Design Ecosystems Fellowship Report 2022

The Living Textiles Ecosystem

Author: Jane Scott

FUTURE OBSERVATORY

Author

Jane Scott[1]
1 NUAcT Fellow, Hub for Biotechnology in the Built Environment, Newcastle University jane.scott@newcastle.ac.uk

Overview

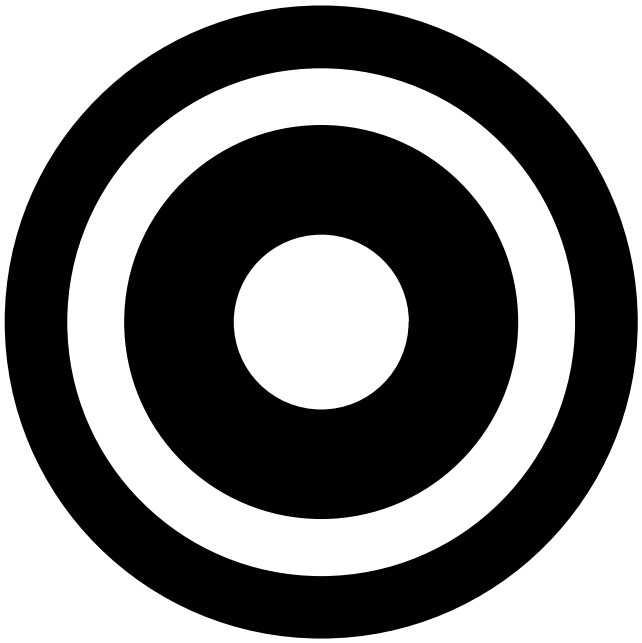
The Living Textiles Ecosystem maps the interrelationships between materials and technologies within the new interdisciplinary field of Living Textiles in the North of England. The purpose of the ecosystem is to explore how to repurpose waste from agriculture and industry into the material flow to produce biohybrid living textiles for the built environment. Alongside this, the ecosystem aims to determine the impact of material changes on production and the viability of adapting industrial textile processes to new biofabrication techniques. The geographical location of the ecosystem centres on Newcastle upon Tyne, with inputs extending to Cumbria and Yorkshire.

Research dates: 1st August 2022 – 31st January 2023
Total grant award: £19,627.65

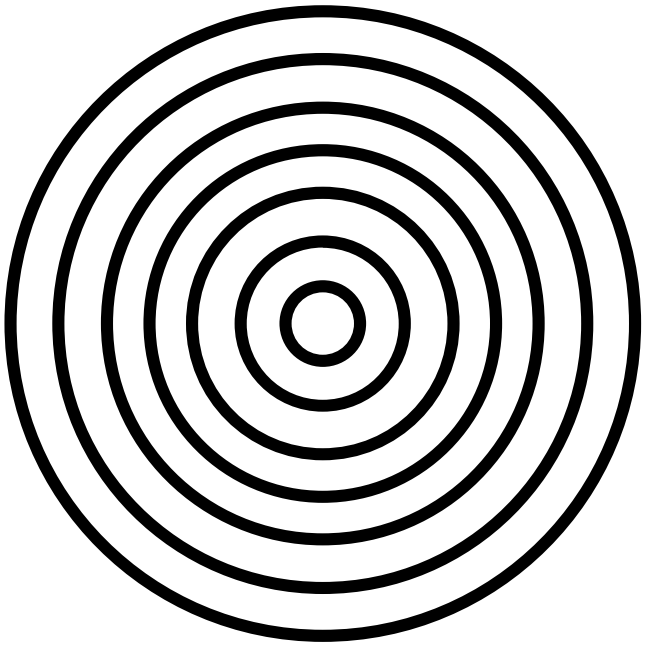
Research objectives

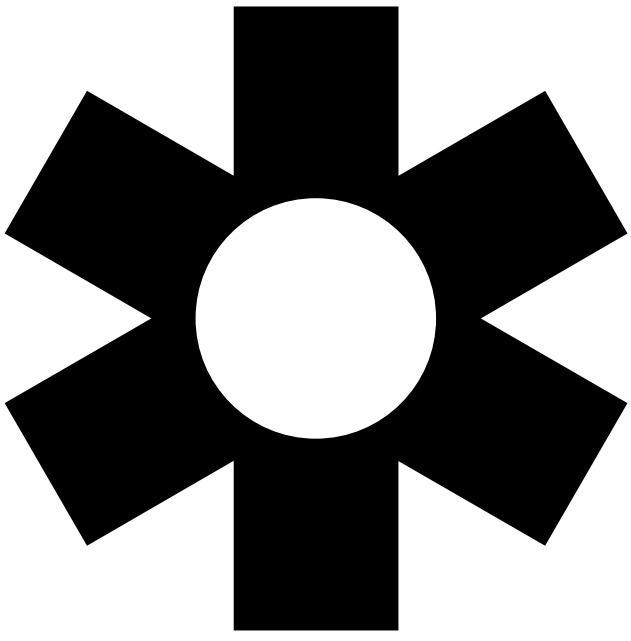
Research Aim: Map the Living Textiles ecosystem, identifying the interrelationship between materials and technologies required to produce sustainable biohybrid textiles for the built environment.

- Objective 1 (OB1): Identify local agricultural and industrial waste resource which are available in the North of England and suitable for production of mycelium/knit biohybrid textiles.
- Objective 2 (OB2): Evaluate how changes to material inputs impact biofabrication processes and resulting mycelium/knit biohybrid textiles.
- Objective 3 (OB3): Using an ecosystem design approach, visualise the interrelationships necessary to implement biotechnology and textile processes into the built environment.



Research activity





The aim of this Fellowship was to map the Living Textiles Ecosystem, identifying the interrelationship between materials and technologies required to grow sustainable biohybrid textiles for the built environment. In 2022, BioKnit, a large scale biohybrid textile structure, was designed and fabricated as grown from wool, fungal mycelium and bulk substrate materials. The materials used to create BioKnit were selected for use with specific technologies, and the material origins were international, for example merino wool (New Zealand/South Africa), beechwood (Europe) and mycelium that is non-native to the UK. As a design team, our aim was to find low impact resources for future prototypes and to create an ecosystem for Living Textiles that would focus on local waste streams. However, the specific impact of changes to materials in biofabrication processes, and the resulting biohybrid mycelium/knit textile structures, were unknown.

A programme of research activities to develop the Living Textile Ecosystem therefore required:

- An evaluation from stakeholders to analyse the current prototype and categorise necessary resources (OB1)
- Engagement with relevant local industries to identify available waste streams (OB1, OB2)
- Iterative prototyping to test materials and processes resulting from changes to the material composition (OB2)
- Ecosystem design to map the results visually (OB3)

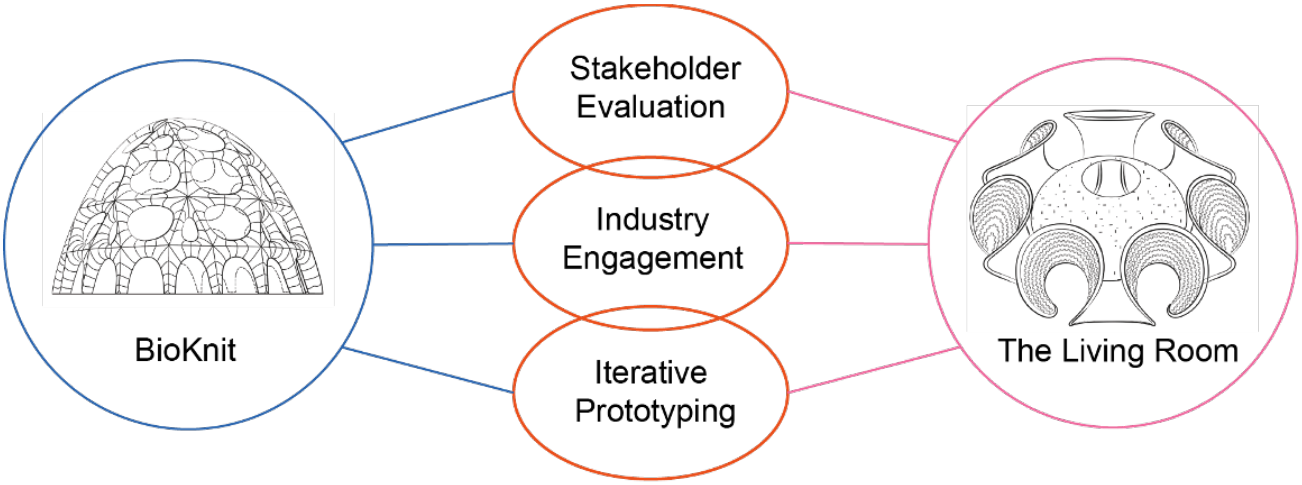


Figure 1: The three research activities undertaken for the Living Textile Ecosystem Fellowship.

The Fellowship began with analysis of the BioKnit prototype, achieved through a series of four stakeholder evaluation workshops undertaken at Newcastle University. The project was able to take advantage of some activities already scheduled within the Hub for Biotechnology in the Built Environment, for example an HBBE Industry Workshop, The ArchInTex Living Textile Architectures symposium, and the Being Human Festival (hosted in Newcastle at the Great North Museum). Each workshop was tailored to different stakeholders. Firstly, the materials and processes used to construct BioKnit were evaluated by the research team to identify the sources of all material inputs and examine the processes used for biofabrication. Two workshops invited experts from the textiles and construction industries to discuss potential industrial waste streams and how biofabrication could fit into conventional textile manufacturing systems. Finally, the public was introduced to the materials and processes during an engagement workshop to discuss how these new materials could be used to enable net zero within textiles and construction.

Alongside this, Industry Engagement visits were scheduled to visit local materials processing facilities to source waste materials. Visits included; local sheep farms, wool processing, spinners, sawmills, and a papermill. In addition to sourcing local waste for materials experimentation and development, semi-structured interviews were undertaken to understand material flows, scale of production and the quantities of waste available. The outcome of Industrial Engagement included sourcing wool fleece direct from farmers, new contacts with small scale UK spinners and access to waste from both sawmills and papermills for testing and development.

The third aspect to this research was to evaluate how changes to material inputs impact biofabrication processes and resulting mycelium/knit biohybrid textiles. This was undertaken via iterative prototyping and materials testing using the waste wool, wood and paper sourced through industry engagement via iterative prototyping and materials testing. This research was undertaken concurrently by the BioKnit research team.

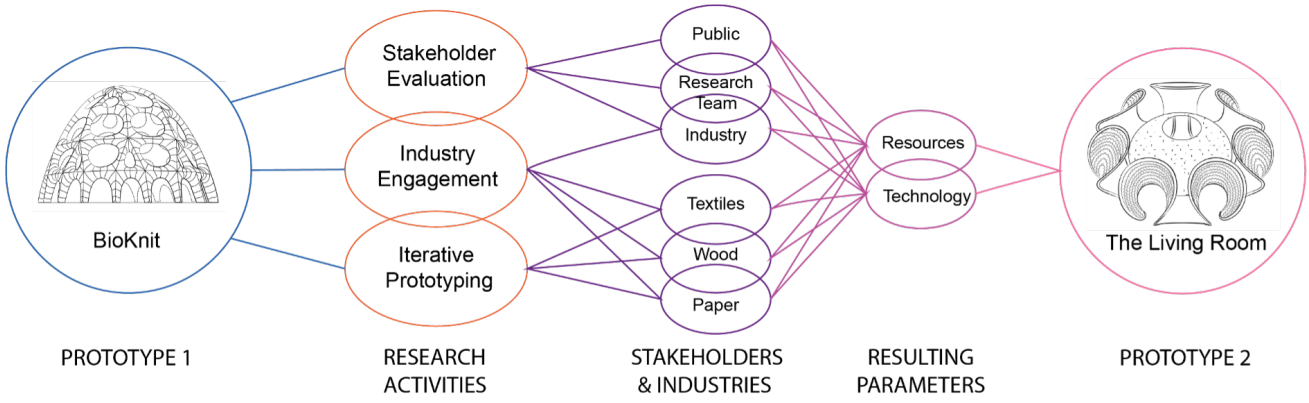
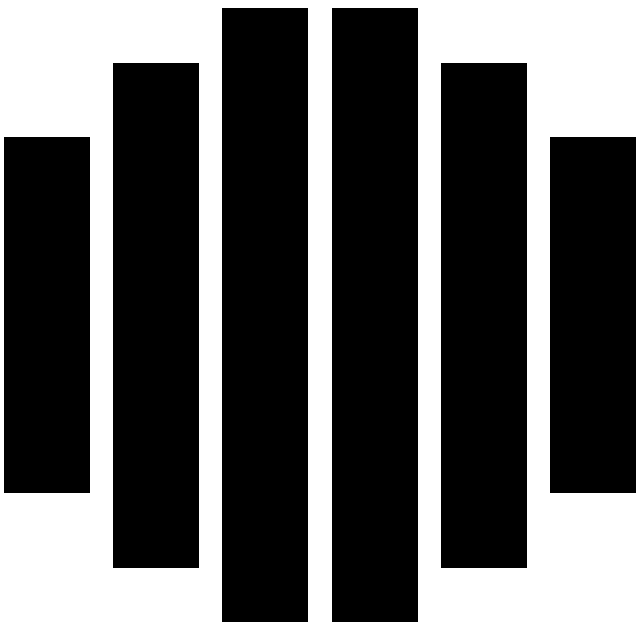


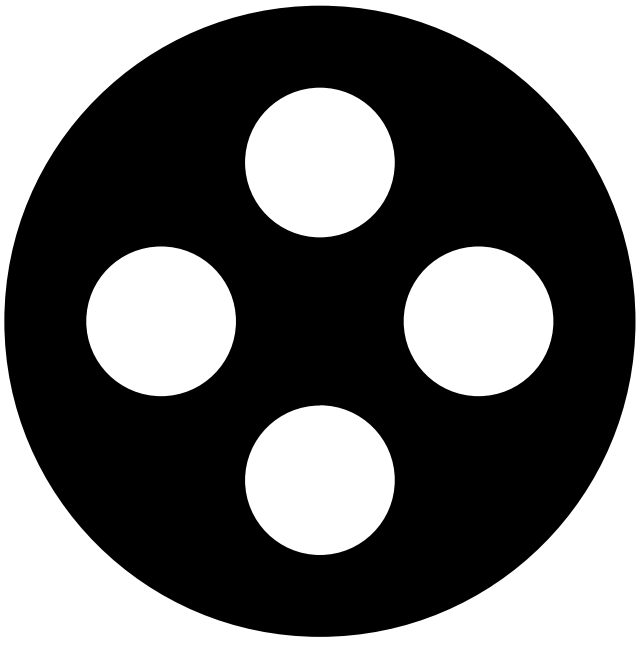
Figure 2: Research activities expanded to include how stakeholders and industries informed activities leading to focus on resource and technologies as key parameters for prototype development

Finally, in collaboration with Beyond Words Studio, the results of the research were mapped visually. Two approaches to enable the commercial development of textile biohybrids are proposed: firstly adaptation of current industrial processes with minimal material changes, eg conventional yarns and knitting processes maintained, and secondly development of new processes for alternative local waste inputs. This approach is tailored to emerging biofabrication technologies, for example unconventional yarns and alternative knitting processes used for The Living Room prototype.

The initial proposal planned for all activities to be undertaken on site in Newcastle, with experts joining a series of three one-day workshops. During the Fellowship, it became clear that conducting research into industries beyond textiles would be critical to sourcing and accessing local waste streams. Industrial visits were essential to understanding not only the available waste streams, but also the scale of local manufacturing sites and the available technology for future manufacturing.

Proposed design ecosystem Knitting a mycelium house



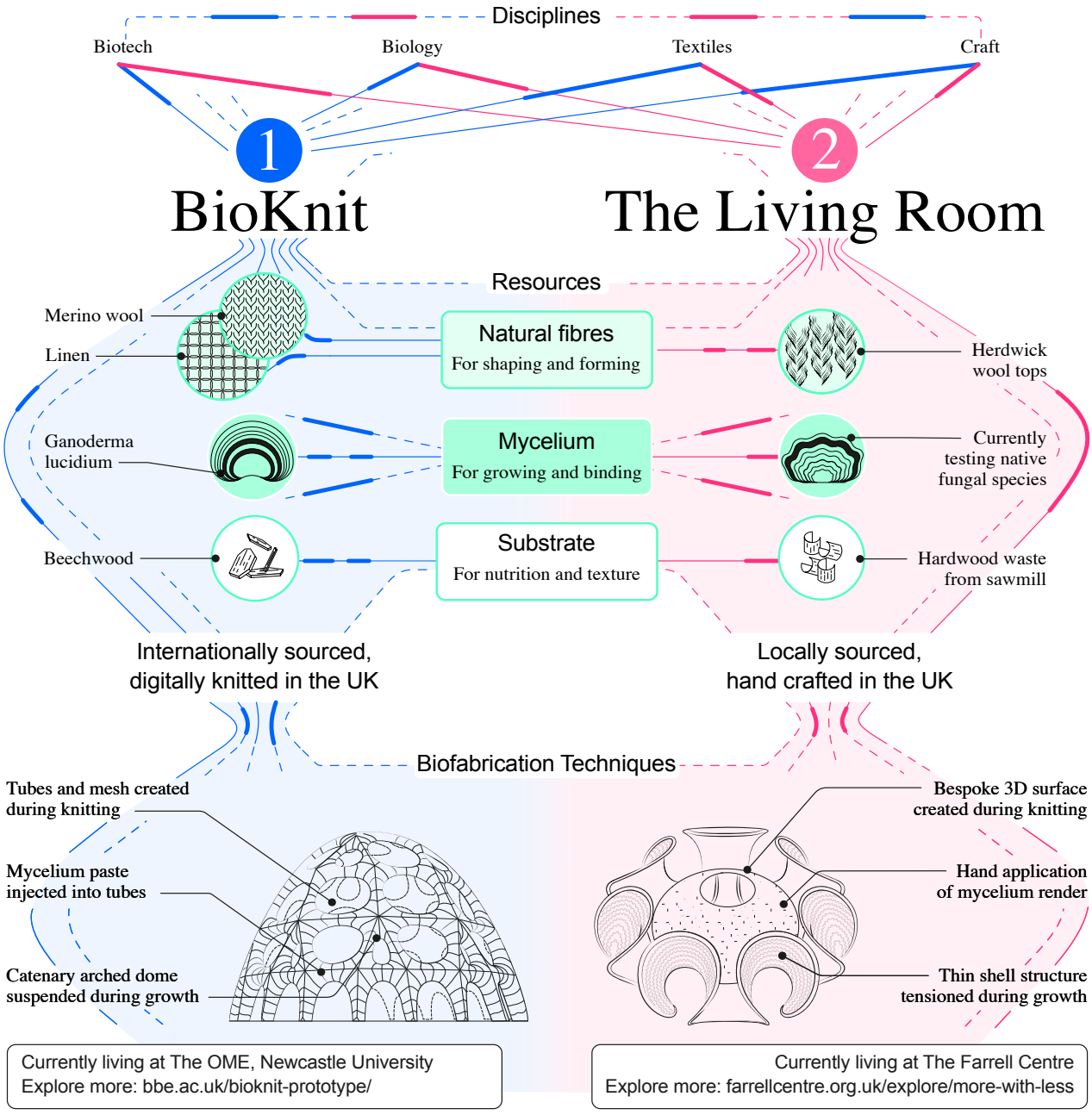


Knitting a mycelium house

How might we develop low-impact biohybrid textiles for the built environment?

At Living Textiles Research Group, we are approaching this challenge by blending disciplines, using local resources, and adapting industrial textile processes to develop new bio-fabrication techniques.

Through iterative prototyping, we're developing a flexible ecosystem tailored to local resources and requirements. Understanding this ecosystem is essential to creating scalable solutions that can transform the look, feel, and health of our architectural spaces.



Source: Hub for Biotechnology in the Built Environment, Newcastle University, 2023.

The ecosystem is located at the intersection of four key disciplines:
- Biotechnology (biofabrication, construction)
- Biology (mycology and microbiology for mycelium/knit biohybrids)
- Textiles (design, engineering and science)
- Craft (material practices)

Stakeholders are identified in relationship to resources and biofabrication techniques. From the perspective of resources, the key industrial stakeholders include the wool industry (farmers, processors, spinners) biotechnology (growlabs and suppliers) and bio-based material processing (timber industry and paper industry). In terms of biofabrication techniques, the stakeholders include UK textile manufacturers (spinners, woven and knitted textile manufacturers), and biotechnology. Additional stakeholders include a range of industries associated with construction (architects, building engineering, commercial development, materials suppliers) and biosciences (mycology and microbiology). Academic stakeholders include Newcastle University and Northumbria University, and within these institutions, the Hub for Biotechnology in the Built Environment (HBBE). In the HBBE, research is catalysing innovation within biotechnology for the construction industry. Finally, UK exhibition venues such as The Farrell Centre are supporting the research by promoting the technologies in public exhibitions.

This ecosystem proposes new applications for textiles in the construction industry, and ways to repurpose post-industrial waste. The framework focuses on two propositions each illustrated in the Ecosystem. The first approach addresses the adaptation of current textile technologies for biofabrication processes. This approach involves existing UK spinners, and exploits the advanced 3D knit technologies available within the UK knitting industry to develop bespoke preforms for use within composite systems for construction. It is illustrated by the BioKnit Prototype. The second approach looks at the opportunity for development, focusing on new techniques and technologies specifically tailored to the use of post-production waste as a resource for biofabrication. This approach is illustrated in The Living Room, where unconventional knitting processes enable waste wool and waste substrate (from a sawmill and a papermill) to form the biohybrid knit/mycelium structure.

Both approaches facilitate change in multiple interconnected areas of the textile and materials processing industries in the North of England. The aim is to develop high value products from waste resources readily available in the North of England. Interdisciplinary research organisations such as the HBBE are critical to the ecosystem, academics bring together industrial partners, undertake research and development of new materials and technologies, and explore the challenges of production and scale up in collaboration with UK industry.

This Ecosystem incorporates important industries within the UK; the textile industry, the biotech sector and the construction industry. As living textiles is an emerging field, there is significant opportunity for targeted intervention. By interpreting the ecosystem from the perspective of the available resources, interventions can be directed towards the adaptation of existing technologies or development of novel processes. Conversely, by focusing on existing industries, such as 3D knitting, interventions supporting specialised processing techniques are required to transform waste into appropriate constituent materials. Expertise across all disciplines is essential to enable the ecosystem to have a positive environmental impact.

The Living Textiles Ecosystem was developed through an experimental methodology that includes iterative prototyping to produce prototypes for testing and integration into the built environment. This approach demonstrates through design practice how the ecosystem works in action. The use of waste as a resource is the key measure of environmental performance. In addition, the regional focus to the ecosystem aims to reduce the environmental impact of transportation, a significant problem for the textile and construction industries that currently rely on international supply chains.

Target outcomes and priority action areas

The target outcomes for this research are categorised against the resources, biofabrication techniques and disciplines mapped onto the Ecosystem.

In terms of resources, the first target outcome is the use of UK sources for all textile fibres and yarns in the development of living textiles. The long-term aim is to use 100% of local resource repurposed from waste for living textiles production. Currently, research has focused on post-industrial waste streams, further research is required to integrate complex mixed fibre post-consumer textile and clothing waste into the resource flow.

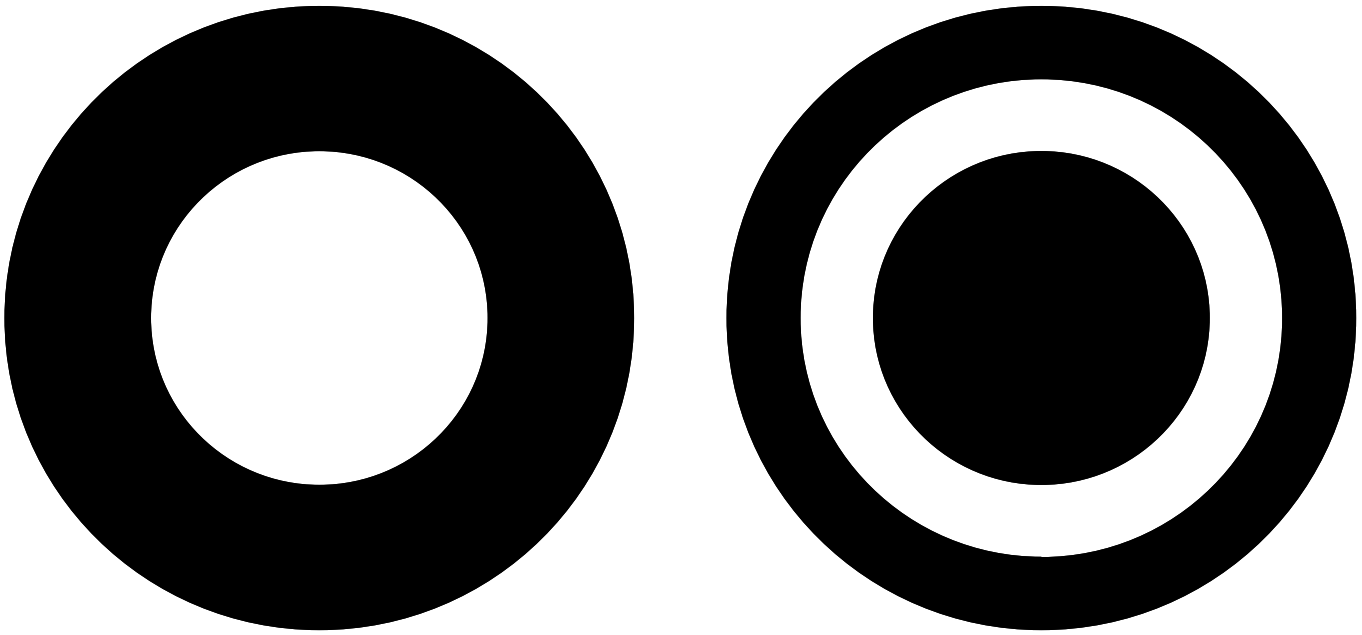
From the perspective of biofabrication techniques, the target outcome is to develop a Centre for Living Textiles in the North of England. This interdisciplinary centre will focus on the development of a range of textile specific biofabrication techniques, utilising the capabilities of the UK textile industry and initiating collaborations with existing research facilities located in the North of England. The success of the Centre for Living Textiles will be measured against the ability to spin out technologies and support and enhance local industry.

A fundamental change proposed by the Living Textile Ecosystem is a change to disciplinary thinking highlighted by the interactions between four distinct disciplines, biology, biotechnology, textiles and craft. This ecosystem embeds interdisciplinary thinking between design and science as a method to develop and test new living textiles for construction.

Suggested actions

1. Wool Board: This ecosystem focused on wool as the key textile fibre and work undertaken included processing waste fleeces. Currently it is not economical for some farmers to sell coarse wool that is a by-product of the meat industry. Suggestion 1 is to review the quantity and range of wool produced by farmers that is currently not processed via the Wool Board to understand the current surplus and promote it for alternative uses.
2. Industry: One challenge identified through this research project was the difficultly of replacing conventional materials with waste materials. Whilst the composition of waste may be equivalent to conventional materials, waste resources required additional sorting and processing to enable them to be used within the ecosystem. Suggestion 2 is a recommendation to industry to consider waste collection and storage, as careful management of this resource will ensure efficient production of high-quality outputs.
3. Legislation: Although industry engagement with initial materials development has been excellent, concern has been raised about the risks associated legislation and regulation of new biomaterials. Suggestion 3 is to engage regulating bodies with research at an early stage so that biomaterial development can align with industry standards and regulations.
4. Education: To support the transition to net zero within the UK textile industry, a good understanding of materials and resources is required. Suggestion 4 is to explore opportunities for closer integration between higher education and industry to engage the next generation of textile designers and engineers with ecosystem design.
5. Research: The research activities undertaken for the Living Textile Interface are collaborative and interdisciplinary, working across disciplines to achieve innovation. Suggestion 5 is to embed interdisciplinary practices across academic research, developing teams that support and enhance innovation at the interface of science, technology and design.

Conclusions



Conclusions and achievements

This fellowship aimed to map the Living Textiles ecosystem. Through stakeholder evaluations, the materials and processes required for the production of BioKnit were analysed and alternative waste streams were identified (OB1). A network of industrial partners in Cumbria, Northumberland and Yorkshire has been established to supply waste materials.

To evaluate how changes to material inputs impact biofabrication processes and resulting biohybrid textiles (OB2), materials experimentation and iterative prototyping was undertaken. Findings demonstrate that textile materials and technologies are adaptable to new biofabrication techniques, particularly when the focus is on adapting the underlying technologies for different material inputs.

In collaboration with Beyond Words Studio, the ecosystem was visualised through the lens of two biohybrid textile prototypes (OB3). The research demonstrates how a practice-based approach can be used to develop and test ecosystem design and how this could be significant for other researchers in the field.

The original proposal sought to engage with regulating bodies to understand how low carbon materials, such as biohybrid textiles, could be implemented in buildings. Whilst problems associated with unconventional materials in construction were discussed during workshops, this aspect of the research requires further work as material prototypes develop into commercial products.

Principal Investigator’s personal evaluation

The Living Textile Ecosystem provides a focused investigation of one biohybrid textile system. This provides a snapshot of the potential for living textiles. A broader programme of research is now required to assimilate the ecosystem into a low impact industry for sustainable construction.

One key success of the research was the positive response from industry. The development of a network of industrial partners has been extremely valuable to exchange knowledge and supply resources. The greatest challenge of the research was the compressed timescale which demanded the development and evaluation of the emerging ecosystem within a period of just six months. Despite this, a key success of the research is the identification and testing of waste materials to replace all of the key components of the knit/ mycelium biohybrid composite system.

One highlight of the fellowship was the opportunity to collaborate with Beyond Words Studio. Whilst the final visualisation does not capture all of the interrelationships within the Living Textiles Ecosystem, the model identifies key processes and will act as a template for an extended and expanded ecosystem in the future.

Other outputs based on the research

Exhibition
The Living Room: installation developed with the research team from HBBE for the More With Less exhibition at The Farrell Centre. The work used the local resources identified through this fellowship in the design and biofabrication of textile biohybrid architecture. https://www.farrellcentre.org.uk/explore/more-with-less

Journal
Living Textiles: Research Question for Research Directions Cambridge University Press: Living textiles

Conferences
Scott, J et al. 2023. The Living Textiles Ecosystem: A Local Textile Biofabrication Strategy, Textile Institute World Conference. https://www.textileinstitute.org/events/tiwc/
Scott, J. et al. 2023. The Living Room: Transitioning to Regional Waste Streams for Biohybrid Textile Production. 2nd International Conference on Construction, Energy, Environment and Sustainability (CEES). https://www.cees2023.uc.pt
Scott et al. 2023. The Living Room, ACADIA 2023 HABITS OF THE ANTHROPOCENE: SCARCITY AND ABUNDANCE IN A POST-MATERIAL ECONOMY, conference paper (under review) https://acadia2023.cargo.site/

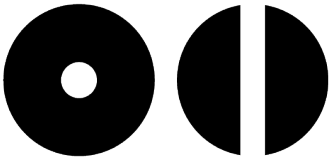
Future research plans

Research addressing the Living Textile Ecosystem will expand to consider alternative biofabrication processes and waste resources. Two new projects will begin in February 2023.

- Co-investigator (CO-I), Biotechnology and Biological Sciences Research Council (BBSRC) Enzymatic upcycling of textile waste into biodegradable mycelium leather. 2-year project led by PI Dr Paul James (Northumbria University) to develop enzymes to degrade post-consumer waste textiles into a low cost substrate for the production of mycelium leather.
- CO-I BBSRC Fibre Fusion: Circular Manufacturing of Water Repelling Bacterial Cellulose through a biological approach. This 2-year project led by Dr Meng Zhang (Northumbria University) addresses the whole life cycle of bacterial cellulose-based textiles focusing on material properties, robustness, and end of life.

These Design Ecosystem Fellowships reports were commissioned by Future Observatory. Future Observatory is a national programme for design research supporting the UK's response to the climate crisis. The three-year programme is coordinated by the Design Museum in partnership with the Arts and Humanities Research Council (AHRC), which is part of UK Research and Innovation (UKRI)

Arts and Humanities Research Council



FUTURE
OBSERVATORY