Revista Iberoamericana para la Investigación y el Desarrollo Educativo
ISSN 2007 - 7467

Instrumento de evaluación para materiales didácticos digitales de apoyo al proceso de enseñanza-aprendizaje de tipos de datos abstractos

Evaluation instrument for digital teaching materials to support the teaching-learning process of abstract data types

Instrumento de avaliação de materiais didáticos digitais para apoiar o processo de ensino-aprendizagem de tipos de dados abstratos

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Resumen

En este artículo se presenta una serie de materiales didácticos digitales que fueron desarrollados como *applets* en el lenguaje de programación Java para reforzar los conocimientos sobre tipos de datos abstractos (TDA), los cuales fueron tratados en cursos de estructuras de datos de licenciaturas en computación y carreras afines. Los materiales didácticos que se describen en este artículo se ajustan a escenarios de la vida real, lo cual resulta determinante como estrategia de aprendizaje, y fueron valorados por alumnos de dos licenciaturas de la Universidad Autónoma Metropolitana, Unidad Cuajimalpa (UAM-C), mediante un instrumento que se enfocó en aspectos de diseño estético, funcionalidad y utilidad. En tal sentido, se puede indicar que los resultados obtenidos son alentadores, ya que la mayoría de los participantes considera que los recursos son adecuados y muy adecuados. De hecho, más del 85% de los entrevistados cree que facilitan la comprensión, el aprendizaje y el reforzamiento del tema de tipos de datos abstractos.

Palabras clave: estructura de datos, experiencia docente, instrumento de evaluación, material didáctico digital, tipo de dato abstracto.

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Abstract

This paper presents a series of digital teaching materials that were developed as applets in the Java programming language to reinforce the knowledge about abstract data types (ADT), which were covered in courses of data structures of computer science and related undergraduate degrees. The teaching materials that are described in this paper are adjusted to real-life scenarios, which is a determining factor as a learning strategy, and were assessed by students of two undergraduate degrees from the Autonomous Metropolitan University, Cuajimalpa Campus (UAM-C), through an instrument that focused on aspects of aesthetic design, functionality and utility. In this sense, it can be pointed out that the results obtained are encouraging, since most of the participants consider that the resources are adequate and very adequate. In fact, more than 85% of respondents believe that they facilitate comprehension, learning and reinforcement of the abstract data types topic.

Keywords: data structure, teaching experience, evaluation instrument, digital teaching material, abstract data type.

Resumo

Este artigo apresenta uma série de materiais didáticos digitais que foram desenvolvidos como applets na linguagem de programação Java para reforçar o conhecimento sobre tipos de dados abstratos (ADT), que foram tratados em cursos de estruturas de dados de graus computacionais. carreiras relacionadas. Materiais de ensino descrito neste artigo cenários ajuste da vida real, o que é decisivo como uma estratégia de aprendizagem, e foram classificados por alunos de dois graus na Universidade Autônoma Metropolitana, Unidade Cuajimalpa (UAM-C) por um instrumento que se concentrava em aspectos de design estético, funcionalidade e utilidade. Nesse sentido, pode-se indicar que os resultados obtidos são animadores, pois a maioria dos participantes considera que os recursos são adequados e muito adequados. De fato, mais de 85% dos entrevistados acreditam que eles facilitam a compreensão, o aprendizado e o reforço do tema dos tipos de dados abstratos.

Palavras-chave: estrutura de dados, experiência de ensino, instrumento de avaliação, material didático digital, tipo de dados abstrato.

Fecha Recepción: Agosto 2018 **Fecha Aceptación:** Enero 2019

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ISSN 2007 - 7467

Introduction

Computer programming is a fundamental skill that must be developed by students of any degree in computer or related career, for which you must start with the mastery of the contents taught in subjects related to structured programming and data structures. .

However, in the specific case of the curriculum of the degree in Information Technologies and Systems (LTSI) of the Autonomous Metropolitan University, Cuajimalpa Unit (UAM-C) (2018a), these subjects are called Structured Programming (UAM-). C, 2018b) and Data Structure (UAM-C, 2018c), which are studied in the second and third quarter, respectively, of the twelve that make up the syllabus of the aforementioned bachelor's degree.

The first teaching-learning unit (UEA), as the subjects are called in this house of studies, seeks to equip students with the basic principles of computer programming, such as problem solving, the concept and the formulation of algorithms, simple data types, variable and constant handling, arithmetic and logical expressions, input / output operations, procedures and functions, parameter passing, program flow control structures, among other topics . On the other hand, the UEA Data Structure addresses issues related to the design of abstract data types (TDA) and their operations, linear data structures in static and dynamic memory, implementation of TDA (lists, stacks, queues), structures of non-linear data (trees and graphs), ordering algorithms, recursion, search algorithms, etc.

Given the great importance of the knowledge and skills that students must acquire in these subjects, which are fundamental in their academic formation, it is necessary that teachers use various pedagogical resources to support the teaching-learning processes. For this reason, this article presents a series of digital teaching materials, which were developed specifically to reinforce the knowledge on the subject of abstract data types of the UEA Data Structure. The details of the design and implementation of the teaching materials can be consulted in García-Mendoza, Ruiz-Mendoza, Real-Flores, Jaimez-González and Villatoro-Tello (2015), which were made by students of the LTSI of the UAM-C , in the context of a project carried out in a thematic laboratory of the aforementioned degree. Likewise, a detailed explanation of the thematic laboratories, their objectives and scope, as well as an academic experience of their driving can be reviewed in Jaimez-González y Luna-Ramírez (2016).

Specifically, this article is organized as follows: the first section presents the relevance of the TDA in the course Data Structure, as well as a description of the TDA for which the teaching material was generated. The following section explains the design and operation of the digital teaching materials that were developed, and then offers the assessment tool used to evaluate the resources implemented, as well as the results obtained, the conclusions and future lines of research.

Abstract data types

In computer programming, simple data types are regularly used to store various values, such as whole numbers, real numbers or characters. However, there are times when it is necessary to process collections of more complex values, such as lists of names, ages, temperatures, etc., for which the use of simple data processing can make the task difficult. Therefore, most programming languages include data structures that allow the management of these collections by means of arrays that represent matrices and vectors known as static structures, since the variables that store the values are symbolic addresses of memory positions that represent a static relationship established by the declaration of variables (Joyanes, 2008; Wirth, 1999).

In this sense, and given that it is difficult to know how much memory would be required to solve many problems of life, it is necessary to have methods that allow obtaining additional memory positions when they are required during the execution of the program or releasing them when they have already been vacated. These additional memory positions that are created and available during the execution of a program are known as dynamic variables, which are used to create data structures that can be extended and reduced to measure during the execution of a program. The dynamic variables are classified as linear and non-linear (Joyanes, 2008; Wirth, 1999), and the latter are also known as abstract data types (TDA), that is, a model that has a series of operations defined in that context. model or data set (Aho, Hopcroft and Ullman, 1988). There are several ADTs that are normally covered in a course of data structures, some of which are lists, stacks, tails, circular tails, graphs, among others.

A stack is an ADT that stores elements that can only be added or extracted from its top; a stack is considered a structure of type last in, first out (LIFO for its acronym in English), since the last element to enter the stack is the first to leave, as in a stack of dishes or in a pile from books.

A queue is also an ADT that stores elements and allows access to them by one of its extremes; an element is inserted in the tail by its final part and is extracted from the front; a queue is considered a structure of type first in, first out (FIFO for its acronym in English), since the first element to enter the queue is the first to leave, as it happens in a customer service window in a store or supermarket. A circular queue is also a TDA similar to a queue, but in this structure all of its positions are allowed to be used to store items without needing to move another, so that the final end can be joined to the front end of the item. The tail.

Having explained the above, the following section presents the design and operation of the digital teaching materials that represent some of the TDA mentioned, that is, tail, circular tail and stack.

Design of teaching materials

For the design of teaching materials, analogies with real-life scenarios were considered as a teaching strategy, since relating a new experience with a set of prior knowledge and experiences can increase the possibilities of understanding it. In the words of Díaz Barriga and Hernández (2010), by activating students' prior knowledge, they can determine what they know and act accordingly to promote new learning.

The digital didactic materials that were developed were applets, written in the Java programming language. These are software components that can be run independently or through a web browser. In particular, three applets were developed to represent the following TDAs: the queue, the circular queue and the stack. Below, some screenshots are shown and the scenarios used for each TDA are described, although it is worth noting that the details of the design, implementation and operation of them can be consulted in García-Mendoza *et al.* (2015).

In the design of the didactic material to illustrate the TDA queue, a party hall, some gift boxes, as well as a person who wrapped and opened them were used as main elements. In this scenario, there is a certain number of empty gift boxes, which are filled as the person wrapping the gifts passes, in order of the box on the right to the box on the left. The gifts are wrapped as the person passes, who can also open them; however, each time a gift is opened, the box in which it was found is unusable because in real life the box and its envelope normally break. This situation reflects that it is not possible to reuse memory spaces in a queue.

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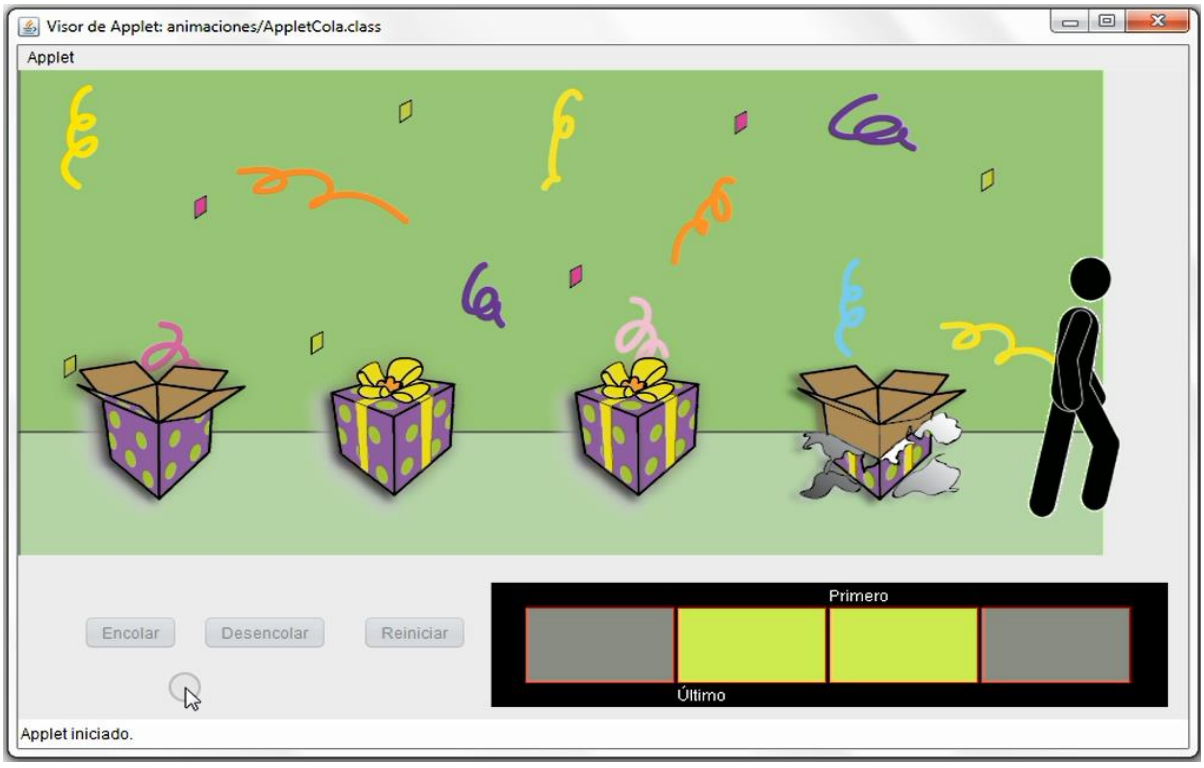
In this context, several states arise through which a gift box passes: a) when the box is new and empty, that is, no gift has been wrapped in the box; b) when the box is full, that is, the gift has already been wrapped in the box, and c) when the box has been opened to take out the gift and becomes unusable, that is, it can no longer be reused to pack another gift due to the ruptures of the envelope and the box.

These phases through which the gift box goes coincide precisely with the way in which memory spaces function when inserting (gluing) and extracting (undoing) elements of a TDA queue: a) the empty gift box represents a space of available memory in the queue, b) the full gift box constitutes a memory space occupied in the queue, that is, an element that has been glued, and c) the open gift box symbolizes a memory space that has been vacated in the queue, that is, an item that has been undocked and, therefore, can not be reused.

Figure 1 shows a screenshot of the TDA applet queue being executed. In that image a tail is observed that has already been created with four spaces in memory represented by the four gift boxes that are initially empty.

Figura 1. *Applet* del TDA cola en ejecución con cuatro cajas de regalo



Fuente: Elaboración propia

In figure 1 it can be seen that the student, when interacting with the applet, coiled three elements in the queue and uncoiled an element (images of the gift boxes): the first memory space has been uncaged (open gift box that it is on the right), the next two memory spaces have glued elements (full gift boxes), and the last memory space is still empty (empty gift box).

The person who appears walking is the one who glued and uncoils elements in the queue (wrapping gift boxes and opening gift boxes) according to the interaction the student performs with the applet through the glue and undo buttons.

As additional support for the understanding of the functioning of the TDA queue, the representation of the elements in memory is shown in the lower right part of the applet, a traditional form used in textbooks of data structures, where the gray squares symbolize the positions of empty memory (empty boxes), while the yellow boxes constitute the full memory locations (filled boxes), which matches what is shown in the upper part of the applet. Finally, the first and last element of the queue is also indicated in the memory representation.

In the design of the didactic material to illustrate the TDA circular queue, the main elements were a waiting room for a medical office, the chairs that are inside the waiting room and the patients who are arriving to be attended. In this scenario, there are a certain number of chairs in the waiting room of the doctor's office, which are occupied as patients enter from the nearest door to the office to the farthest. Every time a patient enters the doctor's office that chair is released, which can be reused later by another patient who comes to consultation, which did not happen in the previous scene, where the open gift boxes were unusable because they broke when opening them

This new illustration, logically, originates three different states: a) when the chair is empty; b) when the chair is occupied by a patient, and c) when the chair has been vacated because the patient entered the office. These stages through which the chair passes coincide exactly with the way in which memory spaces function when inserting (gluing) and extracting (undoing) elements of a TDA circular tail: a) the empty chair represents an empty memory space in the circular queue; b) the patient sitting in the chair constitutes a memory space full in the circular queue, that is, an element that has been glued, and c) the chair unoccupied by a patient symbolizes a memory space that has been vacated in the circular queue , that is, an element that has been undocked and that, unlike the previous case, can be reused.

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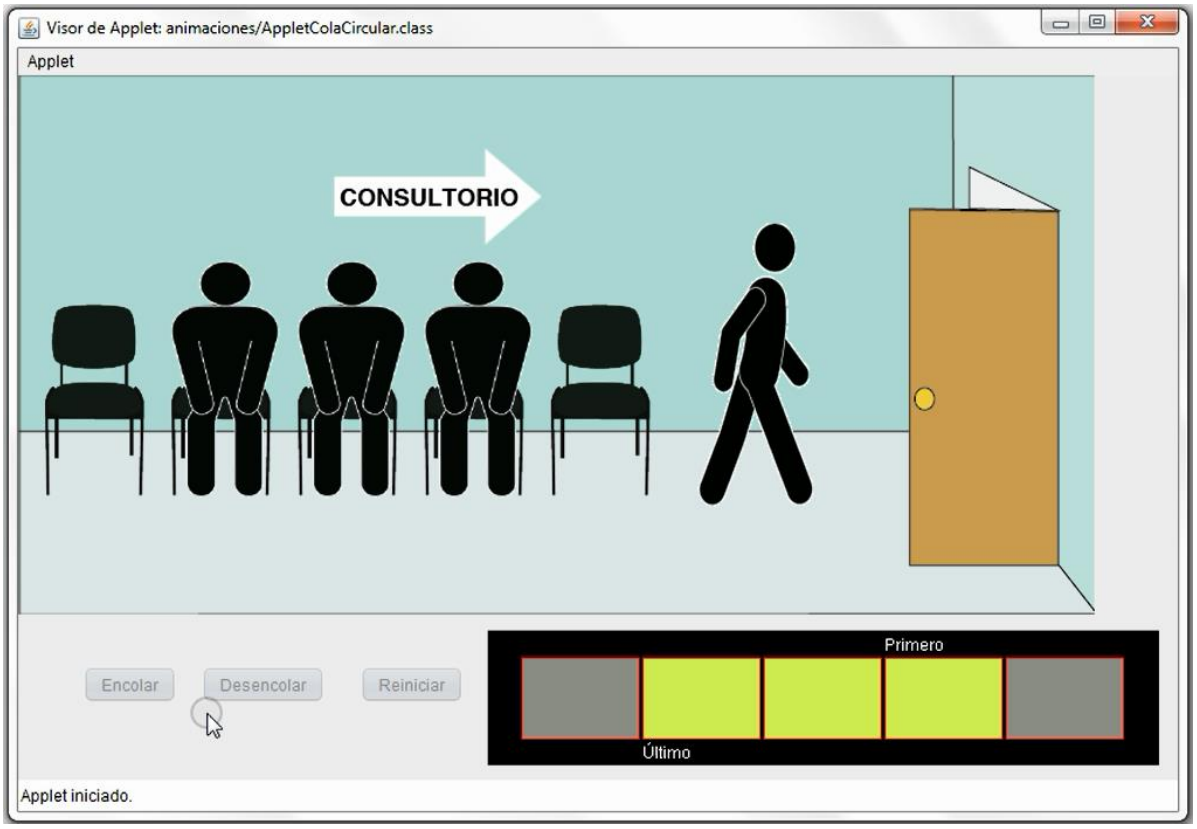
Figure 2 shows a screen capture of the TDA applet circular queue being executed. This image shows a circular tail that has been created with five memory spaces represented by the five chairs, which are initially empty.

Figura 2. *Applet* del TDA cola circular en ejecución con cinco sillas



Fuente: Elaboración propia

In figure 2 it can be noticed that the student, when interacting with the applet, encoló four elements in the tail and desencoló an element, as it is appraised in the images of the chairs: the first space of memory has been desencolado (the patient is vacating the chair to enter the office), the next three memory spaces have glued elements (patients occupying three chairs) and the last memory space is still empty (unoccupied chair). The person who appears walking is the one who has just been lifted from the first chair (item that has been undocked), this due to the interaction that the student performs with the applet, in this case through the undock button.

As additional support for the understanding of the operation of the TDA circular queue, the representation of the elements in memory is shown in the lower right part of the applet, where the

gray squares represent the empty memory positions (empty chairs), while the yellow squares represent the empty memory positions. they symbolize the full memory positions (occupied chairs), which coincides with what is shown at the top of the applet. Finally, the first and last elements of the circular queue are also indicated in the memory representation.

In the design of the didactic material to illustrate the TDA pile, the main elements used were a warehouse, some wooden boxes and a crane that is responsible for moving the boxes from one place to another to stack them. In this scenario, there are a certain number of wooden boxes in the hold, which are taken one by one to group them. The crane is able to place a wooden box to stack it, as well as take a box from the pile to remove it and move it to another place. This situation reflects that it is possible to reuse memory spaces in a stack, since a box can be placed or removed from the stack as many times as necessary.

In this context, the states through which a wooden box passes represent its placement in the pile (push operation of the pile) and its removal from the pile (pop operation of the pile), which is done by the arm of the crane. Each place where a wooden box is located constitutes a memory space of the pile, which can be reused taking into account that only the last element placed in the pile is the one that can be removed.

Figure 3 shows a screenshot of the TDA applet stack being in execution. In this image we can see a stack that has been created with five spaces in memory, which are initially empty when the stack has been created. In addition, it can be noticed that the student, when interacting with the applet, stacked four elements in the stack, as can be seen in the images of the wooden boxes: the upper memory space has not been occupied yet, while the following four memory spaces have stacked items (wooden boxes). The arm of the crane that appears is the one that has just stacked the fourth box in the stack (push operation of a stack), this due to the interaction that the student performs with the applet, in this case through the button *push*.

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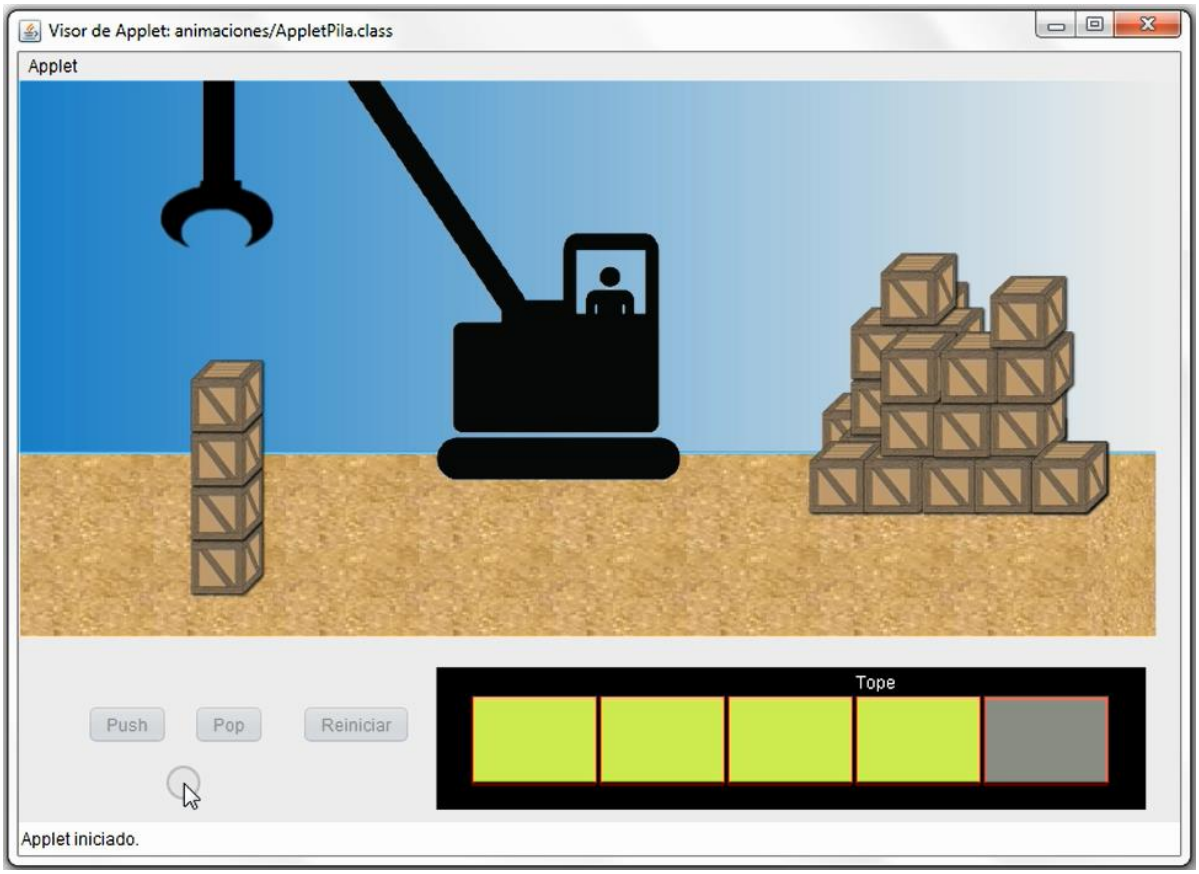
Figura 3. *Applet* del TDA pila en ejecución con cuatro cajas apiladas



Fuente: Elaboración propia

As an additional support for the understanding of the operation of the TDA stack, in the lower right part of the applet the representation of the elements in memory is shown, where the gray squares symbolize the empty memory positions, while the yellow squares constitute the memory positions full (stacked boxes), which matches what is shown at the top of the applet. Finally, the top of the stack is also indicated in the memory representation.

Evaluation instrument

The digital didactic materials presented in this chapter are in the category of digital content (Aguilar, Ayala, Lugo and Zarco, 2014), since it includes educational resources that offer diverse content, activities or evaluations related to any area of the digital content. knowledge, whether curricular or non-curricular. It also groups tools that focus on teacher or student training, as well as reference and reference materials, among others. These types of resources are characterized by

providing structured information and providing a certain degree of interactivity through simulation. These, in addition, can be consulted through a web browser or through various storage media, such as CD-ROM, DVD, among others.

Given that with these didactic materials an attempt was made to reinforce concepts of abstract data types in undergraduate students, the recipients or target population were the students of computer degrees or related careers. In particular, the sample population was composed of students from the LTSI and the Bachelor's Degree in Computer Engineering (LIC), both from the UAM-C. As the only requirement to participate in the evaluation, the students must have previously studied the UEA Structured Programming. The selection of the sample corresponded to the group of students enrolled in the UEA Data Structure in the spring quarter of 2017. The final sample was constituted by 26 students: 6 women and 20 men, all students of the LTSI and the LIC.

In order to evaluate the didactic material developed, an instrument was created to estimate the following aspects: aesthetic design, functionality and utility. The evaluation scale used was the following: a) very adequate, b) adequate, c) not very adequate, and d) not adequate (table 1). It should be noted that the instrument was applied in class once the subject of abstract data types had ended.

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Tabla 1. Instrumento de evaluación

Diseño estético
1. ¿Considera que es adecuada la organización de la información en la interfaz? ( ) Muy adecuado ( ) Adecuado ( ) Poco adecuado ( ) Nada adecuado
2. ¿Considera que son adecuados los botones y ventanas que se despliegan? ( ) Muy adecuado ( ) Adecuado ( ) Poco adecuado ( ) Nada adecuado
3. ¿Considera que son adecuados los colores utilizados? ( ) Muy adecuado ( ) Adecuado ( ) Poco adecuado ( ) Nada adecuado
4. ¿Considera que son adecuados el tamaño y el tipo de letra utilizados? ( ) Muy adecuado ( ) Adecuado ( ) Poco adecuado ( ) Nada adecuado
5. ¿Considera que son adecuadas las imágenes utilizadas en las animaciones? ( ) Muy adecuado ( ) Adecuado ( ) Poco adecuado ( ) Nada adecuado
6. Escriba uno o varios adjetivos que relacione con las imágenes:
7. ¿Considera que es adecuada la interfaz en general? ( ) Muy adecuado ( ) Adecuado ( ) Poco adecuado ( ) Nada adecuado
Funcionalidad
8. ¿Considera que son adecuadas las instrucciones dadas para el uso del material didáctico? ( ) Muy adecuado ( ) Adecuado ( ) Poco adecuado ( ) Nada adecuado
9. ¿Considera que es adecuada la secuencia de acciones en cada una de las animaciones? ( ) Muy adecuado ( ) Adecuado ( ) Poco adecuado ( ) Nada adecuado
10. ¿Considera que son adecuados los mensajes de error que se muestran? ( ) Muy adecuado ( ) Adecuado ( ) Poco adecuado ( ) Nada adecuado
11. ¿Considera que el material didáctico es de fácil manejo? ( ) Sí ( ) No
Utilidad
12. ¿Considera que el material didáctico es adecuado para la comprensión del tema de TDA? ( ) Muy adecuado ( ) Adecuado ( ) Poco adecuado ( ) Nada adecuado
13. ¿Considera que el material didáctico es adecuado para el aprendizaje del tema de TDA? ( ) Muy adecuado ( ) Adecuado ( ) Poco adecuado ( ) Nada adecuado
14. ¿Considera que el material didáctico ha reforzado su conocimiento sobre los TDA? ( ) Sí ( ) No
15. ¿Considera que es adecuado el uso de las metáforas gráficas utilizadas en el material didáctico? ( ) Muy adecuado ( ) Adecuado ( ) Poco adecuado ( ) Nada adecuado
16. Nos interesa su opinión sobre el material didáctico presentado, por lo que agradecemos cualquier comentario o sugerencia adicional.

Fuente: Elaboración propia

Results

In this section the results obtained from the evaluation of the didactic material described above are presented. Due to space constraints only some selected question figures are shown. At the end of the section, a table with all the results of the evaluation is provided.

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Figure 4 shows the results obtained from question 6, related to the aesthetic design. In this question the students were asked to write one or several adjectives associated with the images of the didactic material. The representation shown in figure 4 is a word cloud, in which all the terms mentioned by the students are found; the larger the word, the greater the number of times it was mentioned by the participants. For example, the word pretty had a frequency of 16, the word simple was repeated 12 times, the word ugly was mentioned 2 times, while the word chidas only 1 time. The complete list of words with their respective frequencies is shown later in table 2.

Figura 4. Nube de palabras con los resultados de la pregunta 6 del instrumento de evaluación

Fuente: Elaboración propia

In Figure 5, on the other hand, a graph is shown with the results obtained from question 7, which is linked to the aesthetic design.

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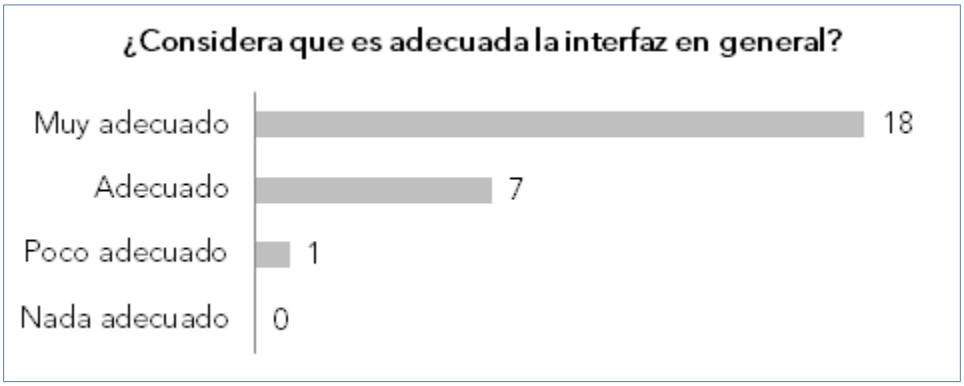
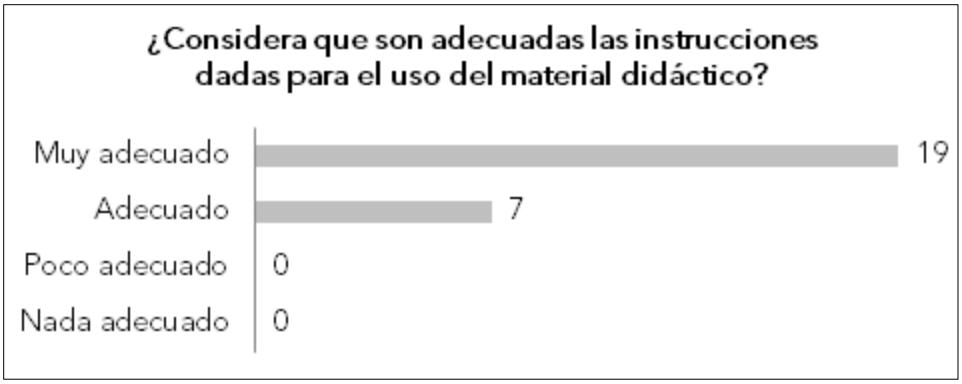
Figura 5. Resultados de la pregunta 7 del instrumento de evaluación



Fuente: Elaboración propia

Figure 6 shows a graph with the results obtained from question 8, which is related to functionality.

Figura 6. Resultados de la pregunta 8 del instrumento de evaluación



Fuente: Elaboración propia

Figure 7 shows a graph with the results obtained from question 11, which is linked to functionality.

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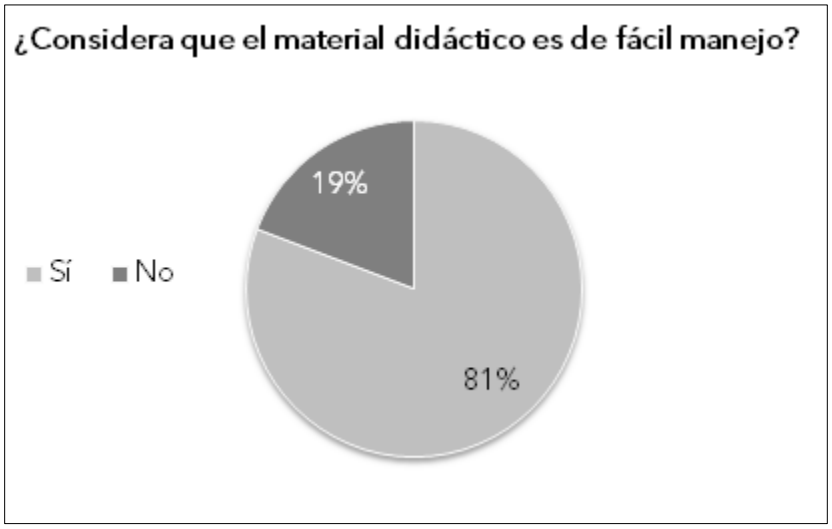
Figura 7. Resultados de la pregunta 11 del instrumento de evaluación



Fuente: Elaboración propia.

Figure 8 shows a graph with the results obtained from question 14, which is related to utility.

Figura 8. Resultados de la pregunta 14 del instrumento de evaluación

Fuente: Elaboración propia

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Table 2 shows the full results of the evaluation; for each option the percentage obtained is provided and, in parentheses, the number of students who chose that option. Following this table, a summary of the results obtained in question 16 is provided.

Tabla 2. Resultados completos del instrumento de evaluación (N = 26 encuestados)

Diseño estético							
1. ¿Considera que es adecuada la organización de la información en la interfaz?							
Muy adecuado		Adecuado		Poco adecuado		Nada adecuado	
n	%	N	%	N	%	n	%
10	38	12	46	3	12	1	4
2. ¿Considera que son adecuados los botones y ventanas que se despliegan?							
Muy adecuado		Adecuado		Poco adecuado		Nada adecuado	
n	%	N	%	N	%	n	%
25	96	1	4	0	0	0	0
3. ¿Considera que son adecuados los colores utilizados?							
Muy adecuado		Adecuado		Poco adecuado		Nada adecuado	
n	%	N	%	N	%	n	%
8	31	14	54	4	15	0	0
4. ¿Considera que son adecuados el tamaño y tipo de letra utilizados?							
Muy adecuado		Adecuado		Poco adecuado		Nada adecuado	
n	%	N	%	N	%	n	%
23	88	3	12	0	0	0	0
5. ¿Considera que son adecuadas las imágenes utilizadas en las animaciones?							
Muy adecuado		Adecuado		Poco adecuado		Nada adecuado	
n	%	N	%	N	%	n	%
6	23	14	54	4	15	2	8
6. Escriba uno o varios adjetivos que relacione con las imágenes:							
Bonitas		Sencillas		Simples		Interesantes	
16		12		10		7	
Divertidas		Claras		Básica		Amigables	
6		6		5		4	

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Útiles	Chistosas	Aburridas	Feas
4	3	2	2
Chidas	Curiosas		
1	1		

7. ¿Considera que es adecuada la interfaz en general?

Muy adecuado		Adecuado		Poco adecuado		Nada adecuado	
n	%	N	%	N	%	n	%
18	69	7	27	1	4	0	0

Funcionalidad

8. ¿Considera que son adecuadas las instrucciones dadas para el uso del material didáctico?

Muy adecuado		Adecuado		Poco adecuado		Nada adecuado	
n	%	N	%	N	%	n	%
19	73	7	27	0	0	0	0

9. ¿Considera que es adecuada la secuencia de acciones en cada una de las animaciones?

Muy adecuado		Adecuado		Poco adecuado		Nada adecuado	
n	%	N	%	N	%	n	%
19	73	7	27	0	0	0	0

10. ¿Considera que son adecuados los mensajes de error que se muestran?

Muy adecuado		Adecuado		Poco adecuado		Nada adecuado	
n	%	N	%	N	%	n	%
26	100	0	0	0	0	0	0

11. ¿Considera que el material didáctico es de fácil manejo?

Sí		No	
n	%	n	%
21	81	5	19

Utilidad

12. ¿Considera que el material didáctico es adecuado para la comprensión del tema de TDA?

Muy adecuado		Adecuado		Poco adecuado		Nada adecuado	
n	%	N	%	N	%	n	%
23	88	2	8	1	4	0	0

13. ¿Considera que el material didáctico es adecuado para el aprendizaje del tema de TDA?							
Muy adecuado		Adecuado		Poco adecuado		Nada adecuado	
n	%	N	%	N	%	n	%
23	88	2	8	1	4	0	0

14. ¿Considera que el material didáctico ha reforzado su conocimiento sobre los TDA?			
Sí		No	
n	%	n	%
24	92	2	8

15. ¿Considera que es adecuado el uso de las metáforas gráficas utilizadas en el material didáctico?							
Muy adecuado		Adecuado		Poco adecuado		Nada adecuado	
n	%	N	%	N	%	n	%
20	76	3	12	3	12	0	0

16. Nos interesa su opinión sobre el material didáctico presentado, por lo que agradecemos cualquier comentario o sugerencia adicional.

* Los comentarios obtenidos en esta pregunta se resumen a continuación.

Fuente: Elaboración propia

The answers obtained in question 16 are summarized below:

- The students are interested in teaching materials that are different, innovative and interesting.
- The use of graphic metaphors (real-life situations that compare with ADD) seemed like a great idea. They mentioned that it was easy for them to identify the ADD that they wanted to represent and to intuit how the operations of glueing and decolling worked given the experience in real life situations.
- The students considered it useful to represent the ADT with the pictures and arrows with which they are commonly represented in the books, since it helped them to observe the actions in two different forms of representation.
- They mentioned that the drawings used are funny, simple and understandable, but consider that if they were of better quality, the material would be more interesting.

- They would like the material to have more options, which could be represented by other ADTs and some sorting algorithms, since, as with the ADTs, they are complicated to understand on paper, which is fundamental for their implementation.
- The students would like this type of material to be used in the classroom, and not only in the end to reinforce, because they believe that they could help them in the teaching-learning process.
- The students mentioned that they would like the material to be migrated to other more current technology to facilitate their access.
- It was mentioned that it would be useful for the material to be online, and not only in the computer labs, as they would like to use it at home at any time.

Conclusions and future work

In this article we presented a teaching experience in which a series of digital teaching materials were used that were developed by students of the LTSI to reinforce the knowledge on the subject of abstract data types of the UEA Data Structure, which were valued by students of two bachelor degrees through an instrument that focused on aspects related to aesthetic design, functionality and utility.

In this sense, it can be indicated that the results obtained are encouraging, since most of the participants consider that they are adequate and very adequate. In fact, more than 85% of respondents believe that resources facilitate understanding, learning and reinforcement of the topic addressed (abstract data types).

All the comments and suggestions issued by the students, on the other hand, are very relevant and will help to improve the didactic material in its following versions and will even serve to elaborate new ones. In this sense, it should be emphasized that working with students is fundamental for the development and evaluation of teaching materials, since they are the main users of this type of tool.

As future work, it is recommended to incorporate the modifications suggested in the evaluation and in the creation of new applets to represent other types of abstract data, following the same idea of using scenarios close to real life to generate learning from previous knowledge .

In addition, it is estimated to make a contrast between students who have used the didactic material and students who have not used it in order to analyze the differences between both samples.

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