Serious Applications of Technology in Games and Health

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Serious Applications of Technology in Games and Health
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Facultad de Ingeniería y Ciencias
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Contenido

Introduction

This book constitutes the refereed proceedings of the 13th International Conference on E-Learning and Games, Edutainment 2019, and the Workshop on Computing and Technology in Health (CoTH) 2019, held within the same conference. Edutainment was held in Cali, Colombia on august 15-17, hosted by Pontificia Universidad Javeriana Cali and supported by Hangzhou Normal University, Xi'an University of Technology and Tianjin University of Technology in China; Bournemouth University and Liverpool John Moores University in UK; National Polytechnic Institute, México; Divsar, Argentina; Universidad Libre Seccional Cali; Universidad del Cauca, Popayán; Universidad Santiago de Cali and Pontificia Universidad Javeriana Bogotá in Colombia. Edutainment 2019 has become a major international event which combines education and entertainment, covering not only the research issues of game-based learning but also the issues of learning experiences which may be gained from entertainment.

At first, when we talk about serious applications of technology in games and health, we are referring to serious games or games in which the objective goes beyond mere entertainment, which in Edutainment 2019 refer to education. Additionally, we decided to use the term "serious" to refer to the use of technology in applications that search to contribute to the solution of relevant social problems, in this case health. We did not want to limit the scope of the workshop to serious games applied to health or edutainment in health; indeed, we wanted to hear about new ideas related to the applications of technology to health.

The papers were organized in one prologue and four sections; because the focus of the main conference is Edutainment, the prologue was written by the founder, chair of the steering committee of the Edutainment conferences. The first section includes one extended paper from one of the keynote presenters; the second, contains the nine papers submitted to the CoTH; the third section includes three

papers chosen 12 Edutainment's poster paper candidates; and the fourth encompasses one abstract from a Colombian student representative from International Game Developers Association (IGDA) and five abstracts chosen at the Expoposter 2019-1 in Universidad Central del Valle to be presented at Edutainment 2019, which have not been previously published.

The Edutainment Conference had 41 submissions: three papers were presented during the Edutainment's 2019 poster session; 22 in parallel sessions, whereof 21 are to be published in IEEE Xplore in collaboration with the 9th International Conference on Virtual Reality and Visualization (ICVRV 2019). Seventeen papers were invited for extended versions to the Revista Facultad de Ingeniería Universidad de Antioquia and the Virtual Reality and Intelligent Hardware journals. On the other hand, the Expoposter 2019-1 had 21 submissions, the CoTH 2019 had nine and all of them were presented. The 13 full papers and six abstracts presented in this volume were carefully reviewed and selected from 71 submissions. The listings of chairs, committee members and keynote speakers follow before the prologue.

This compilation, is part of the project No.125174455451, entitled "Apoyo a la Terapia de Rehabilitación del Lenguaje Oral y Escrito en Niños con Discapacidad Auditiva", funded by the Departamento Administrativo de Ciencia, Tecnología e Innovación de la República de Colombia (COLCIENCIAS). It was also possible thanks to ICETEX Colombia and the Chinese delegation that came to Cali. The volume is written in English and Spanish, the two official languages of the event.

Keywords

Edutainment, gamification, training, health, serious games, e-learning, medicine, video game.

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Luisa Fernanda Rincón- Pontificia Universidad Javeriana Cali.

Keynote speakers at the Edutainment 2019 and CoTH 2019

Dr. César A. Collazos

Full professor at Universidad del Cauca (Colombia), Phd in Computer Science (Universidad de Chile) and keynote invited of different workshops. Postdoctoral staying in Spain and Chile working in aspects related with human-computer interaction and computer supported cooperative work, and visiting professor of different ibeoramerican universities in Chile, Spain, Per**ú**, M**é**xico and Argentina.

Dr. Mario Diván

Full professor and head of the Data Science Research Group at National University of La Pampa (Argentina). Honorary Professor of the Amity Institute of Information Technology (Noida, India), Dr. Diván is a specialist in High Performance and Grid Computing from the University of La Plata, where he received the degree of Ph.D. in Computer Science. His scientific interests lie in the area of data mining, data stream, stream mining, high-performance computing, big data, measurement, and evaluation. Moreover, Dr. Diván integrates the academic committee for the Master and the Ph.D. in Computer Science at the National Technological University of Córdoba, Argentina; directs the Professional Council of Engineers and Technicians of La Pampa, and has been recognized by the Argentinian Computing Society with the National Award of Electronic Government.

Dr. José Tiberio Hernández

PhD in Applied Informatics, ENSTA (Paris, France), and Master in systems and computer engineering (Universidad de los Andes), he is the head of the Visual computing Area (IMAGINE Group) and has served as a full-time professor and Dean of the Faculty of Engineering at the Universidad de Los Andes.

Professor Edmond C. Prakash

PhD in High Performance Computing and Scientific Visualization, Edmond is currently Professor in Computer Science and Associate Dean for Research at Cardiff Metropolitan University, United Kingdom. With research interests around games technology, big data visualization, human computer animation, high performance computing, interactive digital media and AR/VR, he has held positions and research collaborations in India, Singapore, China, Colombia, UK and USA.

Professor Xun Luo

Professor Xun Luo is a distinguished member of China Computer Federation (CCF). He leads the Technical Committee on Virtual Reality and Visualization (TC-VRV) of CCF as TCVRV's standing director. Luo is a titular professor at Tianjin University of Technology, as well as Chief Scientist of CAS-Jinyun Cloud Inc., one of the top cloud-service providers in China. Professor Luo's research interests include virtual reality and augmented reality systems, and natural human-computer interfaces. Also, he obtained B.S. in Computer Science from the University of Electronic Science and Technology of China, Masters in Applied Mathematics and Ph.D. in Computer Science from University of Illinois at Chicago, and he is the inventor and co-inventor of 28 U.S. and international patents. Besides basic and applied research, he is also an expert in education and has served as Program Evaluator for ABET and Chinese Engineering Education Accreditation Computer Engineering Commission.

Dr. Sergio Albiol-Pérez

Main Researcher of the "Health Multimodal" Consortium of Campus Iberus (Spain), and also of the team "Sistemas tecnológicos en el campo de la salud" at the Instituto de Investigación Sanitaria Aragón (Spain), he defended his PhD thesis with Cum Laude at the Universitat Politécnica de Valencia, Spain, and has been teaching since 2001 at the Computer Science and Systems Engineering Department, Universidad

de Zaragoza. With research interests focused on patients with serious injuries and illnesses by using virtual rehabilitation techniques, in the area of Virtual Motor Rehabilitation and systems based on interaction for the recovery of mental disorders, he has organized workshop sessions regarding Virtual Rehabilitation Theories and Applications and has co-authored more than 40 papers around this topic (articles, conference papers and chapter books). Therefore, his research lines are: multimodal systems in patients with neurological disorders, gross and fine rehabilitation in patients with sensorimotor disorders, virtual rehabilitation: fall prevention in old people, and cognitive rehabilitation.

CEO Cyri Jones

CEO- Zen Maker Lab, Canada. In his own words: As far as I can remember, I have been drawn to entrepreneurship. While I was doing an undergraduate science degree at the University of Guelph, I got my first taste of a starting a new serious business, a leading environmental news scanning business run out of my dorm room and then later doing an MBA from UBC with a focus on technology entrepreneurship. A course at UBC with the legendary Haig Farris where business students were matched up with engineers was inspirational and sent me down the pathway of appreciating the benefits of cross-disciplinary teams and what it takes to start and grow a venture. From that one course came billions of dollars in local start-up valuations. Haig would show us the ropes and bring in guest speakers from industry each week with insights beyond any textbook. I was hooked (C. Jones, personal communication, 18 July 2019).

Eng. Fernando Alonso Gómez Carrillo

Systems Engineer from the Universidad Piloto de Colombia, Master in Direction and Management of Educational Institutions from the Universidad de la Sabana and Java Programmer certified by Sun Microsystems, with more than 19 years of experience. Moreover, for 11 years he has been Technology Director in the Tourism Sector (Carlson Wagonlit Travel), where he developed specialized software

for the management and operation of this type of companies (ERP). Furthermore, he's lecturer and author of articles on topics related to e-learning and virtual worlds applied to educational environments.

Artist Luis Astorquiza

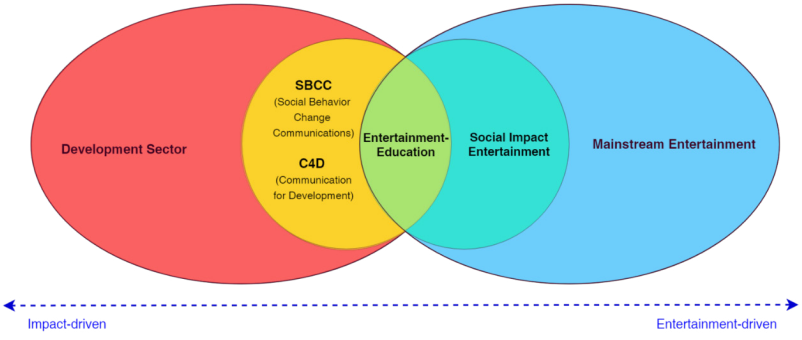
Systems and Computing Engineer (Pontificia. Universidad Javeriana Cali), PhD Candidate in Design and Creation (Universidad de Caldas), and Director of the DaVinci Program for Transdisciplinary Research and Development in Digital Creation (Pontificia Universidad Javeriana Cali), he has exhibited his works in Colombia, M**é**xico, Argentina, Brazil, Spain, South Korea. Invited by ACC (Asia Culture Center of South Korea), Medialab Prado (Spain), Technological Institute of Monterey (M**é**xico), University of Sao Paulo and University of Vitoria (Brazil), Tres de Febrero University (Argentina), among others; he's the guest digital artist for Edutainment 2019 and leads the global initiative ACADEMIALAB promulgated in Medialab Prado, that seeks to bring the academic world closer to the digital experimentation spaces in Labs.

1. Prologue

Wikipedia (2020, par. 1), defines edutainment or educational entertainment as "media designed to educate through entertainment," and states that the interest to do this has been present for hundreds of years. One example is the Poor Richard's Almanack which demonstrated early implementation of edutainment; here, Benjamin Franklin combined entertaining and educational content into and instructional booklet of rules of conduct for colonists using puzzles. In this way, *Figure 1* shows edutainment as part of a continuum: "the continuum and overlaps between the world of development and entertainment; multiple sectors lie in between, such as SBCC (Social and Behavior Change Communications), C4D (Communication for Development), Entertainment-Education and Social Impact Entertainment" (Deml, 2018, par. 1), with applications range from TV (e.g. Sesame Street) to games, theme parks (e.g. Epcot Centre) and museums.

Figure 1.

Impact-Entertainment continuum



Source: (Deml, 2018).

Today, technology has pervaded all fields of human knowledge and activity, and edutainment is not an exception. Fields such as virtual and augmented reality, gamification, serious games, graphics, imaging, game rendering, animation, computer vision and e-learning are now considered important in education. Therefore, edutainment was born keeping in mind the need of collaborative research and practice required by innovative educational entertaining applications; it is important to learn to what extent technology and entertainment are useful for learning. That is why Edutainment 2019, the 13th International Conference on E-Learning and Games, was a place where researchers from all over the world and particularly from Latin America, exchanged experiences in the emerging field which combines education and entertainment. As previous versions which took place in China, Canada, Germany, Australia, UK, Edutainment 2019 covered all aspects of pedagogical principles, designs, and technological issues for education, research, and entertainment.

Professor Zhigeng Pan
Founder, Chair of Steering Committee of Edutainment Conferences

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2. Invited Keynote paper

While planning Edutainment 2019 and CoTH, the organizing committee were aware of the importance of making Cali the world centre of serious games and health technologies for a few days. The event reunited around 100 participants from 10 countries with several profiles: we had undergraduate and graduate students, a group of students from a public high school (for whom we designed two training sessions), and excellent authors, artists, entrepreneurs, and professors from Latin America, North America, Asia and Europe; also, we had the local press and one International Game Developers Association (IGDA) representative. Although there were a lot of chances for networking, we wanted to show the world what we were able to do in Colombia. For that reason, we not only invited five keynotes from overseas to bring knowledge from the world to Colombia, but also four keynotes from Colombia so people from all over the world could take Colombian knowledge back home. In this section, one Colombian author discusses his experiences with Minecraft as an educational tool.

Introduction and justification to virtual immersive learning environments supported by the MinecraftEdu platform in Piloto University of Colombia

Fernando Alonso Gómez Carrillo[1]
Universidad Piloto de Colombia

Abstract:

The current document presents, in a contextualized manner, the use of digital games in learning environments and the difficulties that many educational institutions have faced when trying to adapt this kind of tools. In this case, it's presented a new concept for learning environments that emerged with the Minecraft platform: the Voxel classroom and its application as immersive learning environment. The document justifies the use of these tools in the Piloto University in Colombia, emphasizing their open structure and advantages as the "Game of life" or "Virtual lego" and pointing its flexibility and adaptability for different kind of subjects or courses. The use of Minecraft in many real-world architectural projects is illustrated, for instance "Block by Block" by United Nations and the course "Design I" belonging to the Building Architecture program of Piloto University. At the end, an inventory of basic game resources is presented in addition to a general evaluation of partial results.

Keywords: Minecraft, immersive learning, games, gamification, virtual worlds, courses.

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Introduction

Since it was created, the Virtual Education Department of the Universidad Piloto de Colombia develops a training process to teachers that seeks to facilitate the adoption and application of information and communication technologies for online learning, relying mainly on learning platforms (LMS) and synchronous tools (videoconferencing). However, as a result of the recent appearance of new educational technologies, this support unit presents to the institution the resources to develop a new line of teacher training in immersive educational environments supported by the Minecraft platform, understanding that an immersive virtual learning environment is a 3D digital scenario, with a structure and organization intentionally defined for the achievement of learning purposes organized into didactic units or components of a course, contributing to the development of the learning goals proposed by an educational program (Gómez, 2012). This new line of training, will make it easier for teachers to adopt this immersive learning platform and incorporate it into their subjects, but first doing a reflective exercise to justify and contextualize its use. This is how the Universidad Piloto, becomes one of the first institutions in Latin America that explores learning in immersive platforms as a sustainable alternative to support learning-teaching processes in various areas of knowledge.

The complexity of using digital games in an educational environment

"One of the main goals of education must be to enlarge the windows through which we appreciate the world".

Arnold H. Glasow

Improving teaching and making it a pleasant experience for the student is a common requirement for teachers. Then, it´s not rare to find in every education or e-learning congress a mention to game-based learning, virtual simulators and innovative tools as means to achieve this much desired goal. As Piaget (Bringuier, 1980) would say: "Childhood

is the creative phase par excellence..." (p.115), and it seems that many modern teachers and students yearn to recover the child that exists in each person and articulate it with teaching-learning processes. In this perspective, it can be said that many of the methodological related questions that educators have, can be answered with the application of immersive and playful tools with a pedagogical sense. Some of these questions are the following:

- How to make learning truly meaningful and centered on the learner?
- How can we simulate complex real-life environments without boring or demotivating the student who is facing them?
- How to facilitate flexibility, collaborative work and interdisciplinarity?
- How can we mediate our traditional pedagogical strategies in a more effective, enjoyable and attractive way?
- How to keep students motivated?

However, reaching a consistent and viable application of these tools within an educational institution is a complex task. Following the production of playful environments and simulators with a pedagogical sense, to date there are multiple investigations showing their benefits and contributions to learning, but despite having many reasons to use them the institutions have not found an adequate formula to achieve the continuity and transcendence of these resources in the curriculum of their careers or programs. Thus, a large part of the experiences with immersive environments and videogames with a pedagogical sense have been localized and somehow limited to contexts of certain topics and teachers, and do not succeed in impacting the development of academic programs on a large scale.

In addition, forming teams of specialists for the production of playful virtual environments or virtual simulators is costly and requires times that the institution and teachers are often unwilling to sacrifice; the situation worsens because, in general, these resources are relegated

to the level of support activities for courses, being difficult to adapt them to other contexts and uses. In other words, it's not easy to justify large investments in the development of educational games or immersive tools within many educational institutions, a situation aggravated by the era of the internet, where "free" resources are always found.

For Smeaton 2012, the main reasons for the non-application of immersive and playful environments in educational institutions are the following:

- It is difficult for teachers to identify resources that could be relevant to the curriculum, just as it is difficult to measure how appropriate is their use in the classroom.
- It is difficult to persuade principals about the value of immersive and playful environments for education.
- Teachers lack time to familiarize themselves with games and integrate them effectively into the classroom.
- Games usually have a part of content that is irrelevant and can interfere with lesson time.
- Non-specialized resources, like games for learning environments, do not fit neatly into the traditional curriculum of educational institutions.

In conclusion, it can be said that talking about virtual immersive learning environments has somehow become a recurring theme for educators, but at the same time it has become a costly, difficult, and arguably almost utopian theme because of the complexities it implies for the institution.

However, it is also true that technology evolves by leaps and bounds: platforms become more efficient and levels of abstraction in software development evolve day by day; there is no end to human creativity. Therefore, it is necessary to highlight the recent appearance of new immersive environments capable of simulating or adapting easily to

educational purposes, for example, it is already known the scopes that the SecondLife platform had in the educational fields, its benefits and limitations, but as we already said, until now it has not transcended beyond being a tool for promotion and support for some processes and academic activities. Now, in 2019, the Minecraft platform appears with the potential to become a transversal tool for an educational institution, where it will be able to dynamize courses, activities and academic programs through a variety of immersive learning environments prefabricated or developed by the teachers themselves or by specialized teams. Minecraft, unlike SecondLife, has almost infinite possibilities when it comes to simulating virtual learning environments, as we will see below.

History of the Minecraft and MinecraftEdu platform

Developed by the Swedish programmer Markus Alexej Persson "Notch", fond of LEGO toys since childhood, Minecraft is a videogame or the first "Voxel world[2]" that allows the concurrent access of users to virtual worlds, where, as we will see later, all kinds of creative processes can be given free rein. Though Notch began programming Minecraft in 2009 as a personal project, in May 2013 (after multiple versions sold) the version containing the main and basic "architecture" and functionalities known today was launched (Redstone Update); since then, the game continues receiving updates. Moreover, Minecraft has versions for all operating systems: Windows, Mac, Linux, Xbox 360 and there is a version with limited functionality for Android platforms and IOS (Minecraft Pocket Edition), which over time is getting closer to the functionalities that has the version for desktop computers. As of May 2019, Minecraft in all its versions exceeded 176 million registered users, and in April of the same year, there were more than 30 million registered users just on the PC/Mac platform, making Minecraft one of the most popular "video games" in history.

Starting as a project spread in the Google group "Minecraft Teachers", created by Joel Levin, one of the founders of this module for the

2 The voxel classrooms are virtual recreations of reality using the minimum unit of 3D object (voxel or volumetric pixel), giving each of these units the characteristics that constitute the full virtual world.

Minecraft platform, in 2011 was developed the MinecraftEdu, a specialized version of Minecraft designed to give teachers more control and flexibility when using Minecraft for educational purposes. Levin (quoted in Smeaton, 2014), presents the MinecraftEDU platform as well:

> The "MinecraftEDU" module was custom developed by teachers for teachers. It works right on top of the original Minecraft game and is designed for academic use. We have eliminated many barriers in such a way that any teacher benefits from this wonderful game (p.12).

The MincecraftEDU platform includes the functionalities of the commercial version of the game, adding basic tools for the teachers that will allow them, among other functionalities:

- Follow and accompany students into the virtual world.
- Define fixed learning paths (if necessary).
- Define activities.
- Control the functions that the student can use in the game and limit materials and construction areas, if necessary.
- Model worlds for courses.

This is how since 2014 the use of MinecraftEdu as an educational tool became popular in several countries, reaching at the end of 2015 more than 120 courses developed and published by various teachers. These courses can be downloaded and reused by other teachers in MinecraftEdu, and some even work without problems on the commercial platform of Minecraft (PC version, Mac and Xbox 360).

In 2016, Microsoft acquired the MinecraftEdu version, rewriting it and converting it into Minecraft Education Edition, a new educational version that retains much of the philosophy of MineraftEdu with the particularity that has been specializing in curricula of american

schools. Thus, by May 2019 there were more than 250 courses available on the portal of Minecraft Education Edition, with courses that implement the curriculum CSTA (Computer Science Curriculum Association) for learning algorithmic thinking (learning of computer programming). Notwithstanding that, this new version is based on Minecraft's "Bedrock" platform, therefore does not allow the use of MODS (Plugins) or highly specialized content. For this reason, Piloto University has opted to continue with the JAVA version, which allows the implementation of specialized plugins for very specific and customized functionalities, making it easier to respond to visual and thematic needs of higher education teaching. With the implementation of a Minecraft "SPONGE" server, it was possible to carry out orientation and academic support functions similar to the functionalities of the "classroom mode" module of Minecraft Education Edition.

The Minecraft platform at the Universidad Piloto de Colombia

Although for the purposes of an educational institution, the fact of incorporating a tool with high levels of adoption facilitates its integration and articulation with all the members of the institution, and despite its popularity as a game, Minecraft as an educational platform has been little explored at the national level. In the context of the Universidad Piloto de Colombia, in 2015 a student of the Architecture program modeled his Design I project on the Minecraft tool, finding interesting results from the exercise where Minecraft enriched his perspective of the proposed solution, allowing him to optimize materials for the construction of the final model and also enriching his spatial notion of what he would finally shape in the model of the project. This first experience has given rise for the Faculty of Architecture and other academic programs to express their interest in broadening and deepening the use of this tool.

In 2016, within the framework of the microcurriculum of the Design I course, a group of first semester architecture students adopted the tool to develop volumetric and conceptualization exercises on the Minecraft platform. The Virtual Education Team supported this group of students by creating the "World of San Cayetano", a virtual

Minecraft world that approaches the land of the well-known hacienda that belongs to the Universidad Piloto and that is located near the municipality of La Calera, a few kilometers from Bogota; this with the purpose of make it easier for students to develop their Architectural Design projects, since the course proposes the same construction site as the one where the emblematic mansion is located.

Being a keynoter during Bogota´s Moodlemoot 2016 (Unipiloto virtual, 2016), dean Edgar Camacho, of the Architecture program of Piloto University, pointed that an immersive platform such as Minecraft can favor the learning of architectural design if the following aspects are taken into account :

- In any project and especially in those that have to do with design, the moment of the generation of ideas or concepts is key because in the middle of how schematic or abstract they may be, if they are correct and reflect what the author wants to synthesize in them, the development of the project will be facilitated until its final finish and later realization.
- The specialty of design (architectural, graphic, industrial and others) is that its objects are tangible things about which people form images; among the designs, the architectural one has more complexity in that the buildings are lived, unlike a graphic or a piece of furniture that can be perceived more as a whole.
- Some designers, being apt to be so, have some difficulty of imagination for buildings that do not yet exist, since from the mind you must have the ability to walk through them, to live them and, more importantly, to know what the designer proposes to the future user as sensations to inhabit the spaces of the building.
- Although the creation of proportion and volume in the spaces begins from the stage of formation of the concepts, expressed by means of sketches on the side of the designer, it does not count with the exact measure of the things. Hence, it is a propitious moment to acquire a tool that allows the designer to materialize those ideas or germinal concepts of a project as far as possible.

In addition to the above, , also during Moodlemoot 2016 (Unipiloto virtual, 2016), Adriana Gómez Ceballos, professor of the Architecture program, points out the following contributions from the use of the Minecraft platform as the most significant for the subject she is in charge of (Design I):

- It allows to apply all the concepts of basic design in architecture, mostly based on cubic forms.
- It allows working on the conical perspective and explain in a simple way the different vanishing points identifying in a virtual world the different elements of the perspective.
- To develop and understand examples of base planes, depressed planes and elevated planes.
- The construction of architectural objects for the theme of circularity and permanence.
- The development of famous constructions from the foundations and an almost infinite number of urban and architectural examples available on the web.

This is how the Minecraft platform opens a new door for educators to involve immersive and playful dynamics (or both) in their subjects; therefore, it is necessary to understand a little more about the benefits of immersive virtual learning environments and video games in order to measure the scope and impact of such a platform in educational settings. Finally, this document will understand the scope of the Minecraft platform through its particular "philosophy" of play.

Advantages of immersive educational environments for learning

In general, the department of Virtual Education of the Universidad Piloto de Colombia, proposes as part of its training proposal for most virtual courses, the convenience of establishing as a general objective the "derivation of solutions and answers", favoring the development of original products by the students, turning them into authors of

knowledge rather than a simple receptor of information. In this regard, Piaget (1973), relying on the psychological development of children, considers discovery to be the fundamental basis of learning: "To understand is to discover, or reconstruct by rediscovery, and such conditions must be complied with if in the future individuals are to be formed who are capable of production and creativity and not simply repetition" (p.20).

It can be affirmed that immersive worlds applied in educational environments support these pedagogical approaches, bearing in mind that understanding is systematically constructed through the active participation of the student, who is able to literally "build knowledge" through the activities and products. Regarding this theme, Méndez (2014) says:

> From the point of view of constructivist theory an individual builds knowledge through the interaction between human beings and the environment. When a person learns a new subject he establishes an assimilation relationship according to his knowledge. At the same time, this new information modifies the existing knowledge and through transformation, the individual adapts the new information to the previous knowledge (p.3).

In this regard, Figueroa (2015), says:

> the inclusion of these new technologies constitutes a new model of learning that allows the student to empathize completely with the content and facilitates the methodology of Learning by doing; because it immerses the students in the scenario on which they are learning at the same time as it allows an interaction with it, which favors the assimilation in a more natural way of certain concepts and processes (p.1).

Additionally, immersive tools well used can lead the student to have more vivid, participative or significant experiences in the learning process than those proposed by traditional means such as writing, audio or video. Donati (2015), explains it in the following way:

> The realistic conception of education is based on the following fundamental observation: in education, the human mind learns much more from the "testimony" -that is, from experiencing (feeling, touching, seeing) reality-which comes from the senses (seeing from practice in action, living a certain relationship with another person, a friend, a teacher) than from the conceptual definition that comes from the discourse and thought in the "I". The child's ego is formed in practice, first natural and then social, rather than in the use of a language and a culture (that is, it precedes the consciousness based on Karl Popper's World 3) (p.315).

This is how it can be said that, in general, immersive technologies allow different experiences for the construction of learning that would be impossible to reproduce or finance in the real world. Below we will see a little more in detail what these "different experiences" are and that can be accessed in immersive virtual learning environments.

> According to Serrano (2014) "One of the most useful aspects of immersive virtual spaces is the ability to transfer the public to other spaces that would otherwise be physically inaccessible, due to the different limitations of time, distance or security, among others (Jackson & Winn, 1999; Furness, Winn, &Yu, 1998; Youngblut, 1998). In other words, this type of space offers the possibility of generating localized learning, which is the capacity to implement learning in the time and space that the content develops, something unthinkable in traditional classes (Youngblut, 1998). In addition, if there is interaction, these spaces allow the user to manipulate features that in the real world would be impossible, such as physical laws, so that users can visualize their effects on the environment (Yacci, M., et al. 2010) (p. 7).

An example of localized learning using the Minecraft platform is the "Block by Block" (UN) project, where the same community that inhabits a city proposes urban changes, modeling those changes in a

minecraft environment. These proposals become real projects with the support of the United Nations.

In addition, Serrano (2014) also says:

> On the other hand, immersive technologies allow three different types of experiences in the construction of learning that would be impossible to reproduce in the real world: experiences in scale, transduction and reification. Scale experiences refer to the capacity of immersive spaces to change the scale in the environment to facilitate learning in users, for example being able to reproduce an atom to the solar system (p.8).

An example of learning using scale experiences on the Minecraft platform is the "Molecraft" (MinecraftEdu) course, which allows the students to transport themselves and appreciate giant versions of the main molecules that make up the course syllabus.

"On the other hand, the transduction experience refers to the possibility of presenting information that is impossible for humans to perceive as concepts of physics" (Serrano, 2014). An example of this is found in the plugin or module designed to learn principles of Quantum Physics in the Minecraft worlds: Qcraft. "Finally, reification refers to the ability to materialize concepts without physical presence, such as mathematics (A. Mikropoulos, T., Natsis, A. 2011)" (Serrano, 2014). In this sense, there are several courses on mathematics on the Minecraft Education Edition platform that exemplify the concept of reification.

Finally, referring to the learning of abstract and complex subjects, Serrano (2014) affirms about immersive and virtual learning spaces:

> They help the visualization of abstract concepts through the concretion of concepts: one of the benefits of computer simulation is the ability to represent environments and processes that human beings are not normally able to observe (Limniou,

> M., et al. 2008). Humans have more facility to concretize information in symbols than in abstract processes (Byrne, 1996). Information contained in virtual spaces allows students to focus on presented content rather than on abstract systems of symbols that would otherwise have to be used (Jackson & Winn, 1999). In addition, abstract information can be presented through concrete forms and visual metaphors (Bryne; Jackson & Winn). In this way, using fewer abstract symbol systems, we can make learning construction more robust and direct (Furness, Winn, & Yu, 1998, part 2.II, Symbol Systems section) (p.9).

An example of simplification of the learning of abstract themes in the MinecraftEdu platform is the MOD or Plugin for the learning of programming "ComputerCRAFT" that, as we will see later, simplifies programming by reducing it to commands in graphical mode; optionally, a traditional programming language (LUA language) can be used.

Advantages of ludic and immersive environments in education

Quoting Rodari, Triana (2016), shows how with the use of games teachers discover that classes do not need to be linear and that knowledge can be thought and expressed in many ways: through theater, literature, drawing, reading, cinema, music, sports, pedagogical outings, painting, video games, internet. By providing game scenarios, other ways of assuming and expressing what one wants to teach appear. In addition, it is known that recreational environments in an educational context have a motivating potential, since teachers can retake elements of the game that promote motivation in order to dynamize the activities, such as: uncertainty, tension, risk, competition and chance; in immersive spaces this potential is multiplied, being practically impossible for the students to divert their attention from the content, since in general it occupies all the space in which each one interacts (Serrano 2014 p. 10).

For Ebner and Hozniger (quoted in Smeaton, 2014), game-based learning is similar to problem-based learning, bearing in mind that scenarios or problems are framed in a dynamic of "playing" to

learn. In addition, citing Motsching-Pitrik & Holzinger, Smeaton (2014) also highlights how game-based learning can be favorable for the creation of learning environments; In this sense, Minecraft and its philosophy of the "player doomed to be free" becomes the ideal tool for configuring immersive environments centered on the learner, where depending on the pedagogical intentions of the teacher, the student can autonomously modify in whole or in part the resources that make up the Minecraft worlds.

Finally, it can be said that one of the strongest and most interesting values that a game can help to form in a student is the ability to persist and face adversity. Indeed, a person who faces a game usually ends up trying again and again until he succeeds in overcoming the proposed challenge; this phenomenon does not occur so easily in other learning environments, where, for example, there is still no news of a book that is capable of somehow penalizing the reader for not following its rules properly. The paradox of a game is that the player will try again and again to dominate the game, depending on the attractiveness of the challenge. In this sense, it is possible that playing will help the students reinforce or form their ability to face adverse scenarios without becoming so easily demotivated.

The philosophy and application of the Minecraft platform

Cody Sumter (Wikipedia, 2019), a member of MIT Media Lab's Human Dynamics group, commented, "Notch didn't just build a game. He fooled 40 million people by teaching them how to use a CAD program" (p.18). Indeed, just as Minecraft can be taken as a game, it can also be assimilated as a simulation and a design tool (CAD), or even as a learning environment (Minecraft Education Edition). This versatility lies in the fact that Minecraft itself has no specific purpose and allows the protagonists to decide how they want to play and what they want to create within the virtual worlds, getting impressive results. A recent episode of The Culture Show: Lego- The Building Blocks of Architecture (BBC, 2014) speculates that, just as we can see the influence of children's toys on the work of architects of the past and present,

for example, Richard Rogers (Meccano-esque Lloyds Building), James Stirling (Lego No.1 Poultry Building), future designers will inevitably be influenced by the Minecraft style too.

The potential of collaborative creativity at Minecraft has already been proven in urban design projects. The Swedish Centre for Architecture and Design created Blockholm, an interactive tool for re-imagining the city of Stockholm using Minecraft. The program allows users to reconstruct the city's 100,000 building lots using information generated from current usage data. Even the United Nations is working with Mojang, using Minecraft to help communities in developing countries collaborate on the design of their cities and countries through the Block by Block initiative. Thus, one of Minecraft's greatest strengths is to recreate a metaphor of life that is surprisingly close to real life, without forgetting what it really is: a metaphor. Indeed, perhaps the success of this game lies mainly in not having rules, unlike traditional games where generally there are schemes that guide the history of the game, but at the same time limit it. Instead, what Minecraft proposes are four arts that the protagonist should master in order to have a better performance in his "life": survival, combat, construction and technology.

However, we must not lose sight of the fact that the objects and worlds created in Minecraft will not always be as realistic as those developed in other CAD design tools (Autocad, 3DMax, etc). Here it must be remembered that some call Minecraft "the virtual LEGO", and as such it applies the philosophy of block construction and not construction based on design meshes like traditional design programs. This has both positive and negative aspects: among the positive are the incredible ease of use, the simplicity with which 3D spaces can be modeled, and the ability to integrate special blocks with user-defined functions or properties, such as textures, plugins or Mods.

On the negative side, it could be said that many criticize Minecraft for its "square" aesthetics and extreme popularity. However, after understanding the possibilities of everything that can be created and done with this game, we must recognize that the "minecraft" aesthetic

becomes a minor theme and sometimes just anecdotal. As Piaget (1968) would say: "knowing reality implies constructing systems of transformations that correspond, more or less adequately, to reality". This statement is very close to the fact that Minecraft represents a more abstract view of reality. As Nicole Joseph (2018) states, "abstraction makes you work for the meaning of the piece, while realism shows off skill and technique".

In short, Minecraft, appointed by some as the "game of life" or the "virtual lego", is an "open world" game where the protagonist lives in a virtual world without rules or "levels" and no defined game goals. The constructions in Minecraft are defined in terms of "blocks" in a very similar way to how Lego toys are created, with the difference that being a digital tool there is no limit to the materials and objects that can be built, taking various forms depending on the preferences of the protagonist. Additionally, it can be said that, instead of rules, Minecraft is built providing mainly two contexts for player´s actions: the types of virtual worlds where the protagonist appears and the day and night cycle (good and evil cycle).

Indeed, Minecraft worlds can be configured in two ways:

- Worlds in survival mode: where the protagonist can "die" and has to take refuge every night so as not to be attacked by creatures. This type of worlds can be configured in such a way that if the protagonist dies, he dies forever (HARDCORE). In survival mode the protagonist has no access to materials to improve his performance in the game and must get them for himself through mining, combat and survival in a hostile environment.

- Creative Worlds: in these worlds, the protagonist has all the powers and access to all construction materials. This type of worlds is ideal for modeling solutions or simply learning to use the game before facing a world in survival mode. In this type of world, the protagonist is immune to any attack and only dies if by bad luck and falls from the virtual world to do mining beyond the limit allowed.

Each day in a Minecraft world lasts 10 minutes. During the night, the protagonist must take refuge in his house and rest in a bed because randomly evil creatures appear that will attack him in the outside world. This is how Minecraft can be understood as a stage where the protagonists can define their own rules and objectives within very general contexts. Furthermore, to achieve its purposes, the protagonist must know four "arts" or basic skills of the game:

Survive

The protagonist will learn to move through the different dimensions of the game: the first dimension or "Overworld", where there are different ecosystems or "biomes", such as extreme hills, taiga, desert, forests, plains, jungle, ice plains, ocean, swamps or even imaginary ecosystems such as the biome of mushrooms. From Overworld, the protagonist can move (if it's wished) to "Nether", an infernal place or also enter to the world of the End, a world in the middle of nowhere, inhabited by the Ender Dragon. The protagonist will learn how to cultivate plants, domesticate and raise animals, get food and how to obtain materials and resources through mining for artisan elaboration in "work tables".

Fight

The protagonist must learn to defend its home, build a fort, fight monsters, set traps, develop player vs player combats, avoid the death of hell and fight the dreaded dragon of the world of the end.

Build

The protagonist goes from building basic shelters, to mansions with beautiful gardens or elaborate amusement parks; can even build entire cities or countries and continents close to real life.

Create Technology (Redstone)

The Redstone metaphor is unique to the Minecraft worlds and is one of the most amazing features that make Minecraft completely different from other platforms; this ability offers the protagonist the tools to simulate almost any electrical or electronic circuit, and its applications are almost infinite. Redstone has created everything from basic electrical circuits for building lighting to complete digital computers, constructions that can take several months of work for the protagonist, and also interconnect real devices with Minecraft worlds (e.g. Arduinos, Raspberry PI), opening up new possibilities for learning by using these game components.

Among the most sophisticated constructions that have been developed on Redstone there are digital computers, chronometers, clocks, calculators, construction automation (elevators, access control systems, etc.), simulation of electronic components such as logic gates and transistors and all kinds of video screens, or explosion engines of several "cylinders" that function as power plants that feed cities of the Minecraft world. It is important to note that just as Redstone is vital for the creation of technological products, it is also the fundamental pillar for the creation of customized or custom-built worlds or maps. In fact, Redstone allows a player to create the essential mechanisms to include mini-games or maps with sophisticated scripts in Minecraft, so if the player needs to include very specialized functions that cannot be created using "Redstone", they may have to resort to installing pre-made plugins or developing plugins directly in Java language (applies only to Minecraft Java edition). In the end, the protagonist ends up combining these four basic skills to create thousands of solutions among which you can count your own games, structures, constructions or immersive cities, ASCII ART or immersive virtual courses using the educational module known as "Minecraft Education Edition".

Plugins and applications that extend Minecraft Java Edition

Minecraft has been developed thinking about its adaptation to diverse environments and needs. Its JAVA-based design facilitates extension with modules or "plugins" developed by third parties or by members of the extensive Minecraft fan community; this has allowed to include functionalities that do not exist in the default version of the game, such as including sophisticated vehicles (trains, planes, cars, etc.); making more accurate historical recreations (plugins that bring historical structures or vehicles and weaponry from world wars); or including fantastic animals and fauna to the game world. Below are some of the thousands of plugins and additional applications that are useful to enrich the experience with the Minecraft platform.

Plugins or "MODS"

DECOCRAFT.

Some Mods or plugins have brought Minecraft closer to behaving like traditional design tools; this is the case of DECOCRAFT, a plugin that allows to include in a Minecraft world a large number of decorative elements for buildings like electrical appliances, paintings, food, furniture, etc.

CustomNPCs.

It allows non-participatory characters to be incorporated into Minecraft worlds, among other equally valuable decorative elements. Characters serve to deliver important directions or messages to players or students.

Computercraft and OpenComputers.

Other applications of Minecraft are found in the teaching of engineering disciplines where the mods for learning to program (ComputerCraft) stand out, allowing to incorporate an endless number

of technological implements in a Minecraft world: computers, wired and wireless networks, printers, screens, modems, PDAS and the recognized "Minecraft Turtles" that are nothing more than robots with a varied capacity of actions and that are left to program on the part of the student to fulfill diverse functions in the game; for instance, you can create and program turtles that make constructions, fight monsters, do mining or interact with Redstone devices in the Minecraft world. This is how the teacher can invent virtual worlds where the different components of ComputerCraft are integrated with the already recognized dynamics of Minecraft.

Computers can also be integrated to facilitate student dynamics, for example, by controlling access to homes. It is known that some programmers have even connected these virtual computers with real Arduino devices; each of the ComputerCraft devices (computers and turtles), has an Operating System "OSCraft" that works similarly to a MS-DOS system and has a compiler to develop programs in "LUA", one of the most recognized programming languages when it comes to enabling software development in applications not originally intended for that. Its simple syntax makes it ideal for learning programming in early stages.

In addition to that, some fans have developed complete operating systems capable of replacing the limited "OSCraft" that comes pre-installed in ComputerCraft. This is how you can download the sources of many operating systems that bring Computer Craft computers closer to equipment with operating systems similar to the old Windows 3.1, created following the design principles of the real Operating Systems and being evident its potencial for academic use. Some outstanding Minecraft operating systems are CCWIN, OneOS, VoidOS, etc. Moreover, ComputerCraftEDU used to incorporate a compiler with graphic language (remote control) that hides the LUA instructions and masks them with icons in front of the student, facilitating even more the learning of the programming, if we remember that this is a technique that seeks to facilitate the learning of abstract concepts.

QCraft.

Though Qcraft is a MOD that brings the principles of quantum physics to the world of Minecraft, it is not a simulation, but provides analogies that attempt to show how quantum behavior is different from the experience of common physics, being useful for introducing and experimenting with principles of quantum physics.

Instant Structures Mod (ISM).

This MOD facilitates the extraction of parts of worlds to be reused in other worlds, and makes it easy to share structures through files that can be sent to other builders in Minecraft. ISM has a list of reusable structures that protagonists can copy into their worlds and modify if necessary, so players or builders can suggest to the ISM developer to include their structures in the downloadable database.

Minecraft Education Edition MAKECODE.

The version of Minecraft Education Edition has incorporated an additional module that facilitates the learning of computer programming for children from 8 to 16 years old. This module gives each player a robotic "Agent" who can be programmed to interact with the Minecraft world through a programming language with block type instructions (equivalent to tools such as Scratch, Blockly, etc.); through this, the teacher can create activities and complete courses to learn algorithmic thinking through the basic concepts of programming. It is worth noting that a complete example of the curriculum for CSTA (Computer Science Teachers Association) exists and was implemented using this tool.

Texturizers and Shaders.

The graphical presentation of Minecraft can be considerably upgraded incorporating modules for the handling of shadows and

textures that improve the graphical presentation of Minecraft. There are hundreds of libraries intended for this purpose, with surprising results when compared to the proposal that comes with the basic version of the game. To get the most out of these resources, it is recommended to install the OptiFine module.

Complementary applications

Mineways

An independent developer has created a free use module called Mineways, that allows the creation of 3D renders of parts of Minecraft worlds and print them on 3D printers.

WorldPainter and MCEdit

Worldpainter, used to model the "World of San Cayetano", is able to read images of real terrains, and if they have relief information, it can create Minecraft worlds very close to reality. Furthermore, MCEdit allows the editing and creation of Minecraft worlds, facilitating the terrain modeling and including an undo function in case of any error (a function that does not exist directly in the game). Both editors make it easy to model Minecraft world terrains.

Conclusions

In conclusion, it can be said about the Minecraft platform, that it has defined a new standard for virtual worlds with high possibilities of being applied in educational contexts. These virtual worlds, or voxel classrooms, allow the teachers to involve different ingredients in the student's training, facilitating more meaningful and realistic experiences for them. In 2016, 32 students of the Piloto University modeled their projects of the subject "Design I" through the Minecraft platform. In the second semester of the same year, teacher Adriana Gómez's course was reformulated, incorporating additional learning activities into the final project, which accompanied the students from the earliest

phases of this subject. The testimonies of the students indicate that the platform has facilitated the formulation of the projects through a construction "from within", which in some way could change the traditional process of design in the first semesters of Architecture. It is still too early to indicate what the future of this tool will be, even more taking into account the profound changes that Microsoft is applying in its new Windows 10 version; what is clear is that Minecraft has defined a model or "standard" for the creation of virtual worlds, which has many points related to the didactic and project needs of teachers of different disciplines.

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3. Workshop on Computing and Technology in Health- CoTH 2019

The deployment of new Information and Communication Technologies (ICT) for health have improved healthcare and quality of life. This is a major research topic that continues attracting cross-disciplinary research groups, whose combine emerging technologies around the development of software and hardware to change the experiences for patients and their families, enhance healthcare access, and improve medical processes. The purpose of this workshop was to bring together researchers interested in the application of information and communication technologies to healthcare, to present and exchange ideas of non-ready publications and projects in progress within the area. The workshop papers were mainly addressed to young researches, like Ph.D. or MSc students or researchers who wanted to share the ideas they are developing in their ongoing projects.

Serious game for learning sign language in Colombia

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Abstract

Sign language is the means by which people with hearing and vocal disabilities communicate, in such a way that being a natural language has its own complexity of learning for those with a disability and those who handle verbal communication. Thus, in this article we propose as a contribution the construction of a serious game for the learning of the basic signs of the colombian sign language, such as the most important letters of the dictionary, aiming to support in a playful way the learning process of people with hearing and voice disabilities. The proposed videogame was developed taking into account the design thinking methodology, as well as the unity3D development environment, the OpenCV libraries for sign detection and TensorFlow for the creation of the recognition dataset.

Keywords: Hearing disability, learning, serious games, sign language, OpenCV, vocal disability.

Introduction

Communication is considered a fundamental priority in the social development of human beings, becoming a process of constructive interaction that favors the learning of each person (Chacón, 2013). Globally, there are two ways of communication: verbal, characterized

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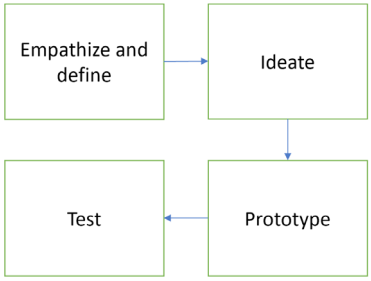
by emitting spoken sounds is distinguished, and non-verbal, represented through gestures and body movements (Muñoz, 2014). In spite of this, not all individuals have the necessary conditions to make proper use of verbal communication, due to some disability related to making it difficult to pronounce and listen correctly to the language; therefore, sign language is one of the most widespread methods of communication to this population, which involves different types of movements and expressions through the hands, eyes, mouth and face. However, this language is not universal because its structure depends on the geographical location, making it a challenge to learn and understand for people with hearing disabilities and their family or friendship circle (Valencia & Villa, 2014).

According to the statistics provided by DANE (2018), in Colombia there are 317.195 people with hearing and vocal disabilities, which is equivalent to 1% of the population. In this sense, with the aim of facilitating an adequate communication, it is necessary to provide tools and technological resources to reduce the complexity of the sign language learning process in the colombian context. Among the tools that enable a ludic and effective learning in different application contexts are serious games, tools designed to achieve one or more objectives beyond fun like skills training or the acquisition of knowledge (Rodríguez, 2018; Matas, 2019). In order to this, in this article we propose as a contribution the design and construction of a serious game as a support to the learning process of basic elements of sign language, formed by three levels that allows the user to study and practice the interpretation of the letters corresponding to the Colombian sign dictionary and built taking into account the design thinking methodology, as well as the unity3D development environment, the OpenCV libraries for sign detection and TensorFlow for the creation of the recognition dataset. The rest of the article is organized as follows: second section presents the methodology used for the construction of the videogame; third, describes the functional design of the proposed videogame, as well as the final prototype; fourth, presents the usability test of the game; and fifth, the conclusions and future works obtained from this investigation are presented.

Methodology

For the development of the game, it was carried out an adaptation of the design thinking methodology with the following stages: empathize and define, ideate, prototype and test (Steinbeck, 2011).

Figure 1.
Considered methodology



Source: the authors.

In the first phase, an exploration of sign language was carried out in the Colombian context in order to know its grammar, syntax and vocabulary; from there, the letters E, I, O, L, N, R, Y, and W of the dactylological dictionary were selected as the first step to teach this language and introduce it into the video game. Second, user stories and mockups of characters, rooms and colors were generated, and in the third phase, the prototype of the video game was generated from the designs obtained in phase two. This test also demonstrates the contribution allowed with games in learning sign language.

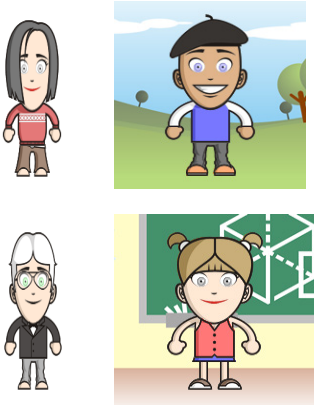
Construction of the video game

Based on the problem of not evidencing the existence of a technological tool for the teaching-learning of sign language, in this section we present the high-level design and prototype generated from the video game as an educational support, focused on the ludic learning of the letters of the basic dictionary of the Colombian sign language.

Video game design

Using the free online tool DoppelME, the game has 2D characters with the function of guiding the user through the different levels proposed.

Figure 2.
Avatars mockups



Source: the authors.

On the other hand, *Figure 3* shows the map of the building in which the different levels are framed, generated using the SweetHome3D tool, which allows exporting the design of the building to the Unity3D platform, being possible to perform 3D animation. In level one of the game, the users will be able to visualize the different signs of the colombian sign language, while in levels two and three they'll have to interpret the signs learned in the first level by means of the movement of the hands in front of to the camera. It is important to note that at the end of the third level, the player accesses a last room of the building, in which the different achievements during the game are presented.

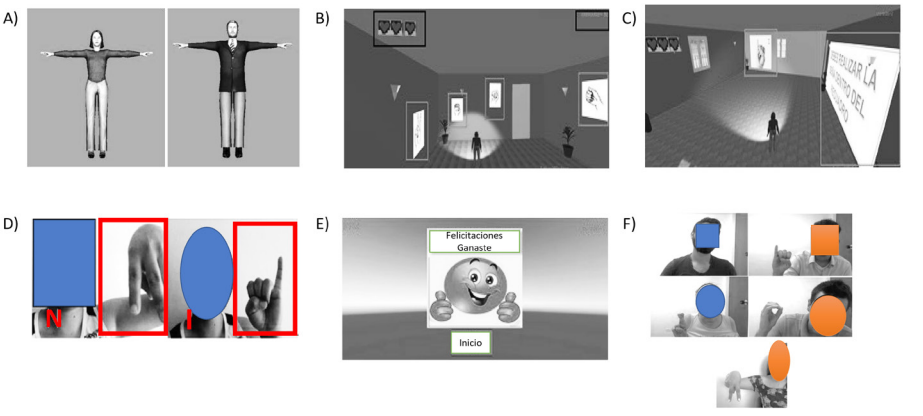
Figure 3.
Building design

Source: the authors.

Video game prototype

In this section, we describe the video game prototype; thus, *Figure 4* shows two of the four avatars designed in 3D through Autodesk character generator, which can be chosen by the player as the main character within the video game. The movements of these characters were reused from the free features of the Unity3D environment.

Figure 4.
Some aspects of the game. A) Videogame characters. B) Level 1 of the videogame. C) Level 2 of the videogame. D) Detection of dictionary letters. E) Award message. F) Test users



Source: the authors.

As previously mentioned, the proposed game has three levels, where the player must familiarize with the colombian sign language and later interpret its signs through the movement of the hands in front of the camera; regarding level one, it has three sub-levels whose general objective is to appropriate the learning of the letters of the dictionary. In this sense, as the player advances through the rooms of the building, it is possible to observe the different sign language symbols arranged on the walls and in other parts of the rooms. According to the information provided by the game guide, the user must collect the indicated symbols, so that in case of hitting the player will receive as rewards gold coins and in case of failure, will lose one of the three lives assigned; the information of the coins and lives in turn will be available at the top of the game (game status bar). So, in sublevel one the user must collect only the signs corresponding to the vowels in the sign language dictionary in a given time, without losing the three lives available and collecting the coins available in the different rooms associated with the level. Similarly, on sublevel two (Figures 4B and 4C), the user must collect within the game rooms the consonants between the letter B to the M, while on sublevel three the symbols between the letter N to the Z. In this sense, the video game allows the player to identify the correct symbols by means of a blue rectangle and the incorrect ones by means of a red rectangle.

Once the user has visualized some of the signs, in level two the player must interpret the vowels E, I and O with hand movements in front of the camera.

In accordance with the above, in level three the player has a greater challenge: the interpretation by the movement of the hands in front of the camera of the letters L, N, R, Y and W. Considering that the environment in which the video game was developed does not have the direct support for the recognition of images, a communication was made via TCP socket with a Python script for the detection of the user's gestures, using the OpenCV library and the TensorFlow tool which allows the creation of a dataset of 54.000 images, where each letter of the dictionary has a total of 3000 images; in the same way inside the dataset,

the images that represent the absence of signs are included. Finally, it is important to mention that the interpretation of gestures by users in levels two and three of the game, must be done inside a blue rectangle, in a room with good lighting, white background and without the user having objects in the hands(*Figure 4D*). In this way, a better recognition of the signs within the proposed video game is guaranteed.

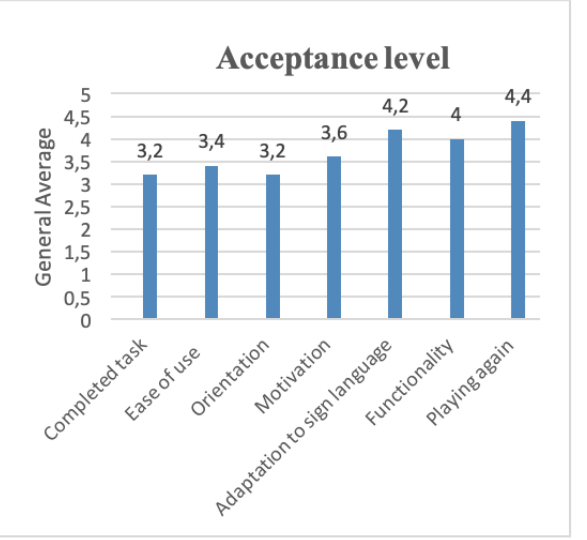
Finally, once the player has overcome the challenges proposed in the three levels, the video game shows a message of congratulations and indicates the level at which it was left based on the number of coins collected and challenges fulfilled correctly (*Figure 4E*). In the same way, through the message shown on the screen, the player can restart the game.

Video game evaluation

The proposed video game was evaluated from user tests developed in the usability laboratory of the Colegio Mayor del Cauca, a test that evaluates the capacity of a product to meet the expectations of a user through observation and analysis of the experience of use. In this sense, in user tests the most appropriate users are chosen depending on the type of application and a set of tasks to be developed within the software (Matas, 2019). According to this, five users (three men and two women) between the ages of 25 and 27 years participated in the usability test developed on the proposed video game (*Figure 4F*), structured in four phases: confidentiality agreement, informing that the data obtained in the test will be used only for academic purposes; pre-test questionnaire, where the profile of the user is characterized; task list, defined by the test coordinator, where the users develop in the usability laboratory a set of specific tasks within the evaluated software; and post-test questionnaire that evaluates user's perception of the interaction with the game. In this specific case, the five users developed tasks corresponding to the exploration of the instructions of the video game and the compliance with levels one, two and three thereof.

Based on the results obtained by the users in the post-test questionnaire of the usability test, *Figure 5* presents the level of acceptance with respect to different elements of the evaluated video game.

Figure 5.
User acceptance level



Source: the authors.

It is possible to see that the lowest grades correspond to the aspects of Complete tasks and Orientation, given that users found it difficult to complete task one, so they repeated on several occasions the first level. Similarly, among the most positively valued aspects of the game are the user's adaptation to the use of sign language (4.2), the functionality of the game (4) and the possibility of playing again (4.4).

Conclusions and future work

Based on the need to facilitate the learning of sign language in the colombian context for people with hearing and speech disabilities, this article proposed a video game to facilitate the appropriation of the letters in the dictionary of sign language in a playful way, taking advantage of the level of image recognition provided by the OpenCV library and its integration to the Unity3D platform, in order to enrich the interaction between the user and the game. Though the usability test carried out on the game made it possible to show that the interest

and level of acceptance of the users are adequate, it is important to improve the orientation and use of contextual instructions within it, in order to enrich the interaction with the user.

This work aims to serve as a reference for the creation of future projects in the field of video games involving people with voice and/or hearing disabilities as a target audience, which make use of the advantages of image recognition in real time. As future work, it is intended to expand the functionality of the proposed prototype, through the inclusion of words or phrases typical of colombian sign language and adapt the game to the environment of mobile applications, in order to facilitate access to a wider number of people.

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Aplicación para mejorar la agilidad y eficiencia para acceder al servicio de urgencias médicas

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Resumen

Las soluciones tecnológicas en salud a través de la salud móvil o mHealth involucran el desarrollo de diferentes aplicaciones, en cuyo diseño es necesario tener en cuenta tanto las características propias del dispositivo como aquellas de su sistema operativo, los tipos de uso, las ventajas, desventajas y la normativa por la cual están reguladas. De esta forma, ASISalud es una aplicación móvil que busca facilitar y optimizar la atención brindada al paciente antes de su llegada a un Centro de Atención en Salud. A través del ingreso de datos de identificación de la persona, síntomas y signos, los cuales podrán ser tomados previamente por un profesional de atención primaria, se podrá cuantificar la condición clínica del paciente, priorizando su atención y direccionándolo al centro de salud ideal para su condición, alertando al personal médico para la preparación de recursos y/o tratamientos necesarios para una atención óptima.

Palabras clave: mHealth, telemedicina, salud, salud móvil.

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Introducción

El siglo XXI se ha caracterizado por grandes avances tecnológicos que han tomado protagonismo en todo el mundo; uno de ellos es el celular, uno de los dispositivos electrónicos más utilizados a nivel mundial, siendo mayor la cantidad de líneas móviles que el número de habitantes del planeta (Baldé et al., 2017). Cabe resaltar, que los dispositivos externos se han convertido en una herramienta imprescindible, no solamente para la comunicación, sino también para acceder a información de manera rápida y eficiente desde cualquier lugar. Con base a esto, se han abierto las puertas al mundo de la salud móvil con aplicaciones que sirvan como una potencial solución a los problemas de acceso a la salud que se viven diariamente en los países en vía de desarrollo; surge entonces la telemedicina como "una disciplina científica a medio camino entre la medicina y la tecnología" (Monteagudo, Serrano y Hernández, 2005, p.309), y que busca adaptarse a las necesidades de salud que las sociedades van desarrollando (Ryu, 2012). De esta forma, en este artículo se plantea una posible solución en tecnologías de salud para mejorar la efectividad del servicio de urgencias a través de una aplicación móvil utilizada por pacientes, personal asistencial e instituciones médicas.

Referente teórico

Según la OMS (citado por Ryu, 2012), la telemedicina se traduce como "sanar a distancia; es decir, el uso de tecnologías para mejorar los resultados de los pacientes al incrementar el acceso a la salud e información médica" (p.153). Actualmente, en el mundo se están implementando diferentes herramientas en telemedicina, especialmente en el área de cardiología (electrocardiografía) con 28 países reportados, de las cuales 17 están establecidos y nueve son pruebas piloto en la utilización de esta herramienta. En segundo lugar, se encuentran las tecnologías relacionadas con el ultrasonido, donde 15 países han reportado su uso; 10 de ellos tienen programas completamente establecidos de ultrasonido y 5 países aún se encuentran en fase de pruebas. Además de estas, otras áreas en las que se evidencia el uso de la telemedicina (en menor medida) son: mamografía, cirugía, consulta

externa, oftalmología, nefrología, ginecología, diabetes, monitoreo del paciente, cuidado en casa, pediatría, neurología, tratamiento de infarto, urología, oncología y otorrinolaringología (Ryu, 2012).

En Colombia, los principales obstáculos para la utilización de telemedicina en las instituciones son el desconocimiento, los cambios en el paradigma de las EPS y el acceso no autorizado, pérdida o deterioro de la información del paciente. Aunque estas problemáticas incrementan las inequidades en el acceso a la salud, también se evidencian importantes avances en el ámbito de la telemedicina en el país, relacionados con la disminución de riesgos y costos, la ampliación de cobertura y la incorporación de bases de datos (Correa, 2017).

Aplicaciones específicas de Triage

SALT triage, es una aplicación desarrollada por la universidad de Augusta en Estados Unidos, la cual permite clasificar a una persona en cinco diferentes grupos mediante una serie de preguntas: Fallecimiento, Actitud Expectante (paciente con heridas serias, las cuales no pueden ser manejadas en el nivel del hospital por falta de recursos); Asistencia Retardada (paciente tiene serias heridas pero el tratamiento se puede demorar ya que hay riesgo mínimo de muerte); Asistencia Mínima (paciente con heridas mínimas que requieren tratamiento básico); y Asistencia Inmediata (paciente con heridas que comprometen su vida y el hospital tiene recursos para tratarlo) (Lerner et al., 2010). Además de este, otros ejemplos representativos de aplicaciones dedicadas al campo de la salud son: Fotoskin (Rivero, 2016), Diálisis 24h (Yañez, 2016), iManage MyHealth (Schera et al., 2018), y el proyecto "HospitApp", aplicación que pretende agilizar la atención en urgencias en la ciudad de Bogotá con un enfoque en la descongestión de los servicios de urgencias mediante la elección del hospital de destino (Gil el at., 2018).

App propuesta (ASISalud)

"ASISalud"- Tu asistente en salud, es una aplicación que consta de cuatro partes enfocadas al servicio de urgencias: elección de los síntomas y signos vitales, elección del hospital al cual direccionarse, medidas que se pueden adelantar en el camino hacia la institución para mejorar la situación actual y pronóstico del paciente. Esta se conforma por un módulo inicial que contiene un formulario de ingreso, realizando un registro donde el usuario debe ingresar su nombre, apellido, EPS, talla y peso; esta información ingresa a una base de datos para poder tomar decisiones más adelante.

El siguiente módulo de la aplicación se activa cuando la persona se encuentra en situación de urgencia, generando un cuestionario para que el paciente, su acompañante o primer acudiente pueda ingresar los síntomas que padece, incluyendo todos los aspectos que lo caracterizan. De esta forma, se desplegará una lista que divide los síntomas en seis categorías: síntomas generales, cabeza y cuello, tórax, abdomen, extremidades y trauma; de aquí se despliegan una serie de posibilidades para que el paciente elija las que mejor describan su estado. Adicionalmente, para conocer la condición clínica del paciente es necesario reconocer sus manifestaciones objetivas, de manera que la aplicación pueda ingresar manualmente los datos correspondientes a los signos vitales o enlazarse con otros dispositivos para obtenerlos, cuantificarlos y clarificar la severidad de los síntomas, emitiendo una recomendación del tiempo estimado para asistir al servicio de urgencias, el nivel de complejidad de la institución necesaria para su atención y recomendaciones.

Figura 1.
Propuesta componentes visibles y modificables para el usuario de la app "ASISalud"

DATOS DE INGRESO			
Nombre			
Apellido			
EPS			
Talla (m)		**Peso (kg)**	

DATOS DE URGENCIA					
Síntoma					
(Lista desplegable)	Síntomas Generales				
	Cabeza y cuello				
	Tórax				
	Abdomen				
	Extremidades				
	Trauma				
Frecuencia Cardiaca (lpm)		**Presión Arterial (mmHg)**		**Saturación de Oxigeno (%)**	
Frecuencia Respiratoria (rpm)		**Temperatura (°C)**			

Fuente: los autores.

Toda la información se envía a un hospital que cumpla las condiciones requeridas para su atención, teniendo en cuenta el tiempo de respuesta, el nivel de complejidad de la institución y cobertura de la EPS, permitiendo integrar la información del paciente para que la institución pueda prepararse y recibirlo.

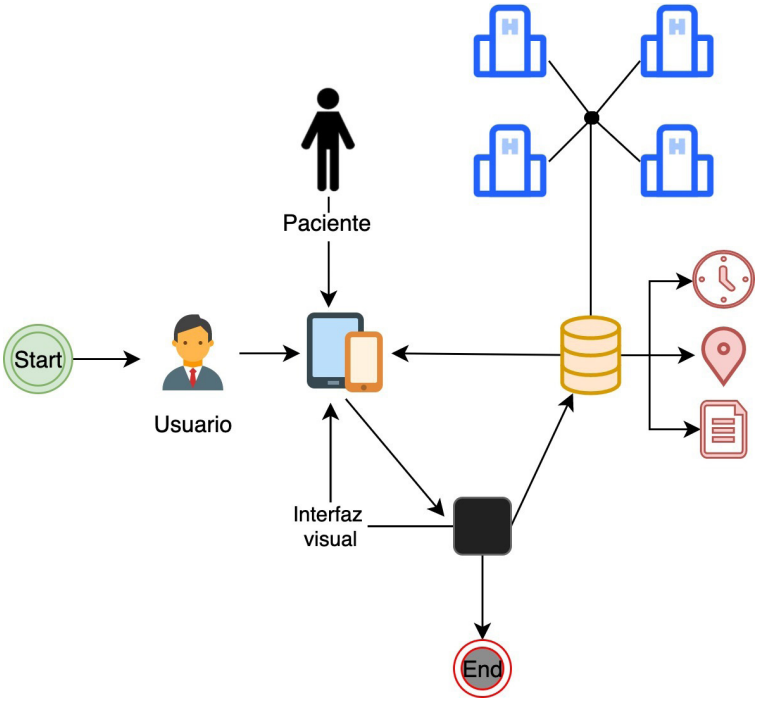
Componentes de la aplicación

Software.

El software permite unir la información del paciente, cargar la situación en urgencias de las clínicas, la capacidad de atención de las Instituciones Prestadoras de Servicios de Salud (IPS), tiempos de espera y complejidad según el personal disponible en tiempo real. De

esta manera, la aplicación se integra con dos bases de datos, una de ellas con los atributos de los pacientes, como síntomas, complicaciones y datos de ingreso; la otra, con la información de las IPS de la ciudad incluyendo el nombre, nivel de complejidad, ubicación y Entidad Promotora de Salud (EPS). Inicialmente, se genera un cuestionario para describir los síntomas y permitiendo el enlace con dispositivos inteligentes para la obtención de signos vitales; el sistema integra toda la información generando una respuesta al paciente con los siguientes datos: hospital al cual recurrir, tiempo de espera y acciones que pueden ser realizadas o recomendaciones. A su vez, la aplicación notifica a la IPS que el paciente va en camino.

Figura 2.
Diagrama de la aplicación "ASISalud"



Fuente: los autores.

Hardware.

- Dispositivos externos de signos vitales.
- Relojes y dispositivos inteligentes que registren signos vitales.
- Teléfonos inteligentes.

Etapa actual del proyecto

Este proyecto surge a partir de un trabajo realizado para la asignatura Informática Médica de la carrera de Medicina en la Pontificia Universidad Javeriana Cali, basándose en los avances realizados en Colombia, como el mencionado anteriormente "HospitApp", y diferentes aplicaciones enfocadas al triage en EE. UU. Así, esta propuesta pretende unificar las necesidades existentes en el servicio de urgencias con un enfoque sobre las IPS y las consultas más comunes en la ciudad de Santiago de Cali, partiendo de las necesidades identificadas desde una perspectiva de médicos en formación, donde se evidenció la necesidad de generar una herramienta que mejore la eficiencia y agilidad de los servicios de urgencias en la ciudad. Además, se pretende generar una solución conceptual para optimizar la atención en estos servicios en las instituciones, disminuyendo las complicaciones relacionadas con los tiempos de atención y oportunidad del servicio para los pacientes. Por esto, en primera instancia desarrollamos este artículo y el primer modelo de la aplicación, con el fin de contribuir al desarrollo y bienestar local para, en un futuro, lograr aplicar esta tecnología en el resto del país.

Conclusiones

ASISalud nace como una propuesta para mejorar la agilidad en el acceso a los servicios de urgencias médicas utilizando tecnologías móviles para el beneficio en la atención del paciente. A través de esta aplicación, se plantea una optimización de los servicios de urgencias al brindar la mejor atención en el menor tiempo posible, lo cual significa menores complicaciones para el paciente y a su vez genera un aporte en la reducción de la morbimortalidad al lograr un acceso oportuno

a los servicios de urgencias. De esta manera, este artículo abre un espacio para futuras investigaciones donde se integren el desarrollo de tecnologías móviles con el personal asistencial y la población general, para implementar soluciones en beneficio de la salud de la población e igualmente evidenciar el posible impacto económico sobre el sistema de salud colombiano al llevar a cabo este tipo de estrategias. Además, se proyecta seguir trabajando en la propuesta y así desarrollar las siguientes fases de la aplicación.

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Rehabilitación fonoaudiológica a través de telemedicina, caso clínico

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Fonoaudióloga Magister en Seguridad y Salud en el Trabajo

Resumen

El caso clínico que aquí se evidencia muestra la experiencia de la rehabilitación de un paciente del servicio de Fonoaudiología a través de telemedicina, caso se desarrollado como prueba piloto para la creación de protocolos de valoración, intervención y habilitación de un servicio de tele rehabilitación en fonoaudiología. Los resultados de la terapia haciendo uso de técnicas y herramientas digitales, se obtienen después de 10 sesiones virtuales, donde se demuestra que el paciente presenta una mejoría en la inteligibilidad del habla, mayor eficiencia respiratoria y producción vocal efectiva. Este estudio proporciona ítems de evaluación e intervención en terapias remotas, donde se espera que puedan ser usados como medio de estandarización en procesos futuros de la tele rehabilitación.

Palabras clave: Telemedicina, teleasistencia, tele rehabilitación, fonoaudiología, rehabilitación, protocolos de intervención.

Introducción

Según el Ministerio de Protección Social (2014), la telemedicina es la provisión de servicios de salud a distancia, utilizando la tecnología como medio de apoyo para ofrecer promoción, prevención, diagnóstico, tratamiento y rehabilitación por profesionales del área de la salud. Conocida en Colombia como tele asistencia (desde 2014), esta novedosa técnica se basa principalmente en la lectura de exámenes

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clínicos, asesoría médica y consejería, evolucionando en la actualidad a la telemedicina y tele rehabilitación; es decir, son tratamientos y procesos de rehabilitación tradicional o manual llevados al mundo digital (Poliszuk, Salazar y Gómez, 2006). Las plataformas destinadas a ello, consisten en portales web donde paciente y usuario se conectan a través de salas virtuales, apoyándose en recursos que suplan el contacto físico, tales como video, grabaciones y proyección.

De esta forma, el caso clínico presentado en este trabajo aplica técnicas de telemedicina, principalmente la tele rehabilitación, y se distribuye de la siguiente manera: primero, describe algunas investigaciones y trabajos relacionados sobre telemedicina desarrollados en Colombia, para después presentar el desarrollo del caso clínico, metodología y protocolos utilizados en la evaluación, intervención y estrategias para la rehabilitación virtual. Posteriormente, se muestran los resultados y la discusión del artículo para, finalmente, llegar a las conclusiones y lecciones aprendidas del caso.

Trabajos relacionados en Colombia

Inicialmente, señalamos el trabajo de **Álzate Castrillón** (2019), "Desafíos del derecho y la medicina en la actualidad", un breve recorrido por la evolución de la telemedicina en Colombia desde 2014, considerando la definición de la Organización Mundial de la Salud sobre la telemedicina "como la atención médica prestada a través de la comunicación interactiva de sonido, imágenes y datos que permite la atención en salud por medio del uso de herramientas tecnológicas, es innovadora y a la vez controversial" (p.50). De esta forma, en casos como la fonoaudiología, donde los servicios tradicionalmente realizados de manera presencial por la necesidad del contacto físico, son suplidos por la iteración a través de una plataforma digital, se crean grandes desafíos en la generación de nuevas estrategias terapéuticas.

Además del anterior, también resalta el trabajo de Correa-Díaz (2017), donde señala la importancia de la regulación y los vacíos jurídicos en la prestación de servicios en salud a través de telemedicina, o el

artículo de Durán Peñafiel (2014) "Experiencia de la Red de Salud de Ladera con su Unidad de Tele salud", al mostrar la importancia de la tele salud como respuesta al acceso y oportunidad de los servicios de salud, principalmente en el Valle de Cauca, con el fin de implementar modelos que permitan mejorar el cubrimiento del sistema de salud actual. Finalmente, El Grupo de investigación tecnologías en salud (2013), resalta la importancia del compromiso ético de los profesionales que realizan intervenciones a través de la telemedicina, sustentando la necesidad de adoptar protocolos regidos por asociaciones reconocidas como la American Speech-Language Hearing (ASHA), La Asociación Americana de Fisioterapia (APTA) y la Asociación Americana Terapia Ocupacional (AOTA) (Giraldo, Serna, Robledo & Hurtado, 2013).

Desarrollo del caso clínico

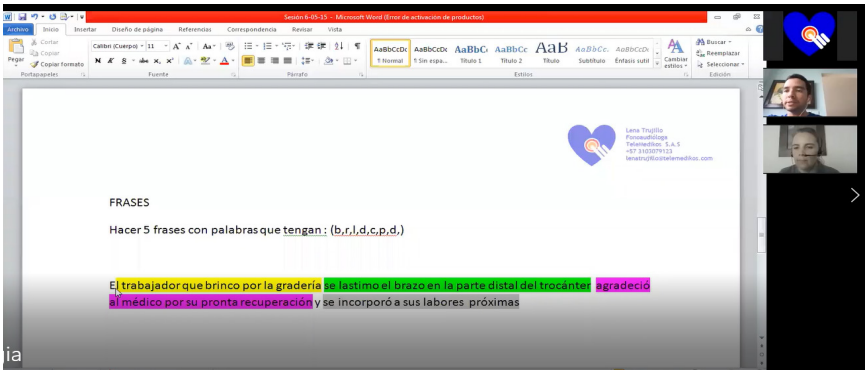
En este caso de estudio se utilizó una plataforma web de telemedicina (Telemedikos) que ofrece servicios de salud de forma remota a través de internet, por medio de aplicación Zoom en diferentes salas virtuales; para acceder se debe hacer uso de un identificador personal que asegura la privacidad y confidencialidad de las sesiones, grabadas para anexo a la historia clínica. El paciente en cuestión, es de la ciudad del Salvador, tiene 40 años y es profesional en administración de empresas, anteriormente corredor de bolsa. En 2014 el realizó un viaje a Corea donde presentó un evento hemorrágico en la arteria cerebelosa superior con alteración de conciencia, deambulación, disfagia y disartria. Estuvo en la unidad de cuidados intensivos 11 días y, posteriormente, retornó al país donde se encontraba radicado para iniciar un proceso de rehabilitación. Recibió tres meses de tratamiento en fisioterapia y fonoaudiología de manera presencial en la ciudad de Miami, lo cual le permitió recuperar la marcha, además de mejorar la ingesta de alimentos sólidos; sin embargo, continuaba con disfagia en la de ingesta de líquidos claros, dificultad expresiva, habla lentificada y disfonía.

En busca de nuevas alternativas, en 2015 el paciente consultó a una empresa privada en Bogotá- Colombia (Telemedikos) prestadora del servicio de telemedicina, para recibir intervención fonoaudiológica a

través de internet; de esta forma se contactó con una fonoaudióloga especialista en el área referida para paciente ubicado en Miami, Florida. Primero se realizó un diseño de protocolos contenidos en una prueba piloto, los cuales incluyeron anamnesis con datos de identificación, biográficos y ocupacionales, parte del diseño de investigación iniciada en 2015 por el área de la fonoaudióloga y la empresa privada para la habilitación como prestadora de servicios de telemedicina (Trujillo, 2015). Al iniciar la valoración por medio de la exploración de procesos motores básicos, necesarios para la producción de la voz y el habla como la respiración, articulación, resonancia, prosodia y fonación, se estableció la conducta del paciente, los objetivos terapéuticos y el plan de intervención, que en este caso contó con 10 sesiones de 45 minutos cada una (dos veces por semana), a través de la plataforma de telemedicina, utilizando el modelamiento, repetición-memorización de nuevos parámetros necesarios para la rehabilitación (*Figura 1*), y la aplicación de maniobras compensatorias establecidas para la rehabilitación de la voz presencialmente, pero adaptadas a la virtualidad.

Figura 1.

Ejercicios prácticos de tele rehabilitación para la fluidez y prosodia del habla



Fuente: el autor.

Resultados

La evaluación determinó que el paciente presentaba respiración corta y jadeante tipo costal superior, sin coordinación fono respiratoria lentificando la melodía, ritmo y entonación; y resonancia nasal,

esfuerzo laríngeo y baja sonoridad, produciendo aislamiento y el cese de labores cotidianas al restringir su participación social, laboral y personal. Sin embargo, después de las 10 sesiones de intervención se logra cumplir los objetivos propuestos en plan, tales como lograr una respiración eficiente de modo nasal; tipo costal diafragmático con el fin de aumentar el volumen de la voz; y mejoría de los rasgos prosódicos en entonación, velocidad y ritmo haciendo su habla inteligible. Gracias a esto, el paciente pudo reintegrarse y participar en actividades sociales, familiares y laborales.

Tabla 1.

Plan de intervención de 10 sesiones para la realización de las terapias por medio de tele rehabilitación

Área	**Sub área**	**Aspecto**	**Actividades**	**Sesiones**
Habla	OFA	Fuerza del alcance y coordinación. Punto y modo y agilización silábica.	Estimulación activa y pasiva de OFA.	5
Voz	Respiración Voz Prosodia	Modo, tipo CFR, intensidad, tono, timbre, ritmo, acento, entonación.	Aumentar tiempos de fonación y CFR, subir el volumen de la voz, bajar tono, matizar timbre, aumentar ritmo, disminuir acento y modular entonación.	4

Lenguaje	Expresivo comprensivo	Discriminación fonética, sintáctica. Ejercitación, contenido y uso.	Interiorizar fonemas trabajados en el habla espontánea. Explorar contenido y uso del lenguaje en situaciones cotidianas.	1

Fuente: el autor.

Discusión

Este caso clínico es el punto de partida para la profundización en el área de la fonoaudiología, al aporte de evidencia científica, la investigación de nuevas alternativas de intervención y la ruptura de paradigmas en la atención, abriendo la oportunidad para el diseño y atención a través de la telemedicina por medio de protocolos y guías de manejo estandarizados (Jaramillo, 2015; Gutiérrez, 2018). De esta manera, los resultados aquí obtenidos evidencian una serie de ventajas en la prestación de servicios de salud por telemedicina, la cual permite prestar servicios de calidad y aumentar la oportunidad de acceso (Giraldo, Serna, Robledo, & Hurtado, Ocampo); esto puede comprobarse a través de los archivos en video de cada sesión, las entrevistas y encuestas de satisfacción contenidas en la historia clínica, así como el video testimonio del usuario sobre las ventajas de recibir tratamiento fonoaudiológico a través de esta modalidad.

Conclusiones

Con la implementación de servicios de telemedicina en casos como el aquí presentado, se demuestra que esta modalidad posee mayores ventajas que desventajas en comparación con los servicios prestados presencialmente, pues se proveen innumerables oportunidades que benefician tanto al paciente como al profesional como el acceso

remoto, costos, disminución del tiempo de rehabilitación y oportunidad de acceso a más profesionales. Teniendo en cuenta que los servicios de telemedicina deben estar regulados por protocolos estandarizados bajo las asociaciones y agremiaciones profesionales, así como de la normatividad vigente en la prestación de servicios de salud en Colombia, con la realización de este caso se están construyendo y proporcionando herramientas para definir un estado del arte del diseño de protocolos y habilitación del servicio de fonoaudiología por telemedicina.

Agradecimientos

Este trabajo fue logrado gracias al estudio realizado en conjunto con la empresa Telemedikos; además, se reconoce la participación de la Dra. Carolina Gómez y el paciente Fernando Fonseca, quien dio el consentimiento informado para el desarrollo de este caso clínico.

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Normal gait parameters estimation based on simplified walking model

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Abstract

Motion capture techniques and gait analysis protocols, both imply a precise measurement and quantitative assessment of human locomotion during walking, where the results can be used on several healthcare related areas, such as rehabilitation, medical diagnosis and sports. In this study, a simplified human gait model is computationally evaluated, by means of classical mechanics using Newton-Euler laws, with the goal of verifying its applicability for the estimation of gait parameters in adults, which includes step length, cadence and velocity of walking. The response of this model is compared with previously reported experimental data, captured on a gait analysis laboratory, by calculating cross-correlation of signals, such as angular displacements and velocities. Subsequently, the dynamic stability of the model is analyzed; the gait parameters calculated and results compared with reported experiments on adults. Finally, important findings such as high correlation coefficients between signals, and low gait parameter estimation errors, prove that despite simplicity, this model represents a valuable approach for understanding basic gait parameter estimation, from a multidisciplinary perspective, including health and engineering sciences.

Keywords: Human gait, numeric simulation, motion capture, gait parameters.

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Introduction

Several factors have motivated important advances in theories such as multibody approaches (Pamies et al., 2012), and technologies such as inertial sensor procedures (Sant' Anna et al., 2013), which have been developed and applied in motion capture protocols and gait analysis on adults; this implies a precise measurement and quantitative assessment of the human locomotion during walking (Ghoussayni et al., 2004), where the use of results varies between different areas, such as rehabilitation and sports. For example, in orthopedics and rehabilitation, it is employed to categorize gait disorders and serve as a guide for therapeutic interventions (Pirker & Katzenschlager, 2017), as well as to evaluate the effectiveness of rehabilitation programs of gait parameters at usual and fastest walking speeds (Leone et al. 2018). In certain types of physical training, it is used to recognize failures in athletic performance and to improve the efficiency of athletes (Wahab & Bakar, 2011).

Currently, there is a concern of difficulty and restriction in human movement assessment, which depends mainly on the experience, knowledge and observational skills of the physical therapist. In addition, the use of conventional technologies, would be limiting its application within a few specialized medical centers and the unobtrusive monitoring of the patient during spontaneous movements, where the typical ability to walk, in contrast with the best performance, is still unexplored (Cutti et al., 2010). Gait analysis relates the spatial coordinates as well as the angles of joints. The spatial coordinates of the anatomic points on lower extremities, determine a number of parameters, that are commonly used to describe human gait, for instance, the cadence, the step length and the walking velocity. On the other hand, the anatomic joint angles are important because these indicate how a body segment is oriented in relation to another (Paróczai et al., 2006), and the range of movement is of interest for clinicians, for example, the abduction-adduction of hip joints, and the flexion-extension of knee joints. Several authors have addressed the problem of human walking characterization, for instance, through studies from

two main models of gait: six step determinants and an analogy with an inverted pendulum (Kuo, 2007), or where the main research tool is a numeric simulation (García et al., 1998), presenting a special mass distribution that simplifies the underlying mechanics and mathematics.

Few multidisciplinary efforts have been identified, in which through a qualitative understanding of human gait from health sciences, in combination with methods of classical mechanics using Newton-Euler laws from engineering sciences; perform a stability analysis and experimental verification of results leading to a comprehensive estimation of gait parameters in adults. Therefore, his work has been done with the main objective of performing an evaluation on the applicability and validity of modelling and simulating human walking for gait parameter estimation in adults, studying particularly computer assisted tools and techniques, and applying theoretical and practical fundamentals from dynamic systems that enable an appropriate analysis and interpretation of the human locomotion phenomena.

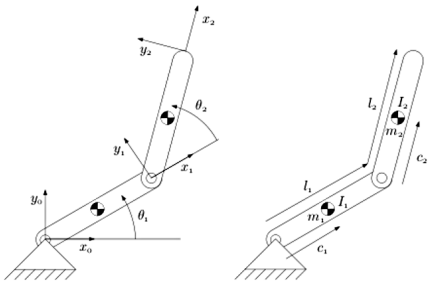
Materials and Methods

Mathematical Formulation

By means of classical mechanics, the Newton-Euler laws were applied to determine the movement equations of a double inverted pendulum which, in aggregation with restrictions, comprise the set of movement equations completely describing the system dynamics. It was necessary to define all forces and moments that actuate on two different bodies (*Figure 1*); this set of equations can be arranged to isolate torque variables τ to formulate the nonlinear system in a convenient form.

Figure 1.
Double inverted pendulum

$$\tau = D(q)\,\ddot{q} + C(q,\dot{q})\,\dot{q} + G(q)$$



Source: (Zutven, 2009).

The corresponding $D(q)$, $C(q,\dot{q},)$ and $G(q)$ are nonlinear matricial functions, written in terms of the constant masses $(m_1 m_2)$, lengths $(l_1 l_2)$, centroids $(c_1 c_2)$, , inertias $(I_1 I_2)$, and the variable angles $(\theta_1 \theta_2)$, angular velocities $(\omega_1 \omega_2)$.

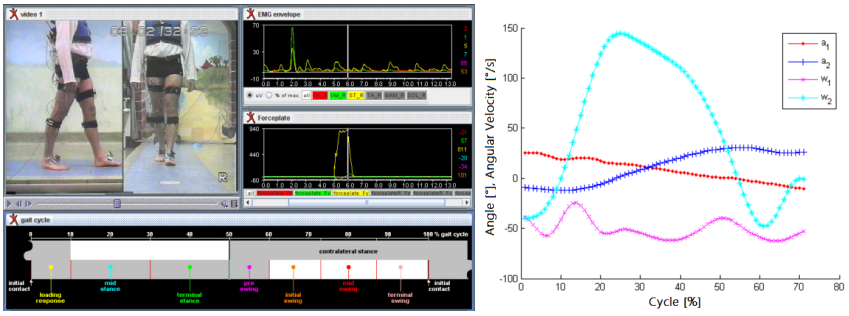
Numerical Simulation

Solutions for the mathematical expressions of the double inverted pendulum (1), were achieved through numerical simulation adapting a source code developed in Matlab R programming language to perform the required operations (Karssen & Wisse, 2008); the state of the model is determined by absolute angles and angular velocities of segments with respect to ground's normal. The estimated model parameters for a 32 year old male were: length (0.924 m), radius (0.420 m), mass (15.120 kg), inertia (1.076 kg) and centroid (0.427 m), calculated from body weight and height of the subject by using segment proportions (Winter, 2005). Moreover, the function called 'step' simulates the model dynamics by integrating the movement equations until the segment in swing phase hits the ground; when this event is detected, the numerical integration is stopped and the calculations for the successive state following a collision are determined. Afterwards, the segments are interchanged so the swing becomes the stance segment and vice versa. Function named 'animate' displays a sequence of the movement for a simple dynamic biped.

Human Motion Capture

The software package BodyMech V.3.06 (Harlaar & Doorenbosch, 2006) was used as source of experimental information and for human gait kinematic analysis based on low-speed walking style, emulating the adult conditions; the available data set consists of different walking styles and velocities. In *Figure 2*(b), the angles (a_1,a_2) and angular velocities (ω_1,ω_2) of the hip joint are represented during walking once the movement is initiated, plotting a single step of approximately 0.72 seconds of duration, with the following measured reference gait parameters: cadence (83.33 spm), gait velocity (3.42 km/h), step length (68.00 cm), and flexion range (72.00 deg).

Figure 2.
Human gait analysis. Hip Joint Variables



(a) Motion capture data **(b) Hip joint variables**

Source: (Harlaar & Doorenbosch, 2006).

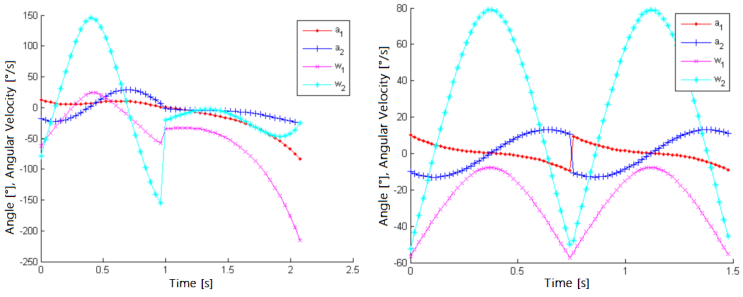
Results and Discussion

Considering the gait period as a limit cycle that is repeated continuously, it is characterized by several equilibrium points which might be of stable or unstable nature. On one hand, stable implies that when small perturbations are applied to the system, the response is contracted, whilst unstable means the opposite situation. In this context, *Figure 3*(a) represents system response for the variables $(a_1,a_2,\omega_1,\omega_2)$, given the border conditions:

$$S_o = [+0.2200 \quad -0.3110 \quad -1.0820 \quad -1.3720] \quad (2)$$

Describing a limit cycle that has an unstable behavior, which can be observed graphically by noting that all four signals diverge from the previous critical points to undetermined real values, this in fact disables the cycle from repeating.

Figure 3.
Limit cycle response



(a) Unstable (b) Stable

Source: the authors.

In order to find a stable limit cycle for the model, the difference between the input and output states was minimized by using the function *lsqnonlin*, which produced the state vector:

$$S_o = [+0.1752 \quad -0.1752 \quad -0.9877 \quad -0.9136] \quad (3)$$

Considering the eigenvalues of the Jacobian, which is, the principal values of the partial derivative matrix , it is possible to determine the type of response from the dynamic system if small perturbations occur; the necessary condition for the system to be stable is that all eigenvalues must have an absolute value less than one. The eigenvalues were calculated, resulting in:

$$\lambda = [+0.8667 \quad -0.6015 \quad -0.3570 \quad -0.0000] \quad (4)$$

This represents the condition for a stable limit cycle, depicted in *Figure 3*, which can be observed graphically by noticing all the signals converge towards the previous critical points, this in fact enables the cycle to repeat indefinitely. Therefore, a comparison of the four simulated signals with respect to experimental data using cross-correlation seemed reasonable. By means of the *corrcoef* function, coefficients for state variables were obtained:

$$C_S = [0.75 \quad 0.80 \quad 0.84 \quad 0.96] \quad (5)$$

For this reason, correlation coefficient values between approximately 0.8 and 1.0 should indicate a very strong relationship between two signals. This similarity implied our numerical simulation model was experimentally verified, thus gait parameters estimation through this model were: cadence (80.25 spm), gait velocity (3.25 km/h), step length (67.00 cm) and flexion range (52.17 deg).

Conclusions

The human gait is a complex and active movement of interest for adult population assessment. However, on the study of walking, it is interesting to find how simple and passive models can exhibit a set of multiple behaviors with stable and unstable nature, corresponding to given border conditions; the dynamics of the system is subject to its mass distribution and geometric properties. Therefore, this study evaluated an approach to modelling human gait (the Newton-Euler method), by incorporating internal and external forces applied to linkages, which results in a system of differential equations where the difficulty is to solve the system numerically. Other methods, like Lagrange-Euler solve the problem using generalized coordinates, although the approach is usually developed for the mathematical formulation on more complex dynamic systems.

The results showed evidence that simple, non-controlled biped walking in a stable way is possible, although there is a possibility of limping

or staggering; this supports the affirmation that dynamic passive modelling can be a starting point to understand certain aspects of human movement. In this context, the results can be useful for those who study aspects of active movement control, enhancing prosthetic devices and determining rehabilitation procedures.

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Diseño de actividades didácticas a partir de un modelo de desarrollo de narrativa en niños

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Resumen

Los niños oralizados con pérdida auditiva presentan un retraso en el desarrollo del lenguaje, por lo cual requieren una intervención terapéutica que les permita alcanzar las habilidades y competencias necesarias para mejorar sus procesos comunicativos, dadas las dificultades en la composición de textos (orales/escritos) y la comprensión de estructuras narrativas. Para contribuir al cumplimiento de las metas terapéuticas en los niños y facilitar la participación de la familia, se diseñaron y documentaron 14 actividades terapéuticas para desarrollar una herramienta informática, acorde al proceso propuesto en un modelo de desarrollo de narrativa en niños; con esto, se pretende facilitar el desarrollo de las competencias comunicativas del niño, necesarias para su interacción social y escolar, así como proporcionar a las familias entornos de trabajo lúdicos acordes con los propósitos terapéuticos establecidos, empleando herramientas informáticas.

Palabras clave: sordera, terapia del lenguaje, desarrollo del lenguaje, lenguaje infantil, narrativa.

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Introducción

La narrativa representa el culmen en el proceso de adquisición o desarrollo del lenguaje infantil, pues evidencia la habilidad alcanzada por un niño para expresar tanto sus ideas y pensamientos, como para contar sus experiencias vitales o la ocurrencia de sucesos (sean reales o imaginarios, producto de la fantasía), en forma clara, ordenada, coherente y comprensible, siguiendo las reglas de un idioma particular (de manera oral o escrita) (Bitetti & Hammer, 2016). Estudios donde se analizan las narrativas de niños escolares sordos frente a los oyentes, muestran que las funciones ejecutivas típicamente se ven alteradas (Soriano, Pérez y Domínguez, 2006) y se observa falta de desarrollo de la superestructura narrativa (Salvador, 1999). Además, desde la práctica terapéutica se observan bajos niveles de organización y comprensión de estructuras narrativas complejas, lo que afecta significativamente el desempeño académico al enfrentarse a textos (orales y escritos).

Debido a su déficit auditivo, los niños sordos oralizados tienen un retraso en la adquisición de la narrativa oral y escrita, por tanto, requieren de intervenciones terapéuticas que propicien actividades significativas para estimular su desarrollo cognitivo, emocional, social y lingüístico (Halliday, Tuomainen & Rosen, 2017). Por esto, en este artículo se describen las actividades terapéuticas del lenguaje diseñadas para una herramienta informática a partir de un modelo de desarrollo de la narrativa, planteado desde fundamentos teóricos de distintos autores y la experiencia práctica lograda en terapias individuales y grupales en la Unidad de Rehabilitación del Instituto para Niños Ciegos y Sordos del Valle del Cauca (INCS). El modelo tiene en cuenta aspectos determinantes en el proceso de la narrativa, para favorecer el desarrollo del lenguaje oral y escrito de los niños con pérdida auditiva oralizados dado los bajos niveles de comprensión (Soriano, Pérez y Domínguez, 2006; Alfonso de Barahona, 1997; Lissi et al., 2011).

Modelo de la narrativa

La necesidad de proponer un modelo surge tras la revisión de la literatura, donde los autores se centran en el estudio de la narrativa en relación con diferentes patologías del lenguaje (Gardner-Neblett & Iruka, 2015), sin evidenciar modelos de desarrollo de la narrativa estructurados como proceso (Muñoz, Prado y Orozco, 2019). Las dificultades que presentan los niños con pérdida auditiva en la estructuración y comprensión de estructuras narrativas complejas, afectan significativamente su desempeño académico al enfrentarse principalmente a textos escritos (Martínez, 2015). A partir de esta realidad, el modelo planteado en el INCS cuenta con aspectos determinantes que se integran y favorecen la construcción de la narrativa de los niños con pérdida auditiva oralizados.

Según Bruner (cita), el acto de narrar constituye un proceso complejo que requiere la integración de habilidades lingüísticas, cognitivas y sociales, y brinda la oportunidad de comprender la complejidad de las interacciones entre lenguaje y pensamiento (González, 2011; Bliss, McCabe & Miranda, 1998). De esta forma, el modelo articula el proceso de desarrollo de la narrativa con los componentes semántico y sintáctico del lenguaje y las habilidades cognitivas requeridas para la comprensión. Desde la semántica, el modelo contempla la adquisición de palabras y sus significados; la evolución de estos presaberes permite llegar a las descripciones estáticas y dinámicas. A nivel sintáctico, el modelo permite llegar a la estructuración de oraciones, teniendo en cuenta las categorías gramaticales; esto favorece el desarrollo de un discurso más estructurado, con mayor cohesión y coherencia, estimulando también el desarrollo de la pragmática que incluye las micro funciones planteadas por Halliday correspondientes al uso concreto y real del lenguaje (Ghio, Navarro y Lukin, 2017). Además, a nivel cognitivo el modelo se aborda desde los niveles de distanciamiento de Sigel (1997), quien plantea que el distanciamiento cognitivo permite el grado de separación psicológica del presente inmediato o distancia referencial que contiene una emisión lingüística.

Metodología

Dada la importancia actual de las TIC en los procesos de rehabilitación, el proyecto partió de la necesidad de ofrecer a los usuarios (niños, familia y terapeutas) un apoyo terapéutico utilizando herramientas de software, favoreciendo la motivación e interés de los niños en tareas de mecanización. Así, se inició con la observación, organización y documentación de diferentes estrategias usadas por fonoaudiólogas y docentes en el INCS para lograr el desarrollo del lenguaje oral en los niños con pérdida auditiva partiendo del análisis de la tarea (Otálora, 2009), lo que permite identificar características de las actividades terapéuticas y garantizar el control de todas las variables necesarias para el cumplimiento de los objetivos planeados en cada intervención; para realizar una actividad, se tienen en cuenta propósitos desde habilidades cognitivas y comunicativas.

Las actividades fueron certificadas con material físico, donde se realizó el análisis del vocabulario, estímulos orales y escritos, secuencia de la actividad, validación de los presaberes en función de las metas propuestas y nivel de interés de los niños (realizando las actividades con diferentes niños). Posteriormente, se inició el trabajo directo con el grupo de investigación Destino de la Pontificia Universidad Javeriana Cali, en donde se planificó el alcance del proyecto y se propuso un configurador de actividades desde la perspectiva terapéutica. En reuniones semanales con el equipo se realizó la socialización de cada una de las actividades, para identificar en conjunto las formas de interacciones útiles para los usuarios que facilitaran el cumplimiento de los objetivos terapéuticos de cada actividad e iniciar el diseño e implementación en el software; cada actividad se validó desde la interacción, claridad de los gráficos y usabilidad.

Resultados

Se diseñaron 14 tipos de actividades para trabajar la descripción estática y dinámica (*Tabla 1*), cada una con diferentes variaciones.

Tabla 1.
Actividades terapéuticas

Actividad	Tipo	Descripción de la actividad	Propósito de la actividad
Historieta de secuencias	Dinámica	Organización de imágenes en una secuencia lógica.	Esta actividad permite que el niño logre ejercitar las descripciones dinámicas a nivel oral y escrito, y realice inferencias usando oraciones simples y compuestas, así como diferentes estructuras sintácticas que desarrollan en el niño competencias para realizar narraciones.
Dominó	Estática	Parear fichas a través de la deducción de variables comunes (verbos, sustantivos, adjetivos).	Esta actividad permite que el niño logre ejercitarse en la elaboración de descripciones estáticas usando diferentes sustantivos, adjetivos y verbos calificativos dentro de una oración simple.
Cómics	Dinámica	Organización de imágenes en una secuencia lógica y relacionar los diálogos de acuerdo con la acción.	Esta actividad permite que el niño realice descripciones dinámicas e inferencias, usando oraciones simples y compuestas, y diferentes estructuras sintácticas, que desarrollan competencias para realizar narraciones.
Ordenando mi casa	Estática	Seleccionar personajes que realicen diferentes acciones.	Esta actividad permite que el niño logre ejercitarse y elabore descripciones estáticas usando diferentes acciones, pronombres, sustantivos, adjetivos calificativos y verbos.

Actividad	Tipo	Descripción de la actividad	Propósito de la actividad
Encajable	Estática	Encajar las partes del cuerpo correspondientes a la silueta del personaje seleccionado.	Esta actividad permite que el niño logre ejercitarse en la elaboración de descripciones estáticas usando diferentes sustantivos y adjetivos calificativos; uso del verbo tener.
Cuento	Dinámica	Observación de imágenes de un cuento y realizar descripciones a partir de preguntas formuladas por el avatar; posteriormente, debe organizar imágenes del cuento en secuencia lógica.	Esta actividad permite al niño responder a preguntas de compresión literal, realizar descripciones estáticas y dinámicas, e inferencias usando oraciones simples y compuestas, así como diferentes estructuras sintácticas.
El viaje	Estática	Selección de prendas de vestir según el destino planteado en las diferentes historias.	Esta actividad permite que el niño logre ejercitarse en la elaboración de oraciones simples usando diferentes sustantivos, adjetivos y verbos calificativos.
Ordenado mi cocina	Estática	Categorizar alimentos y realizar acciones solicitadas.	Esta actividad permite la comprensión y uso de nociones necesarias para la elaboración de descripciones estáticas a través de la comprensión de instrucciones verbales, dando respuestas a preguntas formuladas.

Actividad	Tipo	Descripción de la actividad	Propósito de la actividad
Encontrando la causa y el efecto	Dinámica	Encontrar el efecto a una acción dada, teniendo en cuenta las características de las imágenes.	Esta actividad permite que el niño logre realizar relaciones de causa y efecto, descripciones estáticas y dinámicas e inferencias usando oraciones simples y compuestas.
Ruta al zoológico	Dinámica	El niño debe seleccionar el camino correcto, teniendo en cuenta los pasos para el cumplimiento de la meta planteada.	Esta actividad tiene el fin de desarrollar procesos de planificación en el niño.
El estacionamiento	Estática	Organizar los carros dependiendo de la variable establecida.	Esta actividad permite que el niño, realice procesos de deducción y logre ejercitarse en la comprensión y uso de nociones necesarias para la elaboración de descripciones estáticas, a través de la comprensión de instrucciones verbales.
La receta	Dinámica	Elegir un elemento de una lista para poder realizar la receta y, posteriormente, resolver unas hipótesis.	Esta actividad permite que el niño logre organizar secuencias de manera lógica, realizar hipótesis usando oraciones simples y compuestas, así como diferentes estructuras sintácticas.

Actividad	Tipo	Descripción de la actividad	Propósito de la actividad
Organizando el cumpleaños de Luis	Dinámica	Seleccionar y organizar una lista de elementos y acciones para cumplir la meta.	Esta actividad permite que el niño logre realizar una lista de elementos y secuencias lógicas, descripciones estáticas y dinámicas e inferencias usando oraciones simples y compuestas.
¡Adivina quién soy!	Estática	Descripciones de una imagen, donde el niño debe seleccionar entre varias opciones.	Descripciones de una imagen, donde el niño debe seleccionar entre varias opciones.

Fuente: los autores.

Las actividades se plantearon con un enfoque terapéutico que tiene en cuenta aspectos determinantes para el proceso de la narrativa como los componentes semántico, sintáctico, fonológico, pragmático, así como también habilidades de pensamiento siguiendo el modelo planteado. Desde el componente de pensamiento o cognición, estimula la observación para que el niño determine las características físicas de los objetos que se presenten en el juego y favorece los procesos de deducción e identificación. Además, para lograr que el niño realice descripciones estáticas, dentro de las actividades se generaron diferentes mecánicas, como el Dominó, Encajable, Ordenando mi casa, Ordenando mi cocina, El estacionamiento, El viaje o ¡Adivina quién soy! En cuanto a las descripciones dinámicas, las actividades se estructuraron de tal forma que desde el componente semántico favorecieran el desarrollo de habilidades para realizar descripciones estáticas y dinámicas, secuenciación, planificación de tareas, plantear hipótesis e inferencias. Por esto, la mecánica de los juegos propicia la interacción del usuario fomentando el uso de diferentes estructuras sintácticas para la construcción de oraciones simples y compuestas, necesarias para realizar narraciones. Todo lo anterior le facilita al niño hacer cohesión y coherencia de su discurso a

nivel oral y escrito, para lo cual es necesario que logre establecer una sucesión de situaciones que guarden relación entre sí.

Dentro de las actividades para lograr que el niño realice descripciones dinámicas, se utilizaron las siguientes mecánicas juego: Historieta de secuencias, Cómics, Encontrando la causa y el efecto, Organizando el cumpleaños de Luis, Ruta del zoológico y La receta. Sin embargo, a partir del modelo general se seleccionaron tres para implementar en el software: Dominó, el cual permite el uso de artículos, variación de diferentes sustantivos, adjetivos y verbos; Ordenando mi casa, que facilita el uso de pronombres y variación de diferentes sustantivos, adjetivos y verbos; y finalmente Historietas de secuencia, que permite la variabilidad de diferentes escenas y definir actividad de niños con o sin proceso lector desde la identificación de los aspectos de la rehabilitación del lenguaje oral y escrito. Teniendo en cuenta lo anterior, se implementaron actividades que ofrecieran distintas opciones para favorecer en los niños habilidades en el desarrollo de descripciones estáticas y dinámicas. Las primeras, buscan el ejercicio en la comprensión y uso de diferentes nociones y categorías gramaticales, a través de la comprensión de instrucciones verbales o formulación de preguntas dadas por la terapeuta virtual en el software. Por otro lado, las planteadas para las descripciones dinámicas buscan que el niño trabaje nociones temporales, realice análisis de causa-efecto, haga inferencias y deducciones, para ordenar y contar una secuencia de eventos de manera coherente y estructurada (narre).

Discusión y conclusión

Al considerar herramientas informáticas para apoyar la terapia del lenguaje con niños con pérdida auditiva (o con algún retraso en el desarrollo del lenguaje), es común encontrar referencias a herramientas para trabajar aspectos específicos como los procesos fonológicos y de escritura (Nakeva von Mentzer et al., 2013), la lecto-escritura (Folco, 2010), la producción de voz, habla y comunicación alternativa y aumentativa (Rodríguez, 2015); sin embargo, no se observan opciones para el trabajo integral de la comunicación comprensiva, que incluye la articulación tanto de habilidades cognitivas como de los componentes

semántico y sintáctico del lenguaje. De esta manera, el aporte innovador está en permitir que las actividades sean personalizadas según las necesidades del paciente, existiendo la posibilidad de adaptarse a niños con o sin proceso lector teniendo en cuenta las metas terapéuticas de cada uno, posibilitando la coevaluación y heteroevaluación del desempeño de los niños en cada actividad y ofreciendo una guía de trabajo a la familia, esencial para las primeras etapas del desarrollo.

Agradecimientos

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Proposal of a videogame as a support for dyscalculia therapies in educational environments

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Luis Freddy Muñoz S.[18]

Abstract

One of the relevant problems in the educational context regarding the learning process in the area of mathematics is dyscalculia. In order to apply more effectively and playfully the exercises and/or therapies performed to the subjects with this condition, in this article we present as a contribution the construction of an educational video game to support dyscalculia disorder in the classroom. To facilitate the portability of the game and the use in different activities by professors and professionals in the area, it was decided to use portable and open hardware and software platforms, such as Raspberry PI and Java. Therefore, the proposed game aims to support the development of exercises and/or therapies in the classroom in order to improve the skills in association of numbers and quantities, as well as basic operations of addition and counting.

Keywords: Dyscalculia, rehabilitation, therapies, video game.

Introduction

According to the American Psychiatric Association (De La Peña & Bernabéu, 2018), dyscalculia is classified as a specific learning disorder characterized by difficulty in acquiring skills in the area of mathematics, affecting the development and performance of individuals in this discipline, but does not produce a disorder of general mental functions (De La Peña & Bernabéu, 2018; Landerl, Bevan & Butterworth, 2004);

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however, behaviors among people with dyscalculia tend to vary. A common feature are the limited capacities to recognize magnitudes, which is evidenced by the fact that these subjects do not write and name numbers correctly, have difficulty performing sequential series, confuse mathematical signs, present problems in subitization; show low level of transcoding between words of numbers, digits and quantities; and have difficulty solving simple arithmetic operations such as addition, subtraction, multiplication, division and counting. According to studies, these behavioral deficits are independent of the level of intelligence and the school environment (Martínez, Calzadilla & Cruz, 2017; Kadosh & Walsh, 2007).

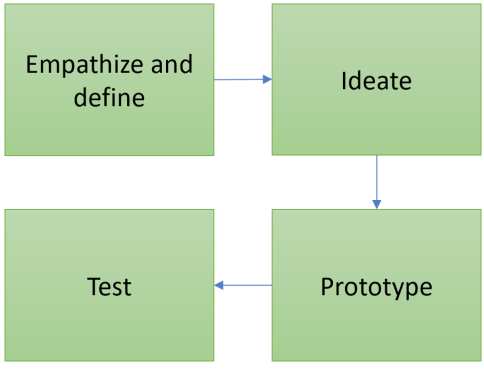
It is estimated that dyscalculia affects between 3 and 7% of school-age children, depending on the country of study and the diagnostic criteria used (Martínez, Calzadilla & Cruz, 2017); the possible causes are attributed to different factors, such as the lack of cerebral communication involving the visual processing and language centers, also related to hereditary conditions, while others consider that it is caused by environmental toxins (Martínez, Calzadilla & Cruz, 2017). Despite there is no doubt that this learning disorder generates a negative impact on the life of the individual who suffers it, it is less recognized, understood and studied by the scientific community with respect to other neurodevelopmental disorders (Beddington et al., 2008; Gersten, Clark & Mazzocco, 2007). Therefore, this paper proposes as a contribution the construction of a video game to support the development of therapies for dyscalculia in educational environments, taking up a set of activities and/or exercises of numerical association and counting, which are presented as challenges within the game. It was developed in the Java programming language, using the components provided by the Swing graphical library, with the intention to be deployed in a portable device type SBC (Single Board Computer) to be used permanently in a classroom of an educational institution, in such a way that it serves as a constant support in the work of teaching in the area of mathematics in basic primary education. In this sense the Java language has been chosen for its compatibility with open platforms such as Raspberry PI. The rest of the paper is organized as follows: section two, presents

the methodology considered for the construction of the video game; section three, describes its functional design, as well as the final prototype developed; section four presents the usability inspection performed on the final prototype of the game; and finally, section five presents the conclusions and future work obtained from this research.

Methodology

For the development of the proposed video game, an adaptation of the phases of the design thinking methodology was used (Serrano & Blázquez, 2015). In this way, the following phases were considered: empathize and define, devise, prototype and test (*Figure 1*). In phase one, the different concepts related to dyscalculia were identified and a set of exercises and/or activities used in the therapies of this disorder were explored. In phase two, a high-level design of the video game was made, taking into account the exercises explored and defined in phase one. In phase three, a prototype of the game designed in the previous phase was developed, making use of the Java programming language. Finally, in phase four, a usability inspection was carried out on the prototype, making use of the video game heuristics proposed by Pinelle, Wong & Stach (2008).

Figure 1.
Considered methodology



Source: the authors.

Construction of the video game

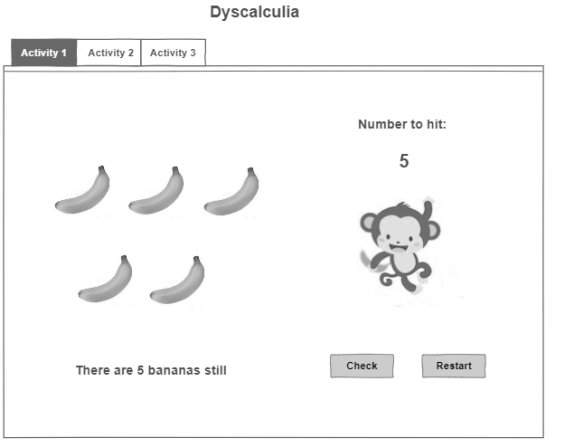
In this section the design and implementation of the proposed video game are presented, which aims to support the development of dyscalculia therapies in educational environments. In terms of design, high-level interfaces and a flowchart are presented, which show its functionality. In terms of implementation, the interfaces of the final prototype generated by the Java programming language are presented, with support from the Swing library.

Video game design

Starting from the problem of dyscalculia and considering the typical exercises used in conventional therapies, related to the use of numerical association activities, arithmetic and counting operations, an interface organized in three tabs was proposed in the design phase, each of which includes a specific exercise. In tab one of the video game, a numerical association activity is included, where the player must feed the monkey with the number of bananas indicated on the label "number to hit". The intention of this activity is to allow the player to relate the concept of number with the quantity it represents, making use of an example of the real context.

Within activity one, as the user drags the bananas towards the monkey, the application indicates the number of remaining bananas of the 10 initial ones. When the user presses the "Verify" button, the application checks whether the objective was met or not, in such a way that if it is not met the game is restarted; similarly, within activity one the player can start the game again at any time by pressing the "Restart" button. The high-level interface that represents the aforementioned is presented in *Figure 2* and was made in the online tool for generating mockups: NinjaMock (Mutis, 2016).

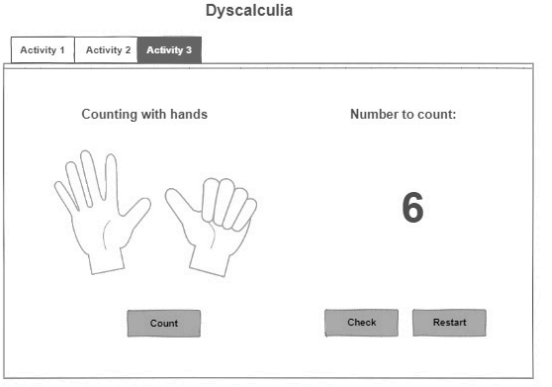
Figure 2.
Activity one



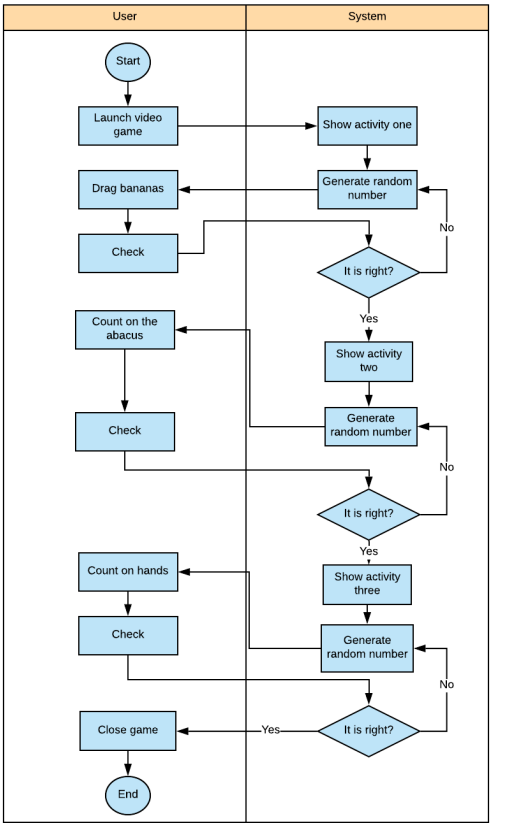
Source: the authors.

In the same way, in the activity two the intention is that players improve their abilities as for the counting and the addition of numerical quantities; for this, the player must select from an abacus the amounts required to count up to a random number generated by the application. In this way, if the number generated randomly is seven, the user must move seven units in the abacus, allowing to count and add quantities at the same time. Finally, activity three aims to improve the skills of a player to count using hands to a number between 1 and 10; thus, once the application has generated and displayed a random number, the player must press the "Count" button until the representation made with the hands coincides with the number generated by the application. When the user presses the "Verify" button, the application checks if the objective was met or not, in such a way that if it is not met the game restarts. *Figure 3*, shows the high-level interface of activity two generated by the NinjaMock online tool.

Figure 3.
Activity three



Source: the authors.



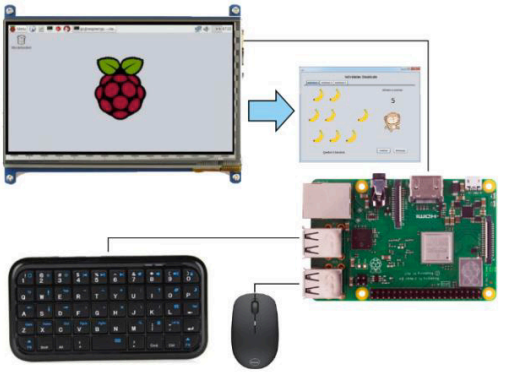
Source: the authors.

Similarly, in *Figure 4* is presented the flow diagram that describes the logic of interaction between the user and the different activities of the video game. As can be seen, when the player launches the game the system displays activity one, in which a random number between 1 and 10 is presented by default; then, the user must drag as many bananas as the random number indicates. Subsequently, the user can verify the fulfillment of the exercise to give continuity with activity two; once the player accesses, the system generates and displays a random number on the screen, which must be represented by the user through adding and counting operations performed with the abacus. When verifying the fulfillment of the exercise, the user can continue with activity three. When the user accesses activity three, the system generates and displays a random number between 1 and 10, which must be represented with both hands presented on the screen. Once the exercise is finished, activity three can be considered completed, thus culminating the activities proposed by the game. It is worth mentioning that the different activities are presented through a panel of tabs.

Implementation of the video game

Taking into account that the idea of the proposed game is to work in a fixed way in an educational institution, the Java programming language was chosen, considering its compatibility with the operating systems supported by the SBC devices. In this sense, it is intended to use a Raspberry PI board with an external screen, a keyboard and a mouse as external peripherals. Then, the intention of the game is to support the activities carried out by the teachers of mathematics in the classroom or in the therapies performed by psychologists in educational institutions. *Figure 5* presents the proposal for the deployment of the video game within the educational institution using the Raspberry PI platform.

Figure 5.
Deployment of the video game



Source: the authors.

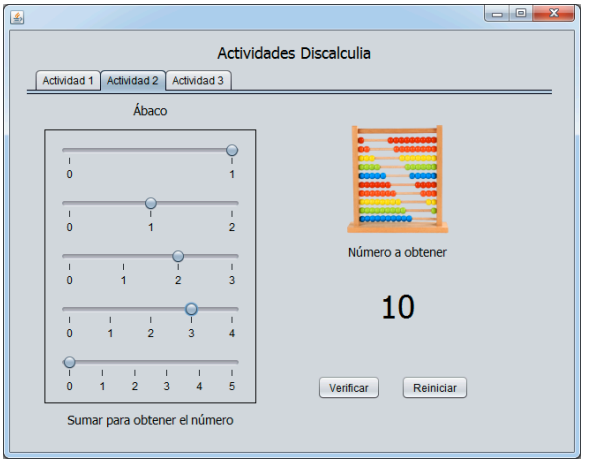
In the same way, in *Figure 6* the main interface of the game is presented, which corresponds by default with the tab of activity one; the player must move to the right 5 of the 10 bananas available on the left side. This exercise seeks to appropriate the relationship between the concept of number and the quantity that represents it.

Figure 6.
Interface activity one

Source: the authors.

In *Figure 7* the interface of activity two is presented, which includes on the left an abacus with a variable number of elements in each of its rows, in order to allow a better exercise of the counting operations according to a random number generated by the game. Thus, the player must count from the different rows of the abacus a total of 10 elements to match the number generated by the system and presented on the right side of the interface.

Figure 7.
Interface activity two



Source: the authors.

Finally, in *Figure 8* the interface of activity three of the game is presented, which shows on the left a representation of the right and left hands, by means of which it is necessary to count up to the number presented to the right of the interface; thus, the player must count to three to match the number generated by the system. This exercise allows to improve the skills to count on the hands on the part of the users with dyscalculia.

Figure 8.
Interface activity three

Source: the authors.

As can be seen, the exercises presented in activities one, two and three of the game, seek to improve the skills of users with dyscalculia in terms of the association of a number with its quantity and the development of counting and basic mathematical operations.

Videogame assessment

The proposed video game was evaluated by a group of experts in the area of human computer interaction using an inspection method, which is guided by Pinelle's 10 heuristic principles. A usability inspection is the generic name for a set of effective forms or methods for evaluating the user interfaces in order to find usability problems; they are very informal and easy to use. Thus, this method consists of gathering a group of experts who analyze or inspect an application to make a report commenting on different usability aspects based on their experience in the area and a set of previously defined principles, report used in order to make the necessary changes or adjustments to the application, solving the specified problems (Enríquez & Casas, 2014).

In this way, the heuristics considered for the inspection were: H1, consistent response to user actions; H2, customization of game's multimedia settings, difficulty, and speed; H3, predictable and reasonable behavior of the controlled units; H4, unobstructed views for the user's current actions; H6, intuitive and personalized inputs; H7, easy to manage controls with an appropriate level of sensitivity and response; H8, information about the state of the game; H9, instructions, training, and help; and H10, easy to interpret visual representations. As for the heuristics that were adequately fulfilled in the video game are H1, H8 and H10, this considering that the game responds consistently and intuitively to the actions of the player (H1), clearly presents the information at different times of the interaction, helping to understand the general purpose and progress of an activity (H8), and finally makes use of visual representations in the different activities, which are easy to understand for a player (H10). On the other hand, according to the evaluation the heuristics that can be improved are H2, H6 and H8, the above considering that the game does not allow the configuration of basic multimedia options for the volume and background music (H2), that it is necessary that the game can be operated alternatively through the use of keyboard commands (H6) and finally, that it does not have an explicit option that allows understanding the objectives and the management of the controls (H9).

Conclusions and future work

In the present work, a video game was proposed as a support to the development of therapies in people with dyscalculia for educational environments, which involves exercises related to numerical associations, basic operations and counting, taken from conventional therapies carried out by professors and experts in this area. Thus, the proposed video game has been designed using a tabbed panel through the components provided by the Java Swing library, which allows the easy integration of a greater number of learning activities associated with dyscalculia. In this sense, the game provides ideas that can be taken into account by designers and developers for the creation of new activities.

In order to facilitate the implementation of the game within an educational institution, this project proposed the use of Raspberry PI boards with their basic peripherals (screen, keyboard and mouse). In this sense, to facilitate the integration of the game with the operating system, it was decided to develop it in the Java programming language, given its portability advantages. According to the opinion of the evaluators, the game review showed that it is simple and intuitive for interaction with the user; however, it is possible to improve certain aspects such as the personalization of multimedia options, facilitate keyboard interaction and improve help options. In this sense, as future work derived from the present investigation, it is intended to perform a validation of the prototype generated in the real environment through the use of conventional usability tests, and improve it including a greater number of learning activities.

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Un videojuego para apoyar la terapia del lenguaje en niños con discapacidad auditiva. El caso de la descripción dinámica

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Resumen

Al realizar terapias de rehabilitación en niños con pérdida auditiva, es importante ofrecer una intervención que favorezca tanto el desarrollo del lenguaje como de los procesos cognitivos. Aplicar técnicas de ludificación en las actividades realizadas en el proceso de terapia puede motivar a los niños y permitir que se desempeñen de una forma más adecuada; así mismo, las dinámicas usadas en los videojuegos pueden ayudar a cumplir los objetivos planteados en la intervención terapéutica. De esta forma, usando el concepto de videojuego, es posible crear una herramienta lúdica que apoye las terapias de rehabilitación del lenguaje, cubriendo factores como el ordenamiento lógico de situaciones o la deducción de elementos ausentes en escenas que representan dichas situaciones. Este artículo presenta *Secuencia de caricaturas*, un videojuego personalizable que apoya el proceso de descripción dinámica en niños con discapacidad auditiva.

Palabras clave: Juegos serios, videojuegos personalizables, terapia de rehabilitación del lenguaje, descripción dinámica, discapacidad auditiva.

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Introducción

El retraso en el desarrollo del lenguaje en niños, común al existir pérdida auditiva, es una condición que impide al niño un desarrollo integral en cuanto a sus habilidades de comunicación y comprensión, desarrolladas durante la infancia (Boeree, 2007); por esto, es necesario un proceso terapéutico, en este caso entendido como una intervención de los trastornos de la comunicación humana, ya sea por alteraciones en el habla o la audición. De esta forma, es necesaria la participación tanto de los fonoaudiólogos, como de los niños y sus familiares con el fin de realizar un abordaje integral de la estrategia de rehabilitación, ofreciendo pautas de trabajo específicas para el uso funcional de la audición y para la intervención de la familia (Maggio de Maggi, 2004).

Teniendo en cuenta lo anterior, los videojuegos se han venido consolidando como herramientas para el apoyo de los procesos de rehabilitación debido a las ventajas que trae para los niños, como la motivación a ser más constantes en las terapias debido a la diversión de las tareas mecánicas y la posibilidad de entender su propio proceso terapéutico de una manera más positiva; además, hay antecedentes de que el desarrollo cognitivo y el aprendizaje en áreas específicas del conocimiento, ha sido exitoso usando este tipo de sistemas computacionales (Kenny y McDaniel, 2011), y que los videojuegos pueden mejorar la atención y la concentración de un paciente (Kirriemuir & McFarlane, 2004). Trabajos previos en el área de las terapias del lenguaje en niños con discapacidad auditiva, han mostrado el potencial de los videojuegos como un complemento útil que estimula a los niños a mejorar gracias a la posibilidad de personalizar el juego a las necesidades de cada uno (Navarro-Newball et al., 2014; Rincón et al., 2017; Martínez et al., 2018; Rincón et al., 2018). Es por eso que en este artículo se presenta el videojuego personalizable *Secuencia de caricaturas*, que apoya las terapias del lenguaje relacionadas con el desarrollo de la narrativa a través de las descripciones dinámicas.

Trabajos relacionados

Existen varios antecedentes en el uso de videojuegos como apoyo al desarrollo del lenguaje en niños con discapacidad auditiva. Uno de ellos es el Speech Viewer (Bernard-Opitz, Sriram & Sapuan, 1999), uno de los primeros sistemas en involucrar elementos de videojuego en un sistema de apoyo a la terapia oral, enfocado en la pronunciación de las vocales: su correcta pronunciación activaba a un mono para escalar un árbol. Además, Tan et al. (2013), propusieron un juego similar al clásico Pac-Man, que activaba el ataque del personaje principal a los fantasmas cuyo nombre se vocalizaba, brindando realimentación acerca del desempeño de la vocalización de los pacientes y evidenciando el potencial de los videojuegos en este tipo de terapia.

Por otra parte, en un proyecto previo de Navarro-Newball et al. (2014), se propuso un videojuego en donde se implementaron niveles basados en tareas sencillas, similares a las propuestas en Speech Viewer pero organizados dentro de una narrativa más compleja. Este trabajo evidenció el potencial de los videojuegos en la terapia del lenguaje utilizando español y demostró, a través de indicadores de entretenimiento, cómo los videojuegos contribuían al nivel de desenvolvimiento, disfrute y estímulo de los pacientes hacia las actividades y a la repetición de las mismas; del mismo modo, en otros trabajos se ha utilizado el paradigma de la Ingeniería de Líneas de Productos de Software (ILPS) para generar mini-juegos personalizados que apoyan diferentes habilidades del lenguaje en niños con discapacidad auditiva (Martínez et al., 2018; Rincón et al., 2018). De esta manera, en el trabajo aquí descrito también se utiliza la ILPS para generar y personalizar un videojuego que apoya las terapias del lenguaje, relacionadas con el desarrollo de la narrativa con las descripciones dinámicas.

Videojuego Secuencia de Caricaturas

Un videojuego se define como un juego electrónico en el que pueden interactuar una o más personas con un dispositivo de video, utilizando un controlador (físico o táctil); típicamente los videojuegos recrean entornos y situaciones virtuales en los que el jugador puede controlar

elementos y personajes, para conseguir un objetivo siguiendo unas reglas determinadas (Rogers, 2014). Los videojuegos se han catalogado como herramientas útiles para inculcar conocimientos, ya que el material que brindan tiene alta capacidad de motivación y de mejorar los aspectos procedimentales del aprendizaje (Revuelta- Domínguez, 2004). Con este enfoque, se desarrolló el videojuego Secuencia de Caricaturas orientado a terapias para niños con discapacidad auditiva, el cual permite al paciente organizar secuencias de manera lógica, además de otorgarle la posibilidad de realizar descripciones estáticas y dinámicas por medio de oraciones simples y compuestas usando distintas estructuras sintácticas; además, permite al niño realizar inferencias de modo que pueda desarrollar las habilidades necesarias para hacer narraciones.

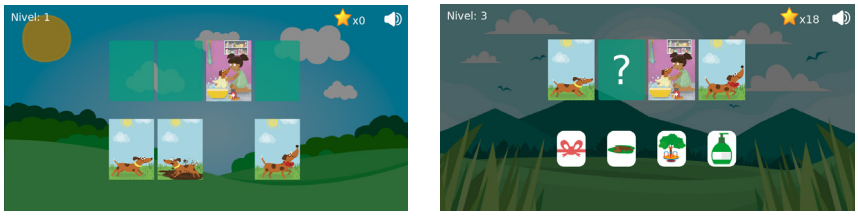
Este videojuego está compuesto de siete niveles diferentes (cada uno con mayor dificultad que el anterior), de forma que el niño pueda trabajar en cada uno de ellos las habilidades del lenguaje antes nombradas. A continuación, se describen cada uno de los niveles del videojuego:

Nivel 1: En este nivel el juego presenta al paciente unas imágenes en desorden para que las ordene y construya una secuencia lógica a modo de historia *(Figura 1*, a*)*.

Nivel 2: El juego selecciona aleatoriamente dos imágenes y les intercambia el orden, con el objetivo de que el niño identifique las fichas desordenadas y las vuelva a poner en el orden correcto.

Nivel 3: En este nivel, el juego selecciona aleatoriamente una imagen y la quita de la secuencia, reemplazándola por un signo de interrogación. Por otra parte, hacen aparición los pictogramas, figuritas relacionadas a cada imagen de la secuencia, de modo que el niño seleccione el pictograma que él crea está relacionado a la imagen faltante *(Figura 1*, b).

Figura 1.
Niveles 1 y 3 del videojuego secuencia de caricaturas

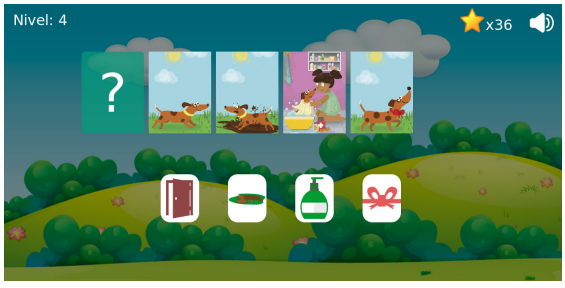


(a) (b)

Fuente: los autores.

Nivel 4: En este punto, el juego agrega un signo de interrogación antes de la primera imagen de la secuencia ordenada y otro después de la última imagen, para que de esta forma el niño pueda inferir, por medio del uso de los pictogramas, lo que pasó antes y después en la historia *(Figura 2).*

Figura 2.
Nivel 4 del videojuego secuencia de caricaturas



Fuente: los autores.

Nivel 5: Se le presenta al niño una secuencia de imágenes que conforman una historia y se le plantean preguntas relacionadas a cada imagen, las cuales él debe responder.

Nivel 6: En este nivel se presenta la secuencia ordenada y una caja de texto para que el niño escriba en ella la descripción de la historia

completa presentada en las imágenes. Para los niños que aún no escriben, se permite también grabar la respuesta oral.

Nivel 7: El nivel final del juego, muestra aleatoriamente una imagen de la secuencia trabajada y una pregunta asociada a la misma (seleccionada también aleatoriamente); la frase se encuentra en desorden con el objetivo de que el niño la ordene.

Al finalizar cada nivel, se le pregunta al acompañante del niño en la terapia si lo resolvió solo, con ayuda o si no pudo resolverlo; esto permite mantener un registro de las interacciones del niño con el videojuego, como retroalimentación para el fonoaudiólogo.

Así, *Secuencia de Caricaturas* es un videojuego, que se genera y configura mediante la plataforma SATReLO, una herramienta computacional que permite la generación de videojuegos 2D personalizados para el apoyo a la terapia del lenguaje en niños con pérdida auditiva oralizados, aplicando el paradigma de las líneas de productos de software (Martínez et al., 2018). Desde el punto de vista semántico, este juego favorece las habilidades del niño en la comprensión e interpretación de eventos, estableciendo y organizando una sucesión de situaciones que comparten cierta relación entre ellos, y favoreciendo la expresión oral y escrita de eventos de diferentes características desarrollados en un tiempo y lugar específicos, de tal forma que el niño encuentre las razones de que cada evento ocurra en la historia.

Evaluación Preliminar

Para evaluar el videojuego desde el punto de vista funcional, se realizaron 44 casos de prueba y cinco iteraciones de cada uno hasta lograr una versión estable y funcional. Esta cantidad de iteraciones fue necesaria, ya que Secuencia de Caricaturas es un producto configurable y personalizable perteneciente a una Línea de Productos de Software, por lo que se podrán generar distintas configuraciones relacionadas a las necesidades particulares de los niños. Esto es, el videojuego está conformado por nueve historias diferentes; a pesar de que la lógica de juego es la misma para todas, se deben evaluar diversos factores como

la correcta carga de imágenes y pictogramas, o la correcta selección de las preguntas relacionadas a cada imagen. Al agregar nuevas historias, en el proceso de validación fue necesario probar las secuencias ya implementadas más la historia nueva, algo que se conoce como pruebas de regresión; es por eso que las iteraciones de pruebas funcionales se realizaron sobre cada una de las posibles configuraciones disponibles para este videojuego.

Adicionalmente, se desarrollaron pruebas de usabilidad a un grupo de seis niños entre 5 y 9 años, con discapacidad auditiva. Los principales resultados de la prueba fueron los siguientes:

- El juego fue útil, incluso en el caso de niños sin experiencia previa en el uso de computadores.
- El videojuego ayuda a los niños a practicar la asociación de elementos, a mejorar su capacidad de deducción y a estimular sus poderes de observación y memoria.
- Los niños son activos y atentos a la actividad, y están interesados en seguir jugando.

La evaluación funcional y de usabilidad permitió identificar las mejoras necesarias en el videojuego, y se determinó que la actividad estaba lista para estimar su impacto en el proceso de rehabilitación; este proceso ya inició, y tomará aproximadamente seis meses.

Conclusiones

Mejorar el lenguaje en los niños con deficiencias auditivas abarca todo un proceso de terapia. El objetivo del videojuego que aquí se presenta es ofrecer una herramienta lúdica en el proceso de intervención realizado por el fonoaudiólogo, que apoye la enseñanza individual y la evaluación constante. Así pues, el videojuego ayuda a monitorear el progreso del niño mientras interactúa con los niveles propuestos y sigue un proceso en el que solo después de cumplir un objetivo, se pueden iniciar las actividades correspondientes al siguiente nivel. De esta forma,

las habilidades obtenidas en una actividad pueden ser necesarias para cumplir con otras, y el objetivo terapéutico cambia de un nivel al otro; al utilizar el formato de niveles es posible controlar el cumplimiento de objetivos en el proceso de terapia e identificar las falencias que el niño pueda presentar en el proceso. En cuanto al seguimiento, al ofrecer opciones de personalización el fonoaudiólogo puede configurar el videojuego para ajustarlo a las necesidades particulares de cada paciente. Finalmente, los resultados de la evaluación preliminar sugieren una respuesta positiva en los niños, siendo el juego de video una herramienta adecuada para mantener la atención y el entusiasmo en las terapias pues, en general, los niños se sintieron motivados a jugar y a realizar las diferentes actividades.

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Disminuyendo la brecha comunicacional con Beeth-Ear

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Resumen

El presente artículo corresponde a una investigación realizada en personas con discapacidad auditiva, con el fin de desarrollar una aplicación que les permita tener una comunicación fluida con los miembros de la sociedad que no conocen el lenguaje de señas; para ello, se siguió la metodología propuesta por Design Thinking donde, a través de encuestas y contacto directo con personas sordas y expertos del lenguaje de señas, se realizaron varias pruebas previas hasta llegar a construir la aplicación Beeth-Ear, que ofrece una comunicación en tiempo real a través de la traducción del lenguaje español al lenguaje de señas colombiano.

Palabras clave: Discapacidad auditiva, aplicación móvil, lenguaje de señas, traducción.

Introducción

Debido a su alta demanda social, actualmente hay un amplio desarrollo de las aplicaciones móviles, cada una con innumerables usos y beneficios. Este eficaz desarrollo se debe a la rápida evolución tecnológica, que ha permitido que las aplicaciones cubran diferentes áreas como la educativa, profesional, de comercio y servicio, siendo común que se involucren en la mejora de aspectos con enfoques sociales, culturales y económicos; un ejemplo de ello es la incorporación de las Tecnologías de Información y Comunicación (TIC)(Cuervo, 2011). Específicamente hablando del área social, uno de los

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problemas que mayores conflictos genera es la deficiente comunicación entre personas del común y las que poseen discapacidad auditiva (total o parcial), llevando a que enfrenten un sinfín de retos que involucran las necesidades más básicas; esto trae como consecuencia dificultades en las relaciones interpersonales y reducción de accesibilidad a la información del entorno (Cañizares, 2015).

Por esta razón, para poder aportar a una solución ante las dificultades cotidianas, es pertinente dar prioridad a los mecanismos de comunicación desarrollados por esta población que, aunque son diversos, en este caso se centrarán en el lenguaje de señas, compuesto de expresiones faciales y movimientos del cuerpo para comunicarse con las demás personas; teniendo en cuenta que todo lenguaje tiene estructuras definidas, este ha pasado por varios cambios lingüísticos dependiendo de cada país (Pérez de Arado, 2011), estando conformado por símbolos simples que indican la trayectoria, dirección y longitud del movimiento de letras de cada alfabeto representadas por símbolos con las manos.

Aspectos preliminares

Es menester tener claros ciertos conceptos que fueron fundamentales durante el desarrollo de este proyecto, los cuales se enuncian a continuación:

Aplicación móvil: Una aplicación (también llamada App) es un programa informático creado para llevar a cabo o facilitar una tarea en un dispositivo. Cabe destacar que, aunque todas las aplicaciones son programas, no todos los programas son aplicaciones (Magazine, 2010).

Discapacidad: La discapacidad parte de la realidad biológica y se considera un problema individual o personal causado por una enfermedad, deficiencia o condición de salud; las limitaciones que provocan en el funcionamiento del individuo se subsanan eliminándolas a través de tratamiento médico curativo y rehabilitador, y mediante políticas de atención a la salud (Seoane, 2011).

Lenguaje de señas: Este lenguaje posee y cumple todas las leyes lingüísticas y se aprende dentro de la comunidad de usuarios, quienes

resuelven todas sus necesidades comunicativas y no comunicativas propias del ser humano, social y cultural; sin embargo, también está al alcance de las personas oyentes, siempre que se sumerjan en el mundo de los sordos y se identifiquen con la lengua, costumbres, valores y tradiciones (Pérez de Arado, 2011).

Trabajos relacionados

Buscando dar respuesta a las necesidades de la sociedad, actualmente existe un alto desarrollo y evolución tecnológica; enfocándonos en la población con necesidades especiales o discapacidades, puntualmente personas sordomudas, se crea la necesidad de conocer las herramientas tecnológicas existentes para aportar al beneficio y evolución en el desarrollo de su vida cotidiana. Un ejemplo de ello es la investigación realizada por Villegas (2015), donde se buscó proponer nuevos proyectos que mejoraran la independencia y calidad de vida de las personas con discapacidad mediante el empleo y/o la adaptación de las características de tecnologías y soluciones existentes. Además, la investigación presentada por Gait (2013), muestra la importancia del mantenimiento y enseñanza del lenguaje de señas, para incursionar en el desarrollo de software de aplicaciones informáticas que favorezcan a personas con discapacidades auditivas; este soporte no tiene fines de lucro, lo cual reafirma el enfoque social necesario en el desarrollo tecnológico. De igual manera, Valenzuela (2011) desarrolló dos aplicaciones destinadas para usuarios sordos, una móvil y otra de escritorio, que acercaran a los usuarios a sistemas interactivos, resaltando la importancia del uso de la tecnología para la reutilización de recursos bajo diferentes herramientas que puedan beneficiar a esta población.

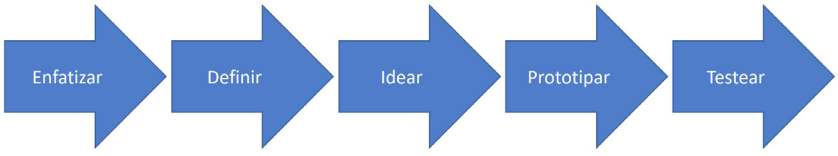
Sumado a lo anterior, se encuentran los estudios de Acevedo (fecha), con el desarrollo de una aplicación para celulares para facilitar la comunicación entre personas sordomudas con otras con y sin esta discapacidad; y el realizado por Cano (2015), un estudio en colaboración entre México y Colombia, donde se diseñó una aplicación para tablet que sirviera como adquisición de conceptos y estructura de oración, con el propósito de capturar atributos de niños con discapacidad auditiva y permitirles adaptar ciertas variables y nivel de aprendizaje

del juego. Finalmente, Tambo (2016) diseñó un guante electrónico sensitivo al movimiento, interpretando las señas más importantes del abecedario empleadas con una sola muñeca, para así establecer una comunicación entre personas con discapacidad auditiva y el resto de la sociedad. Teniendo en cuenta lo anterior, en este trabajo presentamos la aplicación Beet-Ear, donde mediante un teclado y funcionalidades inteligentes se busca que los usuarios sordos, sean niños, jóvenes o adultos, puedan comunicarse más fácilmente en sitios públicos; esto, además de lograr una inclusión social, permite adaptar ciertas variables y obtener un nivel de aprendizaje sobre lenguaje de señas, haciendo más sencilla la comunicación con el resto de la población.

Metodología

El desarrollo de la aplicación móvil Beet-Ear, se trabajó mediante la metodología Design Thinking, donde el objetivo principal es la innovación y empatía; durante su creación se tuvieron en cuenta los requerimientos del usuario, lo que permitió conocer sus problemas y necesidades reales. De igual forma, se utilizaron técnicas de investigación de mercados, analizando al usuario y seleccionando diferentes soluciones para iniciar con el prototipo, y así generar un testeo hasta llegar al resultado final del proyecto.

Figura 1.
Metodología Design Thinking



Fuente: los autores.

Fases del proyecto

Fase 1.

El propósito de esta fase es precisar con claridad el concepto del problema, incluyendo los diferentes conceptos y funciones básicas de la aplicación; para ello se realizó un análisis que identificara y además satisficiera los requerimientos del problema, con el fin de verificar la viabilidad del proyecto y hacer los ajustes pertinentes. Como primera medida se realizó un acta de constitución donde se destacó toda la información relacionada con el propósito y justificación del proyecto, además de su oferta técnica y los requerimientos de alto nivel, teniendo en cuenta los riesgos iniciales bajo unas premisas y restricciones. Por otra parte, el estudio de viabilidad pertinente se realizó con base a una encuesta de 10 preguntas, aplicada de manera presencial a personas sordas y personas sin esta dificultad, buscando determinar la perspectiva de las dos poblaciones, obtener información acerca del estado de conocimiento de esta problemática y cómo el desarrollo de herramientas tecnológicas puede generar un aporte a la sociedad.

Fase 2.

Para esta fase se utilizó la información extraída de la encuesta a personas sordas, en donde se tomaron las principales necesidades para así desarrollar las especificaciones funcionales del proyecto, realizando un diseño previo de la aplicación. En relación con los requisitos no funcionales, también se determinaron con la encuesta, con base a las falencias o ausencia de manejo del lenguaje de señas por parte de las personas sordas, dificultades con el manejo de aparatos electrónicos y la carencia de implementos básicos para la instalación y uso de la aplicación.

Fase 3.

Aquí, el objetivo es estructurar la aplicación móvil, desarrollando un ejecutable que permita realizar un seguimiento de control y un plan de prueba. De igual forma, se pretende evaluar el aplicativo con el fin de

hacer las correcciones pertinentes, siguiendo estas actividades:

- Diseño de la aplicación móvil.
- Desarrollo de la aplicación.
- Ejecución.
- Diseño y realización del plan de pruebas.

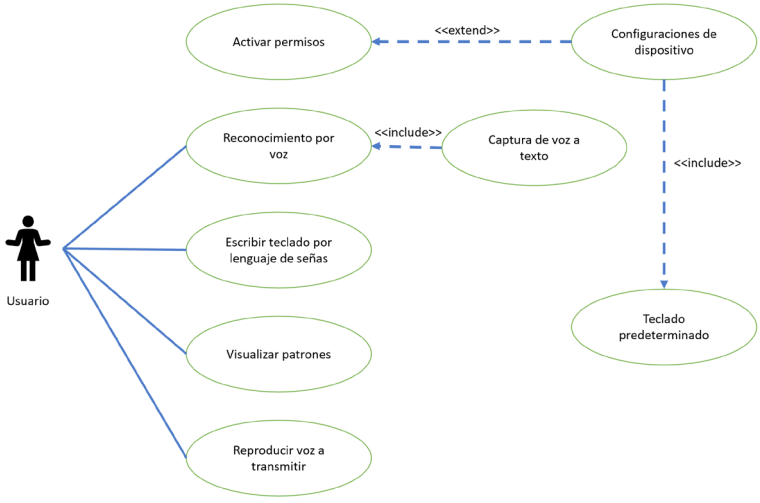
Fase 4.

Esta fase tiene como objetivo entregar la versión final de la aplicación al cliente y evaluar el desarrollo del proyecto en dos subfases:

- Prueba de uso individual empleando la aplicación, monitoreando y ofreciendo ayuda en los pasos a seguir.
- Foro interactivo, permitiendo la socialización respecto al funcionamiento de la aplicación en una asociación de personas sordas de la ciudad de Popayán; de esta forma, es posible recibir retroalimentación en cuanto a sugerencias y falencias, surgiendo ideas para mejorar y ajustar la aplicación.

Luego de cubrir cada una de las fases del desarrollo metodológico del Desing Thinking alineadas al estándar del PMBOOK, se logró la construcción de un producto de software llamado Beet-Ear, el cual atiende las necesidades y requerimientos de personas del común y personas con discapacidad auditiva y vocal, permitiendo su interrelación y mejorando el proceso de inclusión social y comunicativa de esta población en su entorno. A continuación, se muestra cómo es la interacción del usuario con la aplicación, a través del modelo de caso de uso (*Figura 2*).

Figura 2.
Casos de uso de la aplicación móvil Beet-Eart

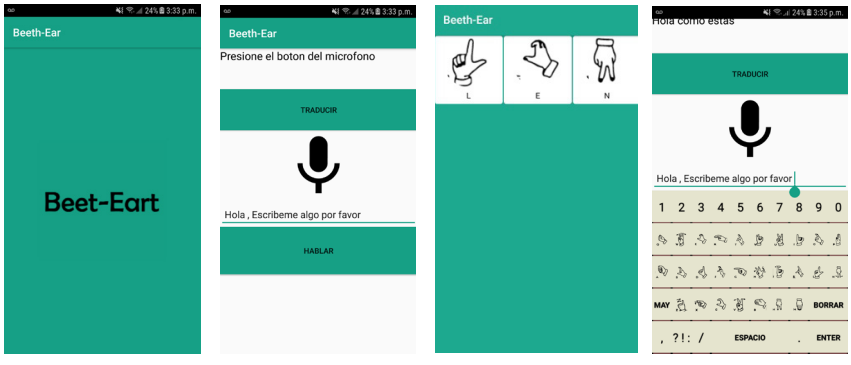


Fuente: los autores.

Descripción de la herramienta

Figura 3.
Aplicación móvil Beet-Eart

(a)Presentación (b) Funcionalidades (c) Traducción (d) Teclado lenguaje de señas



Fuente: los autores.

La aplicación móvil Beet-Eart se dirige a personas sordas, con el propósito de generar una comunicación en tiempo real entre esta población y personas que hablan el castellano (específicamente en Colombia); además, fue desarrollada bajo el entorno de programación Android Studio, el cual proporciona diferentes herramientas para la creación del diseño y funcionalidades. En la *Figura 3*(a), se puede observar la presentación de la aplicación y sus aspectos visuales como colores y fuente, con el fin de obtener un entorno agradable y satisfactorio para el usuario. Dentro de las diferentes funcionalidades de Beet-Eart (*Figura 3*, b), como primera opción se encuentra el micrófono para receptar toda la información del emisor, la cual será visualizada en el panel de texto en lenguaje castellano con la posibilidad de ser traducida al lenguaje de señas colombiano (*Figura 3*, c). Otra forma de que el usuario pueda expresarse es mediante la comunicación del panel de texto, diseñado mediante un teclado personalizado con los símbolos del lenguaje de señas (*Figura 3*, d), permitiendo escribir en este lenguaje y reproducir el texto en castellano bajo la función de "Hablar".

Conclusiones y trabajos futuros

Siendo importante un conocimiento acerca del manejo básico del lenguaje de señas para que la relación con el lenguaje castellano sea la adecuada, la aplicación se desarrolló teniendo en cuenta una amplia cantidad de referentes e investigaciones previas. Actualmente, se están implementando mejoras a la aplicación, como el lenguaje a través de gesticulación para lograr una mejor compresión e interacción, tanto formal como informal; además, se busca tener la función de "autocompletar" o de "predicción del gesto y palabra" con el fin de mejorar el teclado. Cabe anotar que este proceso ha sido un trabajo estructurado en conjunto con expertos en el lenguaje de señas y personas sordas, lo que ha permitido atender a sus necesidades y así disminuir cada vez más la brecha comunicacional mediante el uso de las TIC (Tecnología de la información y comunicación).

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HERO TEST: Instrumento Portable e Interactivo de Tamizaje Auditivo, basado en metodología SUM

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Resumen

Hero Test es una aplicación móvil cuyo propósito es realizar pruebas de tamizaje auditivo, lo que permite hacer una detección temprana de alguna deficiencia auditiva. A diferencia de otras herramientas, a veces con costos elevados, que deben ser manipuladas por un especialista para determinar el estado de audición del paciente, Hero Test puede ser utilizada sin inconvenientes al ser una herramienta muy intuitiva y accesible; además, está alineada a tres categorías: audición normal, audición leve o pérdida audición, lo que hace posible evaluar el nivel de audición a partir de los lineamientos establecidos por instrumentos de tamizaje avalados por el Instituto Nacional Para Sordos (INSOR).

Palabras clave: Aplicación móvil, audición, tamizaje, INSOR, tecnología.

Introducción

Normalmente las pruebas de tamizaje auditivo las realizan especialistas en el área con equipos sofisticados de costos elevados como cabinas sonoamortiguadas, presentes únicamente en clínicas

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o consultorios dedicados al estudio auditivo; por esto, en ocasiones se limitada la posibilidad de detectar a edad temprana la deficiencia auditiva, lo que podría ocasionar en los niños problemas sociales, deficiencias en el campo educativo y finalmente alterar el ámbito afectivo. Además, es importante destacar que la habilidad de escucha es un elemento fundamental en todo proceso de comunicación humana, por lo que una vía auditiva llega a desarrollar el lenguaje, el habla y todo tipo de aprendizajes. Atendiendo un estudio de la Organización Mundial de la Salud- OMS (2015), donde registran 360 millones de personas que padecen pérdida de audición discapacitante en todo el mundo, de los cuales 32 millones son niños, se hace necesario generar alternativas para el acceso a pruebas de tamizaje en audiometría que permitan la detección temprana de posibles patologías o alteraciones en la audición y la comunicación en niños, tomando como referente los hitos que marcan el desarrollo del lenguaje, la audición y la comunicación (Ministerio de Salud y Protección Social, 2019).

Teniendo en cuenta que la pérdida de audición o sordera son evitables si se detectan a tiempo, surge Hero Test, una aplicación que realiza tamizaje auditivo de forma amigable, interactiva, portable y de bajo costo con el objetivo de ser una herramienta tecnológica tanto para la detección de los primeros signos de pérdida en la audición, como para ser utilizado en tratamientos de rehabilitación temprana, minimizando los efectos secundarios de una pérdida auditiva. Además, el acercamiento del paciente con la interacción de la aplicación, permite obtener resultados objetivos para evaluar el nivel de audición inicial a través de la escucha de sonidos con instrumentos musicales o animales de acuerdo a decibeles predefinidos; es importante aclarar que esta prueba no reemplaza a un examen de audiometría tonal ni especializado, solo es una aproximación inicial que permite detectar a tiempo la salud auditiva de un niño en etapa de crecimiento y desarrollo. En cuanto a la metodología de desarrollo, y pese a estar enfocada al desarrollo de videojuegos, se empleó SUM debido a su agilidad y flexibilidad en lo que concierne a los requerimientos, al equipo y al proyecto, manteniendo una interacción frecuente con el cliente (Acerenza et al., 2009).

Trabajos relacionados

Durante el proceso de investigación se encontraron varios referentes que permitieron fundamentar el proyecto desde el enfoque técnico hasta llegar a las bases teóricas, permitiendo argumentar la pertinencia de Hero Test. A continuación, destacamos algunos:

- Solís y Hernández (2016), presentan el proyecto de caracterización del estado auditivo de un grupo de niños de 3 a 5 años de la comuna 5 de la ciudad de Popayán, identificando sus estados de salud para determinar el nivel mínimo de respuesta auditiva. La evaluación audiológica realizada a 85 niños, dictaminó que el 15% de la población tomada presentaba algún problema auditivo. De esta forma, se realizaron pruebas subjetivas que permitieran medir cuantitativamente la audición de un paciente y la capacidad auditiva periférica, mediante un instrumento generador de diferentes tonos puros y desprovistos de armónicos emitidos a diferentes intensidades.

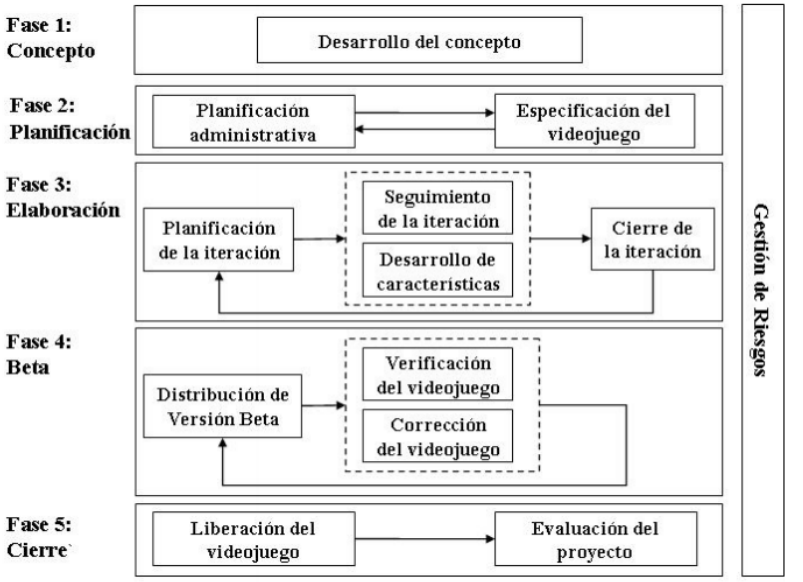
- *hEARo* (Audiomed, 2016), es una aplicación móvil disponible en dos idiomas (inglés y alemán), la cual forma parte del entretenimiento interactivo, ayudando a reconocer y distinguir sonidos y responder a estímulos auditivos con el fin de identificar los primeros signos de pérdida de la audición temprana.

- El INSOR (2002), presenta un instrumento de tamizaje auditivo llamado "Instrumento de Tamizaje para la detección temprana de deficiencias auditivas en los menores de cinco años y escolares", el cual describe la utilización de tres guías sencillas para el personal de salud en lo que concierne a la realización de tamizajes auditivos a través de actividades, procedimientos y recomendaciones en las consultas de crecimiento y desarrollo para la detección de alguna deficiencia auditiva; las pruebas se realizan a menores de 5 años y en edad escolar, las cuales incluyen pruebas con instrumentos sonoros, con objetos sonoros y con voz por señalamiento.

Metodología

Gracias a su adaptabilidad frente a los requerimientos tanto técnicos, humanos y específicos de la aplicación, el desarrollo de esta herramienta fue por medio de la metodología SUM (Acerenza et al., 2009), la cual cuenta con las siguientes fases (Figura 1):

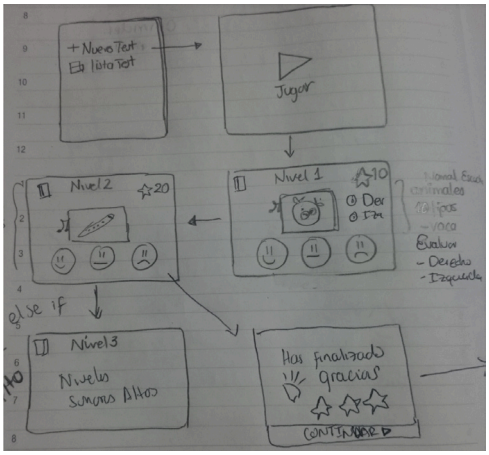
Figura 1.
Fases Metodología SUM



Fuente: (Acerenza et al., 2009).

Concepto: Esta fase tiene como objetivo levantar los requerimientos a partir de las ideas, propuestas e inquietudes presentadas por el cliente, en este caso una profesional de la salud especializada en fonoaudiología, obteniendo como producto el siguiente concepto (*Figura 2*).

Figura 2.
Concepto Hero Test



Fuente: los autores.

Planificación: De acuerdo con la metodología, la planificación se divide en dos: administrativa, la cual organiza las diferentes actividades mediante un cronograma para así definir y priorizar los requerimientos a cumplir; y la especificación de la aplicación, donde se deben tener claros los requerimientos tanto funcionales como no funcionales de la herramienta (en este caso Hero Test).

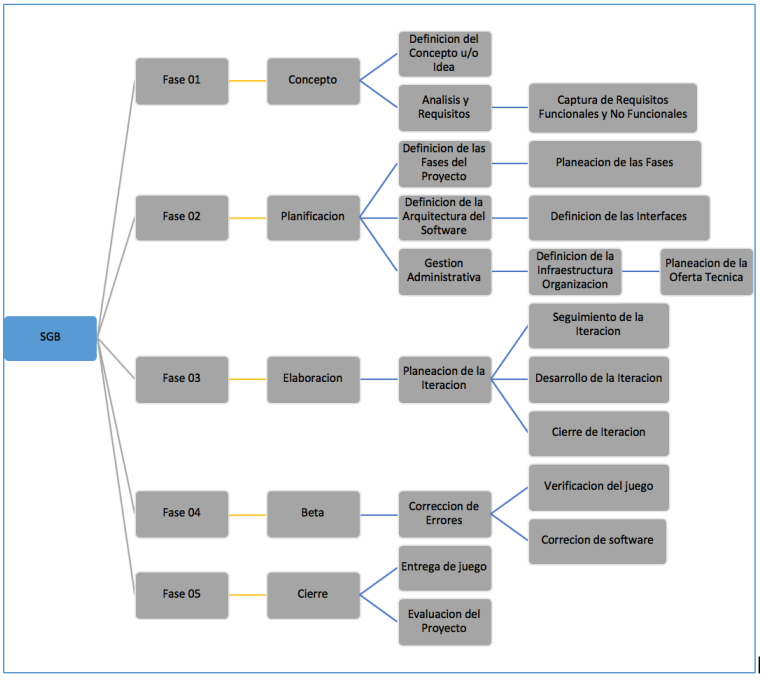
Elaboración: Aquí se implementan todas las actividades planificadas de manera iterativa y creciente, hasta llegar a una versión beta.

Beta: En este momento, se realizan las respectivas pruebas de la herramienta luego del periodo de construcción, con el propósito de verificar que cumpla con los requerimientos especificados desde la etapa de concepto.

Cierre: En esta fase se obtiene la versión final de la aplicación luego de haberla ajustado; aunque inicialmente se pensaba construir Hero Test en Android Studio, luego de conocer los requerimientos se optó por utilizar App Inventor más Tiny DB, un gestor de bases de datos.

Gestión de riesgos: Esta fase es transversal al desarrollo del proyecto para así poder efectuar cambios oportunos en la aplicación (como sustituir la plataforma de desarrollo), y obtener una gran acogida por parte del cliente (fonoaudiología).

Figura 3.
Despliegue de Hero Test en SUM



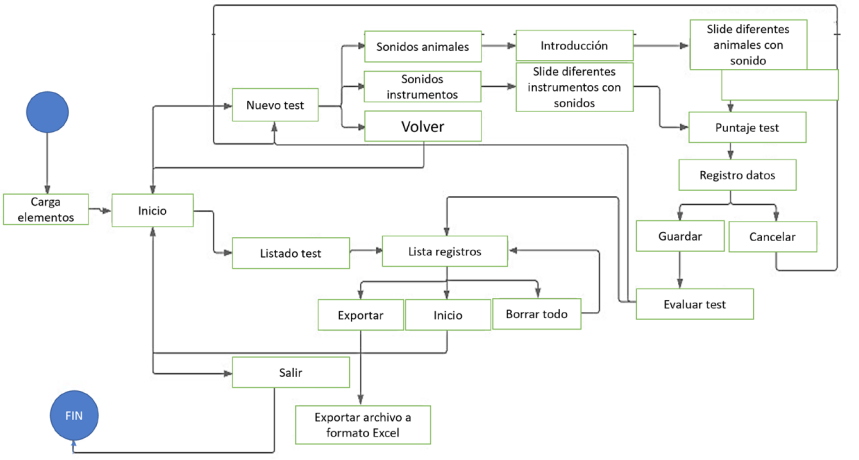
Nota: Aquí se presenta la estructuración del proyecto a partir de SUM.
Fuente: los autores.

Funcionalidades de Hero Test

Este es un modelo basado en la consecución de acciones a realizar de inicio a fin. Por esto, mediante el diagrama de flujo expuesto en la *Figura 4*, se muestra el despliegue funcional de cada uno de los componentes y navegación, evidenciando los niveles para realizar una prueba con la herramienta; es necesario tener en cuenta los pasos a seguir dentro de la aplicación para disminuir el margen de error al emplearla, pues si se

cierra o da por terminada una acción antes de poder completar todo el proceso, se afectará la evaluación y efectividad de la prueba mostrando posibles datos incorrectos.

Figura 4.
Diagrama Funcional Hero Test

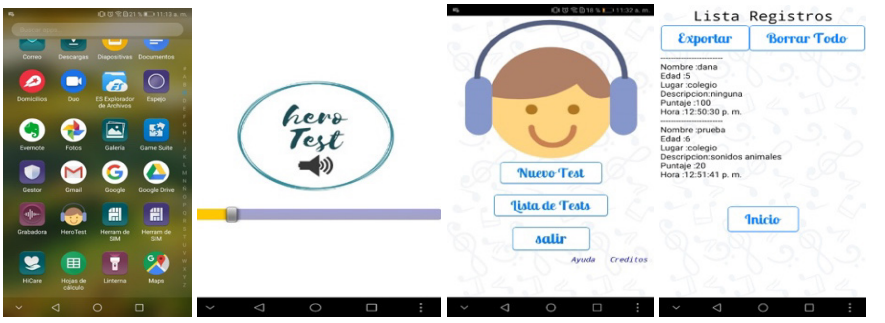


Fuente: los autores.

Luego de comprender el funcionamiento de Hero Test, el usuario y/o paciente podrá acceder a ella e interactuar con las funcionalidades mediante su respectiva descarga e instalación en su dispositivo de plataforma Android, permitiendo poder ser empleada como una herramienta de prevención y detección temprana de problemas de audición y/o sordera en niños.

Figura 5.

Instrumento de Tamizaje Auditivo Hero Test



Fuente: los autores.

Conclusiones y Trabajos Futuros

Es importante continuar con la construcción de herramientas que permitan detectar tempranamente el nivel de audición de un niño, en especial aquellos que se encuentran en espacios vulnerables donde es difícil acceder a exámenes especializados de manera previa. Hoy en día, gracias a Hero Test esta problemática puede llegar a disminuir, siempre y cuando el proceso de tamizaje se realice a tiempo para poder acceder a un examen especializado y tomar los respectivos tratamientos oportunamente. De esta forma, la aplicación se convierte en una herramienta innovadora gracias a su portabilidad y fácil acceso (a través de una descarga), brindando la posibilidad de realizar las pruebas las veces que sea necesario y almacenando los resultados en un repositorio. Por esto, se considera pertinente seguir avanzando en el desarrollo de la aplicación, incluyendo más niveles con diferentes acciones y mostrando gráficamente los resultados. Finalmente, Hero Test contó con una prueba de funcionalidad comparando su desempeño frente a una prueba manual realizada por una especialista en audiología a un grupo de 15 niños entre 2 y 7 años; de aquí, se destaca el número de niños evaluados por la especialista diagnosticados con posibles problemas auditivos respecto a los evaluados por la aplicación, así como la optimización del tiempo del examen por cada paciente, siendo 40% menor al hacer uso de la herramienta tecnológica; esto gracias a que los niños lograron completar de forma intuitiva cada nivel sin dificultades.

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4. Poster session from the Edutainment 2019 Conference

Poster presentations are valuable because authors can discuss its content with attendees; by this way, it is possible to engage with others interested in the same subject, having one-on-one conversations about specific aspects, new ideas, getting constructive critics and insightful discussion. Moreover, posters are a good way to disseminate works in an early stage and offer a nice and dynamic supplement to a conference agenda. Thus, considering the importance of starting works from researches who submitted papers to Edutainment 2019, the Edutainment's organising committee decided to invite authors to be part of a poster session. Enhanced versions of their papers are published in this section.

Serious game for cultural issues

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Abstract

This research is focused on the creation of a serious game aimed to contribute to the preservation of the cultural and intangible heritage of Santiago de Cali; for this purpose, both myths, laws and history of the city were investigated (like Lady in White and the myth of Buziraco), and the way to represent this legacy in a virtual format. Therefore, the study involved 150 teachers from the Lumen Gentium Catholic University Institution, using an exploratory methodology with a quantitative approach, including a data collection instrument designed using the Google Drive tools. In the feedback phase, the game was tested with third grade children from two schools in the city of Cali, whose showed interest and motivation when interacting with the software.

Keywords: Serious game, cultural issues.

Introduction

The United Nations Organization (2018), states that in addition to monuments, buildings, sites of historical importance, archaeological, anthropological and ethnological value, cultural heritage also involves living traditions or manifestations transmitted from generation to generation. For Cañola (2013), there is a link between the history of a region, the identity of its people and its historical cultural and intangible heritage that represents the trace history that the people inherit from

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their ancestors, being obliged to protect, disclose and preserve your legacy; whereas the non-knowledge of this, leaves the wandering peoples in time without their own identity, and without concern for their natural resources, oral, tourist and historical traditions.

In general, elementary students are growing up without knowing much of their cultural and immaterial legacy, which may affect the sense of belonging to their city, their culture and their identity. Therefore, this study highlights the need for the promotion and dissemination of the intangible culture of Santiago de Cali, with the purpose of knowing the historical trace, the sense of belonging and cultural identity. This research problem leads to the question: how to develop a serious game for the promotion and dissemination of the historical, cultural and intangible heritage of the city, having as a model the myth of Buziraco and the legend of the Lady of White?

Methods

The research was carried out in the period 2017-2, transversally from the perspective of exploratory type with a quantitative approach to know the degree of knowledge of the participants in the study on myths, legends and history of the city through a survey. For this, 150 teachers from the Lumen Gentium Catholic University Institution (Unicatólica) participated, which sampling was carried out randomly with 81 teachers using the Google Forms platform to collect the data. Once the need was identified, an exploration of the myths, legends and history of the city was carried out, among them was the myth of Buziraco and the history of the Lady in White. Thus, the project used elements of the SCRUM methodology, focused on the development and management of projects; for the technical part of the video game creation, the lenses technique was used, where elements such as art, narrative and technology are considered.

According to the above, it is necessary to mention that SCRUM is considered a framework of applied work in the development and maintenance of complex projects in an adaptive way, delivering

projects with a great added value (Schwaber & Sutherland, 2016); this means that it is not a rigid technique or process. In this sense, SCRUM is considered within the so-called *agile development methodology*, where an incremental and iterative approach is used to monitor and manage the project; however, there is an essential part that are this three key questions that allow an adequate follow-up to the progress of the project in a practical way (in this case, with a progress bar):

- What has been done since the last meeting?
- What is planned to be done until the next meeting?
- What impediments have been found to do the work according to plan?

Another important aspect of the SCRUM methodology is the clear specification when a process is finished, with the purpose of preventing ambiguities from occurring in certain types of scenarios; by this way, there are the following types of definitions for finished projects: finished without testing, finished and tested, finished and delivered, finished without delivering.

In addition to a strategy for managing and directing projects, it is necessary to use a technical methodology, in this case, the methodology for lenses developed through an iterative process, allowing the debugging of ideas cyclically until reaching a level of consensus in the team. Thus, before starting, it is important that the designer considers that each idea must be explained and presented in writing or any other relevant means that can be clearly transmitted to users. The cycle of iteration proposed is composed of the following elements: brainstorming, independent design, discussion of the design and presentation of the design.

The Tetrad

The serious game allows to transmit an experience that the user can perceive through some senses such as sight, touch or hearing. In this way, it is important that the experience that the designer wanted to

communicate be the same perceived by the player (Schel, 2015). Thus, in the brainstorming phase the development team was invited to present creative ideas; in the part of the independent design, each designer worked on the relevant ideas of the brainstorming stage. Regarding the design discussion, team members met to establish agreements or concessions; and finally, in the design presentation stage, the selected designs were presented and the process was continued.

Since the videogame had to contemplate relevant elements oriented to a good user experience, the Tetrad method was used, for which some useful questions were:

- If you have some intuition of how the game should be, what is reinforcing that intuition?
- What is the experience that you want to transmit to the player?
- What parts of the game are fun? Which parts need to be more fun?

A main objective of the transmitted experience is to awaken the interest of the player; to achieve this, technology, art and history are used (Schel, 2015).Moreover, to get a good result, it is necessary to evaluate the design with questions such as: what aspects will capture the player's interest immediately?

In order to achieve a development of a design oriented directly in the player's experience, the construction of the serious game was based on the four elements that Jeremy Gibson (2015) proposes, which indicates that the video game experience should be oriented with mechanics, narrative, technology and art, to lead a good game design.

Art.

It constitutes all the artistic elements within the serious game, from the Head Up Display (HUD) or elements visible on the screen like the panels, options to the details of the objects, or the movement of these.

Narrative.

Directs the history of the game; a sufficiently planned plot development can directly impact the player and his experience. Likewise, it is necessary to create scripts, the characteristics and personalities of the characters and/or objects of the serious game (*Figure 1*).

Figure 1.
Characteristics of the game

Source: the authors.

Technology.

Serious games are created with different graphics engines, therefore, the investment or use of a good one can allow the realization of each goal of the so-called game design. As far as possible, the game must be of excellent quality and without annoying programming errors for the user, because these can negatively alter the experience of the players and even developers.

Mechanics.

They represent tools with which the player can advance or complete different challenges in their journey through the levels of the game. It is necessary to bear in mind that there may be mechanics that work to improve or worsen a task (*Figure 2*).

Figure 2.
Game mechanics during gameplay

Source: the authors.

Results

The finished Serious game to preserve the cultural legacy of Santiago de Cali, demanded the creation of a script based on a striking story with characters, stages, levels and challenges that reinforced the narrative and quality in graphic design. Thus, as far as the script is concerned, representative sites to unfolds the plot were contemplated: the three crosses with the myth of Buziraco, and the Mansion of San Antonio with the Lady in White, together with scenes such as the Chapel of San Antonio and The Forest; the game includes characters such as the Lady in White and Zam, the main character controlled by the user to know the story and meet the challenges that arise in each level. Moreover, the dialogues between characters, situations, interactions and scenarios, allow telling the history of the city, including photos of the Old Cali.
The story and situations of the script are developed in an environment called stage, made to visually recreate historical sites of the city. In this way, the game consists of four scenarios: Forest Zone (stage one), Mansion Zone (stage two), Church Zone (stage three) and Las Cruces (stage four). Each scenario contains a specific number of levels where part of the story is represented, necessary to show different environments and challenges to the user. In this way, first an easy

challenge to overcome is presented, with the purpose of learning the mechanics of the environment in a gradual and easy way; by overcoming each challenge, the user receives a reward, a help and a comment that depends of the story or myth that is being developed. Joined to the above, the finished project consists of a 2D game with an isometric view, created with the Unity serious game engine free version 5.60f3; by its scope, within the possible options is the Beta version. Then, the serious game is delivered in executable format, installable on computers with Windows operating system under free software license, but its source code and graphics, at the moment, have a restricted type license.

Discussion and conclusions

In Colombia efforts have been made to contribute to the preservation of the so-called cultural and intangible heritage (PCI), since the establishment of law 1185 (Ministerio de Cultura, 2008), where the general law of culture is modified proposing, among others, the safeguarding, protection, recovery, sustainability, conservation and dissemination of the so-called PCI. In this sense, there are research like Preservation of the oral tradition through ICT (Gutiérrez-González, 2017), sought to preserve the folk myths in Anserma, Caldas, through a multimedia application for children between 6 and 9 years old. The Magic Region software is being built in the HTML web language and can work offline; although it is in the design phase, the project has involved children in the creation of representative characters and stories about folkloric myths of the region. Moreover, the authors express that all the children agreed that through a multimedia application, they can learn them in an entertaining and fun way about the Folk myths. In terms of content they said they wanted photos, videos, illustrations and texts (Gutiérrez-González, 2017). Similarly to this project, the children knew about their culture in a more entertaining way through the options offered by multimedia, in this case the video game.

Another project that uses ICT for the preservation of cultural and intangible heritage is Runashimi, a serious game for the conservation of the Kichwa language developed for mobile platforms. This digital

project, created for the initiative by the community of indigenous Sesquilé department of Cundinamarca, "was able to stimulate children and young people of the Kichwa community in Cundinamarca to learn their language and customs"(Ministerio de Tecnologías de la Información y Comunicaciones [MINTIC], 2017). The game is made up of 10 levels where the recreation of the route of the Kichwa ancestors is made to reach their destination Sesquilé; in this journey the u Arians can practice their ancestral language through readings, writing and pronunciation (Efe, 2017). Thus, the present project differs a little from the result obtained with Runashimi, because in this one the preservation of the autochthonous languages, writing and pronunciation is sought; moreover, the serious game of this project is not available for mobile devices.

In the international arena, in Mexico the creators of the Mulaka video game rescue and promote the traditions of the Tarahumara indigenous culture, through characters from its mythology. The history of this game was designed with the collaboration of anthropologists and leaders of the indigenous community, with the purpose of recreating the essence of Tarahumara traditions and culture (Lienzo, 2017). Moreover, it is built in 3D where the player can explore and interact with the environment and the characters, unlike the present investigation where the video game is created in 2D. However, and according to the above, the approaches of interactive didactic strategies in the present project allowed to promote and disseminate the historical, cultural and intangible heritage of Santiago de Cali, to show part of the history of the city, its historical places and that the students who interacted with the video game could know about its culture and heritage immaterial.

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Lightbot: A constructivism approach for learning Function in the Introductory Programing Course

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Abstract

Educators have been trying to motivate students in their introductory programming courses because there are key abstract concepts that are not easy to teach, like functions; that's why we believe that the visual nature of game-oriented approach to teaching abstract concepts is more effective for students. In this paper, we describe our experience in the use of Lightbot to increase student engagement and understanding when learning functions, for which we had a group of students who learned using conventional lectures while another learned with Lightbot. Assessment indicated that students in the experiment group registered significantly higher grades.

Keywords: Game, robot, function, programming, constructivism.

Introduction

The difficulty in understanding abstract concepts and the current teaching method based on traditional lectures with low participation of students in class, generate low motivation and consequently the lack of interest in learning computer programming. Some of these approaches are based on the use and integration of technology in learning; for this reason, the current students, also known as digital natives, have

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a natural acceptance of technology and the use of it in education contributes significantly to an increased motivation in students (Piteira & Hadad, 2011).

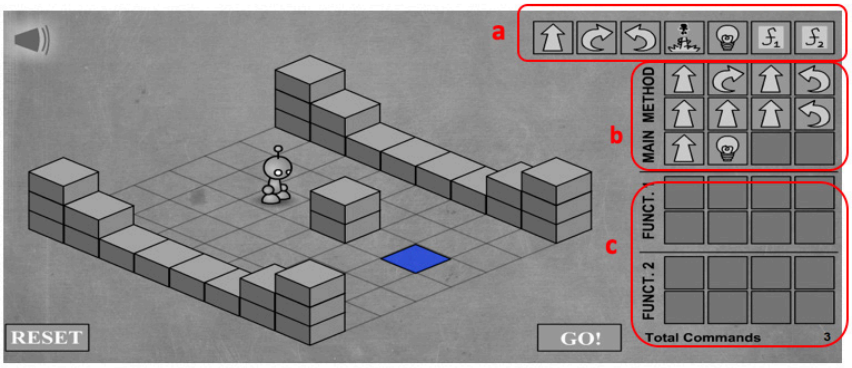
On the other hand, constructivism proposes a paradigm where teaching is perceived and carried out as a dynamic, participatory and interactive student process; in this sense, pedagogy is applied as a didactic concept in action-oriented teaching. According to the expressed by Jean Piaget (Schunk, 2012), students need stimulating environments that allow them to explore actively and include practical activities, facilitating the active construction of knowledge. In order to help the increase of engagement and the interest in learning functions, in this paper we present a web-based educational game: Lightbot; through its use, students discover knowledge and learn while having fun playing. The game is integrated and aligned to introduce concepts from the ACM "Software Development Fundamentals/Fundamentals Programming Concepts/Functions" (Association for Computing Machinery, 2013). Likewise, this article is organized as follows: section two shows Lighbot main characteristics and the experience, section three describes the research methods and the initial results, and finally we present our conclusions.

Lightbot

Description

Lightbot is an educational game with 11 levels with the objective to program a small robot to light up all the blue blocks on a board. This objective is achieved by giving the robot a series of instructions from a limited set of visual commands: forward, turn right, turn left, jump, light, function1, and function2 (*Figure 1*, a) in a finite instruction space called Main Method (*Figure 1*, b). As you progress in the levels, the Lightbot challenge increases too and the Main Method is not enough, so students require to use more sophisticated combinations of commands like functions (*Figure 1*, c).

Figure 1.
Lightbot commands and Instruction Space

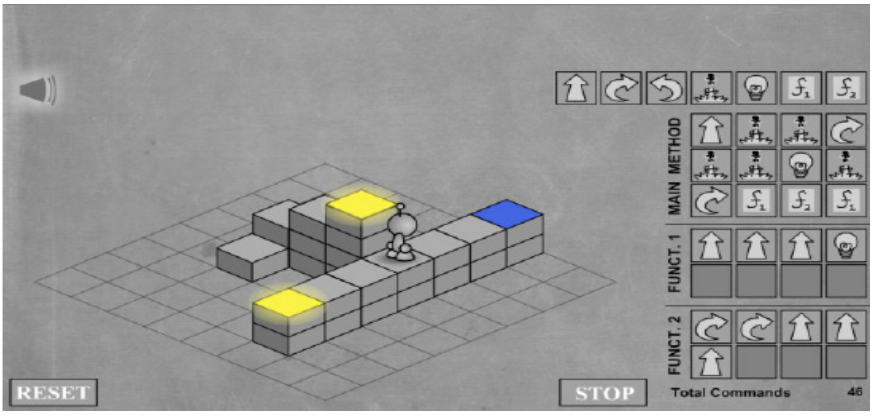


Source: the authors.

The experience

Lightbot has been used since 2015 in the introductory programing course at Universidad Nacional de San Agustín, only in one laboratory session. However, we implemented two Lightbot assignments: the first one focuses on the Main Method which can only hold 12 instructions and is related to levels 1 to 5. In the second assignment (levels 6 to 11) students discover that the Main Method is too short to solve level challenges, so they must group instructions in two different functions using function1 and function2 which can be called from the Main Method using f1 and f2 commands; therefore, they discover by themselves that they can call the same function more than once (*Figure 2*). After the use of Lightbot all the students start programming with Java; the topic of function is included in the third week of classes.

Figure 2.
Lightbot Assignment 2: Creating functions and calling functions



Source: the authors.

The research method
Quasi experimental -study

To evaluate the effectiveness of using Lightbot, in 2018 we carried out a quasi-experimental study with 80 students: an experimental group (40 students who used Lightbot) and a control group (40 students who were not exposed to Lightbot). So, student's learning outcomes were measured using pre-test and post-test. We hypothesized that:

H1: Students who used Lightbot will learn functions significantly better than students who do not.

In order to prove the hypothesis, we used a T-Student test for two related samples, verifying the criterion of the normal distribution of the data (through the Kolmogorov-Smirnov tests and Shapiro-Wilk). The criteria to decide was: if the probability obtained P-value <= alpha (5%), H1 is accepted; if the probability obtained P-Value> alpha (5%) H1 is rejected.

Results and discussion

Table 1 summarizes the averages of Pre and Post-tests, observing that the P-Value obtained in the control group does not show a significant difference between the obtained grades. On the other hand, the experimental group presents a P-Value less than 5%, which shows a significant difference in the grades obtained after having used Lightbot.

Table 1.
Pre-Test and Post Test Evaluation. Grades ranged from 0 to 20

Control Group			
	Pre-Test evaluation	Post-Test evaluation	P-Value
Function Evaluation 40 students	11.75	12.78	0.380
Experimental Group			
Function Evaluation 40 student	10.19	16.48	0.000

Source: the authors.

Conclusions

The results of using Lightbot and the feedback received from students were very positive because they seemed to enjoy the game and the challenge to finish it. The transition to the topic of functions in Java seems to be very smooth since students are already familiar with the idea of a function, so from the data analysis we highlight the fact that Lightbot helped to teach the concept of functions. Finally, another interesting finding is that students pointed out that using Lightbot before learning functions was very helpful to understand programing functions with Java later.

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Videogame design for the inclusion of people with disabilities

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Abstract

Rehabilitation is a complicated process designed to help injured persons who suffer or will probably suffer from a disability, to reach and maintain optimal performance in their interaction with their environment (Ameratunga et al., 2009). While this process is taking place, an important component for the emotional stability of the patient is being able to relate and interact with the same things as the rest of the population, for example, video games. Despite the efforts of the developers of exergames, educational games or re-training, many games that come to market are not designed to fit the population in a condition of disability at some point of its broad spectrum of pathologies. If they are taken into account, patients would be allowed to play famous titles at the time and live similar experiences to healthy people.

Keywords: Design, development, disability, health, rehabilitation, therapy, video games.

Introduction

Nowadays, video games have a huge impact on the people who play them; many of these users are children that are getting smaller and smaller and playing video games can help them to interact with virtual worlds, which results in emotional and intellectual connections that can have therapeutic implications in the hands of a trained and informed therapist (Franco, 2016). On the other hand, though until relatively recently it was believed that the development and recovery of the brain stopped in adulthood, there is evidence that shows that the brain can

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change to adapt to various circumstances, not only during childhood and adolescence, but also during adulthood and even in situations of brain injury, which means that the brain is flexible and modifiable; this implies that although therapy techniques can be applied to all people (with obvious exceptions depending on the degree of injury or disability), in the early stages of development it is much easier to achieve a rapid improvement (Garcés & Suárez, 2014).

Therapy process using video games

Physical therapy

The physiotherapy treatment through exercises is the central point of the whole therapeutic plan with the objective of reorganizing motor skills of the nervous system, creating increasingly advanced postural, tone and movement patterns and following the sequences of normal motor skills development from prone position to standing and walking. Thus, improving the function of the upper limbs is considered a high priority in patients with neurological disorders or altered functions of the locomotor system (such as reaching, grasping and manipulating fine objects) and establishing useful movements to gain independence in daily tasks, decreasing spasticity, strengthening the muscles, avoiding and treating contractures or vicious attitudes and involuntary movements, all conditioned by a degree of active collaboration from the patient, on which the results depend to a great extent; for this, video games are the best option to obtain a playful component in rehabilitation.

According to the above, video games developed to achieve therapeutic objectives must have interfaces that allow a scan of the extremities or parts of the body to be rehabilitated without them generating a greater effort for the patient, for instance, in case of pathologies such as muscle atrophy which requires from the patient to perform a muscle overstress, minimizing the risk of Repetitive Stress Injuries (World Health Organization, 2013). Although repetitive movements are suggested in therapies that grow in frequency or difficulty as therapy progresses, games should consider to be developed as a suite of mini-

games or at least that seek the implementation of multiple dynamics that include the pathology to be treated.

Mental therapy

Attention Deficit Hyperactivity Disorder (ADHD) is a common disorder that affects the ability to stay focused, self-controlled and other important skills for the daily life. It is caused by differences in the anatomy and connections of the brain, and it is often presented by members of the same family; new neuroimaging techniques carried out by the Institutes of Psychiatry show that children brains with ADHD have a maturational delay in the development of some cognitive functions, areas related to attention and executive functions such as inhibition that act on self-control, which could be the origin of this disorder. According to this study, it has been demonstrated with imaging techniques that there are more affected areas in the connections between the frontal lobe and the basal ganglia, important for some executive and attention functions (Game accessibility guidelines, 2019).

Therefore, a component that stands out in the therapies, and in fact, in any type of repetitive work, is motivation which usually reinforces, diminishes and maintains behaviors, whether in a psychomotor or behavioral form (Blog NeuronUP, 2020). Many of the behavioral therapies involve drugs that are administered to the patient to suppress certain behaviors, but that can have repercussions in several body systems and, in most cases, generate a disorder on the patient; for this and other reasons, the Mental Health Action Plan 2013-2020 of the World Health Organization (2013) promotes accessible options and non-pharmacological therapies for young patients (Blandon et al., 2016). In order to this, neurofeedback (Biofeedback applied with neurophysiological signals) video games are becoming popular to induce states of meditation and relaxation through the detection of oscillatory rhythms, specifically Theta and Beta recorded from the frontal lobe, so having a measurement in real time, in situ and with multiple

variables from the game becomes viable and it would give a deep point of view of the patient disorder degree (Dager System, 2019).

Analysis of disability and accessibility

In terms of accessibility, although many video games have begun to adopt certain characteristics to allow more and more people to enjoy the content of these, most designers do not take into account people with disabilities, or failing that, when they take them into account it is in a period in which the development is very advanced and where including this becomes expensive or even impossible without damaging the game completely. Because of this, it is necessary to think about those people with disabilities from the beginning of development.

Hearing impairment

People who experience hearing loss tend to lose a lot of information that could be extremely relevant within the boundaries of the game, so adding subtitles should be contemplates as a priority and as a default option, considering they should be easy to read in a way that contrasts well with different backgrounds; words in white color with a black background are always a good solution, because the user divides its attention between these and everything else that is happening on the screen. Moreover, they should also be large and indicate the important sounds of the game (Material Design, 2019), so adding visual aids in an overlay that visualizes these sounds will also help the player to know where they come from. Above all, it is important allowing the user to modify the subtitles as their convenience, things like font size, background color or even disable them.

Motor disabilities

Video games are based on physical interaction, so players with these disabilities have difficulties when playing certain titles, especially those that involve precision, synchronization, strength or endurance. Fortunately, today there are already accessible controls in the market as we can see with the adaptive Microsoft control for Xbox One and

PC; although this is a great help it is not a definitive solution because there are still barriers within the game. For this, allowing the player to have more flexibility on how the game is controlled is imperative; options like remapping controls and allowing players to adjust control sensitivity, give players the ability to use it as they see it more convenient. For instance, though options like control vibration allow designers generate great feedback, for certain people it may mean difficulty to hold the control, so adding an option to adjust this and even remove it completely should be contemplated by designers.

Visual impairment and color blindness

Working with color blindness is certainly not that difficult but it sure takes time; for this, designers can make use of filters that simulate the visual environment of the game and once observed the combination of colors that may produce problems, work around them. To avoid the use of color to communicate information, it is necessary using of visual tricks to highlight the critical parts of the game using shapes, symbols and animations. Now, in terms of visual impairment, good subtitles are applied as well as with hearing impairment, plus a high contrast option is necessary so that critical parts of the game can stand out against the background (Bannick, 2019), considering a good soundscape so that the player does not lose valuable information such as enemies or objects.

Cognitive disability

Many people feel overwhelmed by the high level of visual activity that occurs on the screen, as this affects a wide range of sensory processing problems, even reaching limits such as photosensitive epilepsy; although solving this is not something difficult to achieve, it is a matter of finding what features involve a sensory load and allowing players to turn them off or reduce them. In terms of learning difficulty and dyslexia, players may experience difficulties in obtaining written information, so allowing them to advance at their own pace gives them time to read and understand the text that for the designer may be something trivial.

In addition to this, receiving, processing and acting on the information provided, becomes extremely complicated for certain people, so using simple language, optional tips, help windows and pointing out locations or objects reminds the user of the actions that can be taken to advance properly, and filtering these signals to not load the player with information that may be unnecessary at the moment. Finally, allowing players to reduce the difficulty of the game becomes a great help as it gives them more time to solve problems and the opportunity to make mistakes before a "Game Over"; if designers want to go even further they can allow all the characteristics of the game to be modifiable like the damage of the enemy, health points of the main character, the frequency of attack, among others.

Celeste: case of extending the scope

As mentioned before, more recent games have given greater weight to accessibility; the case of Celeste is one of the most exposed, a platform game that incorporates a mode of assistance. It is important to highlight the name of the mode because many players do not use them by their name, since they come to feel inferior only because of their condition and this should not be the case. Therefore, Celeste's mode of assistance allows players to modify the rules of the game in order to reduce their difficulty, which includes options such as reducing the speed of the game, granting invincibility or endless resistance and even skipping complete chapters of the game.

Conclusions

Accessibility options allow designers to trust that the player will make the right decisions to play the game in the best possible way without ruining the game experience, so designers should avoid providing critical information aimed just at one sense; additionally, it will always be better and necessary to obtain feedback from people with disabilities or to work with consulting groups (BBC, 2018). Finally, and as a general rule, the more control players can have in the game, the closer the industry will be to make sure that as many people as possible can benefit from all that video games can offer.

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5. Poster Session from the Edutainment 2019 Conference – Invited poster from IGDA Colombia's representative and the REDIS' Expoposter 2019-1 Event

REDIS is an Academic Network formed by different institutions of higher education distributed by regional nodes in Colombia. This network, in the more than 15 years of its history, has managed to articulate the managers of the academic programs of computer science and systems engineering and related programs in the country, working collaboratively and permanently by strengthening the training in this increasingly important knowledge field. By 2019, the South Western Node of REDIS, had already 22 institutions with which teamwork has been consolidated carrying out activities with the purpose of strengthening the programs of the region; one of them is Expoposter. This activity involved students, who present their advances in the development of undergraduate work and their participation in research groups, thus allowing to continue consolidating the REDIS's student chapter. Authors of suitable well evaluated posters where invited to Edutainment 2019 and given the opportunity to publish the abstract of their work; additionally, one IGDA's starting work that was submitted to edutainment was added to this section.

Awareness of video game development in the Colombian Academic Field: how the academy sees young developers

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Abstract

Video games have now surpassed what was believed to be purely entertainment area; however, there are sectors that until recently have approached to the complexity of video game development and with this, the work of the developer. In the university environment, many professionals who act as officials maintain a position based in understanding video games as a form of leisure without technical background, which presents barriers resulting in a lack of interest and support for students interested in the development and research of this topic. With this premise, we seek to open new multidisciplinary spaces for the development of video games and, through a methodology based on the expansion of the scope of the developed software, we wanted to awareness about the its opportunities into different fields of action of the university and the classical academic environment.

Keywords: Academy, video games, development, university.

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Desarrollo de una aplicación web y móvil para el monitoreo y planificación de los programas de acondicionamiento físico utilizando estrategias de gamificación

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Resumen

El uso de los medios de comunicación e información en las prácticas pedagógicas es un recurso indispensable para el desarrollo de las competencias de los estudiantes, convirtiéndose en un elemento fundamental en el proceso de enseñanza y aprendizaje; de esta forma, las universidades enfrentan un importante reto para motivar a los estudiantes a comprometerse con las asignaturas. En ámbitos educativos, se propone fomentar el uso de los medios electrónicos, la televisión, la radio, el cine, el video y otros elementos para mejorar los aprendizajes. En este caso, aunque La Unidad Central del Valle del Cauca (UCEVA) presenta asignaturas en diferentes programas que requieren ser apoyadas con sistemas informáticos, actualmente no se cuenta con aplicaciones que se integren en el aula para propiciar un aprendizaje interactivo con herramientas didácticas que utilicen elementos del juego, buscando incrementar la motivación y favorecer la participación de los estudiantes. Tal es el caso del programa de Licenciatura de Educación física, Recreación y Deporte, que busca identificar y medir el progreso de las actividades físicas en los estudiantes

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en la falta de estructuración de planes nutricionales y para el acondicionamiento físico, apoyados sobre tecnologías móviles y web e integrando estrategias de gamificación.

Palabras clave: Acondicionamiento físico, gamificación, aplicación web, aplicación móvil.

Asistente virtual de computador para personas tetrapléjicas controlado por comandos de voz y gestos faciales

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Resumen

Las tecnologías de la información y la comunicación (TICs) crecen a pasos agigantados con los avances tecnológicos a nivel de hardware y software, pero la forma en la cual interactuamos con esta información mediante un sistema de cómputo dista de ser natural e intuitiva, impidiendo a personas tetrapléjicas controlarlas tecnologías y conectarse con el mundo mediante internet. De esta forma, los computadores digitales son una herramienta presente en todos los ámbitos de la vida cotidiana, desde el hogar, pasando por las entidades educativas hasta los ambientes industriales y centros de investigación; por esto, surge la necesidad de desarrollar herramientas de interacción humano-máquina más naturales que permitan controlar un sistema

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de cómputo a partir de gestos corporales, pues las personas con discapacidad se encuentran en una situación de vulnerabilidad en la cual no les es posible controlar un sistema de cómputo ni siquiera mediante los periféricos tradicionales (mouse y teclado), afectando de forma directa sus posibilidades de comunicación e integración con el resto del mundo. Teniendo en cuenta lo anterior, el objetivo de este proyecto es desarrollar un asistente virtual para computador que permita a personas tetrapléjicas realizar tareas básicas de navegación en internet de forma automática mediante comandos de voz y gestos faciales.

Palabras clave: Asistente virtual, tetraplejia, reconocimiento de voz, gestos faciales.

Anatomía humana en realidad aumentada

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Resumen

La Facultad de Salud en la Universidad Libre de Cali cuenta con herramientas didácticas tradicionales para facilitar el estudio y la enseñanza del funcionamiento de la anatomía humana, tema directamente relacionado con los programas de Medicina y Enfermería. De esta manera, los estudiantes usan libros y aplicaciones que les permiten acceder a la información básica sobre el tema y observar imágenes planas del cuerpo humano en general. Por esto, con el fin de apoyar el aprendizaje en el estudio de la anatomía humana, se plantea el desarrollo de un sistema basado en realidad aumenta que permita a los estudiantes visualizar los órganos en tres dimensiones y brinde información específica sobre sus funcionalidades.

Palabras Clave: Anatomía, realidad aumentada, prototipos, TIC's, pedagogía, paradigma, simulación, didáctica, dinámica.

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Realidad aumentada aplicada a los laboratorios de física mecánica

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Resumen

La realidad aumentada es una herramienta que permite incorporar elementos virtuales a un entorno físico; usada en el ámbito educativo, esta herramienta permite dar una experiencia interactiva a los participantes. Teniendo en cuenta este enfoque, la investigación aquí planteada aplica esta herramienta a los laboratorios de física mecánica para brindar un soporte interactivo que refuerce aspectos teóricos, prácticos y teórico-prácticos del tema a desarrollar en el laboratorio, con el fin de que los estudiantes puedan utilizar el conocimiento obtenido para su vida cotidiana o profesional.

Palabras Clave: Aplicación móvil, física mecánica, multimedia, realidad aumentada.

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Software interactivo para el uso de algoritmia en estudiantes de primaria.

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Resumen

El anteproyecto presentado como opción de grado para la carrera de Ingeniería de sistemas, se trata de la construcción de un software que permita apoyar a profesores de primaria, para formular problemas de cualquier concepto y así estos sean resueltos por los estudiantes. Esto nace a raíz de la necesidad de brindar soluciones a la falta de software que enfoque su esencia en el pensamiento computacional y no en solo la obtención de conocimiento sintáctico de un lenguaje de programación específico.

Palabras Clave: Algoritmo, pensamiento computacional, software interactivo, tecnologías de la información y la comunicación (TIC)

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