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An Implementation of Educational Multimedia Applications in Schools of the Metropolitan Districts

Margarita Zambrano[1], César Villacís[2], Mónica Gómez[3], Walter Fuertes[4]

Abstract

Universities have a crucial role in developing technological, scientific, and educational innovation in schools, and the link with the community is a fundamental pillar for developing a knowledge society. This research presents the general results of a linkage project applied to educational informatics. The main goal was to create educational software applications focused on reinforcing the teaching-learning process of children through online courses on the one hand and interactive learning activities on the oth-er. To carry it out, we used instructional design to develop educational software, and we used the OOHDM method (Object-oriented hypermedia design method) for the navigational and conceptual de-sign of educational multimedia applications for desktops. The results show the satisfaction of students and schoolteachers regarding the organization and structuring of multimedia applications and online courses developed. These educational software applications significantly improve the conceptual and procedural learning skills of schoolchildren instructed in different areas of knowledge.

Keywords: *Educational Software Applications, Online Courses, Interactive Learning Activities, Instructional De-sign, OOHDM, Educational Multimedia*

INTRODUCTION

Universities play a crucial role in our nation's technological and scientific development, so strengthening investment in education and technological innovation, which are necessary to develop the country, must be addressed. The link with the community allows the transfer of technology and knowledge through innovation development with projects for society, the government, and the company, where universities and research centers actively participate (Malagón, 2006). Information and Communication Technologies (ICTs) undergo a process of expansion and evolution that generates a profound transformation in our daily lives as we enter the knowledge society (Lund & Rasmussen, 2010). However, it should be considered that although ICTs influence the formation and organization of a new world. ICTs applied to education must also be aligned with pedagogical changes and modern educational models used by teachers in classrooms, both in schools, colleges, and universities, as is the case of the Constructivist paradigm that implies generating learning strategies to develop the competencies of a student as regards the acquisition of knowledge and development of skills, abilities, attitudes, and values. The knowledge society has also made the role of the teacher increasingly active and competent in the teaching-learning process by becoming a guide or facilitator, a planner, and a creator of new learning strategies, changing their traditional practices for the incursion into new educational models centered on the student such as Constructivism. These changes in the dynamics of the teaching-learning process have led to the development of educational software applications that serve as support for both teachers and students can reinforce their knowledge in different areas of expertise within the study curriculum, such as in Mathematics, Language, Natural Sciences, Social Sciences and Foreign Language (English).

Based on the above considerations, this research tries to answer the question: Does developing and implementing educational software and recreational video games help to improve subject children's theoretical and practical learning in schools? The objective of this project is to design, develop, and implement educational software applications focused on reinforcing the teaching-learning process of children through desktop-type

[1] Universidad de las Fuerzas Armadas ESPE, Sangolquí, Ecuador E-mail: mezambrano@espe.edu.ec

[2] Universidad de las Fuerzas Armadas ESPE, Sangolquí, Ecuador E-mail: cjvillacis@espe.edu.ec

[3] Universidad de las Fuerzas Armadas ESPE, Sangolquí, Ecuador E-mail: megomez@espe.edu.ec

[4] Universidad de las Fuerzas Armadas ESPE, Sangolquí, Ecuador, E-mail: wmfuertes@espe.edu.ec

multimedia applications on the one hand and online courses on the other hand for basic subjects as part of education at school, which are the contributions of this project. To carry it out, we used an instructional design (Dick & Carey, 1996) for the design of educational software and the OOHDM methodology (Object-oriented hypermedia design method) for the navigational and conceptual design of multimedia educational desktop applications (Pressman, 2010). In the first and second phases of the project, we implemented 14 educational multimedia applications containing interactive learning activities and playful games, and we implemented two online Natural Science courses uploaded to the Moodle platform. The results show the satisfaction of students and schoolteachers regarding the organization and structuring of all 16 educational software projects developed.

The remainder of the article is organized as follows: Section 2 describes the theoretical foundation that supports this research. Section 3 explains the design and implementation, detailing the model, the use cases, and the requirements specification. In addition, how the 14 educational multimedia applications were designed and developed, and the two online courses applying the OOHDM methodology and an Instructional Design methodology. Section 4 shows and discusses the results obtained. Finally, section 5 presents the conclusions and possible future work based on the results obtained.

THEORETICAL FRAMEWORK

Educational Software

According to (Marquès, 1995), (Galvis, et al., 1998), (Cataldi, 2006), educational software is an application that can be used for didactic purposes, which allows for supporting the work teacher's tutorial and the teaching-learning process of the students, presenting models of knowledge representation. In harmony with (Marquès, 1995) and (Morejón, 2011), the fundamental principle of educational software is interactivity through multimedia resources, such as text, images, audio, and video, to create tutorials, exercises, simulators, evaluations, etc. The essential characteristics of educational software are:

- Allows interactivity with students;
- Provides feedback;
- Evaluates what has been learned;
- Facilitates knowledge representations;
- Skill development through exercise;
- Enables simulation of complex processes;
- Optimizes the time to impart knowledge;
- Facilitates independent work;
- Allow students to be introduced to different levels of expertise;
- Enable students to assume an active role in the construction of knowledge;
- Allow the assimilation of knowledge in a fun way in less time;
- Develop logical thought processes, imagination, creativity, and memory.

Multimedia Applications for Education

According to Mukherjee (2018), Milková (2014), and Yusra Kapi et al. (2018), in traditional education that focuses on the teacher and the development of memory, the student is a passive entity and lacks problem-solving skills. Conventional forms of learning are primarily linear and focus on the accumulation of information, while in modern learning based on the Constructivist paradigm, the support of learning with multimedia is not linear, and the ideas are linked to each other, which allows the students to choose the path they want to follow.

In the traditional approach to learning, there need to be more educational resources and knowledge students can only be absorbed through lectures and texts. In addition, the conventional approach is less creative, which generates passive and unmotivated students since they need more material resources to express their creativity. Many resources can be used using multimedia, primarily through the Internet, e-learning platforms, online courses, and educational video games (Allen, 2016).

According to Mukherjee (2018), Cheng et al. (2010), and Zambrano et al. (2020), among the benefits of educational multimedia are:

- Deep understanding of things;
- Improvement in problem solving;
- Increase of emotions and positive thoughts;
- Access to a wide variety of information and knowledge;
- Exploration of the natural world;
- Increased creativity and other skills;
- Promotion of teamwork.

According to (Bent & Katja, 2013), students who take courses with multimedia applications for education are expected to develop knowledge, skills, and abilities in the following areas:

- The scenario model related to the use of multimedia in education and the critical aspects of learning and teaching learning with educational multimedia;
- Reflexive and critical selection of educational multimedia by the educational objectives of its use;
- The application of educational multimedia according to different educational scenarios such as face-to-face, distance, virtual, and mixed modality;
- Appropriate methods for evaluating the knowledge and skills acquired.

Instructional Design

Instructional System Design (ISD), or simply Instructional Design (ID), is the methodology used to develop online courses and training programs. The ISD was born from the Second World War to find an easy and effective way to create online courses and training programs. The first ISD models were developed in the 1960s. Currently, the work of Walter Dick and Lou Carey (Dick & Carey,1996), (Dick et al., 2005), (Dick et al., 2015) are widely recognized as the pioneers of this methodology, which is a systematic process made up of 5 stages defined by the ADDIE Model (Analysis-Design-Development-Implementation-Evaluation), as indicated by the works of Lee & Owens (2004), and Sharif & Cho (2015)..

Object Oriented Hypermedia Development Design Method (OOHDM)

According to Schwaber et al. (1996), OOHDM is a method used for the development of Web and multimedia applications that comprises five phases: 1) Conceptual design; 2) Navigational design; 3) Abstract design of the interface; 4) Implementation; 5) Testing and installation. For this project, the OOHDM methodology has been considered for developing the navigational design phase, abstract interface design, and implementation of multimedia desktop applications and online courses. One of the shortcomings of this methodology is the absence of an analysis phase, for which the IEEE-830 standard, known as the software requirements specification document, was applied and also 3 of the diagrams regulated by UML 2.5 (Unified Modeling Language): a) Use Case Diagram; b) Sequence Diagram; c) Class Diagram and or Component Diagram.

Moodle LMS and Learning Objects

Moodle is a free-distribution Virtual Teaching-Learning Environment (VTLE) where various pedagogical processes can be carried out on the Web based on social constructivism and collaborative work (Rice, 2011), (Zambrano et al., 2016), (Zambrano et al., 2021) and (Alvarado et al., 2023). Among its primary functions are: (1) Creation of Courses; (2) User Registration; (3) Control and Monitoring of the Learning Progress; (4) Collaboration Tools; (5) Application of evaluation tests; (6) Interaction with Virtual Worlds.

A learning object (LO) is an educational unit composed of a learning objective, educational content, learning activities, self-assessment, and metadata integrated into a package (De Giusti, 2015).

EXPERIMENTAL SETUP

Software Requirements Specification (SRS)

The IEEE-830 standard was applied to define the requirements specification of the developed software applications. The 14 educational software projects fulfilled the following roles and tasks: (1) Access the Computerized Educational Materials (CEM); (2) Access the course lessons; (3) Solve the interactive learning activities. Each of the two online courses was designed and uploaded in an LMS Moodle virtual classroom to fulfill the following roles and tasks: (1) Access the virtual classroom; (2) Access course materials; (3) Access the course lessons; (4) Access the learning objects of the course; (5) Interact with collaboration tools; (6) Review the solved problems of the course; (7) Solve the proposed problems of the course. Figure 1 shows the use case diagram of an online course, and Figure 2 shows a sequence diagram of how to solve a learning activity, complying with the basic structure and organization of a LO.

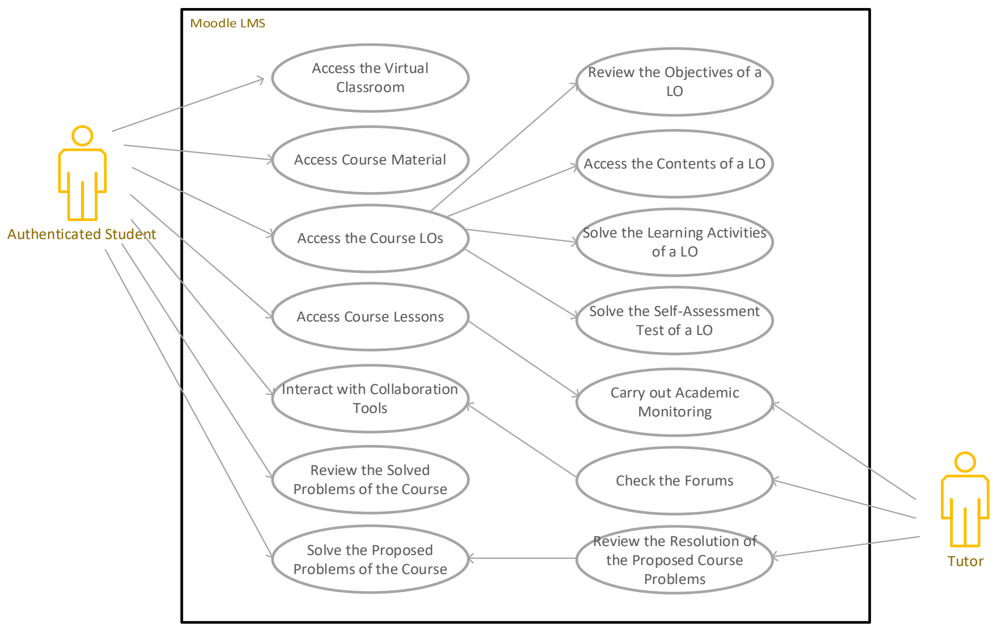

Figure 1. Use case of an online course.

Solution Architecture

The educational software developed and implemented complies with a 2-layer Client/Server architecture, one of which was considered for the Graphical User Interfaces (GUIs) and another for the class libraries and system components. The online courses were developed and implemented on the Web server of the VLBS Company sponsoring these two projects, which complies with an n-Layer Client/Server architecture, as shown in Figure 3. These are a) the User Layer, which allows the user to browse the website; b) the LMS layer, which allows access to the training courses, the Moodle databases, and the lessons of the two courses developed.

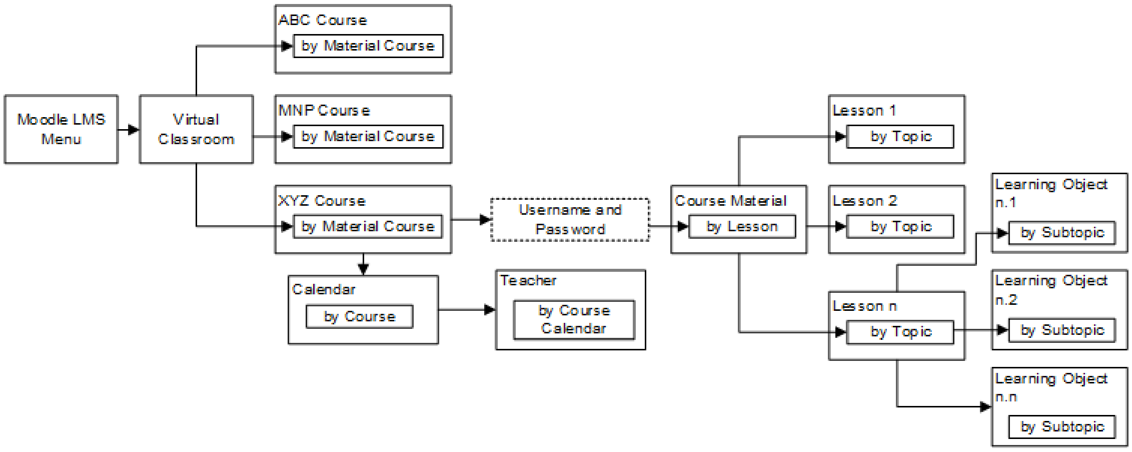

Figure 2. Sequence diagram of "How to solve a learning activity of a LO" of an online course.

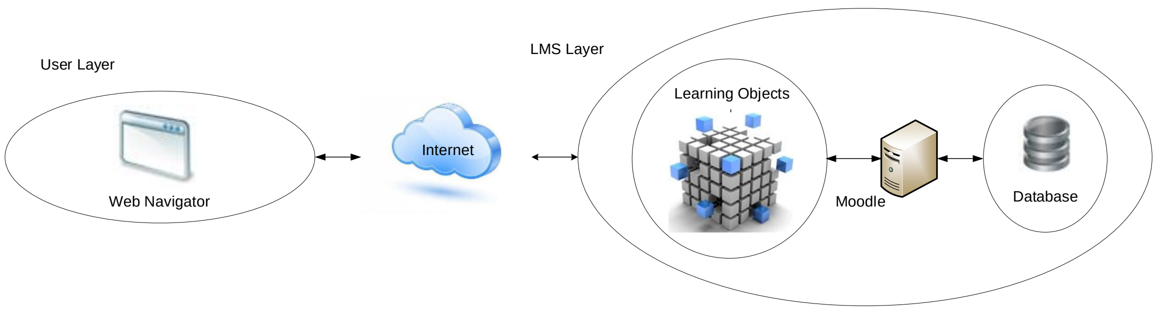

Figure 3. Architecture of the solution of an online course.

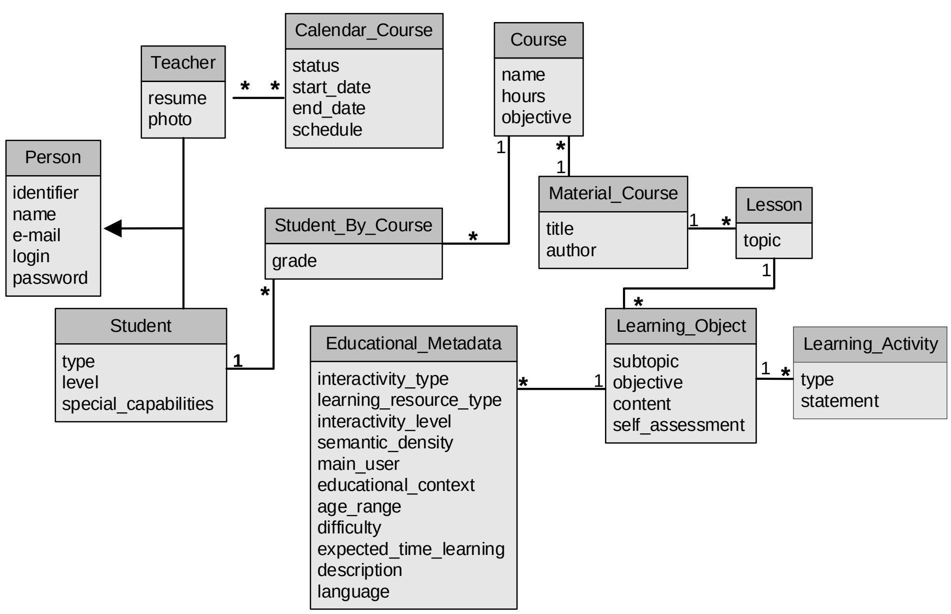

Figure 4. Conceptual model resulting from an online course.

Conceptual Design

In this phase, the conceptual model of the application was generated, where the classes, relationships, and cardinalities are defined according to the rules that apply to the User Interaction Diagrams (UID). In the case of the 14 educational software projects, the entities considered and related to each other were: a) Course Material, b) Lesson, c) Learning Activity. Figure 4 illustrates the conceptual model of the simplified application in detail, considering the main entities that are related within LMS Moodle, complying with the basic structuring and organization of a learning object (LO) for the two online courses, where they consider metadata of an educational nature, according to Hodgins (2002).

Navigational Design

In this phase, the development of the navigational topology allows the 14 desktop educational multimedia applications to execute all the tasks required by the student, considering the use of Windows forms and interactive learning activities. In addition, in this phase, the development of the navigational topology was considered. It allows the two online courses, which are Web applications, to execute all the tasks required by the student, considering the use of LMS Moodle's Web forms and complying with the structuring and essential organization of a learning object (LO) to create all the interactive content of the lessons, using the H5P authoring tool and the Unity 3D framework. Figure 5 illustrates the diagram resulting from the union of all the context diagrams obtained.

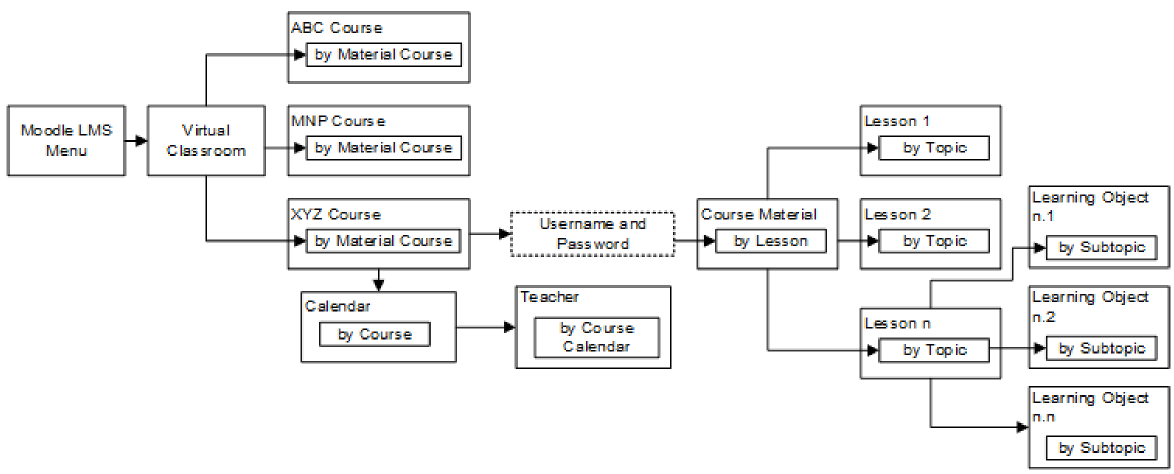

Figure 5. Conceptual model resulting from an online course.

Software Development Process Applied to Educational Software

In the execution of the project, an iterative process flow was considered (see Figure 6), and it is described in such a way that the structural activities, actions, and tasks that occur within each one are organized concerning sequence and time (Pressman, 2010).

Figure 6. Iterative process flow (Pressman, 2010).

Communication. At this stage, the project groups had to carry out some tasks, among which are mentioned:

- Recognize the current state of education in the country. For this purpose, we investigated aspects such as the curricular mesh, themes, and contents that the Ministry of Education considered essential for teaching children from five to 12 years of age;

- Hold a meeting with the teachers of the Educational Units to determine the problems and general needs in a specific subject;
- Determine the causes and effects that caused the main problem in children's learning in the corresponding subject, applying the fishbone technique;
- Assemble a preliminary list of the activities and characteristics of the application based on the contributions of the teachers;
- Schedule a series of meetings to facilitate the development of application specifications;
- Hold meetings with the school teachers involved in the outreach project.

Planning. Over-planning is time-consuming and sterile on many projects (because too much is changing), but under-planning is a recipe for chaos. Like most things in life, planning should be taken in moderation, enough to provide helpful guidance to the team, no more, no less. In the projects developed, the following principles were applied:

- Understand the scope of the project;
- Involve Software participants in the planning activity;
- Recognize that planning is iterative;
- Estimate based on what is known;
- When defining the plan, take risks into account;
- Be realistic;
- Adjust the granularity when defining the plan;
- Define how to ensure quality;
- Describe how it wants to manage the change;
- Follow up on the plan frequently and make adjustments as required.

In order to achieve the objective of building high-quality educational software within planning, the fundamental principles that must always be followed in Software Engineering should be considered. One of them is to understand the problem; therefore, the group leaders had to determine the stages, tasks, human resources, technical resources, costs and time that it would take them to carry out the project, using a tool such as Microsoft Project for this purpose.

Modeling. Models are created to understand better the actual entity to be built. However, the model must take a different form when software is the entity to be built. It must represent the information the software transforms, the architecture and functions that allow this, the features users want, and the system's behavior while the transformation occurs. Models must accomplish these goals at different levels of abstraction, first by illustrating the software from the customer's point of view and then by representing it on a more technical level. In this project, design models were created representing the characteristics of educational software that help children reinforce the learning of a subject using GUIs (Graphic User Interface).

Construction. The construction activity included a set of coding tasks and unit tests that led to operational software being ready to be delivered to the educational units collaborating with its development. The work used two fourth-generation programming languages: Java and C#. Other levels of testing that were applied include:

- Integration testing (performed while the system is under construction).
- Validation tests assess whether the requirements have been met for the entire system.
- Acceptance testing, which the customer performs to use all required features and functions.

The following principles and concepts apply to the coding and testing of the developed educational software: coding, preparation, programming, and validation.

Deployment. This stage included three actions: delivery, support, and feedback. As the software process model was iterative, deployment occurred with small delivery cycles. The application considered delivering user manuals and training children and teachers on its use.

Implementation of Educational Software Applications

Each of the 16 educational software projects complies with Instructional Design principles and Bloom's Taxonomy (Bloom, 1984). This methodology is applied jointly with the OOHDM methodology in each of the phases as indicated below. Table 1 presents a summary of all the projects developed and implemented.

- The **analysis phase**: involved each of the 14 educational software applications and the 2 online courses. The requirements specification was carried out during this phase. The analysis also included how these applications and courses will be delivered to the students and teachers. The students and teachers are the end users.
- The **design phase** involved documenting the specific learning objectives, evaluation instruments, content, and learning activities and designing the different navigation and context diagrams.
- **Development phase**: the computerized educational materials (CEM) for the 14 multimedia applications for children's education and the two online Natural Sciences courses were created.
- **The implementation phase** involved delivering or distributing all these computerized educational materials (CEM) and the two online courses to different groups of students and teachers.
- The **evaluation or testing phase** involved evaluating the implemented computerized educational materials (CEM) and the two online courses.

Table 1. Projects developed and implemented.

Project 1
Name: Mobile Application "QR NATURE" and Virtual Platform "NATURE DIGITAL" Learning with Augmented Reality
Students: Andrea Albuja, Alyssa Cadena
Tutors: Margarita Zambrano, César Villacís
Description: Multimedia application of Natural Sciences that combines the real and virtual worlds through Augmented Reality, virtual classrooms, and learning objects.
Grade: 5th
Project 2
Name: Virtual Natural Ride.
Students: Deysi Báez, Patricia Bucay
Tutors: Margarita Zambrano, César Villacís
Description: Multimedia application of Natural Sciences that combines the real world with the virtual world through Virtual Reality, virtual classrooms, and learning objects.
Grade: 5th
Project 3
Name: Animal World
Students: Rayner Betancourt, Melissa Cedeño, David Cutiopala, Dany Lasso
Tutors: Margarita Zambrano, César Villacís, Mónica Gómez
Description: Development of playful and didactic software to reinforce educational knowledge regarding mathematics in the education of children from 5 to 6 years of age.
Grade: 1st
Project 4
Name: Vowels Laboratory
Students: Diego Huerta, Ricardo Clavón, Stalin Crisanto, Santiago Rivera, Denisse Sandoval
Tutors: Margarita Zambrano, César Villacís, Mónica Gómez
Description: Development of a ludic and didactic software to reinforce educational knowledge regarding language in the education of children from 5 to 6 years old, corresponding to the first year of primary education.
Grade: 1st
Project 5
Name: Little Kids in Action
Students: Diego Borja, Jonathan Altamirano, Kevin Guachagmira, Kevin Taday
Tutors: Margarita Zambrano, César Villacís, Mónica Gómez
Description: This educational software is created for children between 4 and 5 years old, which will allow the child to counter visual memory problems and thus associate an image with its respective meaning.
Grade: Initial 1
Project 6
Name: EDUCA-TECH
Students: Cristian Barragán, Renzo Malla, Bryan Rodríguez, Bryan Talle
Tutors: Margarita Zambrano, César Villacís, Mónica Gómez

Description: Design and implement educational software that helps develop visual and sequential memory in the subject of language and literature in lower schoolchildren.
Grade: Initial 1
Project 7
Name: GAME LAND
Students: Diego Beltrán, Luis Benítez, Abigail Carvajal, Nicolás Ortiz
Tutors: Margarita Zambrano, César Villacís, Mónica Gómez
Description: Development of educational software to reinforce language knowledge in lower schoolchildren's education.
Grade: Initial 1
Project 8
Name: TIC-TAC-TOE GAME
Students: Alejandro Reyes, Edgar Salguero, Karina Zambrano
Tutors: Margarita Zambrano, Gonzalo Puma
Description: The software consists of the traditional Tic-Tac-Toe game but replaces the X and 0 characters with images in English vocabulary text. In addition, while someone is playing the game, the software reproduces the pronunciation of the character, thus reinforcing his or her perceptual abilities. Once a game is finished, the software will ask the gamer to complete the word with the characters used.
Grade: 4th
Project 9
Name: Embedded
Students: Paula Monteros, Javier Nuñez, Kevin Quiroga, Michael Rodríguez, Luigi Villareal
Tutors: Margarita Zambrano, Mónica Gómez
Description: Development of ludic and didactic software to reinforce educational knowledge regarding mathematics in the education of children from 5 to 6 years of age.
Grade: 1st
Project 10
Name: JEDAM
Students: Erick Montero, John Ponce, David Puebla, Melanie Noboa, Anthony Torres
Tutors: Margarita Zambrano, César Villacís, Mónica Gómez
Description: Educational Software to help reinforce the learning of laterality in children.
Grade: 1st
Project 11
Name: My First Adventure
Students: Kevin Sanipatin, Mayra Paspuel, Fernando Yánez
Tutors: Margarita Zambrano, César Villacís, Mónica Gómez
Description: The game is an educational software with recreational activities aimed at pedagogical development and reinforcement of knowledge in mathematics, essentially in the field of statistics that concerns monetary units, quantities, and with a contribution to directionality in children.
Grade: 1st
Project 12
Name: TECNO-FUN
Students: Kennedy Vargas, Jorge Reyes, Fernando Rodríguez, Carla Quinstanchala, Alex Portilla
Tutors: Margarita Zambrano, Mónica Gómez
Description: An educational software reinforces knowledge in lower schoolchildren through games.
Grade: Initial 1
Project 13
Name: Play with Numbers
Students: Melany Palacios, Francisco Sampedro, Francisco Segura, Michael Villarruel
Tutors: Margarita Zambrano, Mónica Gómez
Description: This program consists of a playful game, a series of fun and educational activities that will allow students to reinforce and test the mathematical knowledge taught in class.
Grade: 1st
Project 14
Name: English Educational Software
Students: Cristian Bejarano, Michelle Torres
Tutors: Margarita Zambrano, César Villacís, Mónica Gómez
Description: Ludic pedagogical software to reinforce the learning of English for children.
Grade: 6th
Project 15
Name: Mathematics Educational Software
Students: Edwin Cuichan, Paula Monteros, Stalin Condolo
Tutors: Margarita Zambrano, César Villacís, Mónica Gómez
Description: Ludic pedagogical software to reinforce learning in problem solving and operations with fractions and multiplication in children.
grade: 6th
Project 16
Name: Language and Literature Educational Software
Students: Michael Rodríguez, Mayra Paspuel
Tutors: Margarita Zambrano, César Villacís, Mónica Gómez
Description: Ludic pedagogical software to reinforce learning in the language and literature module for children.
Grade: 4th

Experimental Results and Discussion

To corroborate the pedagogical benefits of the 14 educational multimedia applications and the 2 online Natural Sciences courses, we requested an evaluation of the 16 teachers with whom we worked on developing these educational software products, of which 12 belong to public schools and four to a private school. We took four hundred eighty (480) students enrolled in the three public schools, the same ones who evaluated the 14 educational software applications. Eighty-four (84) students enrolled in a private school were also taken, the same ones who assessed the two online courses in Natural Sciences. Therefore, the total number of students who participated in the surveys was 564, and the total number of participating teachers was 16.

The measurement instruments evaluated the following: 1) Pedagogical and functional aspects; 2) Technical and aesthetic aspects; 3) Didactic resources that use educational multimedia applications; and 4) Cognitive effort required by the activities. Pere Marquès (2005) took these parameters from the sheet to simplify the cataloging and evaluation of educational programs. Below, we present the main findings:

a) After statistically processing the responses and analyzing the surveys carried out at the end of each of the 14 educational multimedia applications and the two online courses in Natural Sciences, it was possible to determine that:
b) Regarding the pedagogical and functional aspects of the 14 educational multimedia applications, they need to improve their didactic versatility, access problem, potentiality of the didactic resources, tutoring, diversity treatment, evaluation, and promotion of self-learning, obtaining a value of 8.18/10.
c) Regarding the pedagogical and functional aspects of the two online courses in Natural Sciences, they need to improve the ease of installation and use, which is understood as a problem of configuration and installation of the Moodle components, H5P libraries, and Unity 3D assets, obtaining a value of 9.54/10.
d) Regarding the technical and aesthetic aspects of the 14 educational multimedia applications, they need to improve the interaction with the activities and the originality and use of advanced technology, obtaining a value of 9.06/10.
e) Regarding the technical and aesthetic aspects of the two online courses in Natural Sciences, they need to improve the interaction with the activities, obtaining a value of 9.38/10.
f) The aspects of didactic resources used by the 14 educational multimedia applications must include previous organizers, schemes, examples, summaries, and synthesis, obtaining a value of 6/10.
g) The aspects of didactic resources used by the two online Natural Sciences courses need to include examples, obtaining a value of 9/10.
h) Regarding the cognitive effort required by the activities of the 14 educational multimedia applications, they need to consider analysis and synthesis, searching for and evaluating information, divergent thinking, activities that promote planning, organization, and evaluation processes, problem solving and hypotheses, and exploration and experimentation activities, obtaining a value of 5.71/10.
i) Regarding the cognitive effort required by the activities of the two online courses in Natural Sciences, they need to consider divergent thinking, activities that promote planning, organization and evaluation processes, problem-solving activities and hypothesis formulation, exploration and experimentation activities, obtaining a value of 7.14/10.

Finally, Figures 7 and 8 show the tabulated and graphed results that are clear regarding the previous analysis.

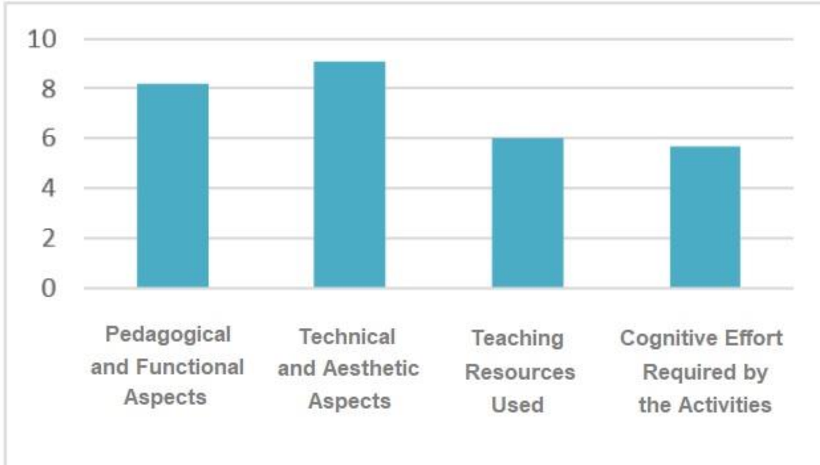

Figure 7. Evaluation of results of the 14 educational multimedia applications.

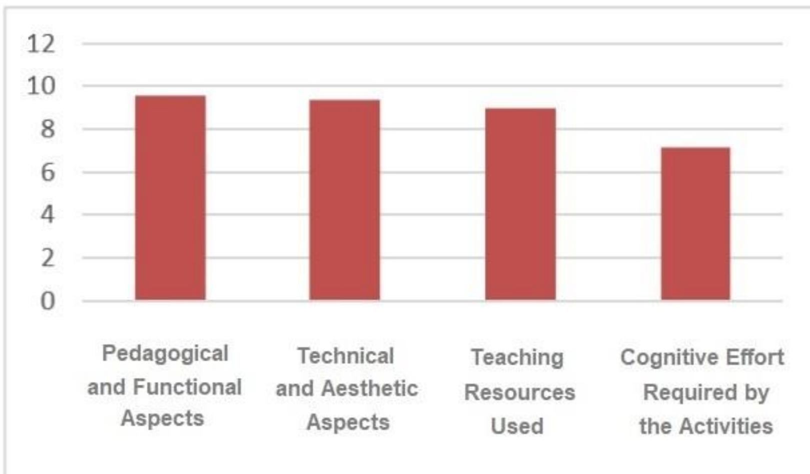

Figure 8. Evaluation of results of the two online courses of Natural Sciences.

CONCLUSIONS AND FUTURE WORK

This research used the Moodle platform to design, implement, and evaluate 14 educational multimedia applications and 2 online Natural Sciences courses. To achieve this, we used the OOHDM method to create interactive learning activities for the 14 educational multimedia applications, the learning objects, the navigational model, and the conceptual design of the 2 online courses. In addition, we applied the ADDIE methodology to the instructional design of all educational software applications. We conducted the tests with 564 students enrolled in three public schools and one private, as well as with 16 teachers from these schools. The results show the satisfaction of the students and professors regarding the organization of the contents and activities of the 14 educational multimedia applications and the two online courses of Natural Sciences. In addition to contemplating their usefulness, the use of practical cases, the use of audiovisual media, the use of group dynamics, the duration, the material used and all with a favorable general perception. For these reasons, these 14 educational multimedia applications and these 2 online courses in Natural Sciences allow for improving the conceptual and procedural learning of school students.

As future work, we planned to develop: i) an intelligent learning and inclusion platform to train teachers and students in current issues that allows improving the teaching-learning process and the inclusion of disabled people in this process. ii) Technological software solutions for the development of computational thinking in children and young people that allow them to enter fields of current technologies such as Computing, Programming, Electronics, and Robotics.

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