in a low-cost training system.

In this paper, we describe the proposed architecture for the intelligent training system and the work in progress in the virtual environment development. The rest of the paper is organized as follows: Section 2 describes the architecture of the proposed model. Section 3 describes the virtual environment. Section 4 includes a discussion. Finally, section 5 presents some conclusions.

2 Related Work

There are some works relating Virtual Reality and Substations. For instance in [3] is reported a work in progress; relevant here is that the authors consider that immersion is mandatory which might be inaccurate since besides visual and auditory feedback, the other senses of users are poorly stimulated, smell and taste are still under research. Full immersion would provide feedback to all five senses, in such a way that users would have the experiencing of being inside of a synthetic environment.

Furthermore the cost of immersion might still be prohibitive for companies with thousands of users, although immersion might still be attractive for demonstration purposes or gamming. Some advantages of VR already mentioned here are included in [4], within a substation in a 3D virtual environment. In [5] a Chinese company mentions other advantages of applying VR to train substation operators such as improving substation operation, provide brake operation ability, strengthen the safety consciousness, and develop strict compliance work style. A closer functionality to our system is reported in [6], where is mentioned that each component of the substation is reproduced in the simulation model, including the behavior laws associated with it, so the complete functionality of the sub-station can be simulated.

3 Electrical Distribution System

The electrical distribution substations receive high tension of 115 kV and delivers medium tension of 24 kV. The substation reduces the voltage which then is transported by the medium tension distribution poles to the cities for industrial and domestic use. Here the 24 kV are reduced to 127 v, which is the Mexican standard, by the small

transformers located on the distribution poles. In an overall view, Fig. 1 depicts the main operation of an electrical substation.

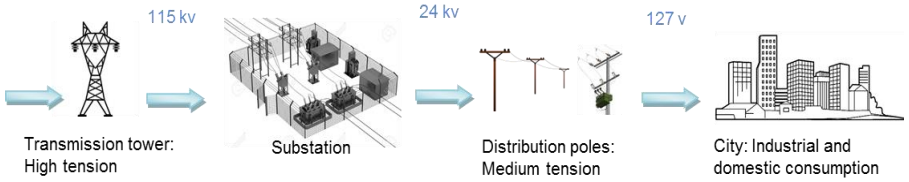

Fig. 1. Operation of the electrical distribution system. The substations receive high tension of 115 Kv and delivers medium tension of 24 Kv. The voltage is transported by the medium tension distribution poles to the cities for the industrial and domestic use. The 24Kv are reduced to 127v, by the small transformers located on the distribution poles. Partial images taken from [7].

4 Intelligent Training System Architecture

The traditional training has been successful; however it takes a long time and therefore it is costly. We are composing a blended model to support traditional training. As can be observed in Fig. 2, in this new model we include intelligent learning systems to provide an adaptive training which in turn minimizes costs and hours of training; also we include virtual environments to provide trainees with a realistic scenario to practice the electrical maneuvers. As we mention, we have developed several systems for different areas of electricity domain, here we are presenting a system to teach how an electricity distribution substation works, its components and relationships. More details about the model can be found in [8].

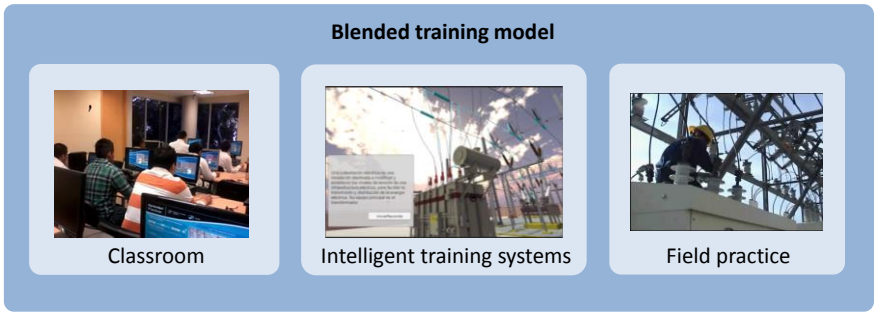

Fig. 2. Blended training model. The model is composed by a) instruction in a classroom with a certified instructor, b) practice in real installations; and c) intelligent training systems with virtual environments.

The new component, the intelligent training systems, complements the classroom classes. The trainees receive the lessons by an instructor and they can practice the maneuvers with the system. The system allows distance training since electricians can learn by themselves about the operation of a substation even before they are enrolled in

a course or have access to a real substation. The architecture of the system is presented in Fig. 3.

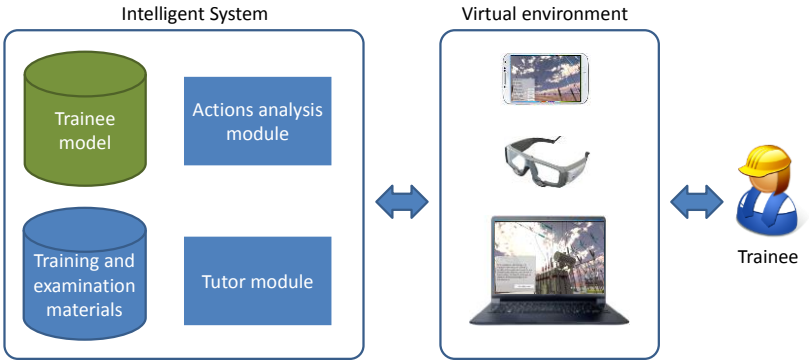

Fig. 3. Architecture of the intelligent training system for electricity distribution substations. The system is composed by two principal components: the intelligent system and the virtual environment. The first one includes two modules: the analysis of actions of the trainee and the tutor module. The virtual environment is a virtual representation of a real substation, and it stands for the interface with the trainee.

The intelligent training system provides adaptation and personalized instruction based on the state and characteristics of the trainees. To do that, the system maintains the trainee model, which is a representation of the trainee; it contains the characteristics of the trainee and what he knows about the subject matter. For the time being, we are including the learning styles [9] of the trainees to present the explanations about the equipment.

A repository stores the training and examination materials. The materials are designed in different degrees of detail; and in different formats to accomplish different learning styles. The training and examining material were developed and designed by a team of experts.

The analysis of actions module determines the equipment which is the focus of the interest of the trainee base on clicks and gazes. This module relies on artificial intelligence algorithms to establish the equipment which is the interest for the trainee. Technologies like eye tracking and augmented reality are being analyzed for detecting the point of interest of the trainee.

The tutor model receives the knowledge about the interest of the trainee and establishes what to teach according to the knowledge about the trainee, stored in the trainee model.

4.1 Trainee Model

We have developed a student model that considers the affect and knowledge to decide the next tutorial action. The tutor monitors the affective state of students and reacts in consequence. Now, we want to have more adaptive instruction identifying the learning style of students and to provide students with an instruction according with their learning style [10].

We based our approach on Felder-Silverman learning styles model [11, 12, 13] which proposes the following learning styles: active, reflective, sensing, intuitive, visual, verbal, sequential, and global. The model also proposes teaching rules for each learning style [9].

In this way, the learning style determines the type of explanations to be presented to the student. However the affect, knowledge and interest determine what should be explained to the trainee.

In this way, our integration approach allows building intelligent tutors that are adaptive in response to the knowledge state, the affective state and the learning style of the students.

5 Virtual Environment

Virtual reality provides advantageous features which make it a good tool to create learning environments. Among other features, we can mention, it allows active learning, provides simultaneous stimulus to different leaning channel for different kinds of students namely visual, auditory and kinesthetic.

The virtual environment allows free navigation throughout the substation, and trainees can first follow the correct sequence guided by the system and then go to particular components in order to review how specific equipment work. Free navigation makes also possible the inspection of the substation.

The system provides a comprehensive view of the operation of a substation. This includes detailed information about each component through the substation. This is achieved by providing visual, text and audio information and enhanced by 3D animations.

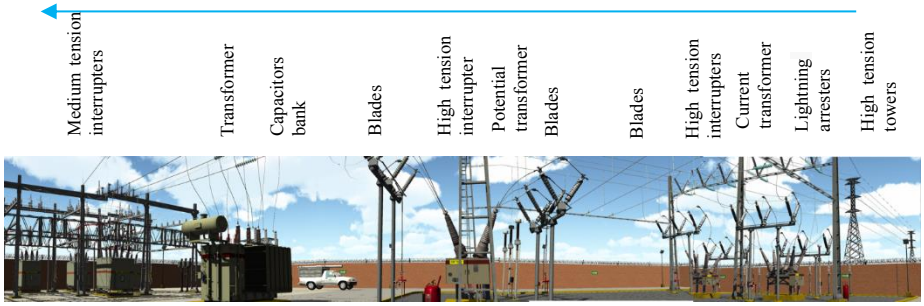

Fig. 4. Virtual representation of an electrical distribution substation. The electricity is delivered to substation by the high tension tower, and it run through the primary equipment.

Following the energy flow shown in Fig. 4, the operation of a substation is accounted for a sequence starting in the high tension towers, then the lightning arresters, current transformers, high tension interrupters (breakers), potential transformers, transformer, capacitors bank, medium tension breakers, and so on.

For instance, the system provides information about lighting arresters (LA) which are the first primary equipment in the substation which receives the high tension potential. The written information explain how the LA work, then some animations are

triggered so that first: a particles animation illustrates the path of the current through the cables until it reaches the LA, and second: under demand by using a button the user can trigger another animation where the LA turn transparent so that the user can see how the internal devices work. Here it is explained that when the LA receive a tension overload, the LA close the circuit to guide the voltage overload towards the ground (Fig. 5).

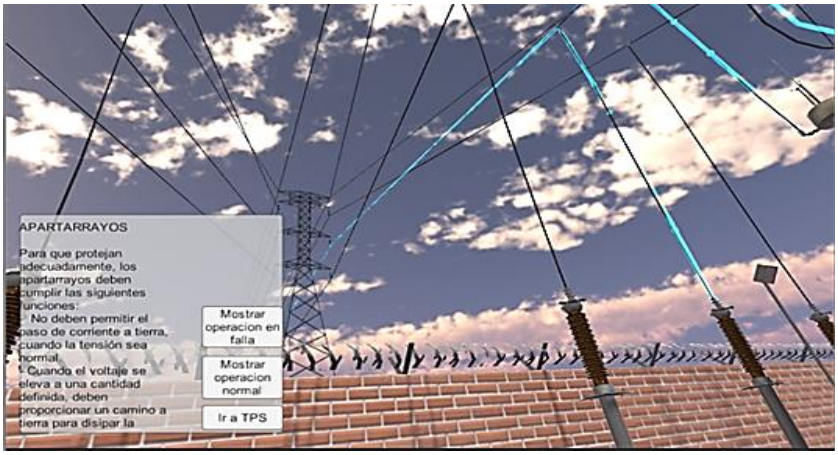

Fig. 5. The system provides information about lighting arrester. A particles animation illustrates the path of the tension. Thus, the system shows how the lighting arresters work in case of over tension based on the animation of the running tension.

As another example that deserves to be mentioned here, has to do with the transformer, since this is the core of a substation. Again using animations illustrating the path of the current, the system shows how on one side it receives the high tension and on the other side it delivers medium tension. In the explanation the transformer turns transparent so that the user will be able to see the inside of it, and an animation will illustrate how the tension is transformed (Fig. 6).

Contingency situations (CS) occur when something goes wrong in the substation, when primary equipment fails due to different possible causes, for instance lightings, voltage overload, short circuit originated by fauna, and so on. CS are associated to corrective maintenance, that is to say some equipment fails and it needs to be fixed or replaced.

Our system also is planned to include training to perform operations in CS within a collaborative environment, where we can have both the console of the instructor and the console of the student. Thus the instructor would be able to introduce specific CS and observe how students proceed to fix the situation. This is suitable for the implementations not only of active learning but naturally for the implementation of problem-based learning.

As an example of a contingency situation we can mention a tripped breaker. In case the breaker is not under observation, here a student must verify whether or not the breaker was operated by a protection (R50). If so, he must restore the relay flags and make a revision of the equipment informing to the operator. In case there is something

wrong in the substation, he should start the maneuvers to bypass the equipment and isolate the failure. Then after correcting the problem, the equipment must be restored into the circuit [14].

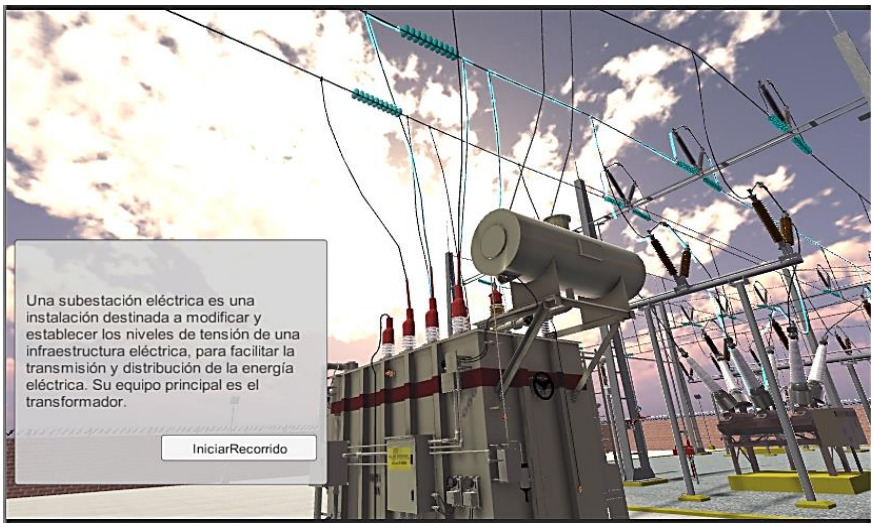

Fig. 6. The system shows how a transformer works. The transformer is the core of the substation since it reduces the high tension to medium tension. The system will show how the transformer works by using animations and transparencies to the see the inner parts of the transformer.

6 Conclusions and Future Work

Thus far, we can navigate or inspect the substation. We have different animations to show closing and opening blades and particles to illustrate the current flow. The system is also able to show textual and auditory information to explain how primary equipment works in the substation. In parallel in a different application we have implemented the collaborative learning environment which we will include in this system. Finally we have developed the controls of an animated agent representing an electrician. Thus, a trainee can move the electrician and control it like in a game. This entire infrastructure will be used to add the collaborative learning environment and the capability to train contingency situations. The system is intended to provide novice students a full view of the operation of a substation and some contingence situations.

There are at least three main functionalities that we will integrate to the system, namely: collaboration, animated agents, augmented reality.

In another development we have successfully implemented the simulation environment including the instructor and student consoles by using the multiplayer potential of Unity (https://unity3d.com/es), the game engine that we are using. We want to replicate and integrate also this functionality into this system. We have also worked on an animated agent that we pretend to integrate to the system as an animated agent.

We pretend shortly to use augmented reality to enhance performance of electricians. Once we have an electrical substation and different animations regarding the electrical

tests, we want to include the image processing to identify different primary equipment in the substation and together with the test sequence we can organize the information and then by using some glasses or a Smartphone to deliver 3D images and explanation so that the electricians are helped to perform maintenance procedures and electrical tests. In fact this would lead us to a different application.

The system is being developed using 3DSMax and Blender for 3D modeling and Unity as an integrator.

To incorporate learning styles in the adaptation of tutoring systems allows identifying the best tutorial action given the students' preferences, strategies, experience, and so on.

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Impreso en los Talleres Gráficos
de la Dirección de Publicaciones
del Instituto Politécnico Nacional
Tresguerras 27, Centro Histórico, México, D.F.
diciembre de 2016
Printing 500 / Edición 500 ejemplares