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Objetos de Aprendizaje digital para personas con discapacidad visual en estructuras de datos: grafos (OAGRAF)

Digital Learning Objects for people with visual disabilities in data structures: graphs (OAGRAF)

Objetos de aprendizagem digital para pessoas com deficiência visual em estruturas de dados: gráficos (OAGRAF)

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Resumen

El método ADDIE (integrado por etapas de análisis, diseño, desarrollo, implementación y evaluación) y la propuesta que integra el modelo instruccional de los cuatro componentes (Modelo 4C/ID) en los Objetos de Aprendizaje (OA) para las estructuras de datos (grafos y del algoritmo de recorrido denominado Dijkstra), permiten a la persona con discapacidad visual incorporarse al estudio de la disciplina computacional en educación superior mediante los recursos multimedia. El presente trabajo muestra un prototipo de OA implementado en la plataforma virtual MOODLE, utilizando recursos multimedia y la herramienta de eXeLearning que le permiten a los estudiantes en Ciencias de la Computación identificar los elementos necesarios en el algoritmo de Dijkstra y su aplicación en una alternativa de aprendizaje mediante el uso de la tecnología. Las pruebas de usabilidad en lo referente a la facilidad de uso, identificación de elementos y tipos de grafos, se consideró entre las categorías de *muy bien* y *excelente*. La facilidad de aplicar el algoritmo de Dijkstra obtuvo *bien* en desarrollo del recorrido.

Palabra clave: Dijkstra, discapacidad visual, Moodle, Objetos de Aprendizaje.

Abstract

The ADDIE method integrated by the phases of: analysis, design, development, implementation and evaluation; and the proposal that integrates the instructional model of the four components (Model 4C / ID) in the Learning Objects (OA) for the data structures: graphs and the Dijksta´s algorithm; In addition to using elements that allow the people with visual disabilities to enter the study of computer discipline in higher education through multimedia resources. The work shows a prototype of OA implemented in the MOODLE virtual platform, using multimedia resource and the eXeLearning tool that will allow students in Computer Science, identifying the necessary elements in the Dijkstra algorithm and its application in an alternative of learning through the use of technology. The usability tests in terms of ease of use, identification of elements and types of graphs, were considered between *very good* and *excellent*, and the ease of applying the algorithm of Dijkstra obtained a *good* in the way.

Keywords: Dijkstra, visual disabilities, Moodle, Learning Objects.

Resumo

O método ADDIE (integrado por etapas de análise, design, desenvolvimento, implementação e avaliação) e a proposta que integra o modelo instrucional dos quatro componentes (Modelo 4C / ID) nos Objetos de Aprendizado (LO) para estruturas de dados (gráficos e do algoritmo da rota denominada Dijkstra), permitem à pessoa com incapacidade visual incorporar ao estudo da disciplina computacional na educação superior por meio dos recursos multimídia. O presente trabalho mostra um protótipo de OA implementado na plataforma virtual MOODLE, usando recursos multimídia e a ferramenta eXeLearning que permite aos alunos em Ciência da Computação identificar os elementos necessários no algoritmo Dijkstra e sua aplicação em uma alternativa de aprendendo com o uso da tecnologia. Os testes de usabilidade em termos de facilidade de uso, identificação de elementos e tipos de gráficos foram considerados entre as categorias de muito bom e excelente. A facilidade de aplicação do algoritmo Dijkstra obtido bem no desenvolvimento da rota.

Palavra-chave: Dijkstra, deficiência visual, Moodle, Learning Objects.

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Introduction

For some time, the applications of computer science have had to begin their particular adaptation to be accessible to people with disabilities. The so-called information society is experiencing a technological advance, but this will not materialize without eliminating all physical and technological barriers that hinder the basic access of all individuals, including people who have a disability to the use of technology. In the case of people with disabilities, the technology is applied to meet the objectives of supporting their inclusion in the environment, which is called support technology, but there are several terms that encompass this objective: technology of rehabilitation (Rehabilitation Technology) , assistive technology (Assistive Technology), access technology (Access Technology) and adaptation technology (Adaptative Technology). Any equipment, device, global or partial device, or adapted to a person, that is used to increase or improve functional capacities to individuals with disabilities through support technology, can modify or establish changes for the benefit of their person.

The inclusion of people in the education sector requires policies that allow integrating the population in the center of human development, therefore, the use of information technologies requires studies to strengthen the leadership of the Organization of Nations United for Education, Science and Culture (Unesco), in the following terms:

> From the rights perspective, educational inclusion is a universal concern, seen as a central strategy to address the causes and consequences of school exclusion (UNESCO-OIE 2008). In this sense, the assessment of diversity and its consideration in the design and implementation of the school curriculum, is the starting point to avoid that differences become educational inequalities among students (Valladares M.A, Betancourt M., Norambuena M. 2016, p. 35).

In addition, social and educational exclusion are growing phenomena in all countries of the world and especially worrying in Latin America, which is characterized by being the most inequitable region in the world and having highly segmented societies. The inequalities between and within countries, the uprooting caused by migration or rural exodus, the unequal access to new information technologies and the knowledge society, or the breakdown of traditional solidarities exclude many individuals and groups of the benefits of development and entail a crisis of the social bond (UNESCO, 1996), giving a new importance to cohesion and social justice (Eroles D., Hirmas C., 2009, p.15).

On issues of law and law, in countries such as Venezuela and Mexico, there are legal frameworks that explicitly recognize the rights of persons with disabilities (Silva, A. and Ponce, G., 2014), where they promote equal opportunities, inclusion, the right to education, as well as non-discrimination for people with some type of disability.

Table 1 shows the countries that have legislated in relation to people with disabilities. In some countries you can find more specific laws that have been generated in each of the states, such as Mexico (PNUD-México, 2011).

Tabla 1. Compendio de las leyes existentes en los países de América Latina.

País	Fecha	Nombre
Argentina	16 de marzo de 1981 Última reforma el 12 de enero de 2004	Ley Nº 22431. Sistema de protección integral de los discapacitados Otras normas de discapacidad, que modifican a la Ley N° 22431.
Bolivia	15 de diciembre de 1995	Ley Nº 1678. Ley de la Persona con Discapacidad
Brasil	24 de octubre de 1989 20 de diciembre de 1999	La Ley Nº 7.853 - Sobre el Apoyo a las Personas Portadoras de Deficiencia, y sobre su Integración Social Reglamento de Ley 7.853 que define la Política Nacional para la Integración de las personas portadoras de deficiencia http://portal.mec.gov.br/arquivos/pdf/decreto3298.pdf
Chile	2010	Ley Nº 20.422 – que Establece Normas sobre Igualdad de Oportunidades e Inclusión Social de Personas con Discapacidad
Colombia	11 de febrero de 1997 Última reforma 13 de julio de 2009	Ley Nº 361 por la cual se establecen mecanismos de integración social de las personas con limitación http://www.inci.gov.co/apc-aa-files/1bf6f0f413a6bcd8c53fc02b1507b997/ley_361_de_1997.pdf Ley 1316 por medio del cual se reforma Ley 361 de 1997 http://www.elabedul.net/Documentos/Leyes/2009/Ley_1316.pdf Otras disposiciones sobre discapacidad en Colombia http://www.icbf.gov.co/transparencia/derechobienestar/1608.html
Costa Rica	18 de abril de 1996 23 de marzo de 1998	Ley Nº 7600 de igualdad de oportunidades para las personas con discapacidad http://www.uned.ac.cr/educacio/documents/LEY7600.pdf Decreto 26831, Reglamento a la Ley 7600 de Igualdad de Oportunidades para las personas con discapacidad http://www.colfar.com/descargas/legislacion/26831_Reglamento_Ley_7600.pdf
Cuba	1996	Resolución Nº 4/96 para la creación el Consejo Nacional para la Atención a las Personas con Discapacidad (CONAPED)
Chile	5 de enero de 1994	Ley Nº 19.284 Establece normas para la plena integración social de personas con discapacidad http://www.ciudadaccesible.cl/images/stories/otros_archivos/ley_19284.pdf

Fuente: PNUD-México, 2011

In Venezuela there are some experiences in the development of technological applications that can contribute positively in the teaching and learning process of people with disabilities, specifically in the visual disability. In 2011, Silva, Hernández and Corrales (2011) published a techno-pedagogical pattern for the development of learning objects aimed at university students with diminished visual capacity. This work included both the interface pattern and the pedagogical pattern of the same.

The aforementioned establishes the basis for the case study, through the OA for students of the

Faculty of Computer Science of the Benemérita Autonomous University of Puebla, considering the Computer Science Engineering (ICC) program, where a line of Disciplinary content extends from the contents of the Methodology of Programming in first semester, Programming I and Assembler in the second, Operating Systems and Programming II in the third and Data Structures and Graphing in the fourth. In the fourth semester of the subject called Data Structure, failure is indicated by 46%, Differential Equations by 35%, Probability and Statistics by 38% and Graphing by 31%.

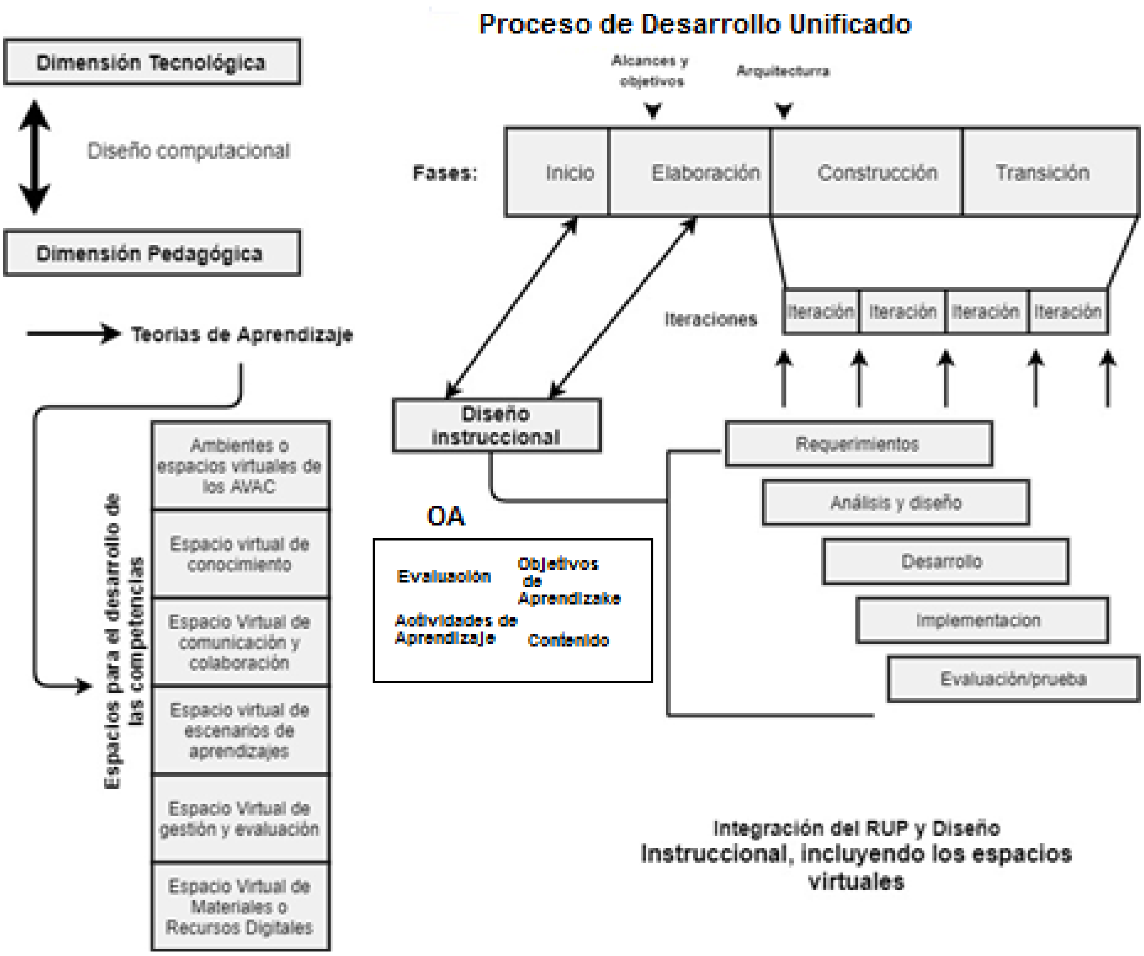
Upon knowing the above data, the importance of including elements for learning to students with visual impairment is identified, applying the multimedia resources contemplated in the methodology called Design of Collaborative Learning Environments (MEDIAVAC), in the content of data structures, in the referring to graphs and Dijkstra algorithm, through digital resources, supported by the Moodle platform, and by the eXeLearning tool.

Materials and methodology

Design of Learning Objects through the MEDIAVAC methodology

The design of learning objects was carried out using the methodology described in the book Design of Collaborative Learning Environments (MEDIAVAC) (Cerón, C., Archundia, E., et al., 2016) (Fig. 1), where the ADDIE instructional design is specified and integrated into the RUP stages for system development and learning scenarios. This methodology allowed to establish the techno-pedagogical design in the following terms: identify the educational intentions (profile, student characteristics, context, etc.), competences to develop, purposes and educational contents, didactic strategies, learning activities, digital resources (images) , audio, video, animations, augmented reality) and evaluation of learning.

Figura 1. Metodología MEDIAVAC.



Fuente: Cerón, C., Archundia E., *et al*., 2016

The MEDIAVAC methodology is contextualized in the study of data structures, which provide the theoretical formal knowledge of logic to handle large amounts of data efficiently and support programming languages. Data structures in the development of quality software are considered a key factor of organization in design or architecture. However, it is appreciated that the failure rate in the fourth semester of the subject is due to the intervention in learning the subject, which forms a disciplinary line of Computer Science. School efficiency must be addressed equally to avoid failure or failure of the subject. The alternative of intervention of learning is suggested through the Technologies of the Information and Communication (TIC), to respond to the needs of knowledge of the current time, in way of propiciar the learning and to avoid raising the index of reprobation in the subject of the ICC program.

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The modality through the ICT facilitates the study of the teaching-learning process with digital didactic resources. Educational institutions have been given the task of creating digital environments built in such a way that each course can be divided into units of knowledge through appropriate resources that explain, guide and motivate the student in order to meet their expectations and their learning needs. , or reinforcement on a specific concept, the LOs have become important with the use of new technologies, motivating students to learn in the case of computer discipline the subject of Data Structures.

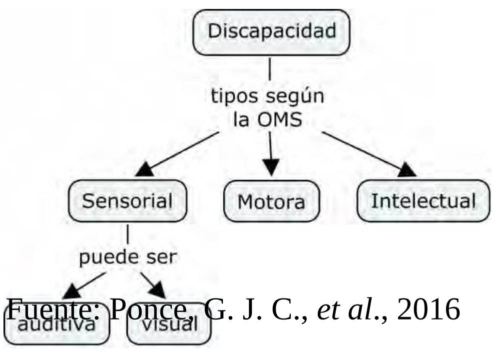
General purpose

The multimedia resource was designed by the OA for people with visual disabilities in the topic of Data Structures: Graphs (OAGraf), for the Moodle Platform.

Theoretical framework

In addition to visual impairment, it is necessary to consider the extent of the contributions made by the World Health Organization (WHO), which published the International Classification of the Functioning of Disability and Health (CIF) in 2001. Figure 2 shows the classification of disabilities in general according to the WHO, where these are divided into sensory, motor and intellectual. In turn, sensory disabilities are subclassified in auditory and visual.

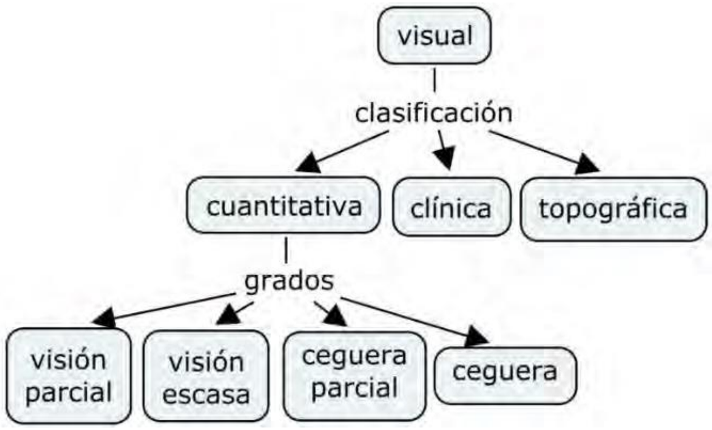
Figura 2. Clasificación de los tipos de discapacidad según la OMS



Fuente: Ponce, G. J. C., *et al.*, 2016

Figure 3 shows the classification of visual disabilities, which is divided into three main factors, which are quantitative (degree of disability), clinical and topographic.

Figura 3. Clasificación de las discapacidades visuales.



Fuente: Ponce, G. J. C., *et al*. (2016)

In Venezuela there are some experiences in the development of applications that can positively contribute to the teaching and learning process of people with disabilities, specifically, in the visual, as it is recognized in the examples presented in Development of Learning Objects Oriented to University Students with Visual Ability Diminished, by Silva, Hernández and Corrales (2011), with the development of a techno-pedagogical pattern.

• Disability and Information and Communication Technologies (ICT)

—Visual disability. Several authors and organizations relate visual impairment and the use of ICT, which is why we focus on support technologies. Alves points out that "ICTs are considered the main support technology applied to the educational resources of students with visual disabilities" (2016, p.148). These technologies can be defined as "computers with programs that allow students to access the digital environment, the promotion of people, social life and inclusive education." (2016, p.148) From this, Alves classifies visual disability in two groups with different characteristics and needs: people with low vision and people with blindness.

- *Low vision people.* They are those in which the visual function has deteriorated, even after optical correction. They use or are able to use their vision to perform tasks. In the field of education, students with low vision have residual vision, which allows them to read the printed material with the help of digital teaching resources and special equipment.

-*Blindness*. Term used to describe the total loss of vision and the conditions on which individuals predominantly depend on substitution / alternative vision skills. In the field of education, a blind student does not use the vision in the learning process, but other senses that allow perception and stimulate their emotions (Cerón, C., Archundia, E., *et al*., 2016, p. 35)

• Alternative and augmentative systems of access to information for people with visual disabilities

Next, the technological elements that allow assistance to people with visual disabilities are mentioned:

- People with low vision have different possibilities to configure the computer screen, so that the texts and icons increase in size, the colors vary according to their needs and to use the maximum contrast between letter and background. They can also use screen magnifiers, which work like magnifying glasses that increase or decrease the screen or parts of it. Also, the operating systems incorporate accessibility options such as sounds, adjust the keyboard in such a way that with alternation keys achieve greater accessibility to a normal keyboard, use the magnifying glass, configure the mouse and customize the screens. Currently, different browsers allow adding extensions for text-speech (voice) conversion and vice versa, such as Chrome Speak and other tools that facilitate navigation.

- Blind people have access to the use of computer resources from the use of different technologies, such as:

a) Screen readers Software installed on a computer. Its objective is to reproduce through a synthetic voice the information shown by the monitor, replacing the use of the keyboard and mouse. They contain functions that allow reading characters, words, paragraphs, complete texts and also allow access to Internet browsers and web pages that have included web accessibility, access to chat and email, and various online applications. Some screen readers, which are more used for their naturalness and free software support, are:

b) NVDA (NonVisual Desktop Access). Free screen reader that allows blind and partially sighted people to use computers. The text is read on the screen with a computerized voice. You can control what you read when placing the cursor, with the mouse or the keyboard arrow keys, in the corresponding area of text. It works under Windows. Allows access to most applications and navigate without difficulties. You can also convert the text to Braille if the user of the computer has a device called a braille line. It is also portable. It is available in *forty-three languages, among which is Spanish. It can be consulted at: https: //www.nvdaproject.*

c) Org or Orca. Free and open source software that has a screen reader and a magnifier. It helps provide access to applications and tools within the Linux environment. It can be downloaded at: https://wiki.gnome.org/Projects/Orca.

d) Braille. The braille system, in ICT, has been represented by devices called braille lines for the entry of information. There are also Braille printers to store information from a computer on paper.

e) Laptops that are including voice synthesizer.

f) Mobile technology. It is impacting the ease of mobile applications (apps) that allow access to information.

• Digital resources for learning

The term OA is attributed to Wayne Hodgins (1992), who was the first to use the metaphor of LEGO to explain the formation of educational materials and their interconnection, in order to facilitate learning. Hodgins defined the OA as any digital resource that can be used to support learning. In this regard, the Standards Committee for Learning Technologies (LTSC), states: "The OA are defined as any entity, digital or non-digital, which can be used, reused or referenced during learning supported by technology "(LTSC (Learning Technology, Standards Committee: 2000-2006).) Most OA definitions agree that their main attributes are: reusability, self-sustainability, scalability, interactivity and interoperability. metadata that contains descriptive information about these objects, which allows their digital cataloging and their reuse in different contexts or platforms (Hodgins, W., 2000, p.34).

Studies of educational research require didactic support to prevent all digital resources from being part of a learning process without the formality of methodologies, therefore the following elements must be integrated (Villarreal, Y., et al., 2016) :

-Content. Type of knowledge addressed by the OA through definitions, explanations, examples and others, using didactic media such as texts, images, audio and video.

— *Learning activities.* Actions designed by the teacher to facilitate student learning, such as problem solving, practical work, discussion forums, and so on.

-*Learning Assessment.* Strategy to make decisions and make judgments about the achievements obtained by the participant at the end of the educational experience.

OAs require theoretical pedagogical formality in their application, therefore the ADDIE method is considered through the five phases of analysis, design, development, implementation and evaluation (Góngora P., et al., 2017, p.350) and the proposal that integrates the instructional model of the four components (Model 4C / ID) and the 10 steps for complex learning, which represent the elements that guide the instructional design process that is suggested to be used for the development of OA digital production (Van Merriënboer, JJ and Kester, L., 2005, p.104) ,. The essential assumption that forms the basis of both the Model 4C / ID and the 10 steps is described by four basic components: learning tasks, support information, procedural information and practice part of the tasks (Table 2).

Tabla 2. Modelo 4C/ID.

Componentes del plan del 4C/ID	**Diez pasos para lograr el aprendizaje complejo**
Tareas de Aprendizaje	1. Diseñar tareas de aprendizaje
	2. Secuenciar clases de tareas
	3. Determinar objetivos de desempeño
Información de Apoyo	4. Diseñar información de apoyo
	5. Analizar estrategias cognitivas
	6. Analizar modelos mentales
Información Procedimental	7. Diseñar información procedimental
	8. Analizar reglas cognitivas
	9. Analizar conocimiento previo o prerequerido
Práctica de parte de las tareas	10. Diseñar prácticas de parte de las tareas

Fuente: Van Merriënboer, J. J. y Kester, L., 2005

• Graph travel concepts

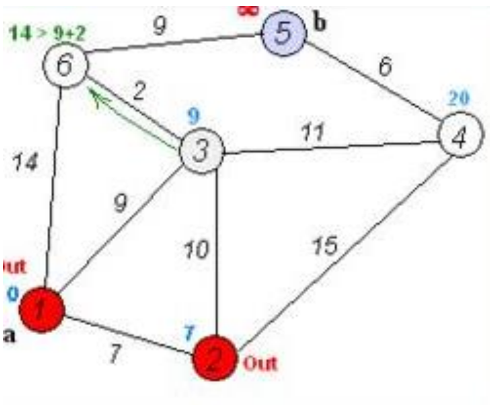
Many transport activities such as order delivery and network distribution are given daily in a city. The city is composed of a group of roads and each has its own meaning. When you want to go from one point to another by the shortest route in search of optimizing resources, it is necessary to solve this question efficiently, which requires interpreting the road network and determining the shortest distances and routes between the different points her. The problem can be approached with different techniques (Restrepo, C. and Sánchez, C., 2004, p.122).

An important application of graph theory is applied in the field of computer science, since it has served for the resolution of important and complex algorithms. A clear example is the Dijkstra algorithm, used for the determination of the shortest path in the path of a graph with data of weights in its vertices.

• Representation and route of graphs

The Dijkstra algorithm, also called the minimal path algorithm (Fig. 4), is an algorithm for determining the shortest path, given a vertex origin to the rest of the vertices in a graph with weights in each edge. Its name refers to Edsger Dijkstra, who described it for the first time in 1959 (EcuRed, 2017).

Figura 4. Representación de un grafo para encontrar el camino más corto mediante el algoritmo de Dijkstra



Fuente: https://www.ecured.cu/Algoritmo_de_Dijkstra

• Stages of the ADDIE Model for OAGraf

-Analysis OAGraf. This phase allows to identify the information prior to the design of the LO.

a) Identification of the problem or learning needs. Currently, for a computer student it is essential to know the different data structures, as well as how they work. However, since it is an extensive subject in most courses, the graph part is not reached. Therefore, we can see that students have deficiencies in this knowledge. The development of OA will provide information to reinforce the knowledge of the students.

-Determination of competence and subcompetences of the study of data structures in the Computer Science Engineering (ICC) program.

a) *Competences Design and implement* OA for the Data Structure called OAGraf. The student will apply the theory of graphs in the solution of problems in computing.

b) Subcompetences. Analyze the elements and types of graphs in solving computer problems. Model the solution of computer problems through graph theory.

— *Analysis of the application context.* The understanding and mastery of the data structure, especially for students of programming in the ICC, is considered in the creation of algorithms that generate efficient execution times. Also in the area of Software Engineering, since through the good design of a graph the optimal path can be found by applying graph algorithms for the construction of roads or bus lines in which the path will be the most suitable for users. users

-Analysis of the student profile and its context.

a) *Prerequisites* established in the program of the Data Structures subject. Knowledge of the control structure and its application in problems. Techniques and tools for solving problems through algorithms. Knowledge of the different ways of solving a problem to choose the most appropriate through structured and object-oriented programming languages. It is convenient to have knowledge in the use of matrices.

b) Characteristics of the group. Students of Computer Science or some similar area that use graph theory. It can also be directed to teachers in the area. It is expected that the main users are students of Higher Education.

• Design (OAGraf)

Designing an OA of the data structure called graphs to encourage students to learn and impact the failure rate in the matter of Data Structures requires the instructional design of the course contents in the subject of graphs. The content of the Module I of graphs is integrated in the following way:

Module I. Graphs

Identify the basic concepts for the analysis, design and programming of graphs, as well as their application in the context of real life.

Topic 1.1 Concepts and classification of graphs

1.1.1. Frame and introduction

1.1.2. Graph conceptualization

1.1.3. Classification of graphs

1.1.4. Types of graphs

1.1.5. Graph paths Dijkstra

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• Multimedia resources

The use of multimedia resources (text, audio, video, images and simulators) in learning the application of the graph data structure, is done through eXeLearning, which was incorporated into Moodle (SCROM) as a repository for teachers in the creation and publication of didactic contents through computer supports (CD, USB sticks, on the web), without having to apply the knowledge in Adobe Dreamweaver HTML, XML or HTML5.

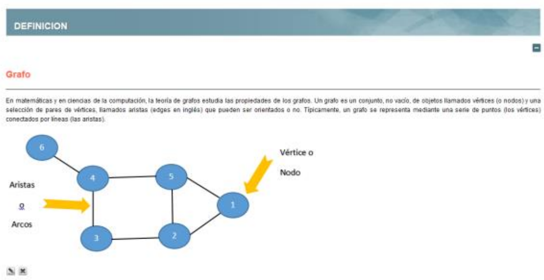
Results and discussion of OAGraf development and implementation

The development and implementation was done with the SCORM content (from the Sharable Content Object Reference Model) in the Moodle Platform (Moodle.org, 2017) for the learning activities. The exeLearning tool was used, indicated in the content of module I. The presentation of the graph structure (Fig. 5) and the elements that make up the graph are shown below. (Exelearning.net, 2017) (Fig. 6).

Figura 5. Presentación de la estructura de datos grafos.

Fuente: elaboración propia de los autores.

Figura 6. Identificación de los elementos grafos



Fuente: elaboración propia de los autores.

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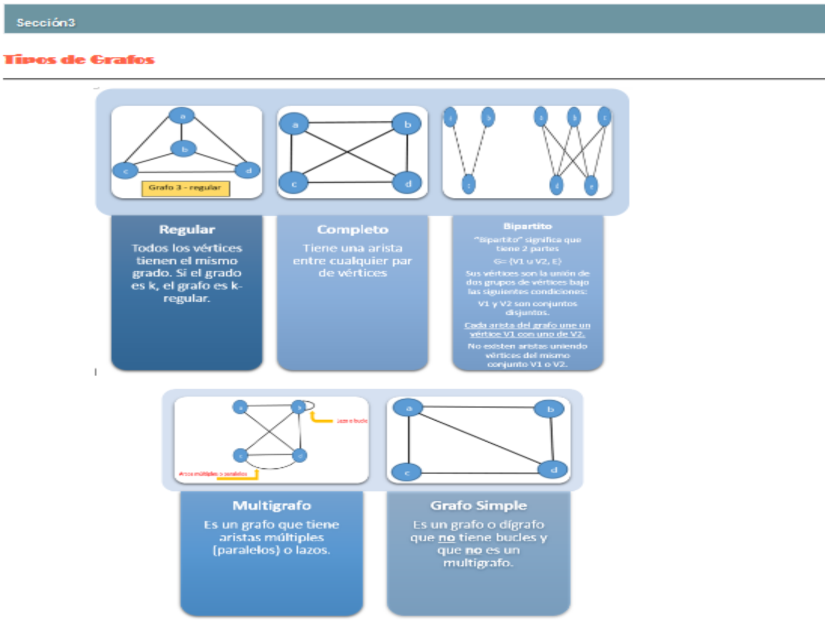
In module I the types of graphs are studied: regular, complete, bipartite, multigraph and simple graph (Fig. 7).

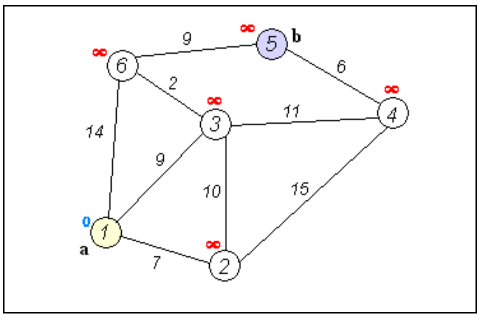
Figura 7. Presentación de los tipos de grafos.



Fuente: elaboración propia de los autores.

Figure 8 shows the Dijkstra algorithm to find the shortest path between two vertices, with weight in its edges.

Figura 8. Presentación del algoritmo Dijkstra.



El algoritmo de Dijkstra determina la ruta más corta desde un nodo origen hacia los demás nodos para ello es requerido como entrada un grafo cuyas aristas posean pesos.

Fuente: https://en.wikipedia.org/wiki/Dijkstra%27s_algorithm

OAGraf evaluation

The functionality of the OA is evaluated by asking the users (visual impairment) to identify the elements that make up a graph and the routes. At the end they are asked to answer the following:

- Ease of use of the Interface (visual).
- Ease to identify the elements of a graph: nodes and edges.
- Ease to identify the elements of the types of graphs.
- Ease to apply the route algorithm (Dijkstra).

Results of usability tests

The two users of the ICC provided feedback to identify the weak points of the OA. Both people thought that the OA expresses in an easy way a graph and could create elements without problems (nodes and edges). Neither of them had problems understanding and understanding the algorithm's paths. Weakness comes in applying the Dijkstra algorithms.

Tabla 3.

Criterio de evaluación	Usuario 1	Usuario 2
Facilidad de uso de la interfaz	5	5
Facilidad para identificar elementos (nodos, aristas, etcétera)	5	5
Facilidad para identificar los tipos de datos	4	3
Facilidad para aplicar el algoritmo de recorrido Dijkstra	3	3

Escala de likert
5.- Excelente
4.- Muy bien
3. -Bien
2.- Regular
1.- Mal

Elaboración: propia de la autoras.

Conclusion

In the elaboration of the multimedia resources for OAGraf, the following conclusions are obtained:

The instructional model allowed structuring the backbone of the OA. In this case, the MEDIAVAC methodology was followed, achieving an orderly procedure, according to the characteristics and components of the OAGraf.

The development of OAGraf is a strategy in which students can develop activities in an asynchronous and synchronous manner, with the ability to build their own knowledge. At the same time, it is a clear example of the incorporation of ICTs, by facilitating the use of interactive multimedia tools, providing the student with an approach to learning through information technologies.

Taking into account the feedback of the users, as future work is intended to develop more content of the data structures: stacks, tails, linked lists, trees, the path to the width, to the deep, generate the minimum extension tree with Prim and Kruskal, to integrate them into a Massive Open On-line Course *(*MOOC).

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References

Alves, C.C.F., Monteiro, G.B.M., Rabello, S., Gasparetto, M.E.R.F., y Carvalho, K.M. (2016). Assistive technology applied to education of students with visual impairment. En *Revista Panam Salud Pública*, *26*(2), 148–152.

Cerón, C., Archundia, E., *et al.* (Eds.). (2016). *Avances en Tecnologías Interactivas Aplicadas a la Discapacidad*. Puebla: Dirección Fomento Editorial BUAP.

"Compendio de Legislación sobre Discapacidad, Marco Internacional, Interamericano y de América Latina [PNUD-México]". (2011). Recuperado de: http://www.laredIberoamericana.com/wp-content/uploads/2012/07/Compendio-leyesdiscapacidad-en-AmL.pdf.

EcuRed. (2017). *Algoritmo de Dijkstra*. Recuperado de: https://www.ecured.cu/Algoritmo_de_Dijkstra.

Eroles D., Hirmas C. (2009). Experiencias educativas de segunda oportunidad. Lecciones desde la práctica innovadora en América Latina, Santiago, Chile: Ediciones de la UNESCO y la OEI, p. 15.

Exelearning.net, (2017). "Los recursos elaborados con eXeLearning pueden exportarse en diferentes formatos: IMS, SCORM 1.2, SCORM 2004, ePub3, HTML5... También como páginas web navegables…". Recuperado de: http://exelearning.net/.

Góngora, P. y Martínez, L. O. (2012). Del diseño instruccional al diseño de aprendizaje con aplicación de las tecnologías. Teoría de la Educación. Educación y Cultura en la Sociedad de la Información. En. Sistema de Información Científica Redalyc . *13*(3), 342-360. Recuperado de: http://www.redalyc.org/articulo.oa?id=201024652016.

Hodgins, W. (2000). *Into The Future*. *A Vision Paper*. Recuperado de: http://www.learnativity.com/download/MP7.PDF.

LTSC (Learning Technology Standards Committee: 2000-2006. Recuperado de http://ieeeltsc.org

Martínez, R. y Quiroga, E. (2002). *Estructuras de datos, referencia práctica con orientación a objetos*. México: Thompson Learning.

Moodle.org (2017). Moodle es una plataforma de aprendizaje diseñada para proporcionarle a educadores, administradores y estudiantes un sistema integrado único, robusto y seguro para crear ambientes de aprendizaje. Recuperado de: https://moodle.org.

Ponce, G. J. C., *et al*. (2016). Avances en Tecnologías Interactivas Aplicadas a la Discapacidad. En Muñoz, A. J., Rojano, C. J. R., Archundia, S. E. (Eds.) La Educación Inclusiva en Latinoamérica. Puebla: Dirección de Fomento Editorial BUAP.

Restrepo, C. J. y Sánchez, C. J. (2004). Aplicación de la teoría de grafos y el algoritmo de Dijkstra para determinar las distancias y las rutas más cortas en una ciudad. En *Scientia Et Technica*, *X*(26), 121-126.

Roldán, A. (2017). *Desde un punto de vista intuitivo un grafo es un conjunto de nodos unidos por un conjunto de arcos*. Recuperado de: http://www.ciberaula.com/articulo/grafos.

Silva, A. y Ponce, J. (2014). RbraiLe: OER Based on Intelligent Rules for Reading Braille. En *Revista Vínculos: Ciencia, Tecnología y Sociedad*, *11* (2) p. 18.

Silva, A., Hernández, Y., y Corrales M. (2011). Patrón Tecno-pedagógico para el Desarrollo de Objetos de Aprendizaje Orientados a Estudiantes Universitarios con Capacidad Visual Disminuida. En *Docencia Universitaria*, *12*(1), 55.

Sisa, A. J. y Muñoz, J. V. (2002). *Estructuras de datos y algoritmos: con énfasis en programación orientada a objetos.* Prentice Hall .Bogotá.

UNESCO (1996). La educación encierra un tesoro. Informe de la UNESCO de la Comisión Internacional sobre la educación para el siglo XXI, presidida por Jacques Delors. Paris: Ediciones de la UNESCO.

UNESCO-OIE (2008). La educación inclusiva en América Latina y el Caribe, Un análisis exploratorio de los informes nacionales presentados a la conferencia internacional de educación: Ediciones de la UNESCO.

Valladares M.A, Betancourt M., Norambuena M. (2016). Educación Especial e Inclusión Educativa: Currículum e inclusión educativa de estudiantes con discapacidad en América Latina, Organización de las Naciones Unidas para la Educación, la Ciencia y la Cultura, París, Francia y la Oficina Regional de Educación para América Latina y el Caribe, OREALC/UNESCO Santiago, con el apoyo del Ministerio de Educación, Cultura y Deporte de España: Ediciones de la UNESCO, cap. 1, p. 35

Van Merriënboer, J. J. y Kester, L. (2005). The four-component instructional design model: Multimedia principles in environments for complex learning. En Mayer R. E. (Ed.) The Cambridge handbook of multimedia learning, USA.

Villarreal, Y., Morales, M., Béliz, N., González, E., Gómez, B., y López, V. (2016). Objetos de Aprendizaje. En *El Tecnológico*, *26*(1), 18-19. Recuperado de: http://revistas.utp.ac.pa/index.php/el-tecnologico/article/view/376.

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