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Non-formal education and virtual tools: an instructional design for comprehensive sustainability training

Educación no formal y herramientas virtuales: un diseño instruccional para la formación integral en sustentabilidad

Educação não formal e ferramentas virtuais: um design instrucional para uma formação integral em sustentabilidade

Abstract

Introduction: building sustainability in non-formal educational contexts presents several challenges. The diversity of participants requires methods centered on individual needs, which can hinder the creation of a cohesive instructional design. Additionally, incorporating virtual tools into this process adds an extra layer of difficulty. **Objective:** to implement an instructional design for comprehensive training in sustainability, using virtual tools, in a non-formal educational environment aimed at sustainability trainers. **Method:** the ADDIE model was applied, and an integrated analysis was conducted through a 15-item interview with 10 members of the Research Center for Engagement and Sustainability at the Autonomous University of Querétaro. **Results:** a course was developed that addressed the needs of the specific context in which it was implemented. One key finding was the necessity for trainers to possess solid knowledge of formal education and pedagogical tools relevant to this context. **Conclusion:** this study highlights a valuable framework for implementing sustainability training programs, emphasizing the importance of strong pedagogical training and strategies that promote active, contextualized, and collaborative learning.

Keywords: instructional design, non-formal education, education for sustainable development, virtual tools

Resumen

Introducción: formar la sustentabilidad en contextos educativos no formales presenta una serie de desafíos, la diversidad de los participantes exige métodos centrados en las necesidades individuales, lo que puede dificultar la creación de un diseño instruccional cohesivo. A su vez, incorporar herramientas virtuales en este proceso añade una capa adicional de dificultad. **Objetivo:** implementar un diseño instruccional de formación integral para la sustentabilidad, con el uso de herramientas virtuales, en un ambiente de educación no formal, dirigido a formadores en sustentabilidad.



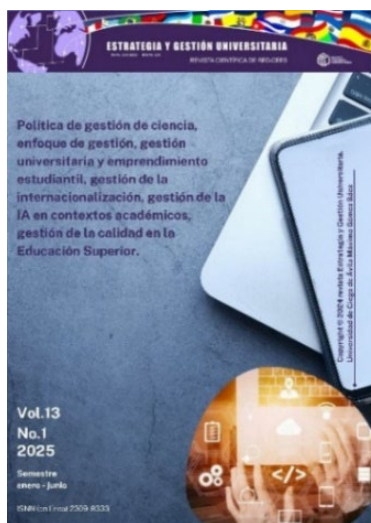
Método: se aplicó el modelo ADDIE y se llevó a cabo un análisis integrado por una entrevista de 15 reactivos a 10 integrantes del Centro de Investigación en Vinculación y Sustentabilidad de la Universidad Autónoma de Querétaro. **Resultados:** se obtuvo un curso que atendió las necesidades del contexto en el que se desarrolló; uno de los hallazgos clave es la necesidad de que los formadores posean un conocimiento sólido sobre la educación formal y las herramientas pedagógicas pertinentes a este contexto. **Conclusión:** se evidencia un marco valioso para la implementación de programas de formación en sustentabilidad, subrayando la importancia de una capacitación pedagógica sólida y de estrategias que promuevan el aprendizaje activo, contextualizado y colaborativo.

Palabras clave: diseño instruccional, educación no formal, educación para el desarrollo sustentable, herramientas virtuales

Resumo

Introdução: construir a sustentabilidade em contextos educacionais não formais apresenta vários desafios. A diversidade dos participantes exige métodos focados nas necessidades individuais, o que pode dificultar a criação de um design instrucional coeso. Além disso, a incorporação de ferramentas virtuais neste processo adiciona uma camada extra de dificuldade. **Objetivo:** implementar um design instrucional para formação integral em sustentabilidade, utilizando ferramentas virtuais, em um ambiente educacional não formal, voltado para formadores em sustentabilidade. **Método:** o modelo ADDIE foi aplicado, e uma análise integrada foi realizada por meio de uma entrevista com 15 itens, envolvendo 10 membros do Centro de Pesquisa em Vinculação e Sustentabilidade da Universidade Autônoma de Querétaro. **Resultados:** foi desenvolvido um curso que atendeu às necessidades do contexto em que foi implementado. Uma descoberta importante foi a necessidade de que os formadores tenham um conhecimento sólido sobre a educação formal e as ferramentas pedagógicas pertinentes a este contexto. **Conclusão:** o estudo evidencia um marco valioso para a implementação de programas de formação em sustentabilidade, ressaltando a importância de uma formação pedagógica sólida e de estratégias que promovam a aprendizagem ativa, contextualizada e colaborativa.

Palavras-chave: design instrucional, educação não formal, educação para o desenvolvimento sustentável, ferramentas virtuais



Introduction

In 1992, when the Earth Summit was held in Rio de Janeiro, Brazil, convened by the United Nations, it was established that it was necessary to adopt certain forms of production with a perspective of environmental respect. This was intended to create a balance between the protection of ecosystems and economic development, which would ensure a dignified world for future generations without compromising their well-being (Madrigal, 2020).

Since 2015, the sustainability model and the Sustainable Development Goals (SDGs) have garnered significant interest in international strategies and agendas, as well as in educational research, in order to contribute to the achievement of the SDGs (Alonso-Sainz, 2021). Sustainability should be interpreted as a structured discipline of knowledge and as an innovative way to reconsider the human relationship with nature, based on the integral relationship among environmental, economic, and social dimensions that drive a global transformation of survival with the planet (Zarta, 2019).

Since the Brundtland Report of 1987 defined sustainability, the negative impact of environmental issues on the physical environment has been recognized, as well as the importance of achieving a balance among nature, society, economy, politics, culture, and technological advancements. Therefore, it is essential to implement strategies that promote economic and social development while ensuring the responsible use of natural resources, both renewable and non-renewable. In 2015, the SDGs were designed and published with the intention of establishing goals to support the achievement of sustainability, positioning education as a fundamental component for accomplishing them (García-Arce et al., 2021).

Lamanauskas and Alinauskienė (2024) assert that education is one of the main tools for achieving sustainability. Worldwide, it is recognized that current trends in economic development are not sustainable, and that public awareness, education, and training are key tools to ensure a society with more sustainable practices. The ability to live appropriately (sustainably) and manage and efficiently use natural resources is fundamental.

Education for Sustainable Development (ESD) is an emerging and dynamic approach that reframes education as a key tool to empower individuals in building a sustainable future (Imara and Altinay, 2021). This approach promotes competencies, skills, and knowledge aimed at social transformation (Scherak and Rieckmann, 2022), motivating students to actively participate in sustainable change processes (Rieckmann, 2018). ESD is closely linked to the Sustainable Development Goals (SDGs), which provide a global framework to address challenges such as climate change, poverty, and inequality.

From the educational perspective, the SDGs not only provide thematic content but also require a transformative pedagogical approach that fosters comprehensive training and critical reflection (Alonso-Sainz, 2021). While various studies have focused on implementing ESD in formal contexts, such as schools and universities, its systematic application in non-formal education settings remains limited, where the diversity of participants and teaching methods pose particular challenges (Hirsch Adler, 2023).

A fundamental aspect to consider in Education for Sustainable Development (ESD) is the strong influence that Information and Communication Technologies (ICT) have had on it. The increased use of social media, tools, applications, and the acceptance of innovative pedagogical methods in educational processes offer new possibilities for ESD. Digital technologies present alternative forms of learning and understanding necessary to implement complex solutions for sustainable development (Boulahrouz et al., 2019).

ESD is a fundamental pillar in the formation of citizens capable of facing the environmental, social, and economic challenges of this era. However, developing its teaching in non-formal educational contexts poses significant challenges due to the lack of institutional structure, as well as the diversity and flexibility of participants. For the purposes of this study, non-formal education is understood as the process of acquiring knowledge that occurs in non-academic contexts, that is, outside of an institutional structure. It is a type of education that takes place outside the formal educational plans of the school system. This type of education relates to experiential, everyday experiences and individual values (Escudero-Nahón et al., 2020).

Therefore, the use of virtual tools emerges as a key strategy to facilitate comprehensive training, but also presents a significant challenge for sustainability trainers, who are responsible for innovating and adapting their pedagogical approaches and strategies to achieve more effective results. Virtual tools provide flexibility, access to resources, and opportunities for interaction that help overcome barriers of time and space. However, it is not sufficient to simply apply them; it is essential to have an instructional design that strategically integrates content and activities, ensuring that participants achieve meaningful learning.

A well-structured instructional design (ID) establishes a clear guide for student learning, aligning the use of digital technologies with educational objectives. It also ensures that learning about sustainability is easily accessible and genuinely useful for transforming how this knowledge is understood and applied (Rodríguez and Cubillas, 2024).

Agudelo (2009) notes that creating and implementing new training processes involves not only developing educational materials and using innovative methods but also rethinking roles within learning, posing a significant question: What is instructional design and how can it be applied?

Currently, in response to the growing demand for quality education that addresses student needs and leverages technology to offer flexibility in time and space, it is necessary to consider virtual learning environments. These environments must integrate all relevant resources, content, and tools to support the educational process and foster the development of competencies (Vera et al., 2021).

Correa (2021) mentions that in various educational modalities, instructional design (ID) models have evolved alongside learning theories and technological advancements. Teaching tools have diversified and adjusted to these changes, leading to increased demands on didactic resources to maintain pedagogical coherence. This entails progressively more complex interactions and relationships

among the learner, the instructor, the content, and its environment. The implementation of design aims not only for students to engage in intellectual activities but also to create an impact on their identity construction and social relationships (Morales, 2022).

Understanding what students need, using the best teaching strategies, constantly assessing their progress, and incorporating technology are key components of instructional design (Torres, 2024). However, applying these principles in the field of ESD presents significant challenges that require detailed analysis and a deep understanding of the particular characteristics of this important area.

The development and implementation of an ID can occur across various educational contexts, one of which, and the objective of this study, is non-formal education. Non-formal education plays a fundamental role, as it can complement, supplement, and provide an alternative to formal education (Deldén et al., 2023).

Khumsamart (2022) defines non-formal education as a management process to develop students' competencies in terms of attitudes, skills, and knowledge. This process can be more flexible than learning within the general school system and develops personal skills necessary for satisfactory social living. Furthermore, Almeida and Morais (2024) affirm that non-formal education seeks to address the limitations and challenges of formal education, as the latter does not reach all communities nor provide all essential competencies and capabilities for their comprehensive development.

Today, it is crucial to educate citizens in sustainable practices, not only in formal educational contexts but across various educational settings. In this regard, non-formal educational environments face several challenges, such as a lack of resources and appropriate methods.

These difficulties reduce trainers' capacity to impart essential knowledge and skills that promote environmental awareness and responsible behaviors. Therefore, there is a need to develop an instructional design that allows sustainability trainers to effectively utilize virtual tools.

The fundamental objective of this work is to implement a course based on a suitable ID aimed at sustainability trainers in non-formal educational contexts, integrating virtual tools to enhance the teaching and learning of sustainability.

It is intended that through the various researched techniques and instructional design models, a solution will be proposed based on a model that generally guides the ideal structure that a course should follow for its effective development, as well as a model to be applied in the teaching-learning process that enables the trainer to develop each content area, providing activities related to the themes.

A relevant aspect to consider in instructional design (ID) is that the design of content and curricula must respond to the appropriate factors and characteristics of the target population. According to Muñoz-Sánchez (2023), there are various instructional design models, among which the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) model stands out.

The ADDIE model follows a series of stages that begin with defining learning objectives, choosing a theoretical approach, and analyzing the context in which the intervention will take place. Additionally, in this case, evaluation is approached from two perspectives: formative, to monitor the process, and summative, to measure final outcomes (Losada and Peña, 2023).

This ID model is highly versatile and can be adapted to a wide variety of situations and needs. It is developed in a dynamic, recursive, and flexible manner (Quinde et al., 2022), which is very useful for achieving the objectives of this study, as it guides the methodological work and design that should be followed to create a course. Thus, its phases served as the basis for constructing the teaching-learning process described in this research.

Methods and materials

The development of this work was based on field research, employing a qualitative design through inductive analysis (Acosta, 2023), aimed at creating instructional materials focused on facilitators and trainers in sustainability in non-formal educational environments utilizing virtual tools.

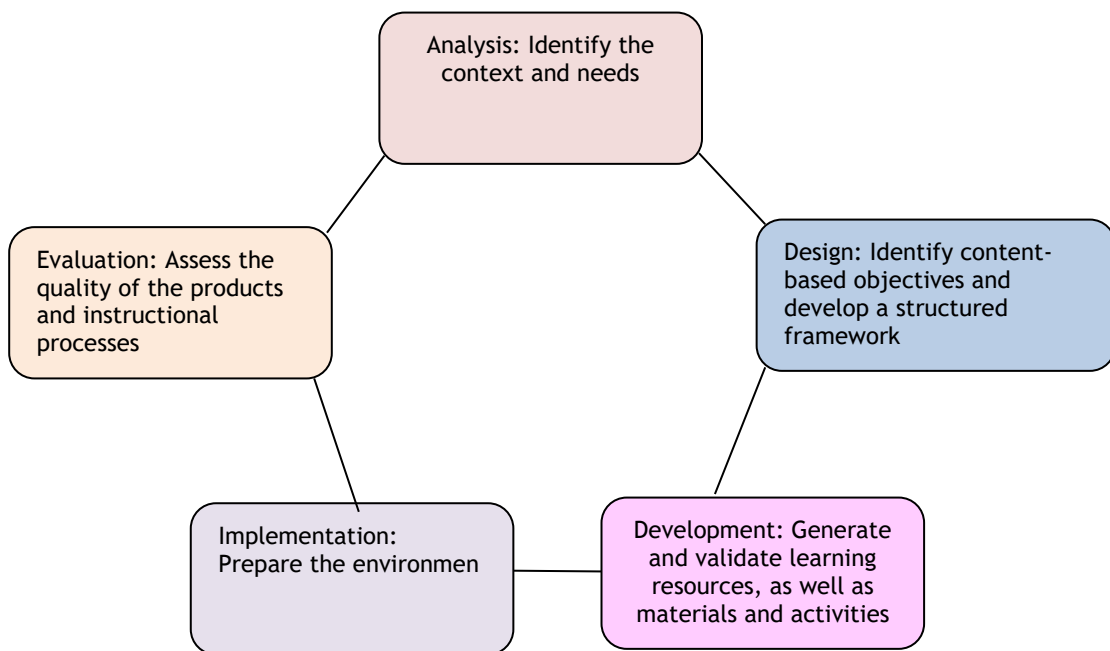
The research included conducting a participatory diagnostic, of a qualitative nature and with a phenomenological orientation, as it focused on interpreting the diverse perceptions of participants regarding the issues, their causes, and consequences. Additionally, elements of the socio-critical paradigm were incorporated to foster collective reflection and critical analysis. The ADDIE model was used for instructional design.

Some studies have applied the ADDIE model to develop websites using tools such as Content Management Systems (CMS) and Learning Management Systems (LMS), as well as various applications. The goal is to create functional and well-designed prototypes that contribute to improving students' academic performance (Ghani and Daud, 2018), in addition to providing support, feedback, and effective teaching of language skills (Jurado and Marto, 2022).

ADDIE represents one of the most successful models in its application, characterized by its focus on five phases, which is quite useful and appropriate for developing courses that meet the required demands. This ID model is viewed as a general approach due to its fundamental stages in creating an educational structural design, as they are interconnected and enable adaptation to achieve teaching objectives. Below, each of the stages integrated into this model is described:

Figure 1

Phases of the ADDIE Model



Source: Adapted from Morales (2022).

The first step involves examining the students, the content, and the context to gain a clear understanding of the situation and determine their training needs (Juárez et al., 2022). For this stage, a semi-structured interview was designed and applied. The experimental subjects were a group of 10 members of the Research Center for Linking and Sustainability at the Autonomous University of Querétaro, Jalpan Campus. The subjects' profiles are prominent in the field of sustainability training in non-formal education settings, as well as their experience in using virtual tools for training.

Results and discussion

The fundamental purpose of the first phase, corresponding to the analysis, was to identify the needs and context in which the problem to be solved arises, with the intention of identifying probable causes and determining whether the proposed instructional design contributes to solving the problem.

Table 1

Categories and codes

APRIORISTIC CATEGORY	CATEGORY	CODES
ICT and its benefits	Meaning of ICT	22
	Contribution of ICT	25
	Ways to implement ICT in non-formal education	21
	Frequency of ICT use	9
	ICT resources used	32
	Communication resources	11
Tools and resources used and created	Created digital material	24
	Software used	13
	Technological media	18
	Difficulties	19
Difficulties and solutions in using ICT	Solution strategies	28
	Required training	15
Required and expected knowledge	Expected knowledge of students	25
	Non-formal education	22
Non-formal education		

Source: Authors' own elaboration.

In the last category corresponding to the procedure for training in sustainability in a non-formal education environment using ICT, various procedures were obtained, none of which were the same.

Once the perceptions of the members of the CIVS Jalpan were identified, the analysis indicated that in the category of ICT and its benefits, they perceive ICT as a fundamental tool in the knowledge society. These tools allow them to disseminate knowledge and receive information in all contexts, identifying computers and other digital tools as necessary resources for digitalization, facilitating processes and reducing time and effort.

This suggests that the interviewees have a good grasp of the concept of ICT and recognize the benefits of its use as sustainability trainers, as they state that ICT has revolutionized the educational process, providing a series of advantages that enhance both learning and teaching.

Their use of ICT in their role as sustainability trainers in non-formal settings is very frequent; some even claim to always use them. This leads us to the next aprioristic category, which corresponds to the technological tools they use and create to carry out their work as sustainability trainers in a non-formal education environment.

Initially, the main technological media they use include computers, projectors, mobile phones, televisions, speakers, and cameras, among others. On the other hand, the technological tools they use in their teaching processes can be classified into presentation tools, schematics, diagrams or knowledge instruments, video tools, portfolio tools, communication tools, evaluation tools, and tele-training, which they use to create didactic material.

Carrying out their teaching processes using ICT has brought various complications. The interviewees report that power outages and internet issues have been their main limitations, as well as the fact that many of their students lack the necessary training to fully leverage the possibilities of ICT in education. There is resistance to virtuality; some individuals may lack access to devices or connectivity, which limits their participation in the process.

To overcome these difficulties, the interviewees indicate that they have implemented various strategies and resources to facilitate adaptation, such as creating clear and engaging content, fostering creativity in the use of ICT, and recognizing the different learning curves among members of the educational community. They also prepare with physical materials and revert somewhat to traditional methods, especially adapting to the target student.

In the aprioristic category corresponding to the expected knowledge in students being trained in sustainability and the knowledge required of sustainability trainers using ICT, the interviewees expressed that they aim to achieve knowledge across various dimensions. They want to foster greater participation and reflection, encouraging students to become agents of change, actively participating in building a sustainable future.

Furthermore, they expect students to develop critical thinking and social awareness centered on responsibility toward their community and the environment. They state that education in sustainability should be cross-cutting and interdisciplinary, achieving more collaborative work.

Additionally, they mention that students must acquire skills to solve complex problems, developing a more critical and analytical character. It is essential that the knowledge acquired transcends the educational realm and is applied in the students' everyday and professional lives. This training should be conceptual, providing students with a deep understanding of the dimensions of sustainability and the intrinsic value of their contributions.

The interviewees indicate that, as sustainability trainers, they require

certain competencies, skills, and knowledge that enable them to achieve their educational goals. They must be aware of how to appropriately use ICT, facilitate and leverage teamwork through technological tools, and adapt educational resources that are effective and, above all, engaging. Lastly, training should include understanding and applying the relationship between education and sustainability to prepare students for future challenges.

Regarding the aprioristic category of non-formal education, most stakeholders approach a conceptual idea; however, some confusion is observed. They refer to it as what is not considered traditional education, outside the classroom, involving people who do not attend school, cross-cutting, and outside an official curriculum, among other aspects. These responses indicate that clarification of the concept is needed.

After analyzing the results obtained from the diagnostic evaluation, it was determined that the members of the CIVS Jalpan (sustainability trainers) need to prioritize the following list of needs:

- Identify the characteristics of non-formal education.
- Identify appropriate learning processes and strategies for training in sustainability.
- Use of ICT and virtual tools in a non-formal education environment.
- Identify the appropriate process for training in sustainability in a non-formal education environment.

It is essential to consider that in the case of ESD, learning occurs in many types of social contexts. This learning is not limited to what happens in the formal educational system; it also encompasses what occurs in daily life and in the professional sphere (Organización de las Naciones Unidas para la Educación, la Ciencia y la Cultura, 2004).

In the analysis section, the "Expert Review of Processes and Learning" in Education for Sustainable Development was used as a basis, as part of the United Nations Decade of Education for Sustainable Development (2005-2014). This document aims to realign policies, practices, and investments in education towards sustainability, guiding the design of the course based on accepted learning processes for ESD (Organización de las Naciones Unidas para la Educación, la Ciencia y la Cultura, 2011).

Thus, the course design proceeds as follows:

Course name: Sustainable teaching mediated by virtual tools in non-formal educational contexts.

Table 2

Course information

PURPOSE

Identify suitable pedagogical strategies for training in sustainability in non-formal educational contexts using ICT and virtual tools.

OBJECTIVES

- Understand what a non-formal educational context entails.
- Identify appropriate learning processes and strategies for training in sustainability.
- Identify virtual tools that contribute to sustainability training in non-formal educational contexts.

GENERAL ASPECTS

User profile	The ideal profile for this course is educators conducting teaching processes in sustainability (social, economic, or environmental dimension) in non-formal educational contexts, preferably members of the Regional Corridor for Integral Training in Sustainability (CORESU).
Type	Private
Location	Autonomous University of Querétaro, Jalpan Campus
Synchronous or asynchronous	Asynchronous
Level	Undergraduate
Teacher-student interaction	Moderate
Student-teacher interaction	Moderate
Duration	25 hours

Source: Authors’ own elaboration.

Table 3

General course design

Module number and name: Module 1. Non-formal education

Purpose	To provide a theoretical-conceptual foundation regarding what a non-formal educational context entails.				
Topics and Subtopics Covered:	Introduction. What is non-formal education and why is it important? Teaching strategies in non-formal education.				
Knowledge	Acquire practical knowledge about non-formal education, its importance according to contextualization, and teaching strategies to achieve meaningful learning.				
Presentation Outline					
Section	Topic	Activity	Estimated Time	Technological Resources	Evaluation
1	Welcome and introduction	Presentation forum	30 MIN	Moodle platform, Canva	Participation and comments on two peers.

Module number and name: Module 2. Commonly accepted learning processes in harmony with ESD

Purpose	To identify learning processes and strategies suitable for training in sustainability.				
Topics and Subtopics Covered:	Introduction. ESD. Commonly adopted pedagogies in ESD. Educational transformations proposed by ESD.				
Knowledge	Acquire relevant information that directly impacts their role as sustainable educators.				
Presentation Outline					
Section	Topic	Activity	Estimated Time	Technological Resources	Evaluation
1	Introduction		30 MIN	Moodle platform	
2	ESD in my context	Video and	120 MIN	Moodle platform, Lumi	Rubric for forum

Forum				participation	
3	ESD pedagogies in teaching and their transformations	Mind Map	180 MIN	Moodle Platform	Rubric
Modul number and name:		Module 3. The relationship between ESD, non-formal education, and virtual tools.			
Purpose		To identify virtual tools that contribute to sustainability training in non-formal educational contexts.			
Topics and Subtopics Covered:		Introduction. Virtual tools in ESD. Virtual tools in non-formal education. Course Closure.			
Knowledge		Identify ICT and suitable virtual tools for training in sustainability in a non-formal education environment.			
Presentation Outline					
Section	Topic	Activity	Estimated Time	Technological Resources	Evaluation
1	Introduction		30 MIN	Moodle platform	
2	Digital technologies and education for sustainable development.	Canvas on Padlet	180 MIN	Moodle platform, Padlet	Participation in the canvas
3	Using digital tools for teaching in non-formal educational contexts.	Memory game	180 MIN	Moodle platform	
4	Course closure.	Forum: reflection and proposal	180 MIN	Moodle platform	Participation in the forum

Source: Authors' own elaboration.

For the development stage, all necessary materials and didactic resources were created to address the needs identified in the first phase of ADDIE, the analysis. The developed resources include infographics, interactive images, presentations, illustrative videos, and H5P formatted virtual learning objects. Each of these materials was designed based on the previously established learning objectives. Accessibility and clarity were also considered to ensure relevance and coherence in the context of implementation.

During the implementation phase, all materials were uploaded to Moodle through the UAQ Jalpan Virtual Campus. Regarding evaluation, various formative and

summative feedback activities were designed and applied, integrated into each module. These activities included quizzes, discussion forums, and practical exercises.

As part of the discussion, it is important to mention that developing an instructional design for training in sustainability within a non-formal educational context presented both challenges and opportunities. The results highlight the importance of adapting teaching strategies to the needs of trainers and having a solid understanding of formal education and digital tools. This section defines what these findings mean, how they relate to other research, and how they can improve sustainability training. Additionally, it reflects on the challenges of integrating virtual methodologies and potential improvements for future applications.

These findings reinforce the idea that teaching sustainability in non-formal educational contexts is not only a challenge but also an opportunity to rethink how teaching strategies are designed and applied. The lack of familiarity with the concept of non-formal education among trainers themselves indicates that there is still much to explore in this field, especially concerning teacher training. Furthermore, while the use of virtual tools is common and various authors support this idea, not all are equally effective for teaching sustainable development, underscoring the importance of selecting technologies that go beyond mere information transmission and foster action. Ultimately, these findings confirm the need to investigate and develop pedagogical approaches that adequately combine the flexibility of non-formal education with the potential of ICT, ensuring that sustainability education is truly meaningful and applicable to contemporary challenges.

In his work “Education, Environmental and Human Sustainability,” Madrigal (2020) underscores the importance of generating a new consciousness, highlighting how not only public organizations and institutions but also private ones are joining efforts to achieve a different kind of education—one that allows for a fulfilling life in harmony with nature. However, the results of this work demonstrate the significant distance that still needs to be covered. Although there has been substantial progress in implementing ESD, alarming challenges remain, such as the lack of sufficient knowledge and skills to effectively teach sustainability.

The findings of this study align with those proposed by Tilbury (2011), who notes that ESD in non-formal educational contexts requires flexible approaches and more participatory methodologies that provide opportunities for both trainers and students to generate meaningful knowledge. Additionally, authors such as Álvarez-Cadavid and González-Manislava (2022) emphasize the importance of prioritizing the use of technological tools in professional training. However, while these studies highlight the significance of active student participation, the results of this research reveal that the trainers themselves need a better understanding of non-formal education and its methodologies, pointing to a gap in teacher training that has yet to be thoroughly addressed.

On the other hand, Lozano et al. (2017) discuss the importance of developing specific digital competencies for teaching sustainability in various educational contexts, including non-formal ones. This directly relates to the results obtained, as

it was reinforced by showing that while participants were adept at using ICT, not all the tools employed were effective in generating meaningful learning.

Authors such as Llanos (2021) affirm the importance of non-formal education, noting the global consensus on the necessity of lifelong learning and how all individuals should have the opportunity to learn continuously, both inside and outside formal educational settings. However, this study observed a lack of full understanding of what formal educational processes involve. While this type of education is indeed critical, it has not received the necessary attention for effective implementation of the teaching-learning process.

Conclusions

One of the main contributions of this study is that implementing sustainability teaching represents a significant challenge, and its complexity increases when applied in non-formal educational contexts, especially when integrating virtual tools. Throughout the research, an instructional design for comprehensive sustainability training mediated by digital technologies was successfully implemented, aimed at trainers in this field. One of the most relevant findings was that course participants indicated they were not familiar with the concept of non-formal education, despite much of their educational activities occurring in such environments. This lack of clarity highlights the urgent need for teacher training focused on more flexible pedagogical approaches that transcend traditional schooling frameworks and recognize the diversity of spaces and forms of learning.

Although participants demonstrated adequate handling of digital tools, a key point emerged for future research: not all technologies are relevant or effective for teaching sustainability in non-formal contexts. While they provide advantages in accessing information and interaction, their true impact depends on strategic selection aimed at promoting not only knowledge but also critical reflection and practical application in everyday life. This observation suggests the need for deeper studies on the relationship between types of educational technology, teaching methodologies, and significant learning outcomes in sustainability.

The instructional design of the course “Sustainable Teaching Mediated by Virtual Tools in Non-Formal Educational Contexts” appropriately addressed the needs identified in the analysis phase. It enabled participants to recognize the distinctive characteristics of non-formal education, understand the learning processes that occur within it, and use ICT more critically and effectively in teaching sustainability. These capabilities strengthen their teaching profile, promoting a more reflective, contextualized, and inclusive practice.

As future research directions, it is suggested to explore more deeply the impact of using specific digital tools in teaching the SDGs in non-formal environments, as well as to analyze changes in trainers’ pedagogical practices after receiving training based on instructional models such as ADDIE. It would also be relevant to investigate the institutional or cultural barriers that limit the full adoption of non-formal approaches in education for sustainability.



In summary, this study reaffirms that education for sustainability, aligned with the Sustainable Development Goals (SDGs), must extend beyond formal educational environments, and that its effective implementation requires not only technological resources but also solid teacher training that is sensitive to the context and committed to social transformation.

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Declaration of author responsibility

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