

GROWING SKILLS AND INCLUSION WITH A HYDROPONIC ORCHARD

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Abstract

The participation of individuals with intellectual disabilities in higher education has traditionally been limited. However, this situation is gradually evolving due to the growing number of university programmes designed to foster their educational and social inclusion. At the University of A Coruña, the initiative “Espazo Compartido” offers an educational pathway focused on developing personal, social, digital, and pre-employment skills essential for autonomy and employability. Within this context, the use of horticultural activities is proposed as an active pedagogical resource, given its proven effectiveness in enhancing mental health, promoting social inclusion, and stimulating cognitive functions through plant cultivation and participation in structured activities. This proposal has been implemented in the TICARE project (Application of High Technology in Centers for the Care of Individuals with Intellectual Disabilities), which aims to innovate therapeutic and educational interventions through the integration of technology in the Centers for the Care of Individuals with Disabilities (CAPD) in Galicia. The HATHOR subproject (inaugurated in April 2025 at the CAPD in Coruña) consists of an indoor therapeutic orchard based on a closed hydroponic system, automated through home automation technologies, sensor networks, and remote control. The system is designed in accordance with universal accessibility principles and incorporates an interface adapted to the specific needs of individuals with intellectual disabilities, following established recommendations. It enables users to perform tasks such as watering, fertilizing, or activating the cooling system in a simple, intuitive, and safe manner—both on-site and remotely. In addition, the system supports continuous monitoring of the orchard’s condition, tracking crop development, and automatic logging of horticultural activities and incidents. All this allows the garden to be semi-automated and for students to acquire basic digital skills. Manual tasks, such as pruning or harvesting, are carried out with the help of therapists and in compliance with accessibility and safety protocols. The resulting educational experience integrates experiential learning, assistive technologies, and engagement with the natural environment, enhancing psychosocial well-being, active social participation, and transitions towards autonomous and meaningful adult lives.

Keywords: *Digital skills, horticultural therapy, intellectual disabilities, orchard.*

1. Introduction

Although Article 24 of the Convention on the Rights of Persons with Disabilities explicitly recognizes the right to education at all levels, the participation of individuals with intellectual disabilities in higher education has historically been very limited in Spain. This situation has begun to change progressively with the emergence of university programmes specifically designed to promote their educational and social inclusion. A pioneering initiative in this field was the PROMENTOR programme, launched in 2004 by the Autonomous University of Madrid, which was subsequently followed by similar initiatives at other Spanish universities. Specifically, the University of A Coruña developed Espazo Compartido, a training programme aimed at individuals with intellectual disabilities and focused on the development of key competences for personal autonomy and employability.

These programmes share a competence-based approach that prioritizes the strengthening of adaptive, social, and digital skills, which are widely regarded as essential for the transition to a more autonomous and socially engaged adult life. Consequently, there is a growing need to identify active learning activities to be included in these programmes that allow these core competences to be addressed in a meaningful, accessible, and motivating manner.

In recent years, horticultural activities have become increasingly established as an effective educational and therapeutic resource in this context. Inclusive, therapeutic, or social orchards are commonly integrated into intervention and training programmes for individuals with intellectual disabilities or situations of dependency, with the aim of fostering personal autonomy, responsibility in task management, and social participation through cooperative work dynamics (Son, Kim and Park, 2022). Despite differences in terminology, these initiatives share a common understanding of the orchard as a structured environment for experiential learning.

In Spain, the National Centre for Environmental Education (CENEAM) has documented and disseminated numerous experiences related to inclusive community orchards, emphasizing accessibility and participation as fundamental design principles (Fundación Iniciativas Sur, 2025). More recently, projects such as the CiBiS/UAL Inclusive Orchard, promoted by the University of Almería (CiBiS/UAL, 2025), have framed horticultural practice within the context of so-called ecological therapies, conceived as a complement or alternative to conventional psychological interventions. Empirical evidence associated with these approaches highlights benefits in terms of social interaction, physical activity, contact with nature, and improvements in psychological well-being.

These outcomes are further supported by theoretical frameworks such as Attention Restoration Theory and Stress Recovery Theory, which argue that exposure to natural environments contributes to the restoration of cognitive resources and the reduction of stress. From this perspective, orchards—even when implemented in urban or indoor settings—can be considered valuable tools for promoting mental health and quality of life, particularly in populations with specific neuropsychological needs.

On this basis, the integration of orchard-based activities into structured training pathways emerges as an effective strategy for reinforcing autonomy, decision-making, and responsible participation in cooperative work processes. This paper presents HATHOR (Hydroponic Automated Therapeutic ORchard), as a proposal aimed at combining experiential learning, accessible technology, and the development of basic digital skills in individuals with intellectual disabilities.

2. HATHOR

2.1. Background

Hydroponics was chosen as a learning environment for two main reasons. First, for students with diverse disabilities, a solution was needed that was safe, and indoor-friendly. A closed-loop hydroponic configuration eliminates the intended users' need to utilize pesticides and heavy tools, functioning indoors within a classroom setting. Second, participants often lack agricultural experience and are involved in multiple competing tasks at the same time, so that, to ensure success, the system requires high autonomy and minimal manual maintenance. To achieve this, the developed closed-loop system automatically recirculates the nutrient solution, that is continuously reused, and precisely and automatically regulates pH, electrical conductivity (EC), salinity, and temperature to compensate for plant uptake. As discussed in (Ramón-Moreno, 2023) and (Gordo-Ruiz, 2017), this level of operational demand makes remote (telematic) monitoring a core requirement to ensure the system remains usable and stable for both students and staff.

2.2. Definition

HATHOR is a hydroponic and automated therapeutic orchard developed within the framework of the TICARE project (Application of High Technology in Centers for the Care of Individuals with Intellectual Disabilities in Galicia (CCIID); <https://ticare.citic.udc.es/>).

HATHOR was launched in April 2025 at the CCIID in A Coruña and, although it was deployed as a pilot project, it aims to establish a scalable model for future seamless replication throughout the regional government's network of centers.

HATHOR allows students at the CCIID to experience the complete cultivation life cycle. They can monitor the full growth cycle and perform routine care (e.g., watering, fertilization, and temperature adjustment) via intuitive digital control, an experience that offers students significant multisensory stimulation. Also, the system is internet-enabled, so that students have real-time remote access enabling them to check crop status and exercise their responsibilities anytime and anywhere. Only physical agronomic tasks (e.g., pruning and harvesting) are conducted under therapist guidance to ensure safety and accessibility.

HATHOR is equipped with a network of sensors and actuators that facilitate semi-automated management, paired with two custom apps. The first schedules and records maintenance activities, while the second provides students with a control panel with intuitive controls for tasks such as irrigation, nutrient supply, and activation of the cooling system.

2.3. Architecture

As shown in Figure 1, HATHOR defines an indoor learning space that utilizes a Nutrient Film Technique (NFT) configuration. The system is housed within a modular support structure engineered to minimize its physical footprint. The frame's design allows for front and lateral access, optimizing ergonomics for maintenance, supervision, and assisted agronomic tasks.

Figure 1. The orchard.



It has also been conceived as high-tech hydroponic therapeutic orchard, so that NFT is combined with advanced sensor monitoring, home-automation tools, and remote connectivity features. Specifically, it incorporates a distributed network of sensors and actuators based on SONOFF devices (ITEAD Intelligent Systems Co., 2025) and powered by a Raspberry Pi 5 running Home Assistant (Nabu Casa Inc., 2025). This architecture enables real-time, WiFi-based data acquisition for both hydroponic and environmental variables, while allowing mechanical components to be managed as individual addressable entities within Home Assistant. Consequently, the platform facilitates complex conditional automations, scripted routines, and contextual mobile alerts.

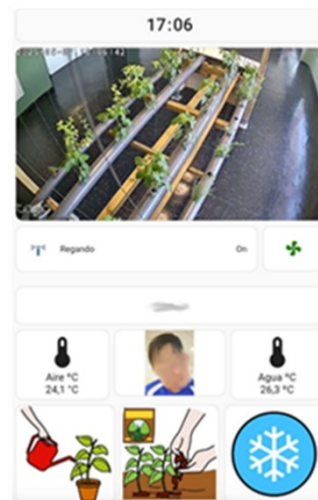
2.4. Automated behavior

The system uses Home Assistant to coordinate sensors and actuators, enabling smart behaviors like self-adjusting lights, timed nutrient dosing, and adaptive cooling systems of water and air. It also oversees user activity and provides a dedicated "maintenance mode" for technical interventions. To ensure these features are accessible to everyone involved, two specialized applications were developed: the Administration App for management and Therapeutic App for participant interaction, shown respectively in Figures 2 and 3.

Figure 2. Administration App.



Figure 3. Therapeutic App.



Designed specifically for staff, the Administration App serves as a unified hub for overseeing the orchard's health and operation. Staff can inspect live sensor data and visualize historical trends for pH, EC, and salinity to support long-term crop care. Beyond environmental monitoring, the app centralizes lighting and shutter control, live camera feeds, and the management of nutrient-solution cycles. It also includes a "maintenance mode" for technical interventions and specific corrective actions with configurable timers. To prevent accidental misconfiguration, users with disabilities do not have access to this app.

The Therapeutic App is designed specifically for tablet use, offering a user-friendly interface for students to interact with the orchard under supervision. It provides a simplified overview of the orchard's status, focusing on key indicators such as air and water temperature. It allows users to perform only three specific tasks: irrigation, fertilizer injection, and cooling activation. This limited number of options contributes to maintaining students' focus of attention. Each interaction is logged with timestamps and duration data, providing therapists with objective metrics to evaluate student engagement and refine future therapeutic interventions.

3. Results

During six weeks, and under the direct supervision of occupational therapists, eight participants with diverse intellectual disabilities participated in scheduled sessions to manage the orchard via the Therapeutic App, whose interface was specifically designed for cognitive and motor accessibility. They performed guided operations such as irrigation, nutrient injection, and climate control reaching the orchard the expected phenological stages (see Fig. 4).

Figure 4. Crops in HATHOR.



Therapists observed measurable gains in digital skills and greater independence in following routines, as well as in task-related autonomy, and visuomotor coordination. These findings were also supported by the data registered in the system's automated interaction logs, that facilitated the quantitative assessment of user activity, revealing specific participation patterns and individual developmental trajectories.

The validation of the installation was also successful, since all automated routines performed without failure or service interruptions. A key highlight was the robustness of the Raspberry Pi 5 core, which utilized local processing to ensure continuous operation during temporary connectivity losses. The overall stability, reliability, and operational efficiency of the platform is demonstrated by successful crop development.

4. Conclusions and future work

HATHOR is a high-tech, indoor hydroponic orchard designed for accessibility. Grounded in universal design, its semi-automated features enable students with intellectual disabilities to manage crop cycles while building real-world digital competencies thanks to the use of intuitive remote interfaces specifically adapted to users with intellectual disabilities. By combining experiential learning with assistive technology, HATHOR promotes psychosocial well-being and prepares students for autonomous lives and employability, as the validation results demonstrate that participants gain in issues such as digital skills and task-related autonomy. It ultimately makes orchards like HATHOR a valuable pedagogical tool to be incorporated in educational programmes dedicated to the social, educational and labor inclusion of persons with disabilities. At present, many universities implement programs dedicated to the social and educational inclusion of these persons, shifting the trend of the limited participation of individuals with disabilities in higher education, especially in the case of intellectual disabilities. At the University of A Coruña, the Espazo Compartido initiative provides a training pathway focused on personal, digital, and pre-employment competencies essential for autonomy. Therefore, future efforts will be dedicated to the systematic integration of HATHOR into the Espazo Compartido programme, as well as into other similar frameworks. It will also allow therapists to perform rigorous clinical evaluation of HATHOR's therapeutic impact.

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