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RESEARCH ARTICLE

Multimedia Instructional Unit for the Approach of Statistical Topics in the High School Diploma for Adults Program Using the eXeLearning Technological Tool

Unidad didáctica multimedia para el abordaje de los temas de estadística en la modalidad de bachillerato por madurez utilizando la herramienta tecnológica eXeLearning

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Summary

In Costa Rica, before 2016 the subject of statistics was not included in the national high school tests in Mathematics. As of 2016, the test, consisting of 60 items, includes 9 statistical items. On the other hand, teachers in their lessons usually use traditional expository methods, mediated by the use of a blackboard and printed materials. In this context, a need to create and implement new teaching techniques in this area was evident, for which a Multimedia Instructional Unit in Statistics was developed and applied through the eXeLearning technological tool. The instructional unit was applied to a group of 30 students belonging to the high school diploma for adults program from the region of Turrialba in Costa Rica. We used a qualitative, interpretive and naturalistic method based on the generation of analysis categories. It was determined that a simple way to show the information and the inclusion of review activities, exemplification, practice and evaluation activities, is desired and well valued by the students. In addition, it was observed that the technological means promoted student interest and motivation, while facilitating the monitoring of the proposed activities and the automatic generation of progress and evaluation reports. It was concluded that the Multimedia Instructional Unit is a didactic complement to the work of the teacher of mathematics, especially in distance education since it allowed self-taught management of the student and achieved their attention and motivation.

Keywords: eXeLearning; Multimedia; Instructional; Statistics; Distance Education.

Resumen

En Costa Rica, antes del 2016 no se incluía el tema de estadística en las pruebas nacionales de bachillerato en la asignatura de Matemática. A partir de 2016, la prueba, compuesta por 60 ítems, incluye 9 ítems de estadística. Por otro lado, los maestros en sus lecciones usualmente utilizan métodos expositivos tradicionales, mediados por el uso de pizarra y materiales impresos. En este contexto, se evidenció la necesidad de crear e implementar nuevas técnicas de enseñanza en esta área, por lo que se elaboró y aplicó mediante la herramienta tecnológica eXeLearning una Unidad Didáctica Multimedia en Estadística. La unidad didáctica se aplicó a un grupo de 30 estudiantes de la modalidad bachillerato por madurez de la región de Turrialba en Costa Rica. Se utilizó un método cualitativo naturalista interpretativo fundamentado en la generación de categorías de análisis. Se determinó que una forma simple de mostrar la información y la inclusión de actividades de repaso, ejemplificación, práctica y evaluación, son deseadas y bien valoradas por los estudiantes. Además, se observó que el medio tecnológico promovió interés y motivación estudiantil, al tiempo que facilitó el seguimiento de las actividades propuestas y la generación automática de reportes de avance y evaluación. Se concluyó que la Unidad Didáctica Multimedia es un complemento didáctico al trabajo del docente de matemática, sobre todo, en la educación a distancia, ya que permitió la gestión autodidacta por parte del estudiante y logró su atención y su motivación.

Palabras clave: eXeLearning; Multimedia; Unidad didáctica; Estadística; Educación a distancia.

Introduction

In Costa Rica, the Ministry of Public Education (MEP) is the governing body of public and private education. Among the modes of study offered, there is the open education program. According to MEP (2016), open education "is an educational alternative where the applicant chooses his mode of study according to his time availability, and advances in his education according to his possibilities" (p.1). In addition, this mode of study includes the *Bachillerato por Madurez* (High School Diploma for Adults) program, which is designed for people over 18 who want to complete their high school education by passing the national high school diploma exams on different subjects.

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The High School Diploma for Adults program offers training opportunities, but the student has to make a great effort as he needs to organize and distribute his time to fulfill his different responsibilities and undertake a self-learning process. Dedicating oneself exclusively to study and having the support of a teacher is not usually possible, so the student may need instructional materials that guide him in the learning process and, at the same time, that awakens his motivation to learn. The State of Education (2015) indicates that the "care of minors, domestic work and work obligations affect the attendance and permanence of students" (p.249) of legal age in the formal education systems, and that when they drop out, they become deprived of appropriate means to continue their studies autonomously; therefore, it is necessary to have instructional materials that help manage the students' own learning.

Furthermore, despite the fact that the MEP (2012) affirms that currently, there is a need for people who are "capable of understanding, interpreting and using information to understand reality, solve different problems and make intelligent decisions" (p.55), and recognizes mathematics and statistics as part of such required training. Before 2016, statistics was not included in the national high school diploma exams on Mathematics. Thus, from 2016, the 60-item exam includes 9 items on statistics. That is, statistics went from having no presence in the exam to accounting for 15% of the whole exam.

In an interview conducted by Ruiz (2016) with Lilliam Mora, director of Quality Management and Evaluation of the MEP, it was confirmed that the percentage of passers of the national High School Diploma for Adults exam on Mathematics that took place in April 2016 was 31.96%. Mora explained that in the last fifteen years, the percentage of passers of the High School Diploma for Adults exam on Mathematics in Costa Rica is between 28% and 35%. The students of the High School Diploma for Adults pass the program if they earn an exam grade higher than 70, but, according to Mora, it is common for the MEP to apply a confidence interval of 10 points, and for students to pass the exam with a grade of at least 60.

The problem of the independent status of the students of the High School Diploma for Adults program, including the lack of formal learning guidance, in addition to the recent inclusion of statistics in the national high school diploma exams on Mathematics, and the low passing rate, suggests the need to consider how these students are preparing themselves, and justifies the interest in designing, applying and evaluating a Multimedia Instructional Unit, with the purpose of creating a resource that helps these students to self-learn statistics.

Alfaro, Alpízar, and Chávez (2012) point out that, in Costa Rica, teachers tend to use traditional expository methods for the teaching of statistics and probability, mediated using blackboards and printed materials, faced with low student participation, and caused by the lack of economic resources for access to labs or other resources.

Ferro, Martínez, and Otero (2009) indicate that the use of Information and Communication Technologies (ICTs) in teaching and learning motivates, catches attention, and promotes activity and thought, promoting more time spent working and learning through student-computer interaction.

Precisely, one of the recently developed technologies for pedagogical mediation is eXeLearning. According to Saavedra (2011) "it is an open source educational website editing program that is unique for its simplicity of use and the tools it incorporates" (p.24). eXeLearning is a tool for editing pages with multimedia contents such as images, video, audio, animations, mathematical expressions, among others. In addition, several studies have determined that this tool: (a) facilitates and improves learning, both theoretical and practical, changing the traditional teaching scheme by making students to be the main actor in the training process, giving them autonomy and the opportunity to develop their creativity, their ability to organize (Chao, 2014; Ulloque, 2016; Henoa & Gonzales, 2014), and (b) reduces costs because it is a free software,

while its multiple functionalities allow easy use, attractive visualization, integration of multiple resources, modification, and updating (Mora, 2010).

Thus, due to the interest in creating an instructional proposal that would provide a solution to the identified problem through a research process, the self-learning management qualities of eXeLearning were taken into account. A study was developed with the objective of designing a Multimedia Instructional Unit to carry out pedagogical mediation with statistical contents such as measures of position, measures of variability and representations for the analysis of statistical information; a Multimedia Instructional Unit to facilitate self-learning, to awaken student interest in studying statistics and, in turn, to manage time according to the specific needs of each student.

Additionally, the design was assessed through its implementation in a group of 30 students from the region of Turrialba in Costa Rica who were chosen for convenience, were enrolled in the High School Diploma for Adults program during the 2017 second call, lacked the necessary time to opt for other on-campus educational programs, and had basic computer and Internet access knowledge. The actions and perceptions of the students were analyzed through interviews and observation in a study session using the Multimedia Instructional Unit developed.

According to Rodríguez and Chacón (2008), a multimedia material is made up of various ways of presenting and processing information (text, images, video, audio, and interactivity), and according to Marques (2011), an educational multimedia material uses all of that for teaching and learning purposes. In order to develop a multimedia material, Belloch (2000) points out that a series of phases is needed, namely: "Analysis, Program Design, Program Development, Program Experimentation and Validation, Development of the final version of the program, Development of the supplementary material" (pp. 5-6).

Therefore, the design process of the Multimedia Instructional Unit using eXeLearning was carried out in five stages or phases. The first one, the diagnostic phase, in which the required characteristics of the Multimedia Instructional Unit were determined by consulting theoretical references and background, and the opinion of experts and students of the High School Diploma for Adults program. In the second phase, a Multimedia Instructional Unit was developed taking into consideration the results of the previous phase. In the third phase, the proposal was validated, supporting it on the judgment of mathematics teaching experts with wide experience in teaching. In the fourth stage, the proposed instructional unit was implemented in students of the high school diploma for adults program with the purpose of carrying out assessments and actions for improvement. In the fifth phase, the initial proposal was reviewed and adapted taking into account the recommendations and comments of both experts and students.

The entire process was carried out taking into account aspects of the Instructional Analysis proposed by Rico (2016), as a general theoretical framework, and specific contributions from Saavedra (2011), Rodríguez and Chacón (2008), and Batanero, Godino, Green, Holmes, and Vallecillos (2009).

The required characteristics of multimedia material, especially material for distance education where there is asynchrony between transmitter and receiver, are mentioned as follows: (a) be available to students; (b) organize the content by blocks, allowing non-linear reading, interactivity, and freedom, but ensuring the overall achievement of the learning objectives; (c) include activities of acquisition, application, and evaluation of knowledge; (d) take advantage of flexibility, inclusion, and accessibility, and consider disadvantages such as cost, connectivity, and training (Saavedra, 2011). Additionally, Rodriguez and Chacón (2008) point out the principles of coherence, redundancy, and signaling to: (a) avoid sensory overload and content repetition; (b) highlight in some way the essential.

According to Rico (2016), instructional analysis is a tool that allows planning, implementing and assessing instructional units, in general and as teachers' main activity, by (a)

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articulating the curriculum organizers: contents, objectives, methodology, and examination, and (b) considering content analysis (selection and organization), cognitive analysis (expectations and activities), instructional analysis (materials and resources), and examination analysis (achievement of expectations).

Strictly speaking about statistics teaching and learning, Batanero, Godino, Green, Holmes, and Vallecillos (2009) point out the common errors and difficulties students may have and the teacher needs to anticipate during planning, among them: (a) extrapolation of application contexts; (b) superficial data reading; (c) wrong choice of mode of representation, and (d) incomplete interpretation of mean, median, and standard deviation.

Method

We used a qualitative, interpretive, naturalistic method to generate analysis categories, deductively based on the theoretical framework of instructional analysis and other references, and inductively based on our findings. This made it possible to identify the required characteristics of the Multimedia Instructional Unit, to develop a preliminary proposal, to validate it by expert judgment, and after implementing it in a group of students, to assess it taking into account their opinions, and to improve it based on the information collected through semi-structured interviews, observation, and focal group. Precisely, this corresponded to the five phases of the method, already mentioned, and to the objectives of the study.

Analysis Categories

With the objective of developing the preliminary proposal and interpreting the results of its implementation and assessment, we developed four analysis categories based on the Instructional Analysis proposed by Rico (2016) and the contributions given by Saavedra (2011), Rodríguez and Chacón (2008), Batanero, Godino, Green, Holmes and Vallecillos (2009), and others.

Category 1: Teacher Planning

This category is defined as the instructional planning the teacher needs to carry out. In this sense, Picado (2006) understands it as a "teacher´s task to guide the mediation between the curriculum established in the study programs and the student. The teacher organizes and structures in this task the elements of instructional planning (objectives, contents, strategies, etc.) to achieve true learning" (p.217).

The four components proposed by Rico (2016) were taken into account as analysis subcategories: content analysis, cognitive analysis, instructional analysis, and performance analysis.

The contents analysis includes the units of meaning corresponding to the identification, selection, and organization of the concepts and procedures used in the development of the Multimedia Instructional Unit. The cognitive analysis includes the units of meaning proving that students have problems to learn statistics. Furthermore, the instructional analysis analyzes how the activities used in the Instructional Unit are selected, designed and sequenced, taking into account the materials and resources used for pedagogical mediation. Finally, the performance analysis analyzes whether the examination activities and tools have achieved the learning expectations in such a way that they fulfill their functionality effectively.

Category 2: Including the elements of an Interactive Instructional Unit

This category covers the inclusion of elements of an Instructional Unit. In that regard, Corrales (2009) indicates that

> it is important to consider that learning needs to be programmed, in the sense that in order to approach learning, it is necessary to set objectives and contents, design development and examination activities, and anticipate the necessary resources. The instructional units, whatever the structure they adopt, are structured around a series of elements that define such units (Corrales, 2009, p.7).

The elements proposed by Saavedra (2011): (a) tools for the acquisition of new knowledge, (b) activities for the application of what has been learned through significant experiences, and (c) assessment tests for the verification of the acquired knowledge, were taken as analysis subcategories.

Category 3: Complying with the principles to follow in the development of a multimedia instructional unit

This analysis category refers to the compliance with the fundamental standards or ideas that are required to be followed for the development of a Multimedia Instructional Unit.

The principles proposed by Rodríguez and Chacón (2008): (a) coherence principle, (b) redundancy principle, and (c) signaling principle, were taken as analysis subcategories. The coherence principle analyzes the use of sounds and images employed in the Instructional Unit developed, according to the students' opinion. The redundancy principle analyzes the students' opinion on the presentation of information in relation to the presence of redundancy. And the signaling principle analyzes the students' perception of the aspect and way of presentation of the multimedia contents of the Instructional Unit.

Category 4: Describing the strengths, limitations, errors, and difficulties of students

This analysis category analyzes the strengths, limitations, errors, and difficulties of the students in applying the Instructional Unit.

Saldaña, Escartín, Peña, Jiménez, Ceja, Rey, Vidal and Rodríguez (2014) define strengths as "forms of behavior, thoughts, and emotions that are associated with an optimal performance" (p.1). The strengths that are considered that the Multimedia Instructional Unit helps students develop were taken as an analysis subcategory. According to Argüís, Pilar, Bolsas, Hernández and Salvador (2012), among the main strengths are: curiosity, open-mindedness, love of learning, perseverance, vitality, and hope. Table 1 shows the concepts of each strength.

Table 1.
Concept of the main strengths that can be developed thanks to the use of the Multimedia Instructional Unit.

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Strength	Concept
Curiosity (interest in the world, novelty-seeking, openness to experiences).	Taking an interest in what is going on in the world; finding fascinating topics; exploring and discovering new things.
Open-mindedness (judgment, critical thinking).	Thinking things through and examining all their meanings and nuances; not jumping to conclusions, but evaluate each possibility; being able to change one's mind in light of evidence; weighing all evidence fairly.
Love of Learning	Mastering new skills, topics, and bodies of knowledge, whether on one's own or through formal learning. It is obviously related to the strength of curiosity, but goes beyond it to describe the tendency to add systematically to what one knows.
Perseverance (tenacity, diligence, industriousness)	Finishing what one starts; persisting in a course of action in spite of obstacles; taking pleasure in tasks undertaken and successfully completed.
Vitality (zest, enthusiasm, vigor, energy)	Approaching life with excitement and energy; doing things with conviction and giving the best of oneself; living life as an exciting adventure; feeling alive and active.
Hope (optimism, future-mindedness)	Expecting the best in the future and working to achieve it; believing that a good future is something that is in our hands to achieve.

Source: Author. Based on Argüís, Pilar, Bolsas, Hernández and Salvador (2012).

Furthermore, Godino, Batanero and Font (2003) establish that a mistake is made "when the student carries out an activity (action, argumentation, etc.) that is not valid from the point of view of the school mathematics institution" (p.69). Likewise, Godino et al. (2003) define difficulty as "the greater or lesser degree of student success in a task or study subject" (p.69).

Sample

In order to assess the use of the Multimedia Instructional Unit by the students, a sample of 30 students (6 men and 24 women) of the High School Diploma for Adults program in the Turrialba region in Costa Rica was chosen for convenience during the second call in 2017. Ages ranged between 18 and 44, with a mode of 24 (for 16.66 percent) and an average of 27.83.

Data Collection and Systematization

In order to assess the Multimedia Instructional Unit, three data collection techniques were used: semi-structured interview, observation, and focus group.

A semi-structured interview was conducted on the 30 students in the sample in order to assess needs, which allowed the collection of relevant information to be taken into account in the design and development of the Multimedia Instructional Unit. Different types of questions were used (general, opinion, contrast and feeling expression), but in a way that allowed the emergence of new questions and issues.

Also, students were observed in their natural environment and during a study session using the Multimedia Instructional Unit. The student's interest in the use of the tool, motivation, environmental characteristics, time spent in the use of the tool, effective use of the resource, interruptions, among other aspects, were observed.

In addition, a focal group interview was conducted in order to gather opinions regarding the use of the Multimedia Instructional Unit to analyze, later, the information obtained and improve it. The focal group interview was conducted on a group of 10 randomly selected students in the sample. A focal group guide was used for the collection and subsequent systematization of the information. In this sense, the researcher guided the questions relevant to the topic of study while observing and taking notes.

The information gathered was systematized using a Microsoft Office Excel spreadsheet matrix, organized by the previously established analysis categories (deductively), taking into account that another category (inductively) may eventually arise in this stage. Finally, the coded categories were grouped into themes and patterns.

Triangulation

Hernandez, Fernandez, and Baptista (2014) define triangulation in research as the "use of different sources and collection methods." (p.418), adding that "in qualitative research we have greater richness, breadth, and depth of data if they come from different actors in the process, from different sources and by using a greater variety of forms of data collection" (p.439) and, furthermore, supports the validity of the results obtained from the information gathered.

Precisely, the semi-structured interview, observation, and the focus group allowed to gather data in different ways and at different times, and to organize and interpret the information in order to achieve the objectives of the study.

The interview made it possible to identify the required characteristics of the Multimedia Instructional Unit against the theoretical guidelines previously identified. The non-participatory observations – in the natural environment or scenario that the student uses in his daily life and during a study session with the Multimedia Instructional Unit – allowed to determine actions, perceptions, moods, attitudes, conflicts, and other aspects, and check them against what was planned during the design. And the focus group allowed to assess the implementation process globally, identify opinions, recommendations, and considerations that need to be included in a new redesign stage.

Results

According to the objectives of this study, the results cover: (a) a proposal for a Multimedia Instructional Unit, an initial design according to its required characteristics previously identified, and a redesign from the results of the implementation; and (b) an assessment of the Multimedia Instructional Unit, its design and its implementation, by checking them against the students' opinions, and the theoretical references and background considered.

The results suggest that designing and applying a Multimedia Instructional Unit, as a resource for the students of the High School Diploma for Adults program, who are independent, lack learning guidance, and have specific difficulties in learning statistics, not only facilitate self-learning, but motivate and entertain. However, the results also suggest that the qualities of the resource depend to a great extent on its planning and its design by the teacher and in consideration of multiple theoretical, practical and experimental aspects, as suggested by Belloch (2000), in the multimedia material development phases.

Description of the Multimedia Instructional Unit designed

With respect to the organization of the content by blocks, allowing non-linear reading, interactivity, and freedom, but ensuring the global attainment of the learning objectives; the

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inclusion of knowledge acquisition, application, and evaluation activities (Saavedra, 2011); and the structuring of the curriculum organizers: contents, objectives, methodology, and examination (Rico, 2016), the designed Multimedia Instructional Unit has a main menu that includes eight sections: Introduction, Prior Knowledge, Chapter 1, Chapter 2, Chapter 3, Chapter 4, Final Exam, and Bibliographical References. The main menu can be seen in figure 1 above.

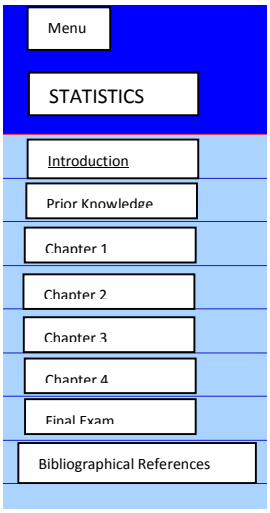

Figure 1. Multimedia Instructional Unit main menu

Specifically on accessibility, and training (Saavedra, 2011), the introduction section includes general aspects that the student needs to consider in order to be able to use the Multimedia Instructional Unit properly.

Specifically on content analysis, its selection, and its organization (Rico, 2016), the Prior Knowledge section gives the student the possibility to study the basic statistical concepts that he needs to know prior to the study of the four chapters indicated.

Specifically, on cognitive analysis, expectations, and activities (Rico, 2016), each one of the four chapters corresponds to a general skill established by the MEP (2017) for the thematic area of Statistics of the educational level:

> *Skill* 1. To assess the importance of summary measures (position) for the analysis of the statistical information, in addition to using position measures to summarize and analyze the information from a set of quantitative data.
> *Skill* 2. To assess the importance of summary measures (variability) for the analysis of the statistical information, in addition to using the main variability measures to evaluate and compare data dispersion.
> *Skill* 3. To use different representations to analyze the position and the variability of a data set.
> *Skill* 4. To analyze the importance of using relative measures of central tendency and variability within the comparative information analyses.

Each chapter is addressed using the problem-solving approach in order for the student to be able to cover the contents and carry out the activities without teacher participation. In addition, with respect to the structuring of the curriculum organizers: contents, objectives, methodology, and examination (Rico, 2016), each chapter is subdivided into four sections:

> *Concepts*. It includes the theoretical foundations of the statistics topic discussed, through the problem-solving technique. The section begins by providing a problem situation in which a series of questions from the problem situation is presented. Later, the solution to the questions is provided at the same time that the statistical concepts relevant to the presented situation are introduced.

Practice. It offers the possibility of solving guided exercises and problems in such a way that the student has access to clues and suggestions to better understand the statistical concepts studied in the chapter.
Assessment Exercises. Exercises are presented without suggestions. In addition, a grade is earned at the end of the activity.
Solution to the Assessment Exercises. It includes the detailed solution of the assessment exercises through a document in PDF format.

Figure 2 shows a subsection of chapter 1.

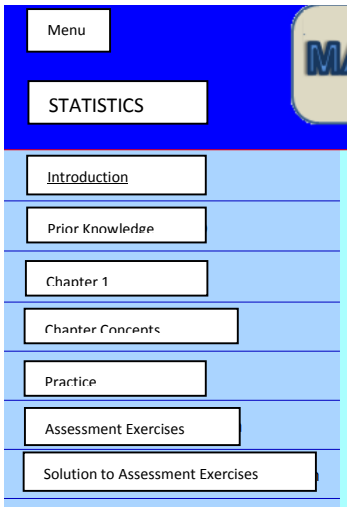

Figure 2. Subsections of Chapter 1 of the Multimedia Instructional Unit

Specifically on evaluation analysis and expectations achievement (Rico, 2016), the Final Exam section, includes exercises and problems relating to all the statistical topics evaluated in the High School Diploma for Adults exam during 2017. The Final Examination is composed of nine items distributed in the four general skills discussed in the four chapters. The student has a time limit of three minutes per item (27 minutes in total) to solve the final exam.

Multimedia Instructional Unit Design and Implementation Assessment

The design and implementation of the Multimedia Instructional Unit were assessment based on the information gathered from student interviews, observations and focus groups and in terms of the established analysis categories.

Teacher Planning

Teacher planning is made up of 4 components, according to Rico (2016): content analysis, cognitive analysis, instructional analysis, and assessment analysis.

With respect to content analysis, the intended skills, according to the assessment agenda of the High School Diploma for Adults Exams on Mathematics taken in the second call of 2017, guided the structure of the contents and related concepts in order to include them in the Multimedia Instructional Unit.

With respect to the cognitive analysis, we identified possible problems in the study of statistics by analyzing theoretical references, background, interviews, and observations, and identifying the learning expectations. It was observed that most of the students did not know the basic concepts of statistics, so it was decided to include the prior knowledge section and its respective assessment instrument. In addition, it was considered that the Multimedia Instructional Unit needs to include clear, specific explanations to address the new contents and to develop the skills. Thus, during the implementation, no problems to understand and apply the statistical

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concepts discussed were observed. The students even indicated that, during the development of the proposed activities, they understood and concentrated, disconnecting from the rest of the world, forgetting their concerns, and describing as "addictive" the fact that once an activity was started, they did not want to stop until it was completed.

With respect to the instructional analysis, the students indicated that the organization of the content of the Multimedia Instructional Unit allowed an attractive interaction, and facilitated access to resources, and to practice and self-assessment activities.

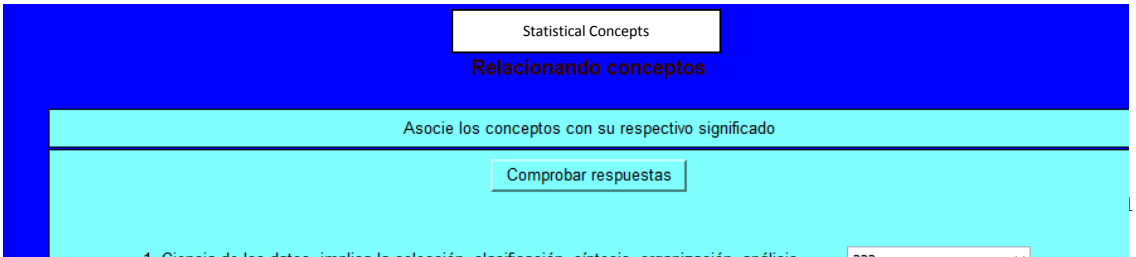
With respect to the assessment analysis, firstly, it was observed that the practice activities help to learn the topic. Based on the signaling principle according to Rodríguez and Chacón (2008), and the possible difficulties to learn statistical concepts as indicated by Batanero, Godino, Green, Holmes and Vallecillos (2009), suggestions guiding the study of concepts were included, in such a way that if, at any time, any doubt arose in solving one of the problems, the student could consult the suggestion and rely on it to clear up his doubt and continue. Secondly, with respect to the mid-term and final evaluation activities, it was observed that the students were motivated after seeing their grades, which were automatically generated and were a reflection of what they had learned. Likewise, a selection of exercises similar to those used in the national High School Diploma for Adults exams was included in order for the student to analyze and solve problems and exercises similar to those he would have in the official exam.

The HotPotatoes software was used to develop the practice and assessment activities as it provides a grade with which the student can measure what he has learned during his study session. In this sense, and as mentioned by Ferro, Martínez and Otero (2009) about the promotion of motivation, attention, activity and thought, encouraging the student to spend more time to work and to learn through the student-computer interaction, the students indicated that that it was excellent that the software gives the answer immediately after answering the question and not once the exam was over, since this allows them to analyze why the answer is wrong and correct it. They also indicated that time goes by very quickly when using the Multimedia Instructional Unit, that they would use the tool any time they had some free time. In addition, they added that the assessment activities give an idea of how much has been learned, which allows us to suggest that the assessment activities and tools awake their motivation and their interest. It was observed that when a student earns a grade lower than 100, he take the whole exam again with the intention of passing.

Including the Elements of an Interactive Instructional Unit

Including the elements of an Interactive Instructional Unit, according to Saavedra (2011), contemplates: (a) tools that help acquire new knowledge; (b) activities that allow applying what has been learned through significant experiences; and (c) evaluation tests that allow verifying the acquired knowledge.

With respect to the tools that help acquire new knowledge, the students indicated that they found it excellent to introduce the topic in the form of a problem situation as this allowed them to understand its real usefulness in everyday life. In addition, activities in which the information was presented in different ways were included, for example, a matching exercise developed using the HotPotatoes software was proposed, where the basic concepts of statistics needed to be matched to their respective meaning (see figure 3).



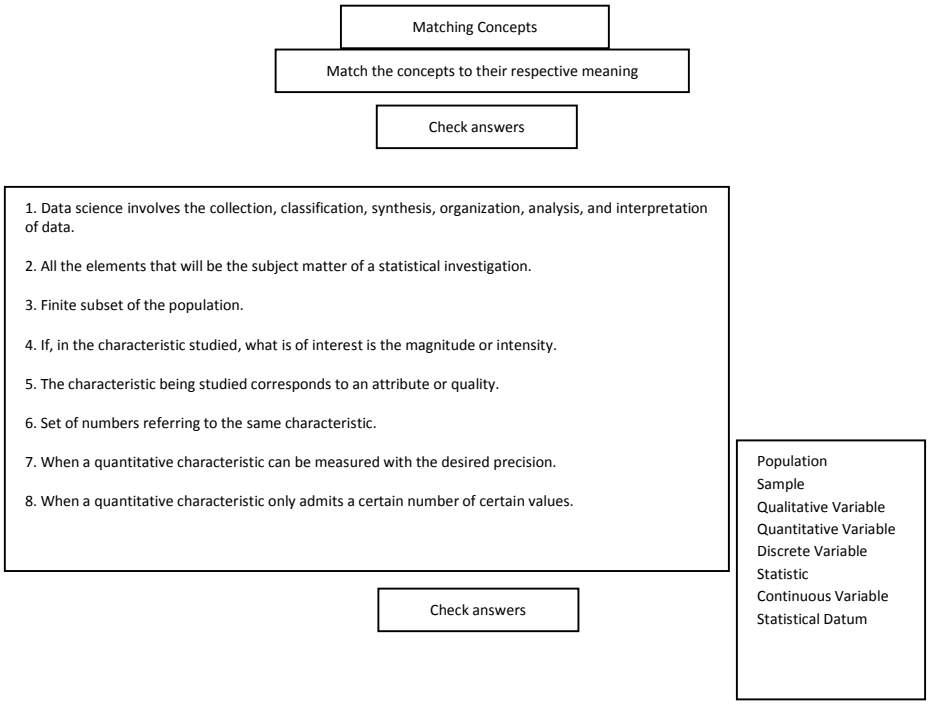


Figure 3. Matching exercise developed using the hotpotatoes software

With respect to the activities that allow applying what has been learned through significant experiences, the Practice sections were included, which exercises were taken from exams previously used by the Ministry of Public Education. In addition, each one included a suggested solution that could be consulted if required. In this sense, the students indicated that these suggestions are an enriching characteristic of the material to help learn the concepts.

With respect to the assessment exams, a final exam was created for each chapter of the Multimedia Instructional Unit. Each one of the assessment activities was prepared using exercises taken from mathematics exams previously used by the Ministry of Public Education in the High School Diploma for Adults Exams. The type of exam used makes it possible to know immediately the score obtained in each question solved, enabling the student to determine if the problem or exercise was solved correctly, or if, on the contrary, he needs to review the relevant concepts to identify a satisfactory solution. The students thought that the assessment by items similar to those used in the high school diploma exams allows approaching the reality they will face and self-assessing regarding the prior knowledge acquired, before advancing with the other contents of the Multimedia Instructional Unit.

One-choice and closed-response items were developed foe both practice and assessment activities. Most of the items proposed were one-choice items as they favored the student-Multimedia Instructional Unit interaction, and the recognition of the type of question presented in the High School Diploma for Adults exam on Mathematics.

Complying with the principles to follow in the development of a multimedia instructional unit

Complying with the three principles to follow in the development of a Multimedia Instructional Unit according to Rodríguez y Chacón (2008), contemplates: (a) coherence principle, (b) redundancy principle, and (c) signaling principle.

With respect to the coherence principle, the use of sounds and images was analyzed. According to the results of the literature review and needs assessment analysis, the use of images

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unrelated to the presentation of the contents was prevented, so that the images and tables presented would be of vital importance for the understanding of the statistical concepts. According to the students' opinion, the use of sound in the video presented in the prior knowledge section was unnecessary, as they pointed out "that there was no need for the sound", which is consistent with the coherence principle established by Rodríguez and Chacón (2008).

With respect to the redundancy principle, given the results of the needs assessment and literature review analysis, the use of any kind of redundancy was prevented in developing the Multimedia Instructional Unit. The students indicated that the language used was simple, easily interpretable, unsaturated with information, very well selected, and specific to the topic.

With regard to signaling, based on the tools compatible with the eXeLearning software, a contextual menu was created on the left side of the screen to guide the student while browsing. Likewise, each section of the side menu included a general instructions section detailing the important aspects the student needed to know in order to be able to develop the respective section without any inconvenience. The students claimed that the Multimedia Instructional Unit is very versatile since it allows quick and fast navigation of each of its sections.

Describing the strengths, limitations, errors, and difficulties of the students

In order to describe the strengths, limitations, errors, and difficulties of the students, both those identified in statistics learning and those presented in the use of the interactive platform developed were taken into account.

With respect to the strengths of the students, curiosity, open-mindedness, love of learning, perseverance, vitality, and hope were identified. Regarding curiosity, the student indicated that the Multimedia Instructional Unit allowed the statistical concepts to be manipulated differently in relation to other study techniques. Regarding open-mindedness, it was observed that the student analyzes the question very well before marking the final answer in order to obtain a satisfactory score in the activity being developed. Likewise, regarding love of learning, the students indicated that the presentation of the contents and the activities helped acquire knowledge and skills in a staggered manner, and that they found it necessary to continue advancing and following the suggested order in order to obtain better results. Regarding perseverance, it was observed that the students who had not been able to earn a grade higher than 70 in the activities solved it again until they succeeded. Furthermore, regarding vitality, even with the different responsibilities of the students (work, family, study, among others), they did the proposed activities with enthusiasm and conviction to learn. Finally, regarding hope, the students were optimistic with the progress in the development of the activities.

With respect to the difficulties of the use of the Multimedia Instructional Unit, one of the limitations presented during its application was a problem of security permissions of the browser in one of the computers. This caused that the information of the assessment activities developed using the Hotpotatoes software was not displayed. However, this difficulty was solved, easily and quickly, by providing the necessary permissions to the browser.

Likewise, with respect to statistics learning, some of the errors made by the students were wrong mathematical calculations. For example, when calculating the arithmetic mean, the students entered the sum of all data into the calculator and at the end included the division by the total amount of data, so the calculator first solved the division of the last datum of the sum with the total data. This error had not been considered among those pointed out by Batanero, Godino, Green, Holmes, and Vallecillos (2009).

Discussion

The main purpose of this study was to develop a Multimedia Instructional Unit on statistics using the technological tool eXeLearning, and apply it in a group of students of the high school diploma for adults program in the region of Turrialba in Costa Rica. This was carried out by identifying the required characteristics of such Multimedia Instructional Unit, by developing a preliminary proposal, by validating the unit using expert judgment, and by implementing the unit in a group of 30 students. The identification of advisable characteristics in the resource was based on theoretical and background review (Rodríguez and Chacón, 2008; Rico, 2016; Corrales, 2009), and checked against a needs assessment and the students' opinions.

It was found that the Unit developed allowed the information to be shown in a simple and practical manner, by taking into account the coherence, redundancy and signaling principles (Rodríguez and Chacón, 2008), and including review, exemplification, practice and assessment activities (Saavedra, 2011). All of this favored self-learning and were positively valued by the students.

It was also observed that the technological means promoted student interest and motivation while facilitating the follow-up of the proposed activities and the automatic generation of progress and assessments reports. This agreed with the research works conducted by Mora (2010), and Ferro, Martínez, and Otero (2009).

In addition, it was found that the Multimedia Instructional Unit developed is an instructional supplement of the work carried by the mathematics teacher with their students, especially in the case of Open Education, since, although it required teacher planning, allows student self-learning management, which agrees with the research works of Belloch (2000), Chao (2014), Ulloque (2016), and Henoa and Gonzales (2014). The results suggest that the usefulness of the resource depends on the planning and design on the part of the teacher, according to his intentions, and including the improvements after each implementation.

Furthermore, new contributions of this study are that the Instructional Unit developed: (a) helped the students with their daily work since the unit allowed them to spend time in other tasks also important to them; (b) enabled the distance education students to understand statistics better and more easily; (c) allows each student to plan his time and advance according to his learning pace since each person advances independently of the advance of others; (d) has all the statistical contents that are examined in the national high school diploma for adults exam on mathematics; therefore, the student does not need to look for information in other sources, and (e) exhibits student strengths such as curiosity, open-mindedness, love of learning, perseverance, vitality, and hope.

Other new contributions of this study are: (a) the HotPotatoes software used for the creation of assessment instruments allows not only to catch student attention and assess the progress of his own learning process, but also has the advantage of grading immediately after answering each question, making it possible to analyze the question again and verify the result; (b) the implementation of a section that includes the answer key of the assessment activities with the detailed procedure to solve the proposed problem situation allows the student to better understand his error in developing the activity; (c) it is convenient that the exercises are similar to the assessment items in order to bring the student as close as possible to the analysis of problems and exercises similar to those that he will have when taking the final exam; (d) it is beneficial that the practices include suggestions and clarifications that guide the study of the concepts and that can be consulted when required; (e) the prior knowledge section allows the student to have the option to consult and make sure that he can advance new topics; (f) the problem-solving approach motivates the student to solve situations that arise in everyday life, and in turn, that serve as a preamble to cover the proposed contents.

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In general, the results suggest that the Multimedia Instructional Unit as a resource for distance education students who have problems due to their independent status, lack of guidance and specific learning difficulties, facilitated self-learning while achieving student attention and motivation.

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