Diseño instruccional para el desarrollo de contenidos educativos digitales para teléfonos inteligentes

Instructional design for the development of digital educational contents for smartphones

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Palabras clave
Diseño instruccional, teléfono inteligente, estadística

RESUMEN

Este estudio describe el desarrollo de contenidos educativos digitales mediante un diseño instruccional que incorporó elementos audiovisuales para ser consultados con teléfonos inteligentes. La metodología se basó en el enfoque de investigación y desarrollo. La primera etapa consistió en la elaboración de contenidos educativos digitales a través del modelo de diseño instruccional de análisis, diseño, desarrollo, implementación y evaluación (ADDIE), mientras que la segunda exploró si este tipo de desarrollo puede funcionar como herramienta pedagógica de apoyo a un curso formal. Los resultados presentados se derivan del pilotaje realizado con 17 estudiantes de posgrado que cursaban la asignatura de Estadística. Algunos de ellos expresaron que el uso de contenidos educativos digitales es agradable y novedoso; sin embargo, hubo confusión en un procedimiento estadístico. Este estudio concluye sobre el uso moderado de animaciones, el reforzamiento de los aspectos pedagógicos de este tipo de desarrollos y algunas consideraciones contextuales para la consulta. Asimismo, ofrece recomendaciones para optimizar los recursos audiovisuales para proporcionar apoyos pedagógicos en contextos de movilidad.

Keywords
Instructional design, smartphones, statistics

ABSTRACT

This study describes the development of digital educational contents through an instructional design that incorporated audiovisual elements to be consulted by smartphones. The methodology was based on the Research and Development approach. The first stage consisted of the development of digital educational content through the Instructional Design of Analysis, Design, Development, Implementation, and Evaluation (ADDIE) model, while the second part explored whether this type of development can function as a pedagogical tool for support for a formal course. The results presented are derived from the piloting carried out with 17 graduate students who were studying the subject of Statistics. Some students expressed that the use of digital educational content is pleasant and novel; however, there was confusion in a statistical procedure. It concludes on the moderate use of animations, the reinforcement of the pedagogical aspects of this type of developments and some contextual considerations for the consultation. This study offers recommendations for optimizing audiovisual resources to provide pedagogical support in mobility contexts.

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INTRODUCTION

According to the United Nations Educational, Scientific and Cultural Organization (UNESCO, 2013, 2017), the use of information and communication technologies (ICTs) in the field of education has increased in recent years; therefore, access to information has been facilitated and learning opportunities have been provided at any place and time. In the case of intelligent telephones, also known as smartphones, the number of users in the student sector has increased in Mexico (National Institute of Statistics and Geography, 2017, Organista-Sandoval and Serrano-Santoyo, 2014). Given this phenomenon, it is obvious that the technological resource that students possess offers a pedagogical potential that, in some cases, is unknown or underutilized (Organista-Sandoval, McAnally and Lavigne, 2013).

The interest of this research is centered on the description of the process of development of digital educational contents to be consulted as pedagogical tools through smartphones. In this context, the digital educational contents are graphic, textual and audiovisual materials designed to be consulted in portable devices (Aguado, Martínez and Cañete-Sanz, 2015, Chiappe, 2016, Hernández, Ramírez-Martinell and Cassany, 2014). The digital educational contents developed in this study address a topic of the course of Inferential Statistics through an instructional design process, which is described below.

INSTRUCTIONAL DESIGN

An instructional design is a process for planning results, selecting teaching-learning strategies, choosing relevant technologies, identifying educational media and measuring performance (Branch & Kopcha, 2014, Moreno, Contreras, Gómez and Martínez, 2014). This process has been used to produce courses, modules, didactic units, learning objects or any other educational resource to be used in person, online or in mobility contexts (Agudelo, 2009). The production is based on learning theories that support the construction of the learning objectives up to the assessment of their fulfillment (Velarde, Dehesa, López and Márquez, 2017).

This procedure allows detailing the activities related to the design, development, implementation and assessment of training proposals. Resorting to an instructional design model facilitates the work of the agents involved in the production, management and execution of the materials, which should be adapted to the needs of the institution and the students to ensure the quality of learning (Agudelo, 2009; Moreno et al., 2014).

According to Belloch (2013), there are different models of instructional design, among which the analysis, design, development, implementation and Assessment (ADDIE [Spanish acronym]) stand out. It is considered a generic model because its phases are essential in an instructional design; they are interrelated as well as they adapt to the achievement of the instructions (Belloch, 2013, Morales-González, Edel-Navarro and Aguirre-Aguilar, 2014, Moreno et al., 2014, Soto, 2013). Table 1 contains a brief description of the actions in each phase of the ADDIE model.

Table 1. Description of the phases of the ADDIE instructional design model

Phase	Actions
Analysis	Problem definition Project limits examination Students' needs identification Objectives determination
Design	Approach to the strategy for the development of the instructions Definition of the content order Activities Planning Technological resources to be used Assessment forms
Development	Development of contents, activities and assessment forms
Implementation	Piloting of contents Delivering contents to the students Verifying the efficacy and effectiveness of the materials and learning achievement
Assessment	Formative: present during all the previous phases. Verification of achievements and adjustments before the final version Summative: Done at the end of the process. Verifying if the expectations have been reached

Note: Personal development based on Agudelo (2009) and York and Ertmer (2016).

Contreras, Herrera and Ramírez (2009), Elias (2011) and Wang and Shen (2011) suggest guidance principles to develop educational content for portable devices. These authors approach the instructional design through dimensions associated with pedagogical, design and technological elements. For the purposes of this study, we return to the dimensions they use and supplement them with information considered relevant in the literature review associated with the development of digital educational contents (See Table 2).

Table 2. Pedagogical, design and technological elements to develop digital educational contents

Dimension	Elements
Pedagogical	• Multimedia learning theory based on the assumption that people's learning is greater through being exposed to words and images (Mayer, 2011) • Adequate use of audio, texts and animations to avoid saturating the student with information (Clark & Mayer, 2016; Mayer, 2005) • Personalize the communication between the student and the instructor (Ginns, Martín & Marsh, 2013; Mayer, Fennell, Farmer & Campbell, 2004)
Design	• Classification of educational audiovisual materials (Moldovan, Ghergulescu & Muntean, 2014b) • The design esthetics influencing learning disposition (David & Glore, 2010; Correa, 2014) • Design elements to achieve a quality virtual resource: video rsolution, adequate use of typography, contrasting colors, support images, duration (Contreras *et al.*, 2009)
Technological	• Identification of the main characteristics of a smartphone (Gutiérrez-Rentería, Santana-Villegas and Pérez-Ayala, 2017; Vázquez-Cano and Sevillano, 2015) • Special design for most used devices considering the diversity of the operative systems, Access and Internet sped, reduced screen, battery and limited memory (Elias, 2011; Lee & Salman, 2012; Wang & Shen, 2011) • Video encoding in H.264 format, also known as MPEG-4 AVC, since it is the standard video compression format in Internet (Moldovan, Ghergulescu & Muntean, 2014a).

Note: Self development.

SUBJECT CHOSEN TO DEVELOP DIGITAL EDUCATIONAL CONTENTS

Learning statistics implies a degree of difficulty that, at times, can confuse students given the language used, concepts, teachers' teaching methods, students' knowledge or previous skills (Zapata, 2011). The study of order statistics is one of the issues that frequently present procedural and conceptual difficulties (Batanero, 2001), which are the basis of non-parametric methods, a topic of interest since it addresses the digital educational content of this study.

In response to this problem, Batanero and Díaz (2004) propose working with projects chosen by the teacher and the students in which a process enables the student to recognize their context in the statistical problems and, thus, the student approaches the topics with interest. Likewise, Batanero and Borovcnik (2016) mention the important role of technology as a didactic and dynamic support. As these are some of the main problems in learning of statistics, we consider it pertinent to address these aspects in the development of digital educational content.

OBJECTIVES OF THE STUDY

The main objective was to describe the development of digital educational contents based on an instructional design that includes audiovisual elements to be consulted on smartphones. Hence, we propose the following specific objectives:

- Determine the specifications of the instructional design to develop digital educational contents to be viewed on smartphones.
- Identify the advantages and limitations of the incorporation of digital educational contents in a formal course, according to the students' opinion.

METHOD

We consider the research and development approach in two stages. The first consists in elaborating three digital educational contents of inferential statistics through the ADDIE instructional design. The second aims at exploring the extent to which the use of this type of development can function as a pedagogical tool to support a formal course. Next, we describe the procedure corresponding to the instructional design.

Analysis

The topics were chosen according to the needs expressed by the teacher of the course. The objective was to offer didactic and audiovisual support, since the subject resorts to the use of different formulae, solution of data tables and interpretation of results. In the content analysis, we outline the presentation of the topic, concepts, explanation and solution of problems, as well as reviewing which graphic or audiovisual elements are needed to support the understanding of the subject.

Design

We defined the learning objectives and organized the contents provided by the teacher of the subject. First, we designed the structure that digital educational contents should follow based on the analysis of the information provided by the teacher. The structure had a section to present the topic, its usefulness, the solution of a problem, the results and conclusions. Subsequently, we adapted the content to the audio scripts (See Table 3).

Table 3. Script of the audio of the digital educational content for the Wilcoxon non parametric contrast

Scene	Voice	Time	Total time
1	Wilcoxon test	3 sec.	00:03
2	Is a non-parametric contrast with ordinal data measurement scale	6 sec.	00:09
3	It is used for two related samples	4 sec.	00:13
4	The equivalent is not parametric to the t-Student contrast for in-pair data	7 sec	00:20
5	We solve a case	3 sec.	00:23

Note: Self development.

After obtaining the audio script, we developed the first *storyboards* with the support of images found on Google (See Figure 1). The objective was to provide a visual guide on how to handle the graphic elements in developing audiovisual supports (Fernández and Barco, 2009). This allowed us to correct and adapt the information before using the editing programs which, in turn, reduced the animation and edition times.

Duration: 00:06 Total time: 00:40

Audio: "Five students assessed a teacher"

FX: Students appear rapidly one after the other. An assessment list is being drawn and the teacher appears (animation)

Notes:----

Scene 6 of 46

Figure 1. *Storyboard* video for the Wilcoxon non-parametric contrast.

To select colors, we consider the characteristics of the lighting intensity in portable devices, as well as the reflection of the external light in the device.

Hence, we prefer dark colors with white text or vice versa to enhance the contrast on the screen and highlight the information, besides avoiding the use of light colors for the images and text. Lastly, we decided on the color palette shown in Figure 2.

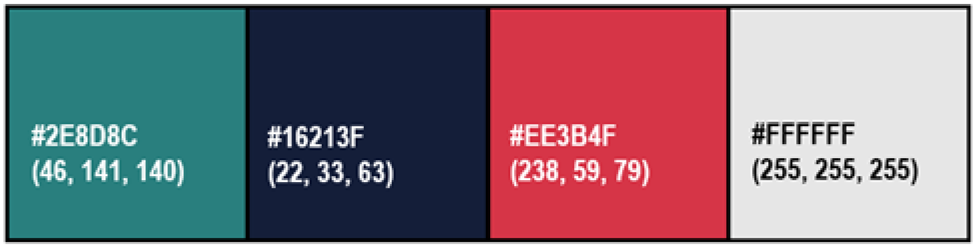


Figure 2. Color palette with hexadecimal and decimal codes.

Typography was another element we considered. We used Microsoft Himalaya which is in the Adobe Creative Cloud programs. Given the versatile range of fonts and based on the professional experience of the designer responsible for the development of graphics for digital educational contents, we chose a font that was easy to read. Microsoft Himalaya is similar to Times New Roman; however, the space between characters is greater and its strokes are more aesthetic, which facilitates reading. For the numbers, we resort to the Arial typeface because it has a common line of Arabic numerals. The color of the text varied according to the type of background in which the text was set or to highlight the presentation of formulae or results.

Development

We use different Adobe Creative Cloud programs to create digital educational contents:

- Adobe Illustrator and Adobe Photoshop, which facilitated the design, editing and composition of the images.
- Adobe After Effects was used to manipulate graphics from their position, scale, rotation, among others.
- Adobe Audition, for volume modulation, edition of audio segments and elimination of environmental noise.
- Adobe Premier Pro, to synchronize animations and audio.
- Adobe Media Encoder, to export the videos in different formats. This program has established values for the export of audiovisual materials depending on the medium or platform for which it is intended.

Implementation

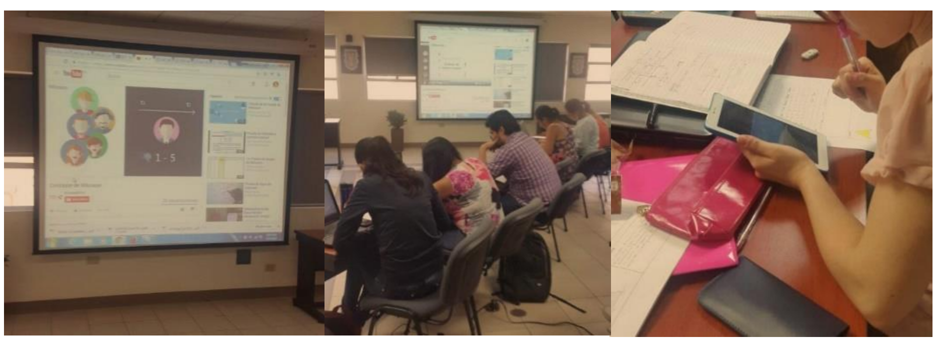
The digital educational contents were presented by means of a pilot program in June 2017 to 17 graduate students who were studying inferential statistics. The contents were distributed through Google Classroom and WhatsApp. First, the teacher of the group sent a notice to the students through Google Classroom, a system that was used regularly for the distribution of the course educational material and tasks. Then the digital educational contents were distributed through a WhatsApp message.

Assessment

We ask graduate students to respond - individually and anonymously - eight open questions referring to their general opinion on digital educational contents. We recovered the assessment of 16 students, since we ruled out a participant who said not having reviewed the material.

The questions formulated aimed at exploring the strengths and weaknesses of the digital educational contents from the user's standpoint. These questions addressed questions about the general opinion of the students, the clarity of the content, the application of what was learned, the access and the visualization of the digital educational contents. They also provided feedback through suggestions and aspects of greater like and dislike.

After the questionnaire, we applied an exercise so the students could solve it with the support of digital educational contents, which they accessed through their portable devices, such as laptop, tablet and smartphones (See photo).



Photography. Resolution of exercise in pilotage of the video of the non-parametric Wilcoxon Test contrast.

Lastly, we asked the general opinion of the students to know the problems they faced while solving the exercise.

RESULTS

As a result of the design, we obtained a 3:23 minute 16.2 Mb video. Figure 3 shows the final design of the scene shown in figure 1 that corresponds to the storyboard of the Wilcoxon non-parametric contrast video.

Figure 3. Final design of a video scene of Wilcoxon non-parametric contrast.

We use an identifier in the upper left screen to remind the student of the topic that is being addressed. Textual indications were shown on the screen to explain the procedures; once the indications are received, the intensity of the color of the text decreases, but it was still visible to avoid the student having to return to a previous point in the video (See Figure 4). The space on the screen was used strategically to show only those data that were needed to continue with the explanation of the topic.

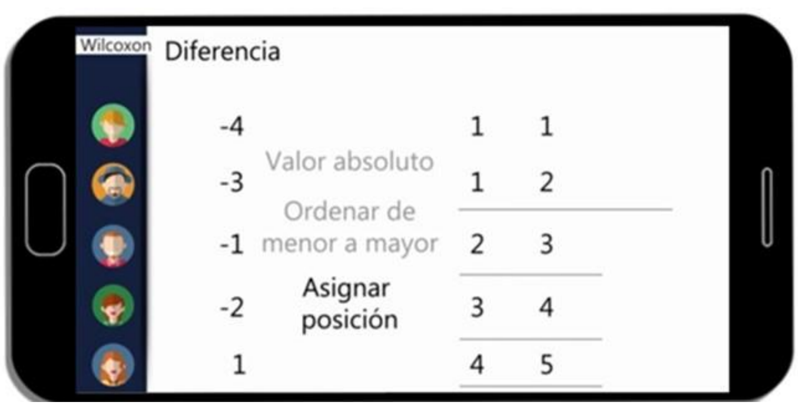


Figure 4. Instructions for the on-screen procedure.

14 of the 16 students accessed the video through their smartphones, one on his laptop and one on his tablet. Table 4 shows the main ideas identified in the students' comments.

Table 4. Students' opinion on the use of digital educational contents

Aspect	Positive	To be improved
Pedagogical	- Didactic support - Interesting - Detailed information - Good information synthesis - Twelve students believed they could solve the exercise with the support of the video - Two students did not experience any difficulty in solving a similar problem	- Explanation not sufficient - Doubts on the statistical purpose of the problem - Dislike given the statistical topic - Lack of knowledge of the statistical language - Three students believed they could not solve the exercise with the support of the video - 14 students had difficulty in understanding and solving part of the procedure
Design	- Like the duration, design, audio, graphs and texts of the video Coherence between the video and the time necessary to explain the topic	- Confusing and rapid animation - Dislike of dark colors - Video too long or too short - Slow voice of the instructor
Technological	- 16 students accessed the material developed	- One student's Smartphone failed - Dislike for the distribution route (WhatsApp)

Note: Personal development.

By means of open questions referring to the likes and dislikes of using digital educational contents, we recovered the main ideas of the students and the number of occurrences (See Figure 5).

Figure 5. Main ideas about the likes and dislikes according to the students' opinión.

DISCUSSION

The students considered the use of digital educational contents as a pedagogical support. Some of them did not know basic mathematical concepts, so they lost the continuity of the explanation. Mayer and Moreno (2002) recommend that students have a first approach to concepts or vocabulary that will be used in audiovisual segments, which will allow them to better understand what is being said. Likewise, there was some confusion about the statistical purpose of the Wilcoxon non-parametric contrast application.

Some students mentioned that they required more examples of the solution of the topic; however, this would complicate issues of the design of digital educational content in terms of length and size. In addition, we assumed that, through the analysis and adequacy of the information, a video was sufficient to explain the topic.

In regard to the design, the students considered the digital educational contents as an attractive and dynamic pedagogical support; this has been addressed in several studies (Berney & Bétrancourt, 2016, Bétrancourt, 2005, Lowe, 2003, Mayer and Moreno, 2002). However, the students were confused by the use of quick animations in a part of the video. Besides Mayer's proposal (2005) to avoid saturating the student with texts and simultaneous animations, in this study, we propose avoiding the saturation of animations, and use only the necessary ones and give the students sufficient time to visualize them on the screen.

Another relevant aspect of the design was to find discrepancies in the opinions of the students regarding the voice of the instructor. Some students mentioned that instructor's voice was slow and rendered the video less dynamic, while others pointed out that it was fast and pleasant. Similarly, there were pros and cons in regard to the length of the video.

Some students mentioned that the time to explain the subject was too short; other students said that the audiovisual support was extensive.

Of 16 students, 12 believed they could solve an exercise similar to the one presented in the video; it seems that using digital educational contents would provide students with a motivational support to learn. This is consistent with the information found in the literature (Correa, 2014, David and Glore, 2010) on the aesthetic component of design and its impact on the perception of users in terms of the information presented to them and the learning disposition.

On the technological elements, we found that the failures of one student's device hindered his access to the digital educational content. This problem highlights the need to offer the student a design that can be adapted to any other device, as well as to facilitate other ways to distribute the materials.

CONCLUSIONS

Designing digital educational contents for smartphones requires pedagogical, design and technological specifications duly assessed and structured. Although students value the attractive design of this type of resources, it is necessary to pay attention to its pedagogical usefulness, analyze and adapt the information in order to transmit it in short periods. Moreover, ensure that the texts being displayed capture the most relevant information in order to avoid saturating the screen with very long or difficult to read texts, as well as use graphics that support what the instructor has shown in the video audio, paying attention to the size, color and type of letter.

To develop the contents, we considered the strategic use of animations to present the information; nevertheless, we conclude that the movements of the text in the animation can confuse the students: hence, it is recommended to use only those necessary to support the explanation.

Likewise, it has been emphasized that this type of development is for the student's personal consultation, since a collective consultation can generate auditory distractors if it is visualized simultaneously in a room without the use of headphones (See photograph).

Lastly, we conclude that smartphones offer great pedagogical potential, which portability features provide opportunities to access educational resources. The digital educational contents described in this study provide information that can be used in a timely manner, because students can access it through portable devices anytime, anywhere.

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