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ORIGINAL

Comparison of tools for the creation of VLO for the subject of Algorithms. UTN case

Comparación de herramientas para la creación de OVA para la asignatura de Algoritmos. Caso UTN

Fausto Salazar-Fierro[1,2], Karla Herrera-Mayorga[1], Cayo Léon Fernández[2], Carpio Pineda-Manosalvas[1], Irving Reascos[1]

[1]Universidad Técnica del Norte, Ibarra, Ecuador.
[2]Universidad Nacional de San Marcos Decana de América. Lima, Perú.

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Corresponding author: Fausto Salazar-Fierro

ABSTRACT

This paper compares the performance of three authoring tools, eXeLearning, H5P and Xerte, used to create Virtual Learning Objects (VLOs). The research stems from the need to identify the most appropriate tool for creating VLOs. The study aimed to evaluate these tools through an objective comparison based on 15 pre-defined criteria. For this purpose, a methodological approach of the UP4VED methodology for virtual environments was used in addition to implementing the ADDIE methodology for developing VLOs. The results showed that eXeLearning achieved the highest score with 10,38 points, followed by Xerte with 8,83 and H5P with 7,74. Subsequently, DeLone & McLean's success model was applied to assess students' perceptions of using OVAs in an online course, with a minimum favourability index of 81,92 % for quality of service and a maximum of 92,80 % for quality of information. These results confirm the acceptability and effectiveness of OVAs as digital resources that enhance self-learning in educational environments.

Keywords: ADDIE; DeLone & McLean; UP4VED; OVA; Tools.

RESUMEN

En este documento se compara el desempeño de tres herramientas de autor, eXeLearning, H5P y Xerte, utilizadas para la creación de objetos virtuales de aprendizaje (OVA), la investigación surge de la necesidad de identificar la herramienta más adecuada para la construcción de OVAs, el estudio tuvo como objetivo evaluar estas herramientas mediante una comparación objetiva basada en 15 criterios previamente definidos. Para ello, se utilizó un enfoque metodológico de la metodología UP4VED para entornos virtuales, además de la implementación de la metodología ADDIE para el desarrollo de los OVAs. Los resultados evidenciaron que eXeLearning obtuvo la puntuación más alta con 10,38 puntos, seguida de Xerte con 8,83 y H5P con 7,74. Posteriormente, se aplicó el modelo de éxito de DeLone & McLean para evaluar la percepción de los estudiantes sobre el uso de los OVAs en un curso virtual, obteniéndose un índice de favorabilidad mínimo del 81,92 % en la calidad del servicio y un máximo del 92,80 % en la calidad de la información. Estos resultados confirman la aceptación y efectividad de los OVAs como recursos digitales que fortalecen el autoaprendizaje en entornos educativos.

Palabras clave: ADDIE; DeLone & McLean; UP4VED; OVA; Herramientas.

INTRODUCTION

The integration of e-learning technologies has significantly transformed traditional teaching methods, as learning management systems (LMS) provide an interactive online experience, allowing students to access educational content, interact with the teacher, and collaborate with other students anytime, anywhere. These systems improve communication between teachers and students, facilitate the sharing of digital resources, and encourage more enriching pedagogical activities.

According to [1], LMSs have been implemented in university institutions to generate improvements in six key aspects: optimizing the teaching-learning process, enriching the educational experience, maintaining institutional competitiveness, managing the growing number of students, centralizing educational administration, and using technology to support teaching. For his part, [2] argues that LMSs promote active and collaborative learning, facilitate communication between instructors and students, support courses with high enrollment, and contribute to academic performance through an organized structure, helping teachers achieve their educational goals through various activities.

Adopting LMSs and other technologies and educational strategies has generated significant changes in universities, such as budget reduction, greater hierarchical control and integration of academia with industry, and the massification and globalization of education. This process has changed students' perception of their teachers, who have gone from mere transmitters of knowledge to facilitators of learning in line with new teaching styles and digital competencies. In addition, academic material is stored in repositories accessible on multiple servers, which facilitates the supervision of students and teachers, with availability at any time and place where there is access to the Internet.[1]

Virtual Learning Objects (VLOs) are defined in several ways. According to [3], they are highly flexible and adaptable tools that can be reused in different educational contexts, making them valuable resources for teachers and students. Unlike other distance education tools, VLOs offer interactive activities with great pedagogical value, combining various multimedia elements that enhance the learning experience and provide immediate feedback, being available at any time.[4] VLOs are digitalized pedagogical resources oriented to learning a discipline, which can be presented in audiovisual and interactive formats, with an information structure to facilitate their identification and designed for specific educational purposes.

Moreria[5] defines Virtual Learning Objects (VLOs) as digital, self-contained, and reusable entities with a clear educational purpose. These comprise three editable internal components: content, learning activities, and contextualization elements.

Implementing VLOs as generators of learning strategies seeks to encourage the student's autonomous work, promoting the continuity of their training over time. Learning strategies encourage quality education, transform society, respond to everyday needs, and form integral individuals.[4] According to the study by [6], VLOs offer students multiple opportunities to enhance their learning, allowing the adaptation of resources, their own pace of study, and interactive activities such as trivia and games, with unlimited access to content and activities that favor the assimilation of information.

Several packaging standards follow specific technical guidelines to facilitate communication between VLOs and LMS platforms to ensure reusability and interoperability. These standards allow the migration of objects to different compatible LMSs, the best known being SCORM, LTI, IEEE LOM, and xAPI.[7] The choice of a standard depends on the objectives and needs of the virtual learning environment (VLE): SCORM focuses on content structure and interoperability, LTI stands out for its integration with external tools, IEEE LOM facilitates the management and distribution of VLOs, while xAPI stands out for its advanced capability to track learning experiences.

In the study by [8], the impact of VLO on teaching programming to university students was evaluated. The results showed their inclusion improved motivation and academic performance, facilitating programming knowledge and skills retention. The authors consider VLOs valuable tools for teaching technical skills in higher education. [9] also highlighted that VLOs are an additional resource that supports teachers, promotes meaningful learning, increases the acceptance of technological tools and student motivation, reduces attrition in programming subjects, and encourages the development of virtual educational material.

Cardona[10] describes the Unified Process for Virtual Environment Development (UP4VED) as a systematic model based on software engineering designed to provide a framework for the design, development, and evaluation of VLE. This model incorporates best practices and addresses problems such as weak architectures, monolithic environments, lack of component reuse, flexibility, and insufficient documentation.

The article aims to compare tools for the creation of Learning Objects (OVAs) by selecting three options based on technological and pedagogical criteria and metrics to design a set of OVAs that will be implemented in the Learning Management System (LMS) Moodle to enhance the teaching of the Algorithms and Programming Logic course in the Software Engineering program at Universidad Técnica del Norte.

The rest of the document is organized as follows: Section 2 describes the methodology and the tools analyzed in this study for the creation of OVAs, Section 3 presents the development of the OVAs using the ADDIE methodology, Section 4 outlines the main results and statistical tests obtained, followed by the discussion

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about other studies, and finally, Section 5 presents the conclusions.

METHOD

Before creating a VLO, planning is essential to clearly define the educational objectives, organize the content in a structured way, and establish the basis for effective development. This planning optimizes both time and financial resources, avoiding delays. In addition, it requires taking into account several key aspects to ensure the success of the construction, such as educational context analysis, human resources analysis, technological and resources analysis, and feasibility analysis.

For the VLO content selection, the Algorithms and Programming Logic course syllabus will be used as a reference. Each object will be carefully structured to align with the most relevant topics covered in the four units, as shown in the link https://recursosalgoritmos.milaulas.com/.

The topics addressed in these units will enable the design and development of robust digital teaching resources to guide students in exploring algorithmic principles and structured programming in depth. This will allow them to analyze, build, and implement algorithms in Java using the VLOs embedded in a VLE. These topics are fundamental to developing skills beyond theoretical understanding, preparing students to tackle more complex programming challenges.

The selection of criteria to evaluate authoring tools (HA) is a crucial step before defining the tools. Creating quality educational content requires considering several factors that will be key to making decisions aligned with our objectives. In this context, aspects such as portability, external requirements, ease of use, whether it is web-based, pre-designed templates, integration with multimedia files, interactivity, responsiveness, real-time view (WYSIWYG), compatibility with standards and platforms, license type, metadata tagging, accessibility according to WCAG guidelines, updates, support and availability of documentation and tutorials have been identified. Evaluating these criteria will enable the appropriate selection of MTs, enhancing the creation of effective learning resources.

The selection of the tools in the **table 1** comparison was based on ease of use and compatibility factors. Priority was given to those that do not require programming skills, allowing users with little technical experience to take full advantage of their capabilities to design and create educational content. In addition, tools were chosen that, for the most part, allow content to be exported in SCORM format, thus ensuring integration and compatibility with Moodle, the platform on which the VLOs will be loaded.

The evaluation of the objects for each of the seventeen criteria was carried out under three categories, establishing (1) point for total compliance, (0,5) points for average compliance, and (0) points for non-compliance.

Table 1. Comparison of VLO Tools

Criteria	Authoring Tools							
	eXe Learning	Adobe Captivate	iSpring Free	H5P	Xerte	Glo Maker	Ardora	Free Course Lab
Portability	1	0	0	1	0	0	1	0
Autonomy	1	0	0	1	1	0	1	1
Ease of use	1	0	0,5	1	0,5	1	1	0
Web-based	0	0	0	1	1	1	0	1
Pre-designed styles	1	1	1	0	1	1	1	0
Multimediality	1	1	1	1	1	1	1	1
Interactivity	1	0,5	0,5	1	1	0,5	0,5	0,5
Responsive Content	1	1	1	1	1	0	0	1
WYSIWYG	1	0	1	1	1	1	1	1
Multiplatform	1	0,5	1	1	1	0,5	1	0
Multilingual	1	0	0	1	0	0	1	0
(en-es)	1	1	1	1	1	0	1	1
Standards support	1	1	1	1	1	0	1	0
Metadata tagging	1	0,5	0,5	1	1	1	1	0,5
Accessibility	1	0	1	0	1	1	1	1
Free license	1	1	0	1	1	0	1	0
Upgrades and support	1	1	1	1	1	1	1	1
TOTAL	16	8,5	10,5	15	14,5	9	14,5	9

After an exhaustive evaluation of the eight tools' criteria, four stood out regarding compliance and functionality: eXeLearning, H5P, Xerte, and Ardora.

EXeLearning performs solidly on most criteria evaluated, except for not being web-based, scoring 16 out of 17 points. This is followed by H5P, which has 15 points due to its lack of pre-designed styles and its free license, which is limited to 30 days of use. Xerte and Ardora followed this with 14,5 points. Xerte does not meet the criteria of portability and multilingualism since the application is only available in English, and it has a moderately steep learning curve compared to the other tools, which means that the user will take longer to understand the functionalities of the resource. Ardora, on the other hand, has drawbacks related to its lack of responsiveness; it is not web-based, it requires the generation of a package to consolidate activities in a single dynamic resource, and the type of interactive content that can be created is limited to a few pre-designed templates, which influences its interactivity.

In the case of the iSpring Free tool, it scored 10,5 points, showing shortcomings in portability, autonomy, not being web-based, the application is in English by default, its learning curve requiring intermediate-level knowledge, its functionalities being limited in the free version, it does not provide support options. It does not comply with all accessibility parameters.

On the other hand, Course Lab and Glo Maker, with 9 points, both tools are not portable and are available only for limited platforms, the first being suitable for Windows and the second for Windows and Mac OS; their interactivity is limited, they do not prioritize the loading of metadata, nor do they mention information on these sections in their official pages, the free versions of their applications are only available in English and have not received updates in recent years.

Finally, Adobe Captivate with 8,5 points, which is a paid tool whose free version has limited features, is not portable, standalone, web-based, not easy to use, not cross-platform, not multilingual, does not allow real-time observation of the VLO being built and does not fully comply with accessibility parameters.

It was decided to use eXeLearning, H5P, and Xerte to compare web authoring tools, as they offer greater capabilities and strengths than others evaluated. Although Xerte and Ardora scored the same in the initial evaluation, Xerte was chosen because it includes the browser's spell checker, which prevents typos. In addition, Xerte provides more interactive content and visual styles, allowing the creation of higher-quality VLOs. The highlights and advantages of these three tools will be summarized below to justify their selection.

First, eXeLearning stands out for its free license, ease of use and template customization, adaptability with the most popular LMS, compliance with standards, and ability to integrate multimedia resources, activities, and games. In addition, it allows the sharing of VLOs as standalone web pages or their integration into various educational platforms.[11]

Secondly, H5P is a commercial tool with an intuitive and user-friendly interface. It facilitates the integration of VLO developed with LMS compatible with the SCORM standard through the installation of plugins, and it allows the construction of interactive and visually attractive objects with the possibility of being reusable; this tool can be used by people with visual or hearing disabilities.[12]

Finally, Xerte is characterized by its intuitiveness, public license, integration of multimedia resources, and template customization. It also offers immediate feedback to verify the understanding of the material. It simplifies the use and access for people with learning disabilities, dyslexia, and hearing impairments.[13]

For the creation of the VLOs, the ADDIE Model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation, has been chosen. In this case, planning, which corresponds to analysis, has already been carried out. The ADDIE model (figure 1) is a generic guide widely used in instructional design;[14] its effectiveness is due to its simplicity and flexibility since the phases can be developed simultaneously or in a bottom-up manner, facilitating the creation of resources for autonomous learning.

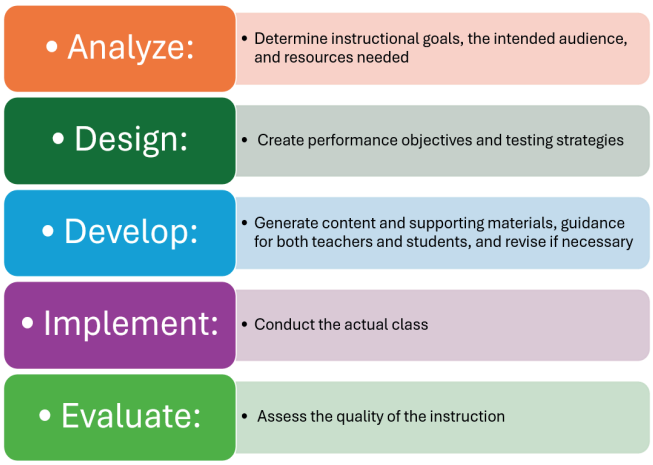

Figure 1. Model ADDIE
Source: Adapt from [15]

A base template was developed after completing the analysis phase, where the educational context, target population, human and technological resources, feasibility, justification of VLO content, and selection of tools were defined. This template includes the essential elements of the model design phase, which coincide with the internal structure of the VLO described above, such as the title, objectives, content structure, and didactic strategies for self-learning and evaluation.

DEVELOPMENT

The implementation of the VLEs for the algorithms and programming logic course was carried out after the evaluation of the resources by two teachers who are experts in teaching software in higher education. After this penultimate stage of the ADDIE model, the VLOs were loaded into the Moodle virtual course and distributed into units according to the syllabus content. The first two eXeLearning VLOs were assigned to the first unit, the H5P VLOs to the second and third units, and the Xerte VLOs to the fourth. The design and implementation of the VLOs in the virtual environment will be detailed below.

The OVA designed in eXeLearning was initially exported to Moodle, completing the mandatory fields according to the metadata of the Dublin Core (DC) standard, an internationally recognized framework for describing and locating educational resources on the web. This framework integrates fifteen generic elements based on simplicity, universal semantics, internationalization, and extensibility. Once the data was recorded, the resources were stored and exported in SCORM 2004 format, ensuring compatibility with Moodle and proper functionality. Finally, the VLO packages were uploaded to Mil Aulas as SCORM resources, incorporating the required information and ensuring their successful integration into the virtual course.

Dublin Core metadata fields were completed to integrate the VLOs created with H5P into the Thousand Classrooms course. Then, the objects were exported as public links, obtaining unique access links to the resources hosted on the H5P website. These links were copied and added to the platform as external URL-type resources.

The Dublin Core metadata fields were completed to integrate the VLO created with H5P into the Thousand Classrooms course. Subsequently, the objects were exported as public links, obtaining unique links to access the resources hosted on the H5P website. These links were copied and added to the platform as external URL-type resources.

The Algorithms and Programming Logic Moodle course, hosted by Mil Aulas, was built following the UP4VED lifecycle, prioritizing ease of use, navigation, and structured organization of the educational material. The content was designed to meet the needs of the students, with a focus on an attractive visual design that would encourage comprehension and participation. Modified banners, images, and icons, customized course aesthetics, improved descriptions to facilitate navigation, and divided content into thematic units. Finally, user accounts were created, and students were enrolled to evaluate the VLOs after becoming familiar with the environment.

Twelve pedagogical and technical criteria were used to evaluate the design of the VLOs. These criteria were defined using the LORI-AD instrument as a reference and the structural elements and characteristics of the VLOs described above.

To compare the three tools used in **table 2**, 14 criteria were defined. Table 2 contains the textual information of each tool for each evaluable aspect and the valuation of the scores obtained, considering that “Yes” equals (1) point and “No” equals (0) points. The numerical results were obtained by dividing the number received by the highest amount reached in a specific criterion among the HA.

Table 2. Quantitative comparison of HA involved in the construction of VLO

Criteria evaluated	Selected authoring tools		
	eXeLearning	H5P	Xerte
Web-based	1	1	1
Access to use or download the application without registration.	1	0	0
Operation without installation	1	1	0
Includes help wizard	1	0	0
Level of interface learning	1	1	0,5
Pre-designed styles	1	0	0,95
Available content blocks	0,84	0,74	1
Interactive content blocks (Activities, games, and multimedia)	0,54	1	0,88

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License	1	0	1
Trial version	0	1	0
Full content and functions in the free version	1	0	1
Aesthetics of created resources	0	1	0,5
Compatibility with SCORM standards	1	0	1
Outputs summary results of interactive activities	0	1	1
TOTAL	10,38	7,74	8,83

Based on the score achieved by each HA, it can be seen that eXeLearning is the best option among the three tools since it meets most of the evaluated criteria, obtaining the highest score of 10,38 points, followed by Xerte with 8,83 points and finally H5P with 7,74 points.

RESULTS

The DeLone and McLean model, proposed in 1992 and updated in 2003 (figure 2), is an approach that measures the success of information systems through six interrelated dimensions: system quality, information quality, service quality, usage intent, user satisfaction, and net impacts.[16] According to [17] understanding these dimensions is key to analyzing the performance of IT solutions, with system quality being fundamental to evaluating characteristics such as ease of use, adaptability, response time, and flexibility.

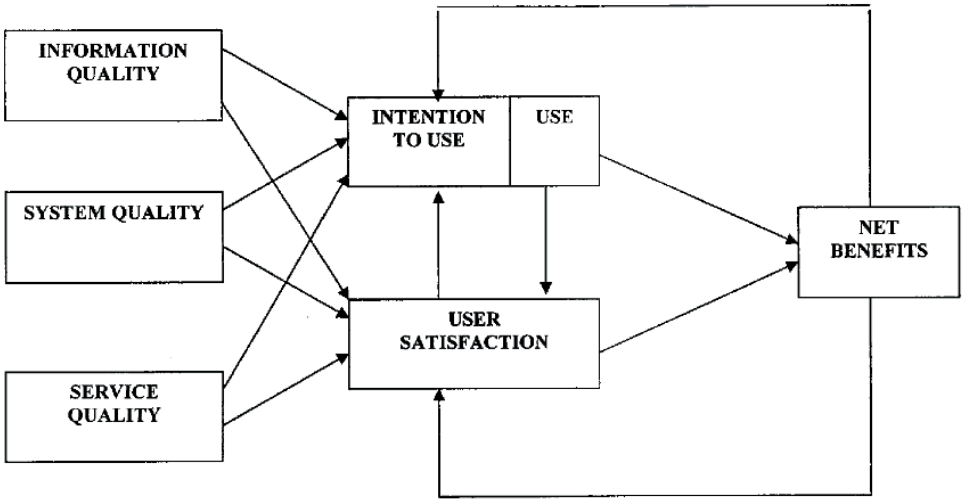

Figure 2. DeLone and McLean model
Source: DeLone & McLean Model [17]

The quality of information is evaluated in terms of usefulness, timeliness, reliability, and data accuracy. Quality of service includes aspects such as reliability, availability, responsiveness, and system support. Usage intention measures the frequency, mode of use, and usefulness perceived by users. User satisfaction focuses on individuals' opinions of the system and net impacts, analyzing individual and organizational effects and evaluating productivity, effectiveness, and efficiency after use.

To assess the quality and impact of VLOs, a survey was designed based on the 24-item questionnaire of the study "Validation of the DeLone and McLean Information Systems Success Model" by [17] $p < 0,001$, where the success of a hospital system was validated by applying the DeLone & McLean model. The 24 questions, formulated according to the six dimensions of the model, were evaluated with a 5-point Likert scale, where five is strongly agree and one is strongly disagree. The questions address students' perceptions of ease of use, usefulness, quality of content, and its contribution to learning. **Table 3** shows the Likert scale and the questions by dimension.

The target population comprises 41 first-semester Algorithms and Programming Logic students and 18 students of different levels. Both groups belonged to the Software career of the Universidad Técnica del Norte. There was a sample of 59 individuals enrolled in the course during the October 2023 - February 2024 semester.

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Table 3. Questionnaire to evaluate the effectiveness of the VLO

Dimensions	Items
System quality	1. Do I find VLO easy to use?
	2. Is it easy to learn how to use them?
	3. Is the response time adequate?
	4. Do I find the design user-friendly and intuitive?
	5. Do the VLOs clearly show the organization of the available content?
Information quality	6. Do you consider that the VLOs provide reliable information?
	7. Is the information presented in each VLO understandable?
	8. Do VLOs provide a variety of ways to view the information (graphics, audio, video, etc.)?
	9. Do VLOs display information on time?
Service quality	10. Are VLOs always available in the virtual classroom?
	11. Do the VLOs comply with the functionalities indicated?
	12. In general, I did not have any problems using them.
Intention to use	13. Do VLOs allow me to learn at any time or place?
	14. Do VLOs provide a dynamic and entertaining learning experience?
	15. Do VLOs allow me to acquire knowledge effectively through digital media?
	16. Generally, do I find using VLOs to learn topics related to Algorithms and Programming Logic useful?
User satisfaction	17. Are you satisfied with the information presented in the VLOs?
	18. Do you feel comfortable using these resources?
	19. Does the VLO meet your expectations?
	20. Would you encourage others to use the VLO?
Net impacts	21. Do VLOs fit my schedule, saving me time compared to face-to-face training?
	22. Do VLOs enhance traditional training models?
	23. Do VLOs facilitate access to open and unlimited learning concerning participation?
	24. Do VLOs facilitate the acquisition of new knowledge quickly, dynamically, and easily?

Source: Adapt to [17]

It is worth mentioning that all participants used the VLOs implemented in the Thousand Classrooms Moodle course, which was developed as complementary material to the traditional lecture method. This population represents the main users registered in the virtual learning environment.

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The applied questionnaire underwent a validation process using Cronbach's Alpha (figure 3) to ensure the internal consistency of the questions. This statistical index measures the reliability of an instrument by analyzing the correlations between items. According to [18] it is necessary to calculate Cronbach's Alpha for each variable in questionnaires with different dimensions. The coefficient varies between 0 and 1; the closer it is to 1, the greater the internal consistency. An acceptable value equals or exceeds 0,7 since lower values are considered questionable.[19]

$$\alpha = \frac{K}{K-1}\left[1 - \frac{\sum Vi}{Vt}\right]$$

Figure 3. Alfa de Cronbach
Source: Alfa de Cronbach [20]

To facilitate data management and obtain a detailed analysis of each item evaluated in the dimensions, we used IBM SPSS Version 25 software.

In **table 4** Cronbach's Alpha results by dimension, the "dimension" column refers to each of the six dimensions

of the DeLone & McLean model, the "items" represent the 24 questions organized by dimension, the "scale mean if the item has been deleted," and the "scale variance if the item has been deleted" indicate the values that the mean and variance would have respectively, in the case of eliminating any of the items evaluated.

In the case of the "corrected total item correlation," the homogeneity of the questions in the questionnaire is shown. This measure allows us to identify and purge problematic items in case of obtaining negative or zero values to improve the instrument's overall reliability.

The "Cronbach's alpha if the item has been deleted" shows the values the alpha would reach if some items were excluded. Finally, the "Cronbach's alpha" represents the internal consistency value of each instrument's dimension.

Table 4. Cronbach's Alpha results by dimension

Dimension	Ítems	Scaling average if the element has been suppressed	Scale variance if the element has been suppressed	Total correlation of corrected elements	Cronbach's alpha if the item has been deleted	Cronbach's Alpha
System quality	Q1	17,14	4,671	0,539	0,728	0,770
	Q2	17,14	4,188	0,557	0,725	
	Q3	17,02	4,948	0,518	0,737	
	Q4	16,86	4,533	0,595	0,709	
	Q5	16,86	4,602	0,510	0,739	
Information quality	Q6	13,25	2,572	0,492	0,796	0,791
	Q7	13,15	2,373	0,617	0,732	
	Q8	13,07	2,685	0,592	0,747	
	Q9	13,25	2,262	0,721	0,676	
Service quality	Q10	8,42	2,179	0,604	0,825	0,822
	Q11	8,27	2,201	0,651	0,783	
	Q12	8,49	1,634	0,796	0,624	
Intention to use	Q13	12,93	3,030	0,662	0,836	0,850
	Q14	12,92	3,596	0,716	0,800	
	Q15	12,86	3,671	0,695	0,809	
	Q16	12,85	3,511	0,726	0,795	
User satisfaction	Q17	12,80	3,682	0,710	0,815	0,857
	Q18	12,80	3,441	0,785	0,781	
	Q19	12,88	3,417	0,783	0,782	
	Q20	12,58	4,455	0,540	0,878	
Net impacts	Q21	12,85	2,683	0,535	0,692	0,747
	Q22	12,92	2,596	0,541	0,689	
	Q23	12,90	2,748	0,554	0,681	
	Q24	12,90	2,783	0,535	0,692	

Survey favorability analysis reviews the results and classifies the responses as positive, negative, or neutral. Percentages are then calculated to determine whether the overall perception is favorable or unfavorable. According to the Likert scale used, "agree" and "strongly agree" responses are considered favorable, while "disagree" and "strongly disagree" are classified as unfavorable, and "neutral" indicates undecided. **Table 5** shows the percentages obtained for each dimension analyzed.

Table 5. Favorability results by dimension

Dimension	Favorability	Unfavorability	Indecision
System quality	85,08 %	1,02 %	13,90 %
Information quality	92,80 %	0,85 %	6,36 %
Service quality	81,92 %	1,69 %	16,38 %
Intention to use	86,02 %	0,85 %	13,14 %
User satisfaction	84,32 %	1,69 %	13,98 %
Net impacts	88,14 %	0,85 %	11,02 %

DISCUSSION

Vargas[21]one of the problems still present is the ignorance of strategies such as the use of (VLO conducted

four VLOs using the Analysis, Obtaining, Design, Development, Evaluation, and Implementation (AODDIE) methodology and validated them only pedagogically with nine indicators through an online survey in Google Forms with Likert scale; 178 students were consulted on their perception of aspects such as academic planning, methodology, didactics and integration of content in the subject. In addition, another survey was designed for 19 Accounting and Auditing professors to evaluate how they apply ICT strategies in the classroom in three areas: teaching-learning methodology, pedagogical methods, and virtual tools. With the data obtained, a VLO was developed for the subject Financial Accounting II, which allowed learning to be strengthened from a new perspective without losing its practical application. The VLO development process included three stages: analysis of key factors, instructional design, and planning of resources and activities. The final VLO shows a cover page of the subject and a screen organized in sections with general and subject-specific information.

The difference of this work is that 16 VLOs compare three tools to create VLOs and validate in technical and pedagogical aspects using the six dimensions that make up the DeLone & McLean theory with 24 questions.

Zamora's[22]apoyados en innovaciones tecnológicas como las herramientas de Realidad Aumentada (AR work aims to develop a methodological proposal for creating OVAs, incorporating technological innovations such as augmented reality tools. c This approach fosters a collaborative process that integrates learning strategies for e-learning training with augmented reality at the University of Boyacá, resulting in a specific methodology for creating OVAs.

In contrast, our work stands out by analyzing tools for OVA development based on 15 technical criteria, applying the ADDIE learning methodology.

The study of Hernandez Urrego[23] adopted a descriptive qualitative approach based on a case study. It focused on the non-achievement of reading proficiency objectives in a group of English learners in an ESP course. A Virtual Learning Object (VLO) was designed to address this issue using the free software EDILIM. The lessons were structured in three cycles, considering objectives, reading authors, grammar, vocabulary, reading strategies, and evaluation. The research included data collection from 15 students through questionnaires, interviews, and reports on the reading cycles on the Moodle platform. The results indicate that the OVA favored implementing reading strategies guided by the cycles and stages proposed in its design, which improved reading comprehension and enriched the students' English reading experience.

This study compares three tools for creating six VLOs in the programming algorithms course using 15 evaluation criteria. The design and validation were carried out using the DeLone and McLean success model.

CONCLUSIONS

The comparative study of tools for VLO creation showed that some, such as eXeLearning and Ardora, stand out for their ease of use. Others, such as Xerte and H5P, stand out for offering a greater variety of interactive content blocks, which facilitates the creation of high-quality VLOs that encourage active participation and personalized learning. In addition, there are tools whose strength is their compatibility with packaging standards, such as SCORM, which allows the interoperability and reuse of digital content on different platforms. Among the HA that supports SCORM export are Adobe Captivate, iSpring Free, eXeLearning, Xerte, Ardora, and Course Lab.

The eXeLearning, H5P, and Xerte tools used to develop the VLOs in the Algorithms and Programming Logic course proved effective in teaching-learning. These tools facilitated the creation of dynamic and interactive content quickly, allowing VLOs to be customized according to the student's needs. The resources designed promoted effective learning because, as a complement to traditional teaching, they enabled students to learn anytime, anywhere, and to receive instant feedback on the activities.

According to the objective evaluation of the three tools, it is concluded that eXeLearning is the best option for the construction of VLOs, obtaining the highest score of 10,38 points by meeting most of the evaluated criteria. In second place is Xerte with 8,83 points and H5P with 7,74 points.

After applying the evaluation instrument based on the DeLone & McLean success model, the results showed that implementing the VLOs in the virtual course was satisfactory for the students since the minimum percentage of favorability obtained was 81,92 % in the quality of service. In comparison, the maximum rate was 92,80 % in the quality of information, which ratifies the successful acceptance of the resources as a digital alternative for self-learning.

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CONFLICT OF INTEREST

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AUTHORSHIP CONTRIBUTION

Conceptualization: Fausto Salazar-Fierro.
Data curation: Karla Herrera.
Formal analysis: Karla Herrera.
Research: Fausto Salazar-Fierro.
Methodology: Irving Reascos.
Project management: Fausto Salazar-Fierro.
Software: Karla Herrera.
Supervision: Cayo León.
Validation: Carpio Pineda-Manosalvas.
Display: Karla Herrera.
Drafting - original draft: Fausto Salazar-Fierro.
Writing - proofreading and editing: Fausto Salazar-Fierro.