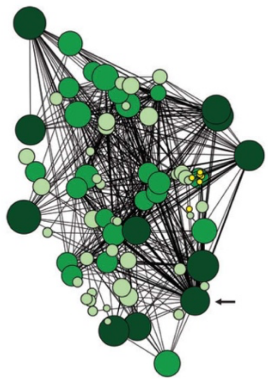
Project Proposal

Topic: (Robotics, AI, Ecological Interactions or Wearable Technology)

We have decided to choose 'Ecological Interactions' as our chosen track for this project. We are also incorporating components of robotic technology, enabling us to create a dynamic and interactive installation.

Project concept:



Study showing individual Douglas fir were linked to other individuals, 2009[1]

As stated in the brief, our objective is to create a 'non-screen-based experience'; therefore, we decided to create an interactive installation. Our initial inspiration came from the proposed concept of the 'Wood Wide Web', a term devised by the scientist Suzanne Simard in her 1997 PhD thesis.[2] The idea is that a mycorrhizal network, which is 'created by the hyphae of mycorrhizal fungi joining with plant roots'[3], is present and actively creates a sense of community as it allows communication between the plants. However, in 2023 aspects of this theory were argued against by Justine Karst and a team at the University of Alberta.[4] As seen through the title of their paper, 'Positive

[1] The wood-wide web – mycorrhizal associations across individuals (2016) Arboriculture. Available at: https://arboriculture.wordpress.com/2016/02/24/the-wood-wide-web-mycorrhizal-associations-across-individuals/ (Accessed: February 13th, 2025).

[2] New Scientist (1971) (no date) "Suzanne Simard interview: How I uncovered the hidden language of trees." Available at: https://www.newscientist.com/article/mg25033320-900-suzanne-simard-interview-how-i-uncovered-the-hidden-language-of-trees/ (Accessed: February 13th, 2025).

[3] Wikipedia contributors (2025) Mycorrhizal network, Wikipedia, The Free Encyclopedia. Available at: https://en.wikipedia.org/w/index.php?title=Mycorrhizal_network&oldid=1287598360. (Accessed: February 13th, 2025).

[4] Yeo, S. (2024) "The 'wood wide web' theory charmed us all – but now it's the subject of a bitter fight among scientists," The guardian, 9 July. Available at:

citation bias and overinterpreted results lead to misinformation on common mycorrhizal networks in forests'[5]. Although they didn't entirely dismiss the idea, they still claim that aspects are not necessarily statistically backed up. For example, they claim Simard utilised anthropomorphism as a tool to evoke feelings in the user and create a connection between them and the tree.[6] But this idea still holds value. This organic form of a network, naturally appealed to us because of the parallels with modern computing, particularly mesh network topologies.

To create our outcome, we will be combining aspects of bionic technology, robotics and Human Centred Interaction theories. The idea of natural communication is at the forefront of our project, and we want to visually demonstrate this to the user in the form of an immersive experience. Enabling the user to actively participate in the 'communication' being shown. Bionics is defined as the 'science of constructing artificial systems that have some of the characteristics of living systems'.[7] This is important as we want to simulate the ideology behind the common mycorrhizal network (CMN), mimicking the way the 'messages' are passed between the roots of the plants, indicating whether they need more water, minerals, nutrients, etc. However, instead of demonstrating this with trees, we have chosen flowers. This is because they create a better visual interest due to the variety of appearance, whereas trees all follow a similar structure regardless of species.

Additionally, it will be easier to model the environmental impacts on the flowers. We can scale up the flowers to ensure the movements are demonstrated, but if we used trees, they would have to be scaled down. Theoretically, we want to create a table-like area, where the robotic plants are placed on top in a seemingly natural environment. Underneath, you can see their roots and the connections between them, just like with the CMN. It would be optimal to demonstrate our outcome in a darker space, as we will be incorporating LED elements on the roots of the plants to light up and show the journey the messages go on when they are sent. Around the room there will be strategically placed sensors. This is where the user can interact with the plants. For example, one sensor could be a moisture sensor; the user could either dry it or add more water, and then they can see in real time the impact this has on our environmental simulation. In a sense, this allows the user to take on 'God like'

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https://www.theguardian.com/commentisfree/article/2024/jul/09/wood-wide-web-theory-charmed-us-bitter-fight-scientists (Accessed: February 13th, 2025).

[5](No date) Nature.com. Available at: https://www.nature.com/articles/s41559-023-01986-1.epdf?sharing_token=-wxqdAiztdyvbbe2P4uWqdRgN0jAjWel9jnR3ZoTv0NhTP-fzuHqUsVVnDaJbaXlPDeSXUxYqcTbqUWYB-bJgnYwYwl2MW_UNDNQISj2SC0YL8WsBj_rqDSe8p66EzcyFqC-C_WSbzGJeSLGQUbr_acM-Qotj6FWH0tSDW46K01Y9cziqxR3aj8HH67q-h_Z2WQ5byo_OPGdyoV_2Dw0_c0gtB0A_dragZCX8-_S5fU%3D&tracking_referrer=www.theguardian.com (Accessed: February 13th, 2025).

[6]Times of Malta (2024) Myth Debunked: Do trees communicate via a wood wide web? Maybe not, Times of Malta. Available at: https://timesofmalta.com/article/myth-debunked-do-trees-communicate-via-wood-wide-web-maybe.1100992 (Accessed: February 13th, 2025).

[7] The Editors of Encyclopedia Britannica (2022) "bionics," Encyclopedia Britannica. (Accessed: February 15th, 2025).

capabilities, they are given full control over the plant's environment, which they can interact with at any point.

Goals:

The project aims to develop a functional, interactive simulation of mycelium-based communication, blending technology, art, and biomimicry. The technical outcome focuses on creating a modular system where users can send signals through an app or physical interface, triggering plant responses. These responses will be visualised through LED pathways, motorised movement, and potentially other sensory outputs. The network simulation will mimic organic information flow, taking inspiration from decentralised computing models and fungal communication pathways.

The impact of the project extends beyond the technical realm into educational, artistic, and scientific fields. By making hidden root communication systems visible and interactive, the installation aims to foster greater appreciation for ecological intelligence and biomimetic design. The immersive experience encourages participants to consider the parallels between natural and artificial networks, inspiring discussions on sustainability, technology, and interconnectedness in biological systems. Additionally, the project provides an opportunity to explore new forms of human-computer interaction that integrate living and synthetic components, contributing to emerging fields such as bio-HCI and biohybrid robotics.

Use Case 1: Artistic Installation – Community and Personal Impact

The installation transforms scientific theory and robotic simulation into a poetic, embodied interaction with the "Wood Wide Web." Inspired by the controversial yet culturally resonant work of Suzanne Simard (1997), the piece uses LED-embedded root systems and reactive robotic flowers to turn invisible fungal signalling into sensory phenomena.
This bio-art approach reflects a broader movement where technology and nature merge into hybrid experiences. Drawing on projects like Akousmaflore by Scenocosme (2009)[8], where users' touch generates sound via live plants, and Biomodd by Vermeulen (2007)[9], which uses e-waste to grow plant ecosystems, this installation continues the lineage of ecological media art that fosters affective ecological consciousness.

Community and Cultural Impact

The installation facilitates collective storytelling about interconnectedness, environmental fragility, and communal resilience. It draws conceptual parallels with

[8] Scenocosme (2009) *Akousmaflore*. [Interactive installation] Available at: https://www.scenocosme.com/akousmaflore_en.htm [Accessed: 11 May 2025]
[9] Vermeulen, A. (2007). *Biomodd*. SEADS. Available at: https://seads.network/hyperproject/biomodd [Accessed at: May 11th 2025]

Christa Sommerer and Laurent Mignonneau's "Eau de Jardin" (2004)[10] and Scenocosme's "Akousmaflore" (2009)[11], where plant interactivity is used to foster relational aesthetics and audience agency. It builds on Nicolas Bourriaud's theory of relational aesthetics where art is as a social experience and collaborative dialogue (Bourriaud, 1998).[12]
Public interaction is not passive; it's generative and by embodying fungal logic through robotic responses, it transforms spectators into stewards thus, drawing from Fulton Suri's empathic design theory (2003)[13], the artwork fosters emotional resonance, particularly when neglected plants dim or "wilt", eliciting care and responsibility from its observants/users.
The collaborative design also resonates with Jane Bennett's (2010)[14] idea of *vibrant matter,* that non-human entities possess agency and vitality. Through this lens, the robotic flowers are not just art objects, but ecological participants co-authoring experience with the audience.

Personal and Psychological Impact

The installation draws on Wilson's biophilia hypothesis (1984)[15], our evolutionary affinity with nature as to enhance personal well-being and reflective introspection. The tactile interaction aligns with theories of embodied cognition[16], affirming that understanding arises through sensory-motor engagement.
Interacting with the robotic ecosystem can also act as a mindfulness practice, similar to digital gardens[17], where people experience presence, rhythm, and consequence which consequently supports affective learning and the therapeutic potential of multisensory ecological installations.

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[10] Sommerer, C., & Mignonneau, L. (2004). *Eau de Jardin*. Available at: https://www.interface.ufg.ac.at/christa-laurent/ [Accessed: 11 May 2025]

[11] Scenocosme (2009). *Akousmaflore*. Available at: https://www.scenocosme.com/akousmaflore_en.htm [Accessed: 11 May 2025]

[12] Bourriaud, N. (1998). *Relational Aesthetics*. Dijon: Les presses du réel.

[13] Fulton Suri, J. (2003). 'Empathic design: Informed and inspired by other people'. In: B. Laurel (ed.) *Design Research: Methods and Perspectives*. MIT Press.

[14] Bennett, J. (2010). *Vibrant Matter: A Political Ecology of Things*. Durham: Duke University Press.

[15] Wilson, E.O. (1984). *Biophilia*. Cambridge: Harvard University Press.

[16] Varela, F.J., Thompson, E. and Rosch, E. (1991). *The Embodied Mind: Cognitive Science and Human Experience*. Cambridge: MIT Press.

[17] Cooley, H. (2021). 'Digital gardening and slow media'. *Digital Culture & Society*, 7(1), pp.113–123.

Use Case 2: Educational Tool – Visualising Hidden Plant Intelligence

Another use case approach to this is an experiential learning platform that visualizes the principles of Common Mycorrhizal Networks (CMNs). It responds in real time to environmental changes triggered by users such as light, moisture, and air flow and using physical feedback like robotic motion and LED-lit root pathways.

Pedagogical and Scientific Integration

The tool aligns with constructivist learning theory (Piaget, 1950; Papert, 1980)[18], which emphasizes learning through doing. The tangible, sensory interface follows Donald Norman's (2013)[19] principles of intuitive interaction, making complex ecological ideas accessible even to children or low-literacy users.

Inspired by educational installations like MIT Media Lab's "Cyborg Botany"[20] and the "Biomodd" project (Vermeulen, 2007–present), this system translates scientific principles into embodied, playful exploration. It supports STEM and STEAM curricula, blending biology, robotics, design, and ethics.

In schools or science centres, it becomes a biological sandbox where students manipulate real-world variables and observe distributed consequences, just as CMNs distribute nutrients and risk.

Cognitive and Social Relevance

The project aligns with the Extended Mind hypothesis (Clark and Chalmers, 1998)[21], proposing that learning occurs through dynamic interaction with tools and environments. The physical simulation acts as a "cognitive prosthesis," externalising otherwise hidden processes like nutrient exchange or resource competition.

Gamified learning, via task-based challenges and consequences (Deterding et al., 2011)[22], enhances cognitive retention and teamwork. The pixel-art UI inspired by Stardew Valley and Minecraft makes it culturally accessible, embedding the learning experience in a familiar visual grammar.

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[18] Papert, S. (1980). *Mindstorms: Children, Computers, and Powerful Ideas*. New York: Basic Books.

[19] Norman, D.A. (2013). *The Design of Everyday Things*. Revised ed. New York: Basic Books.

[20] Myers, A., Matheson, M. and Paradiso, J. (2020). 'Cyborg Botany: Augmenting Plants as Interfaces'. *ACM SIGCHI*. Available at: https://www.media.mit.edu/projects/cyborg-botany/overview/ [Accessed: 11 May 2025]

[21] Clark, A. and Chalmers, D. (1998). 'The extended mind'. *Analysis*, 58(1), pp.7–19.

[22] Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From game design elements to gamefulness: Defining "gamification." Proceedings of the 15th International Academic MindTrek Conference, 9–15.

The modular, low-cost, screen-optional design also supports educational equity, bringing experiential science learning to under-resourced schools and community centres globally.

By merging robotics, bionics, ecological systems, and embodied design, the project offers both a contemplative artistic experience and a compelling pedagogical tool. It makes the unseen visible and the abstract tangible, creating fertile ground for curiosity, empathy, and ecological literacy.

Target Audience Research and Psychology Behind Mycelium Communication & HCI:

The project targets a diverse audience, including academics and researchers studying biomimicry, biohybrid systems, and communication networks. Artists and designers working with interactive installations and kinetic sculptures will find value in the project's aesthetic and conceptual dimensions. STEM students and educators can utilise the installation as a learning tool to explore artificial ecosystems and bioinspired computing. Museum and exhibit visitors, particularly those interested in immersive experiences, will engage with the project on a sensory and conceptual level. Environmental enthusiasts and technologists will appreciate the exploration of ecological intelligence and sustainable design principles.

From a psychological perspective, the project capitalises on humans' natural inclination to relate to organic systems and decentralised intelligence models. The visualisation of networked plant responses enhances user engagement by making abstract biological processes more tangible and emotionally resonant. Allowing participants to directly influence the system through interaction fosters a sense of agency and curiosity, reinforcing the educational impact. Additionally, the project explores the cognitive and affective dimensions of bio-HCI, investigating how people perceive and respond to artificial organisms that exhibit lifelike behaviours.

The philosophy of mind plays a crucial role in how users interpret and engage with biohybrid systems. Concepts such as extended cognition, as discussed by Clark and Chalmers[23], suggest that technology can serve as an extension of human cognitive processes. This aligns with the idea that interacting with the artificial mycelium network allows users to externalise and manipulate an otherwise hidden biological communication process. Additionally, theories of embodied cognition[24] propose that intelligence is not confined to the brain but emerges through interactions between the body and the environment. This perspective reinforces the importance of tactile and

[23] Clark, A., & Chalmers, D. (1998). The extended mind. Analysis, 58(1), 7-19.

[24] Varela, F. J., Thompson, E., & Rosch, E. (1991). The embodied mind: Cognitive science and human experience. MIT Press.

visual engagement in our installation, making the experience more immersive and intuitively understood.

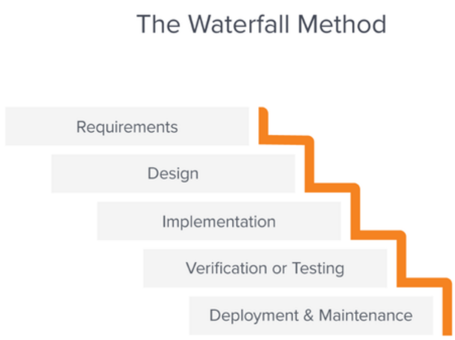
The project also draws from the philosophical debates on artificial life and non-human intelligence. Scholars such as Dennett[25] argue that intentionality can emerge from complex systems, even if they do not possess consciousness. This notion suggests that users may ascribe agency to the artificial fungi and plants, experiencing the system as a form of emergent intelligence. By leveraging these psychological and philosophical insights, the project not only enhances human-computer interaction but also encourages users to reconsider the boundaries between organic and synthetic life.

Timeline of milestones and deliverables:

Gantt Chart:

https://lucid.app/lucidspark/d2b2ae89-9b54-4a1c-b91a-fb94e85b2a50/edit?page=0_0&invitationId=inv_93f6ec4b-d5a9-422e-8b9a-a918d5a6ca89#

Methodology:



Waterfall lifecycle diagram[26]

For this project, we are working on a short timeline of four months, therefore, we have decided to follow the Waterfall Methodology[27]. As we are defining our requirements at the very start of the project in our project proposal, this methodology fulfils all our needs. The clear structure aids in creating our documentation, enabling us to easily collaborate as a team. From the very start, we can explicitly define the tasks we need to complete, who will do them and when they must be done by to reach our goals.

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[25] Dennett, D. (1991). Consciousness explained. Little, Brown and Company.

[26] (No date g) Adobe.com. Available at: https://business.adobe.com/uk/blog/basics/waterfall (Accessed: May 14, 2025).

[27] Wherrity, R. (2025) “Waterfall Project Management: Comprehensive guide for success,” Clearpointstrategy.com. ClearPoint Strategy, 12 March. Available at: https://www.clearpointstrategy.com/blog/waterfall-project-management (Accessed: May 15, 2025).

As we are not working with external clients, we have full control over the design choices, the development and what we create as the outcome. Which means that we do not have to be concerned that the client's requirements will change throughout the project. Otherwise, the entire cycle would have to be restarted, as the waterfall cycle follows a chronological order rather than an iterative approach. Ensuring that we stick to the original timeline and meet our deadline.

List of Deliverables:

Phase 1: (27^{th} February -> 10^{th} March)
- Concept Ideation
    - Develop our ideas and define what we want to create as an outcome.
- Task Allocation
    - Assign tasks equally between team members based on their strengths.
- Initial Sketches and Designs
    - Design the flowers
    - Design the environment layout and the interconnections of the flowers.
    - Design the movement of the flowers

Phase 2: (11^{th} March -> 30^{th} March)
- User Research
    - Determine the target demographic.
    - Explore use cases and applications of our outcome.
- Inspiration Research
    - Explore the scientific, artistic and computational approaches we can take for this project.
    - Explore other projects that are like our concept.
- Hardware & Software Requirements
    - Determine the sensors, components and equipment needed.
    - Determine what IDEs, Software and Code Libraries need to be installed.

Phase 3: (1^{st} April -> 30 April)
- Initial Prototyping
    - Interface wireframes
    - Figure out the Materials needed for the flowers
    - Work out the mechanics of the flower's movement
- Sensor Testing
    - Work out which sensors are easily accessible and can be integrated into our project.

Phase 4: (1^{st} May -> 22^{nd} May)
- Coding
    - The interface
    - The movement of the flowers
- User Testing
    - Get feedback on what went well, what could be improved.
    - Understand how the users were able to interact with the installation

- Final Reflections
    - Reflect individually on our progress within the project
    - Look at further developments