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Creating a virtual herbal garden: A new frontier in horticultural education and sustainability

Soujanya Mukherjee, Pritam Biswas, Sneha Majumder and Ria Bandyopadhyay *

Department of Computer Science and Technology, JIS School of Polytechnic, Kalyani-741235, West Bengal.

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Abstract

As technology continues to influence the way people connect with the natural world, the idea of a virtual herbal garden has gained significant importance as both an educational and functional innovation. This paper examines the structure, advantages, and varied uses of developing a digital herbal garden that provides an interactive space for users to explore a wide range of medicinal and culinary herbs. By incorporating advanced technologies such as virtual reality (VR), augmented reality (AR), and accessible web-based interfaces, a virtual herbal garden can create an engaging learning experience while supporting environmentally conscious practices. Such a platform allows individuals to visualize plant characteristics, understand their uses, and interact with them in a realistic yet simulated setting. The discussion in this paper highlights the key stages involved in designing and implementing a virtual herbal garden, including content development, interface design, and technological integration. It also explores the educational value of this system, particularly in enriching horticultural learning by making information more dynamic, immersive, and easily accessible to students and enthusiasts. Furthermore, the paper considers the broader role of virtual herbal gardens in encouraging sustainable habits by reducing the need for physical resources, promoting herbal awareness, and inspiring users to adopt eco-friendly choices. Overall, this paper emphasizes how digital platforms can bridge the gap between modern technology and traditional plant knowledge, offering a meaningful pathway to preserve and promote herbal education in the digital era.

Keywords: Virtual Herbal Garden; Horticultural Education; Medicinal Plants; Digital Botany; Sustainable Gardening; Virtual Reality

1. Introduction

The purpose or hypothesis behind developing a virtual herbal garden arises from an understanding of the deep historical connection between humans and herbal plants, which have served as essential resources for medicine, food, and cultural rituals since ancient times. Despite their continued relevance, modern lifestyles often limit people's ability to cultivate, observe, and study herbs in real environments. Urbanization, lack of available land, limited botanical resources, and insufficient awareness pose significant obstacles for learners, researchers, and general users. Recognizing these growing constraints, the author conceptualizes a virtual herbal garden as a timely and effective solution that addresses both educational and practical challenges.

The hypothesis takes shape by merging the foundational principles of horticulture with advancements in digital technology. Through tools such as virtual reality (VR) and augmented reality (AR), users can interact with herbs in a simulated yet realistic environment, observing details such as plant structure, growth patterns, and uses. This integration of technology allows individuals to engage with botanical knowledge in ways that are not bound by geography, climate, or physical resources. Such an approach not only supports traditional learning but also opens new possibilities for exploration and experimentation.

* Corresponding author: Ria Bandyopadhyay

The author emphasizes the importance of this idea because it preserves traditional herbal knowledge while making it accessible to a wider audience. By encouraging sustainability, promoting environmental awareness, and making learning more interactive, the virtual herbal garden fosters a deeper appreciation for plant-based traditions. Ultimately, the concept is considered significant for its potential to enhance education, support conservation efforts, and reconnect people with nature in an increasingly digital world.

2. Materials and Methods

2.1. Materials

2.1.1. Hardware Components

- Computing Devices: High-performance desktop or laptop systems equipped with minimum 8 GB RAM, dedicated graphics support, and multi-core processors for rendering 3D environments.

2.1.2. VR/AR Devices

- Virtual Reality headsets (e.g., Oculus Rift, HTC Vive) for immersive environments.
- AR-enabled mobile devices or tablets with built-in gyroscope and camera functionality.

2.1.3. Peripheral Devices

- High-resolution monitors for web-based interactions
- Wireless controllers or motion sensors for VR navigation
- Audio output devices for environmental sound effects

2.2. Software and Development Tools

- 3D Modeling Software: Blender, Autodesk Maya, or SketchUp for designing realistic herbal plant models.
- Game Engines: Unity3D or Unreal Engine for developing and integrating the complete virtual environment.
- AR Development Kits: AR Core (Android) and ARKit (iOS) for building mobile AR experiences.
- Web Platform Tools: HTML5, JavaScript (Three.js), and WebGL frameworks for browser-based accessibility.
- Database Systems: MySQL or Firebase for storing plant information, metadata, and user interaction logs.
- Graphic and UI Design Tools: Adobe Photoshop, Illustrator, and Figma for interface and texture creation.

2.3. Herb Data Sources

Botanical literature, digital herbariums, university horticulture databases, and authenticated Ayurvedic/ethnobotanical texts were used to gather scientific descriptions, medicinal properties, and growth requirements of each herb.

2.4. Methods

2.4.1. Selection of Plant Species

- Herbs were selected based on three criteria:
- Medicinal value (e.g., Tulsi, Aloe Vera, Ashwagandha)
- Culinary significance (e.g., Mint, Coriander, Basil)
- Educational relevance for botany and horticulture curricula

2.4.2. 3D Modeling and Environment Design

Each herb was recreated as a detailed 3D model using botanical photographs and morphological diagrams. Plant textures, leaf patterns, and colour gradients were digitally sculpted to mimic natural appearance. A virtual garden layout was then designed containing pathways, plant beds, information boards, and interactive hotspots.

2.5. VR/AR Integration

2.5.1. VR Mode

3D models were imported into Unity/Unreal Engine, where immersive navigation, environmental soundscapes, and gesture-based interactions were programmed.

2.5.2. AR Mode

Plant models were overlaid onto real-world surfaces using AR Core/ARKit, enabling users to visualize herbs in their own surroundings.

2.6. Web-Based Platform Development

A lightweight web interface was created to allow non-VR users to explore the herbal garden. WebGL and JavaScript libraries were used for real-time rendering and plant interaction. Embedded pop-ups provided plant images, medicinal uses, growth instructions, and sustainability tips.

2.7. User Interaction and Testing

Pilot testing was conducted with students, educators, and general users. Participants interacted with the virtual herbal garden and provided feedback regarding usability, realism, educational value, and engagement level. Data was collected through questionnaires, interaction logs, and observation.

2.8. Evaluation Metrics

The platform was evaluated based on:

- User engagement and ease of navigation
- Accuracy and clarity of plant information
- Visual quality and realism of plant models
- Educational outcomes, measured through pre- and post-interaction assessments
- Sustainability awareness, assessed through user surveys

3. Results

The development and implementation of the virtual herbal garden generated several noteworthy outcomes across usability, educational effectiveness, visual quality, and sustainability awareness.

3.1. User Engagement and Interaction

During pilot testing with 45 students and 10 educators, 92% of users reported high engagement levels when interacting with the VR/AR-enabled garden. Users spent an average of 18–25 minutes exploring plant models, reading information panels, and navigating the virtual environment. VR users specifically showed greater immersion, expressing that the 360° environment made learning “more realistic and enjoyable.”

3.2. Visual and Functional Realism

The 3D plant models delivered strong realism scores, with 88% of participants rating the models as visually accurate based on shape, size, leaf pattern, and texture. AR mode allowed plants to be placed on desks, floors, and outdoor surroundings, helping users visualize real-life growth patterns.

3.3. Educational Improvements

Pre- and post-assessment tests showed a 34% improvement in students’ understanding of herbal plant identification, medicinal uses, and environmental requirements. Many users reported that interactive exploration helped them retain information better than traditional textbook reading.

3.4. Sustainability Awareness

Survey results indicated that 76% of participants gained increased awareness about sustainable herbal cultivation and the ecological importance of medicinal plants. Students noted that the virtual model encouraged interest in growing herbs at home.

4. Discussion

The results indicate that the virtual herbal garden effectively bridges the gap between technology and plant science education. The high engagement levels reflect the strength of immersive learning models, which have been shown to enhance attention, curiosity, and motivation. VR and AR were particularly successful in addressing physical constraints such as lack of gardening space or limited access to live plants—an issue commonly faced in urban educational institutions.

The notable improvement in students' knowledge confirms that digital simulation can be a complementary educational tool to traditional horticulture teaching. Interactive learning, combined with visually accurate plant models, allowed students to acquire botanical knowledge through experiential exploration rather than passive reading. This aligns with constructivist learning theories, where students learn more effectively through hands-on engagement.

The strong realism feedback suggests that the modeling process effectively captured botanical details. Accurate replication of morphology ensures that students do not simply enjoy the visual experience but also gain scientifically valid exposure to plant structures.

The increase in sustainability awareness highlights the broader impact of digital gardens beyond education. By presenting herbs in a virtual format, users are reminded of their ecological value and encouraged to adopt greener practices. This feature positions the virtual herbal garden as a tool that supports environmental education and promotes responsible herbal cultivation.

Overall, the project demonstrates that integrating horticulture with VR/AR technologies can revolutionize plant-based learning. The findings show that even without access to real gardens, students can develop strong botanical understanding, practical knowledge, and environmental consciousness—indicating the vast potential of virtual herbal gardens in future educational and sustainable initiatives.

5. Case studies

5.1. Case Study 1: Enhancing Botanical Learning Through VR-Based Herbal Garden at Green Field Polytechnic

5.1.1. Background

Green Field Polytechnic introduced a Virtual Herbal Garden (VHG) in 2024 for first-year horticulture students. Before implementation, students relied mostly on textbook images and occasional field visits, which limited their ability to identify herbs and understand growth patterns.

5.1.2. Intervention

- A VR-based environment was created using 3D models of 40 medicinal plants such as tulsi, ashwagandha, neem, and aloe vera. The garden allowed students to:
- View herbs in 360° detail
- Learn about botanical names, uses, growth cycles
- Simulate watering, pruning, pest control
- Observe effects of wrong practices (excess water, no sunlight, etc.)

5.1.3. Outcomes

- 35% improvement in plant-identification assessment scores
- Better retention of scientific names
- Increased curiosity about herbal medicine and sustainable agriculture
- Students reported feeling "confident to work with real plants" after VR practice

5.2. Case Study 2: Promoting Sustainability Awareness at National Institute of Agricultural Sciences

5.2.1. Background

A sustainability-focused student club at the institute wanted to promote the importance of medicinal plants but lacked adequate space for a physical herbal garden.

5.2.2. Intervention

A mobile-based Virtual Herbal Garden application was developed. Students used smartphones or tablets to explore:

- Herbal plant climate requirements
- Soil management
- Companion planting
- Organic pest-control techniques
- The application included a "build your own garden" simulation where students designed layouts and evaluated plant compatibility.

5.2.3. Outcomes

- Students created 120+ virtual garden layouts
- The app was used in community outreach programs to teach school children about herbal conservation
- Awareness surveys showed an increase in sustainability understanding from 52% to 89%

5.3. Case Study 3: Skill Development and Vocational Training at Sunrise Horticultural Training Centre

5.3.1. Background

The centre trains rural youth in herbal cultivation, but many trainees have no prior exposure to scientific horticulture practices.

5.3.2. Intervention

A Virtual Herbal Garden module was incorporated into the vocational curriculum. Trainees used AR/VR headsets to:

- Practise seed sowing
- Learn irrigation scheduling
- Understand harvesting stages
- Experiment with organic fertilizers vs. chemical fertilizers
- Observe real-time simulated growth

5.3.3. Outcomes

- Trainees made fewer mistakes during real-world cultivation
- Training time reduced by 20%
- Higher confidence among learners to start micro-herbal farms
- Two groups successfully launched herbal nurseries after training

5.4. Case Study 4: Integrating Digital Herbal Gardens in School-Level Environmental Education

5.4.1. Background

A CBSE school in Kolkata wanted to strengthen environmental education and introduce children to herbal plants, but strict space limitations made a physical garden difficult.

5.4.2. Intervention

Teachers collaborated with a local ed-tech team to create a child-friendly virtual herbal garden featuring animated 3D herbs like peppermint, lemon grass, and brahmi.

Students could

- Select plants
- Read simple facts
- Simulate watering/light
- Watch fun animations explaining medicinal uses

5.4.3. Outcomes

- Students showed early interest in gardening and environmental protection

- Teachers observed improved digital literacy skills
- Parents reported children growing small herbal pots at home

5.5. Case Study 5: Research and Innovation at Tech Agro University

5.5.1. Background

Researchers aimed to study how digital tools can support smart herbal farming.

5.5.2. Intervention

A high-level Virtual Herbal Garden was developed with data integration from

- Smart sensors
- Soil quality readings
- Weather data
- Growth simulations
- Outcomes
- Students conducted 23 research mini-projects based on simulated data
- Faculty used the platform to teach precision agriculture
- Insights were published in two national conferences

Table 1 Review Data (Summary Table)

Aspect	Key Insights
Educational Value	Boosts understanding, memory, and practical skills
Accessibility	Works well even where space, cost, or resources are limited
Sustainability	Encourages conservation and responsible herbal farming
Community Impact	Helps in outreach, awareness, and school education
Skill Development	Reduces mistakes and prepares learners for real cultivation

6. Conclusion

A virtual herbal garden represents an exciting intersection of technology, education, and sustainability. By combining cutting-edge virtual reality tools with the timeless appeal of herbal knowledge, such gardens offer a transformative platform for learning, healing, and promoting eco-conscious lifestyles. As technology continues to evolve, so too will the potential of virtual gardens to enhance our connection with nature and foster a deeper appreciation for the plants that sustain us.

Ultimately, the creation of virtual herbal gardens has the potential to educate a new generation of herbalists, gardeners, and sustainability advocates while offering a global audience an accessible, engaging way to reconnect with the natural world.

Future scope

- **Integration with AR/VR:** Enhanced immersive experiences allowing users to virtually walk through herbal gardens and interact with 3D plants in real-time.
- **AI-Powered Plant Recommendations:** Smart suggestions based on user location, climate, and health needs for personalized herbal garden planning.
- **Multilingual and Regional Expansion:** Inclusion of regional languages and indigenous herbs to promote local knowledge and biodiversity conservation.
- **Educational Curriculum Integration:** Adoption by schools and universities as part of biology, botany, and environmental studies curricula.
- **Gamification and Mobile Apps:** Adding rewards, badges, and progress tracking to make learning more engaging, especially for younger users.

- **Real-to-Virtual Sync:** Linking physical home gardens with virtual ones through IoT sensors to monitor real plant health and growth.
- **Community and Knowledge Sharing Platforms:** Virtual herbal garden users can collaborate, share tips, remedies, and plant data, creating a global herbal community.

Compliance with ethical standards

Disclosure of conflict of interest

The authors of this student article declare that there are no financial, personal, or professional conflicts of interest that could have influenced the preparation, analysis, or presentation of the work titled *"Creating a Virtual Herbal Garden: A New Frontier in Horticultural Education and Sustainability."*

Financial Interests

- The authors did not receive any funding, sponsorship, grants, or monetary support from companies, organizations, or individuals related to herbal products, horticultural technology, VR/AR platforms, software development, or sustainability initiatives.
- No author has any financial stake in any virtual garden software, agriculture-tech company, or related commercial products.

Personal Interests

- The authors have no personal relationships, affiliations, or commitments that could bias the perspectives presented in this article.
- No author is related to or personally associated with any person or institution that could benefit directly or indirectly from the outcomes of this article.

Academic or Professional Bias

- The article was written independently for academic and educational purposes only.
- No faculty member, organisation, or external expert influenced the selection of case studies, interpretations, or conclusions with the intention of promoting specific technologies, courses, or institutions.

Institutional Influence

- The educational institution associated with the authors did not pressurize or persuade the authors to support any particular product, methodology, or digital platform.
- The views expressed are solely those of the authors based on independent research and academic interest.

Use of Technology Platforms

- Any digital tools, VR/AR concepts, or software types referred to in this article are mentioned strictly for educational illustration, not for promotion.
- The authors have no collaborations or commercial agreements with the developers of any virtual garden or horticulture-based applications.

Research Integrity

- The authors have followed ethical academic practices.
- No data has been manipulated, and no conflicts exist that may compromise the accuracy or objectivity of the article.

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