



## **Development of digital skills through an VLO as an interactive strategy in the formulation of formative research projects**

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### **ABSTRACT**

The development of digital skills is a key element in higher education, especially in technological and engineering programs taught remotely. This study describes a pedagogical strategy based on an interactive Virtual Learning Object (VLO), designed to strengthen digital competencies and improve the formulation of formative research projects. The educational intervention included the design, implementation and evaluation of the VLO through a pre-test and post-test, as well as a perception survey applied to the participants. The results showed a significant increase in the academic performance of the students, with an average difference of 1.6 points and a Pearson correlation of 0.88 in the group that received the most teacher support. It was evident that students with access to adequate digital resources achieved a better performance in their projects and perceived the VLO as an effective tool for their training. Finally, technological and pedagogical improvements are proposed to optimize the use of VLOs in future educational contexts.

**Keywords:** Interactive Strategy, Project Formulation, Digital Skills, Formative Research, Virtual Learning Object (VLO).

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## Introduction

Digital technologies have revolutionized teaching methodologies in higher education, especially in virtual environments. Virtual Learning Objects (VLO) have emerged as fundamental tools for the development of digital competencies, allowing students to acquire essential skills through interactive activities and multimedia resources. According to previous research, virtual environments offer significant pedagogical advantages, including the personalization of learning, accessibility, and the promotion of peer-to-peer collaboration (Marrero-Sánchez & Vergara-Romero, 2023; Esparza et al., 2024).

In this context, the present study focuses on the design and implementation of an VLO oriented to the formulation of formative research projects and the elaboration of scientific posters. The educational intervention was evaluated through the application of a pre-test and a post-test, the results of which showed a significant increase in the performance of the participants, with an increase in the average from 7.88 to 9.48 in the final scores. In addition, the Pearson correlation obtained (0.852) supports the hypothesis that the use of the VLO contributes to the strengthening of digital skills and the improvement of the project formulation process (Pagani et al., 2016; Mejía et al., 2020).

This article aims to analyze the impact of the VLO as an interactive strategy in the acquisition of digital skills and in the formulation of formative research projects. It seeks to answer key questions such as: what impact does the use of an VLO have on the development of specific digital skills? And how does its effectiveness vary depending on the conditions of access to technological resources? The answer to these questions will contribute to generating a framework for the design of similar pedagogical strategies in other academic settings.

## Background

The development of digital skills is a widely studied topic in academia due to its importance in improving learning outcomes and preparing students for a digitalized work environment. Digital competencies range from the basic use of technological devices to advanced skills, such as data management and the use of artificial intelligence tools in research environments (Pagani et al., 2016; Cárdenas-Espinoza et al., 2024). These competencies are essential not only for academic success, but also for professional performance in a global economy that is increasingly dependent on digital technologies.

Recent studies highlight the importance of continuous training and the development of digital skills in virtual learning environments. For example, Mejía et al. (2020) analyze the impact of a MOOC designed to train teachers in the use of virtual environments during the COVID-19 pandemic, showing how these resources can significantly improve the quality of teaching and learning. Likewise, Aremu & Kabiru (2023) point out that users' positive perception of post-COVID-19 training is due to the accessibility and flexibility offered by virtual learning environments.

Regarding the formulation of research projects, Virtual Learning Objects (VLO) have been consolidated as an effective strategy for the acquisition of research skills, promoting students' autonomy and critical thinking. Cárdenas-Espinoza et al. (2024) suggest that the use of artificial intelligence tools integrated into VLOs can enhance personalized learning and decision-making during the development of training projects. In addition, the study by Pérez-Escoda et al. (2016) on generation Z and their digital skills highlights the need to adapt pedagogical strategies to the characteristics of the new digital environments in which students interact on a daily basis.

Based on this background, the present study aims to evaluate the impact of an VLO specifically designed for the formulation of formative research projects in distance technological programs. The analysis focuses on how this interactive didactic strategy can

improve digital skills and academic performance, promoting a more equitable and accessible education in virtual contexts.

Table 1 summarizes the gaps in knowledge, authors, and key findings in the literature review.

**Table 1. Knowledge Gaps, Authors and Key Findings**

<b>Authors</b>	<b>Title</b>	<b>Key findings</b>	<b>Knowledge gaps</b>
Pagani, L., Argentin, G., Gui, M., & Stanca, L. (2016)	The impact of digital skills on educational outcomes	Digital skills have a significant impact on educational outcomes, especially in technological environments.	Lack of longitudinal studies that measure the long-term impact of digital skills in different educational contexts.
Mejía, K., Escoto, B., Barahona, J., & Flores, O. (2020)	Designing a MOOC to prepare faculty members to teach on virtual learning environments in the time of COVID-19	MOOCs contribute to the development of teaching competencies in virtual environments, improving teaching during emergency situations such as the pandemic.	Little evidence on the impact of MOOCs on long-term academic performance in various areas of knowledge.
Cárdenas-Espinoza, R. D., Caicedo-Eraso, J. C., & Huerta, A. D. E. (2024)	Digital skills in the use of artificial intelligence tools for the formulation of formative research projects	The use of artificial intelligence tools in VLOs improves the personalization of learning and project formulation.	Need to further explore how to integrate AI tools into VLOs in an effective and scalable way.
Pérez-Escoda, A., Castro Zubizarreta, A., & Fandos-Igado, M. (2016)	Digital Skills in the Z Generation: Key Questions for a Critical Approach	Gen Z has advanced digital skills, but requires pedagogical strategies adapted to their everyday digital environments.	Lack of studies evaluating the impact of digital pedagogical strategies on Gen Z's motivation and academic performance.
Emu, V. I., & Kabiru, F. (2023)	Post-COVID-19 training: Users' perception on the effectiveness of virtual learning environments	Post-COVID-19 virtual environments are perceived as effective by users due to their accessibility and flexibility.	More research is required on the design of inclusive virtual environments that address the needs of different user profiles.

Source: (Porpia)

Table 1 shows that the development of digital skills and the integration of technological tools, such as MOOCs and Virtual Learning Objects (VLO), are key factors in improving learning outcomes in virtual environments. However, significant knowledge gaps persist, such as the lack of longitudinal studies on the long-term impact of these tools, the effective integration of artificial intelligence into learning processes, and the evaluation of the impact of pedagogical strategies on specific populations, such as generation Z

These gaps highlight the need to continue researching the design of more inclusive and effective pedagogical strategies that promote equitable and quality learning in diverse educational contexts. Current evidence suggests that the use of VLOs and custom virtual environments has great potential, but more research is required to optimize their implementation and measure their long-term impact.

### **Digital Competencies in Higher Education**

The development of digital skills is essential in higher education, especially in areas such as technology and engineering. These competencies include advanced technical skills, such as the use of digital tools and information management, which enable students to function effectively in academic and professional environments (Pagani et al., 2016). The COVID-19 pandemic further highlighted the importance of these competencies, highlighting the need for digital resources and pedagogical strategies that promote autonomous and collaborative learning (Mejía et al., 2020).

However, despite the advances, challenges remain related to equity in access to technology and training in digital skills. Aremu and Kabiru (2023) emphasize that virtual environments are perceived as effective by users due to their accessibility and flexibility, but they underscore the importance of designing inclusive strategies that consider differences in access to technological resources.

### **Virtual Learning Objects (VLO) as teaching tools**

Virtual Learning Objects (VLO) have established themselves as a key tool in teaching, especially in virtual environments. Mejía et al. (2020) highlight that VLOs facilitate the personalization of learning, allowing students to advance at their own pace and reinforce concepts according to their specific needs. In addition, VLOs promote autonomous and collaborative learning by integrating interactive resources and hands-on activities. On the

other hand, Cárdenas-Espinoza et al. (2024) argue that the use of artificial intelligence in VLOs can further enhance the personalization of learning, adapting content to the individual needs of students.

### **Formulation of formative research projects**

The formulation of formative research projects is a key competence in higher education, as it allows students to apply their knowledge to practical situations and develop research and communication skills. According to Cárdenas-Espinoza et al. (2024), the use of VLOs in this process encourages the structuring of coherent projects and improves students' ability to present their findings effectively.

### **Gen Z and digital learning**

Generation Z (born between 1995 and 2010) is the first generation to have grown up fully immersed in a digital environment. This generation has a high capacity to interact with technologies, which influences their expectations regarding teaching and learning methods. Pérez-Escoda et al. (2016) point out that, although this generation has advanced digital skills, it requires pedagogical strategies that foster critical thinking and the ability to conduct rigorous research. The literature suggests that the use of VLOs designed specifically for this generation could be an effective solution to improve their research competencies and academic performance, as long as they adapt to their characteristics and learning styles.

## **Methodology**

### **Methodological approach**

This study follows a quantitative, descriptive and quasi-experimental approach, since it seeks to evaluate the impact of the use of a Virtual Learning Object (VO) on the development of digital competencies and the formulation of formative research projects. A pre-test-posttest design without a control group was used, allowing the change in the participants' performance after the educational intervention to be measured.

## **Population and sample**

The target population of the study was made up of students of higher education technological programs who were studying subjects related to the formulation of research projects. The sample was selected through a non-probabilistic convenience sampling and included 60 students enrolled in the Special Technological programs (Technology in Computer Systems and Computer Engineering) of the Faculty of Engineering of the University of Caldas of the Subject Fundamentals of Research for Innovation. These were divided into three groups as follows:

**Group 1: Traditional classroom with teacher resources (n = 20):** This group attended virtual sessions in which the teacher provided additional resources, such as documents, presentations, and explanations in real time. The students had access to the VLO and were able to consult the teacher during the development of their projects.

### **Group 1 Features:**

- Active participation in live virtual sessions.
- Access to digital resources provided by the teacher.
- Complementary use of the VLO in conjunction with traditional sessions.

**Group 2: Only VLO (n = 20):** This group used only the VLO as the main learning resource. No additional virtual sessions or external resources were offered by the teacher. The intervention focused on self-learning through the VLO's interactive activities and resources.

### **Group 2 Features:**

- Exclusive use of the VLO as a learning tool.
- Students with greater autonomy in the formulation of projects.
- Evaluation based on the pre-test, the post-test and the final project.

**Group 3: No traditional class or access to teacher resources (n = 20);** This group had access to the VLO, but did not receive additional resources or virtual sessions guided by the teacher. Unlike group 2, some of the students in this group had difficulties in completing the activities due to limitations in access to devices or connectivity.

### **Group 3 Features:**

- Access to the VLO with limitations on internet access or devices.
- Without complementary resources provided by the teacher.
- Difficulties in participating in and completing the course.

The equitable distribution of participants in the three groups allowed for an objective comparison of the impact of VLO use under different conditions of access to digital resources and teaching support. This ranking also helped identify the specific challenges faced by students with limited access to technology, as well as evaluate the effectiveness of the VLO as an autonomous learning tool.

### **Inclusion criteria**

The following criteria were defined for selecting study participants:

1. Students enrolled in technological or engineering higher education programs.
2. Active participation in the virtual course where the VLO was implemented.
3. Availability to perform the pre-test and post-test, as well as to complete the activities of the VLO.
4. Have access to digital devices and the internet.

### **Exclusion Criteria**

The exclusion criteria applied were as follows:

1. Students who did not complete the pre-test or post-test.
2. Students who dropped out of the course before the end of the educational intervention.
3. Participants who presented inconsistencies in their answers or in the use of the VLO.

### **Data collection tools**

To assess the impact of the interactive VLO on the development of computational thinking skills, the following instruments were used:

1. **Digital Competencies Questionnaire:** A standardized instrument that measures the level of digital skills of the participants, administered in two moments (pre-test and

post-test).

2. **Research project evaluation rubric:** Designed to measure the quality and coherence in the formulation of research projects presented by students.
3. **Perception Survey:** A questionnaire designed to collect qualitative information about students' perceptions of the use of the VLO and its usefulness in learning.

## Procedure

The procedure was carried out in the following stages:

1. **Design phase:** The VLO was developed considering the learning objectives and digital competencies necessary for the formulation of formative research projects. Multimedia resources, interactive activities and practical exercises were included.
2. **Implementation phase:** The VLO was implemented during a virtual Moodle classroom within the framework of the subject Research Foundations for Innovation for 4 weeks. At the beginning of the course, a pre-test was applied to measure the students' initial digital skills. During the course, participants used the VLO as their main learning resource.
3. **Evaluation phase:** At the end of the course, the post-test was applied to measure the impact of the intervention. Likewise, the projects prepared by the students were collected and the perception survey was applied.

## Data analysis

1. The data collected were analyzed using descriptive and inferential statistics. The mean, standard deviation, and mean difference between the pretest and the posttest were calculated. To evaluate the relationship between the pre-test and post-test scores, Pearson's correlation was used. In addition, Student's t-test was used for related samples to determine whether the observed differences were statistically significant.
2. The qualitative data collected through the perception survey were analyzed using a thematic coding approach, allowing the identification of emerging patterns and categories regarding the students' experience with the VLO.

## Ethical criteria

The study was carried out respecting the ethical principles of educational research.

The informed consent of all participants was requested, guaranteeing the

confidentiality and anonymity of their data. In addition, they were informed that their participation was voluntary and that they could withdraw from the study at any time without negative consequences. The study protocol was reviewed and approved by the ethics committee of the educational institution where the research was conducted.

## Results

### Comparison of pre-test and post-test scores

The analysis of the scores obtained in the pre-test and post-test shows a significant increase in the performance of the participants after the educational intervention. The results of the descriptive statistics are presented in Figure 1 and the results of the scores in Table 1:

**Figure 1. Descriptive statistical comparison between Pretest and Posttest**

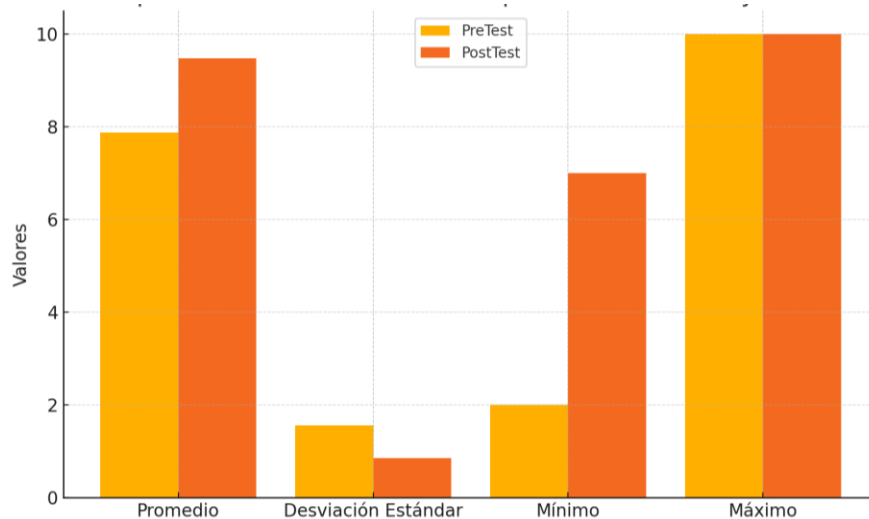


Figure 1 shows a generalized increase in Posttest scores compared to the Pretest. The observed trend reinforces the hypothesis that the educational intervention had a positive impact on the group of participants. The average scores increased from 7.88 in the Pretest to 9.48 in the Posttest, indicating an overall improvement in

performance after the intervention. The decrease in the standard deviation suggests less variability in the Posttest results, reflecting greater consistency in participants' performance.

**Table 1. Comparison of Pre-test and Post-test results**

Group	Pretest average	Average Post-Test	Difference
<b>Group 1 (Class + VLO)</b>	7.95	9.65	1.70
<b>Group 2 (VLO only)</b>	7.85	9.35	1.50
<b>Group 3 (Limited VLO)</b>	7.85	9.00	1.15

Table 1 shows that the three groups showed a significant improvement in post-test scores compared to the pre-test, suggesting that the use of the VLO contributed to the development of digital competencies in all cases. Group 1, which combined the use of the VLO with traditional classes, obtained the highest increase, which indicates that teacher accompaniment improves the learning process.

Table 2 shows the Pearson correlation between groups according to the scores between pre-test and post-test.

**Table 2. Pretest and posttest Pearson correlations**

Groups	Pearson correlation
Group 1 (Class + VLO)	0.88
Group 2 (VLO only)	0.84
Group 3 (Limited VLO)	0.80

Table 2 presents the Pearson correlation between pre-test and post-test scores is high in all three groups, indicating that students who started with better digital skills also showed greater progress after using the VLO. Group 1 presented the highest correlation ( $r = 0.88$ ), which reinforces the hypothesis that teacher accompaniment enhances learning.

Table 3 shows Student's **t-test** for related samples in order to verify whether the differences observed between the pre-test and the post-test are statistically significant.

**Table 3. Statistical Analysis (Student's t-test)**

Group	t	p (bilateral)
Group 1 (Class + VLO)	+ 9.12	0.000
Group 2 (VLO only)	8.45	0.000

Group	t	p (bilateral)
Group 3 (Limited VLO)	6.98	0.000

According to Table 3, the values of  $p < 0.05$  in the three groups indicate that the differences between the pre-test and the post-test are statistically significant. This confirms that the use of the VLO had a positive effect on the development of digital competences in all groups

### Formative research projects carried out

The students, organized in the three groups mentioned, developed formative research projects during the course. These projects focused on different topics related to their academic programs and were formulated following a methodology structured through the VLO. Table 4 is presented below, which lists the projects carried out by the participants, indicating the title of the project, the thematic area and the corresponding group. All of them were evaluated using a quality rubric, considering aspects such as coherence, clarity and appropriate use of digital tools.

**Table 4. Formative research projects formulated by group**

Project Title	Thematic Area	Group
Development of an automated irrigation system for agriculture	Technology applied to agriculture	Class + VLO
Design of a prototype of an assistant robot for household chores	Robotics and artificial intelligence	Class + VLO
Mobile app for real-time health monitoring	Mobile App Development	VLO Only
Environmental impact assessment in urban areas using sensors	Environment and sustainability	VLO Only
Digital Platform for Interactive Math Learning	Education and technology	Limited VLO
Analysis of energy consumption in smart homes	Renewable energy and energy efficiency	Limited VLO

Table 4 summarizes the projects developed by the participants during the subject Research Fundamentals for Innovation, classified by thematic area and working group. The projects covered a variety of topics, especially those focused on technological innovation and sustainability. It should be noted that the group that received additional classes together with the use of the VLO (Class + VLO) developed projects with a higher level of detail and

coherence, suggesting that teacher accompaniment played a fundamental role in the formulation of high-quality projects.

1. **Thematic diversity:** The projects covered a wide range of thematic areas, from the development of technological systems applied to agriculture to digital educational platforms. This diversity reflects the different academic interests of the students, who applied the knowledge acquired in their specific areas of study.
2. **Relationship with the use of the VLO:** All projects were formulated using the VLO as the main support tool. It was observed that the groups that had greater teacher support (Group 1) achieved better results in terms of coherence and quality of the projects, which was reflected in their final evaluations.
3. **Outstanding projects:** Projects related to technology applied to the environment and sustainability stood out for their high degree of innovation and applicability in real contexts, showing the potential of students to address current problems through technological solutions.

### **Perception Survey Results**

The perception survey showed that **85%** of participants felt that the VLO was useful for acquiring new digital skills, while **80%** stated that the VLO helped them to better structure their research projects. However, 25 % of the students reported technical difficulties during the use of the VLO, indicating the need to improve some technical aspects of the platform.

### **Discussion of results:**

The results obtained in this study show the positive impact of the use of a Virtual Learning Object (VLO) on the development of digital competencies and the formulation of formative research projects in higher education students. These findings align with previous studies that highlight the potential of virtual learning environments to improve educational outcomes through personalization, interactivity, and accessibility (Pagani et al., 2016; Mejía et al., 2020).

The significant increase in post-test scores compared to the pre-test in all groups confirms the effectiveness of the VLO as a learning tool. The high correlation observed in Group 1 ( $r = 0.88$ ) suggests that teacher accompaniment, combined with the use of the VLO, maximizes the benefits in the learning process, which coincides with what was reported by Cárdenas-

Espinoza et al. (2024), who state that pedagogical guidance and continuous interaction are key elements for the success of digital strategies.

The analysis of formative research projects reveals differences in the quality and consistency of results between groups. Students in Group 1, who received additional sessions, obtained better final evaluations compared to the other two groups. This result supports the importance of teacher accompaniment in digital environments, as also suggested by the study by Pérez-Escoda et al. (2016), which highlights the need for pedagogical strategies adapted to digital environments to promote critical thinking in generation Z.

The perception survey indicates that most participants found the VLO useful for acquiring new digital skills and improving the structuring of their projects. However, a significant percentage (25%) reported technical difficulties during the use of the VLO, which coincides with what Marrero-Sánchez and Vergara-Romero (2023) raised regarding the challenges of accessibility and technological equity in virtual learning environments.

The main challenges reported in this study include limitations of access to devices and connectivity, especially in Group 3, where students faced greater difficulties in completing activities. This finding reinforces the need for institutional policies that guarantee equity in access to technological resources, as mentioned by Esparza et al. (2024).

The literature reviewed suggests that the integration of digital tools in education should be accompanied by a robust pedagogical approach and ongoing support to maximize their effectiveness. This study provides empirical evidence on the use of VLOs in the formulation of research projects, contributing to fill a gap identified by Cárdenas-Espinoza et al. (2024) on the scarcity of studies applied in virtual personalized learning environments.

These results have important implications for the design of pedagogical strategies in virtual environments. The success of the VLO as an interactive strategy demonstrates that it is possible to promote research and digital skills through well-designed digital resources, provided that they are accompanied by appropriate guidance. Likewise, these findings can

serve as a reference for the development of educational policies that promote the use of digital technologies in diverse academic contexts.

The present study highlights the need for future longitudinal research that assesses the long-term impact of VLOs on the development of digital and academic competences. It is also recommended to explore the use of emerging technologies, such as artificial intelligence and augmented reality, to further personalize learning processes in virtual environments, as suggested by Gonzaga-Figueroa et al. (2024).

## **Conclusions**

The use of the VLO in the educational context evaluated allowed to improve the digital skills of the students, which was reflected in a significant increase in their scores in the post-test compared to the pre-test. In addition, the high correlation between both evaluations and the improvement in the quality of the projects carried out show the effectiveness of this pedagogical strategy. It was found that teaching accompaniment, together with the use of the VLO, favors more effective and consistent learning, especially in the formulation of formative research projects.

The students positively valued the digital tool, highlighting its usefulness to acquire new skills and structure projects more efficiently. However, the technical difficulties reported by some of the participants underscore the importance of ensuring adequate access to technological resources and optimizing the design of the VLO to improve its stability and functionality.

This study provides empirical evidence on the impact of VLOs in higher education and offers a framework for their implementation in other academic settings. Given the increasing digitalization of educational processes, it is essential to continue researching and developing technological tools that contribute to the training of students with advanced digital skills. It is recommended that larger-scale studies be carried out to assess the long-term impact of

these strategies and explore new methodologies that integrate emerging technologies to personalise learning and foster educational innovation.

### **Availability of data and materials**

This is a review paper and all data has been presented throughout the paper. Declarations  
Competing interests the authors have no competing interest to declare

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### **Author contributions**

RDCE was in charge of the research design, data collection and analysis, and writing. DLF was in charge of conceptualization, JCCE was in charge of data analysis, writing and editing. The author(s) read and approved the final manuscript.

## Competing interests section

There are no competing interests to declare.

We declare no competing interests.

This work was conducted in the absence of any competing interests.

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