CIRCE

Estonia – Creative Impact Fund

Mycelium Materials

Exploring the potential of mycelium to replace problematic materials in the construction and furniture sectors

CIRCE Creative Impact Research Centre Europe

u-institut GmbH & Co. KG

Federal Government Commissioner for Culture and the Media

Myceen's exhibition piece at Tallinn Architecture Biennale

A. Summary

Myceen is a cleantech biotechnology startup that develops mushroom materials and products that are unique in the world. We are engaged in the research and development of carbon-negative and environmentally friendly materials, using and also valorising various organic industrial residues (sawdust, wood chips, straw, etc.).

The novel mushroom material has the potential to replace problematic materials in construction, furniture, and other sectors, as it doesn't pose a threat to nature after the end of its use and decomposes naturally. One of the main competitive advantages of the production is the resulting resource savings both in terms of waste valorisation and production - we use natural processes and the material can be produced at only 25 degrees.

Myceen uses wood and agriculture industries' leftovers as production inputs, so the price of the raw material is also very low, and the project also promotes circular economy in every sense. In addition, according to the life cycle assessment method (LCA), mushroom materials are carbon negative or stored, i. e. they bind more carbon than their production emits (ca -1kg CO_2 per kilogram of mushroom material).

Myceen is therefore one of the rare industrial projects that can say that the bigger it grows, the smaller the company's (environmental) footprint is!

As a new but active company, Myceen has completed several international business accelerators in 3 years, attracted initial financing, sold its design products on international markets, exhibited around the world, and received extensive media coverage. Its founders have been engaged in the research of mushroom materials and the development of design products for 6 years. The company has a production space and real experience in the production and sale of mycelium material and design products.

What makes us unique is that we see the mycelium material development and research in a wider picture, and want to become a knowledge center in the field. We know that this material has great potential to shift entire industries towards more sustainable practices and reduce drastically their footprint once taken into mass use.

This is why we have lately extended our research into new uses for mycelium materials, and we are also very keen on open innovation and popularising mycelium research through workshops that we regularly organise for students and children.

Mycelium materials research is interdisciplinary, making it a fascinating R&D subject since we have to combine biology, biosciences, architecture, design, construction, and many other topics. By combining the capabilities of fungi with our knowledge we may discover many new potential solutions and directions that can be pursued after this project.

The market is extremely favorable for such products in upcoming years, as one of the main targets of EU regulations is to reduce the footprint of the construction sector (Green Deal, Fitfor55, New Bauhaus). Currently, the building sector is regarded as one of the most polluting sectors in Europe as it involves 40% of all carbon emissions. Since inefficient and old buildings are all over Europe, the European Commission is paying special detail to renovation and insulation materials. Currently, 75% of EU buildings are inefficient, which is why the EU has set very strong targets to reduce the footprint of the construction sector.

We want to achieve both social innovation and technological innovation. From the social side, we aim to popularise novel and sustainable materials that are needed to transform society to achieve carbon neutrality. From a technological point of view, mycelium materials are very novel in the world and by scaling up the mycelium production we are innovating a whole industry.

Our project within CIRCE's Creative Impact Fund has been a major kick-start for our first scale-up activities allowing us to develop the organisation basically from scratch to a scaling-up biotechnology and creative venture that is expanding its wings over the globe.

More specifically, we managed to build and expand the team including multidisciplinary scientists from different fields and we could focus on R&D activities to further analyse and develop the mycelium material. We carried out tens of different tests and analyses in-house, but also in collaboration with universities and different research institutions.

Importantly, we were able to invest in the production technology and scale-up activities that allowed us to increase production and reach with our products literally around the world. This is the first year of our production and we immediately had major international success. Interestingly, as CIRCE was born from the concern of how Brexit might affect Cultural and Creative Economies (CCE) in Europe and its meaning on further collaboration and exchange, we have found that the UK is our main market. In fact, our pilot project was successfully executed in London, setting the stage for a series of promising projects lined up for the coming years. The pilot project comprised of 26 large indoor panels for a café in London. An important outcome of the project was to deliver pilot projects to the market to prove that there is a vast interest in mycelium materials and products around the world, and that we are able to scale up our production capacity.

Finally, we can see this project in our daily activities as we now have a capable team that has learned the Creative Impact Fund's method of iteration and learning. This method enabled us in a trusted way to iterate our R&D processes over the 8 months and achieve success. Importantly, the iterative learning method is now engrained in the development process and we have now a solid project management process for yearly, monthly, and weekly tasks and goals. The project has been a critical and instrumental factor in bringing Myceen's products to the market and developing the creative industry that has a positive impact on the world.

B. Journey

January - March: Application and Vision Setting

The onset of our year was marked by meticulous planning, focusing on pivotal questions on how to effectively scale Myceen: Who are the ideal candidates for our team? How much space will our operations require? What is a realistic budget, and what achievable targets can we set in both research and production?

In the realm of innovative material development, the caliber of your team is the most important factor. Attracting top talent is a formidable challenge, especially for an unestablished organisation. The best assurance we could offer was to be part of something absolutely new and that they would certainly have an interesting year. Fortunately, we managed to assemble a diverse and multidisciplinary team, comprising a biotechnologist, material scientist, mycelium expert, architect, business professional, and an experienced mushroom producer. This blend of expertise was very important, allowing us to approach the challenge from multiple perspectives. We needed to integrate biology with engineering and ensure financial viability for the future sustainability of the company in the industry. The recruitment process was extensive, utilising every available resource from personal networks to online advertisements, and spanned several weeks.

Another critical step was securing a larger workspace to kickstart our journey. We relocated to a 150-square-meter facility, enabling us to establish all the necessary stages of mycelium material production for our scaled-up operations. Constructing the various rooms required for this expansion took weeks, but this investment ensured our capability to produce the required quantity of mycelium panels for our pilot projects with confidence. As a bonus, this space had a common room with multiple woodworking machines which allowed us to prototype faster.

April - June: Project Commencement and R&D Intensification

The initial setup phase of our project transitioned into research activities, including the establishment of a shared knowledge base within our expanded team, the initiation of material research, and a solid understanding of market needs.

Given our team's diverse background, the early stages necessitated a team effort to align our collective understanding. This involved frequent meetings where our scientists, with expertise in biology and material science, shared their perspectives. Such collaboration was crucial, as the concept of growing living materials presents a stark contrast to the production methods used with inert materials.

Our journey into mycelium research began with the experimentation of various mushroom species and industrial byproducts. The aim was to discover which combinations yielded the most promising results in terms of growth rate, strength, and aesthetic quality, all important characteristics of our novel building materials. Another important finding was that we can use a wide array of byproducts, which shows great promise that this technology is universal and can be easily scaled up.

However, our research was not limited to materials alone. Conducting thorough market research was equally essential to ensure that the building materials we were developing had practical applications in the real world. This involved considering numerous factors such as shapes, sizes, dimensions, and properties. We engaged in numerous discussions with architects, interior designers, and resellers of building materials and design products. A significant byproduct of this extensive market research was the generation of interest for our upcoming 2024 projects, clearly indicating a robust potential client base for our mycelium products.

July - September: Strategic Focus on Economic Viability and Scalability

Throughout the summer, our focus extended beyond materials research as we dived into the implementation of our pilot project. Our objective was to supply a London café with 26 expansive mycelium panels, covering three walls. The intended outcomes were multifaceted, aiming not only to enhance the room's acoustics but also to elevate the overall design and ambiance of the space.

Executing this task presented a formidable challenge, given our lack of prior experience in producing such a substantial quantity of mycelium material. Each panel needed to seamlessly align with its neighbours, avoiding deformations or cracks that had been commonplace in our earlier versions. It took an intensive two-month period of refining through iterations and prototypes before achieving the production of consistently uniform panels and initiating scaled-up production. This meticulous, iterative process not only resulted in meeting the project's demands but also provided invaluable insights into refining our production methods to meet industry standards for building materials.

An equally important aspect during this phase was the realisation that the workload exceeded the capacity of our existing team. To address this, we onboarded another material scientist and three interns specialising in biology and material science into our team. This expansion was not only imperative for the successful completion of the pilot project but also significantly augmented our research capabilities through the remainder of the year. However, managing a team of 10 members needed a rigorous focus on team management and communication strategies. This involved implementing weekly team meetings, establishing clear goals, utilising effective communication tools, and introducing feedback loops between mentors and mentees. We saw this moment as our organisational evolution which was very important for our future growth, as we aim to double our team size in 2024.

October - December: Culmination and Reflection

In the concluding phase of our project, we concentrated on three primary objectives: successfully completing the pilot project, increasing awareness about mycelium materials, and carefully preparing for the expansion of our research and production capacities.
The delivery of the pilot project in London marked a significant achievement, receiving great feedback from both the café patrons and their visitors. We chose a café for our showcase intentionally, recognising its potential as a high-traffic venue visited by dozens of people daily.

Moreover, this pilot project significantly enhanced our organisation's competencies in various domains, including logistics, product development, and packaging. These areas are vital as we aim to distribute our products globally, ensuring fast and secure delivery. This was particularly relevant as we had to safely transport 26 large panels over a distance of 2000 kilometres.

Another key goal was to promote the research and utilisation of mycelium materials. Internally, we built a robust team of 10 experts now knowledgeable in the production and development of mycelium materials. Additionally, we participated in public outreach, such as conducting a workshop at the Pärnu Design Festival and collaborating with a Danish student research group dedicated to increasing mycelium material awareness. We plan to continue these efforts post-project.
Finally, we developed comprehensive business and research plans for 2024 and beyond. This involved applying for additional research grants and initiating discussions with investors for future funding. Our ambitions include doubling our team size, moving to a larger facility, and establishing a pilot factory in the near future. These past eight months have been incredibly intense and impactful, especially for a hardware company breaking new ground in an innovative research field.

C. Innovation

Creating something new is a difficult, but extremely interesting process, where only one thing is certain – it's not a linear journey towards an end goal. In this chapter, we will look into our exploration of mycelium material development as a perfect example of an iterative innovation process.

Employing the iterative learning methodology, our interdisciplinary team – comprising experts in biology, engineering, architecture, and design – embarked on a journey to harness the potential of mycelium for sustainable building materials. Iterative learning is very close to the Build-Measure-Learn methodology that emphasises quick cycles of building a minimal viable product (MVP), measuring its performance, and learning from the data obtained. This iterative loop enables us to continuously adapt and refine our products based on real-world feedback, which increases the chances of creating a successful and sustainable solution.

Build: Crafting the Foundations of Mycelium Materials – Collaborative Synergy and Knowledge Sharing

The 'Build' phase marked the inception of our mycelium material development project. We had to build the team and efficient communication between team members, the physical production, and lab space, and we had to build the underlying approach and development plan for the year to come.

In hindsight, team and communication build-up was one of the key aspects to deliver the pilot project and develop the mycelium material further – every week we spent hours of team meetings sharing each other's knowledge and expertise. From the 'Build' perspective, it was important to allocate time slots at least twice a week where the whole team comes together, as well as individual meetings between team members to focus on specific tasks. At this stage, our approach ensured that no time was wasted on unproductive meetings, emphasizing the necessity of strategic planning within the innovation process. Regarding communication methods, we employed a variety of approaches, including physical meetings, video platforms, online drives for document sharing, and data gathering, along with the use of data loggers.
From the mycelium material development point of view, we spent considerable time and effort gathering information from previous literature – however, there isn't much literature and

research in such detail as we are moving into a new and innovative space. It's important to have experienced scientists since they know very well how to set up scientific research, test plans, and analysis.

On the infrastructure front, we not only conceptualised but physically constructed our new production and working space. Beginning with smaller prototyping and testing needs, we progressively expanded to meet the requirements of larger-scale pilot projects. Over the course of several months, our production space grew, new rooms and testing facilities were established, and additional machinery was acquired to cater to the production demands of the pilot project and the lab requirements for further testing.

The biggest challenge in this phase was to seamlessly integrate the diverse expertise within our interdisciplinary team. Bridging the communication gap between biologists about the secrets of mycelium and architects envisioning its applications required intentional knowledge-sharing efforts. The challenge was not only in understanding the biological intricacies of mycelium but also in translating this understanding into tangible architectural considerations.

Another challenge was the technical point of view of our Build stage – we did not have all the technical capacity to carry out the numerous material tests that were necessary (e.g. fire tests, mold growth, chemical composition, acoustics, etc). We agreed with the team that we need to mainly focus on the mycelium production side, material analysis, and test result analysis, while very specific tests should be carried out in universities and external test facilities that have expensive machinery specifically for this purpose. In addition, we had to be somewhat careful that we test a reasonable number of materials so that we wouldn't go over the budget – on the one hand, it decreased a bit the exploration part, but on the other hand, it increased the quality of previous research analysis before moving to creating a new set of mycelium test bodies.

Internal factors for success in the 'Build' phase were deeply rooted in the depth of scientific knowledge within the biology and material science team, efficient communication and communication tools, and the architectural foresight to envision real-world applications. External factors encompassed stakeholder engagement with experts in biomaterials and sustainable architecture, playing an important role in transforming mycelium into a tangible construction material with very good material properties. To that end, we conducted tens of

interviews with industry players, architects, and resellers narrowing down what is needed on the market.

Measure: Evaluating Mycelium Material Properties – Precision Testing and Collaborative Endeavors

The ‘Measure’ phase for us was a close examination of mycelium material properties and running various material tests.

We aim to create mycelium materials that have certain properties such as fire retardancy, acoustics, moisture and mold proof, and rodent repellence. At the same time, we don’t want to add any chemicals in the process as it would reduce the vision of our material that it would be compostable after use.

The functional properties of the mycelium material can be tweaked according to its need and use of it. Pure mycelium materials display different structural properties depending on the fungal strain, substrate, growth conditions, and processing after synthesis. The mechanical properties are generally defined by species – elongated fibrous mycelium has more elasticity and thus can be used for myco-leather, in contrast with tougher mycelium, building materials stronger than concrete can be obtained.

Secondly, in combination with controlled processing techniques, a variety of substrates and additives can be utilised to bind discrete lignocellulosic (plant’s dry material, which is available in wood, hay, hemp, grain, leaves, etc.) particles into mycelium composites with defined geometry *(see photo below)*. All raw materials and additives that are of organic origin contribute to biodegradability at the product’s end-of-life stage.

Mycelium blocks in the maturing phase

Challenges arose in designing comprehensive test protocols capable of effectively capturing the diverse characteristics of the material, and more importantly, understanding how to change the material's properties. Achieving a balance between quantitative measurements and qualitative assessments demanded an understanding of both biological and architectural aspects. It wasn't always easy to name a cause for some properties, therefore we often needed to dive back into the literature or run additional tests to verify the results.

Internal success factors during the 'Measure' phase were based on the team's ability to put together data from various fields of study. For example, we were exploring which additives can be incorporated into the material mix to maintain high mycelium growth while ensuring that the material remains biodegradable after use, without resorting to chemical additives.. Externally, successful collaborations with material scientists, acoustic engineers, and architects allowed us to understand better the material in actual use and needed parameters. We were also testing our materials in universities and external institutions so that our results would be verified and that we could consult with external professionals.

Learn: Iterative Refinement and Real-World Application – Adapting to Realities and Stakeholder Engagement

The 'Learn' phase is critical for every development process and in our case, from the 'Learn' phase, we analysed our tests' results and planned for the next steps. As background, every comprehensive test took around 1 month from the start of the test planning until running analyses. We had constantly 3-5 studies running in parallel which focused on material studies, product development, and production development.

From a material science point of view, we learned that the material has naturally very good insulation, strength, and fire retardance properties. Further development is needed on the water absorption, mold and rodent repellency, and acoustics. There are several potential avenues including various additives in the recipe, post-process treatments, and even geometry of the products regarding acoustics.

Product development was a very interesting iterative process where we at first experienced several defects including mold, cracks, and deformations of the products (we needed 26 large identical panels for our pilot project in the London café). Through iterations in the shape, recipe, and different production techniques we achieved a new level of quality, which is a monumental achievement in Myceen’s activities for years to come.

Production development learnings were aligned with product development, such as reducing the mold and cracks in the process. Mycelium production is unique, as it involves growing materials where even slight changes in conditions can significantly impact the outcome. For example, mycelium usually grows between 15-35 degrees Celsius – by tweaking this temperature depending on the mushroom species, one can speed up the process multiple times, or stop it. Additional important factors include whether the mycelium material grows in light or darkness (dark is better), and humidity. Throughout the 8 months, we managed to reduce mold growth and cracks by 80%.

The necessity for continuous adaptation and learning from both successes and setbacks underscored the need for a resilient and agile approach. As soon as we went through the 'Learn' analysis phase, we pushed the next 'Build' phase going for the next steps and tests.

Internally, success factors during the 'Learn' phase were rooted in the team's adaptability and the establishment of a culture that embraced failure as a conduit to improvement. Knowledge sharing became even more critical, facilitating quick adjustments to our approach based on the lessons learned from each iteration. Externally, our engagement with stakeholders and customers has been crucial. For instance, in our pilot project, the London café utilised our mycelium materials in acoustic/insulation panels, providing us with invaluable real-world feedback. Understanding end-user experiences and preferences became pivotal in refining our materials for broader market acceptance. Collaborations with universities, consultants, and partners for external validation and testing further fortified the iterative learning process.

External Validation and User Testing

Beyond the core iterative phases, our project saw collaborations with universities, consultants, and partners for external validation and testing. These external engagements played a crucial role in validating the scientific and engineering aspects of our mycelium materials. Collaborating with academic institutions brought a rigorous scientific lens to our work, ensuring that our materials met the highest standards of research and development.

User testing in real-world environments, such as the café in London, was a pivotal extension of the 'Learn' phase. The challenges here were diverse, ranging from user acceptance to the practicalities of integrating mycelium materials into existing structures. The iterative learning process gained depth as user feedback became a compass for refining not only the material properties but also its practical applications. This external validation loop enriched our understanding and facilitated the alignment of our mycelium materials with real-world needs.

Goal Setting, Team Management, and Pilot Projects

Critical to our project's success was the meticulous goal setting, team management, and the execution of pilot projects. Setting clear, measurable goals for weeks and months became the compass guiding our iterative journey. The challenge lay in aligning the diverse skill sets within our interdisciplinary team toward common objectives. Effective team management was crucial for ensuring that each team member contributed their expertise in the best way.

Pilot projects, such as the installation of mycelium acoustic panels in the London café, were milestone achievements that validated our progress. Challenges in these pilot projects included scalability, logistics, and ensuring seamless integration with existing structures. These challenges became stepping stones for learning and refinement. The success of pilot projects not only demonstrated the viability of our mycelium materials in real-world applications but also marked a tangible milestone in our journey toward sustainable construction materials.

In conclusion, our iterative innovation process in mycelium material development has been a dynamic journey marked by collaboration, resilience, and continuous learning. The challenges faced at each stage of the process were met with innovative solutions, internal adaptability, and external validations. The internal factors for success, including effective knowledge sharing, adaptability, and a culture of learning, were very important and needed a lot of work, especially in the initial weeks. Externally, stakeholder engagement with experts and real-world applications in pilot projects solidified our understanding and enhanced the viability of mycelium materials.

D. Impact

London café pilot project on the left and Host store on the right with Myceen's products

The impact of our mycelium material innovation project has specific quantitative achievements as well as qualitative ones. From market validation through successful pilot projects to the internal evolution of our team's culture and approaches, the impact can be seen from all sides.

Compared to last year, we have built a solid team, we have reached international markets with our products and revenues, we have moved and set up a larger production space, and we have carried out tens of material tests and developments. All in all, we have built an organisation during the project and have taken specific steps to increase these quantifiable results two to three-fold next year.

Quantitative Impact

Made the case for Scaling Mycelium internationally as a sustainable material

The delivery of pilot projects stands as a concrete result of the market validation we sought to achieve. Besides the installation of 26 mycelium panels in the Café in London, we've also shipped this year various products (e.g. lamps, chairs, plinths) around the world including the US, UK, Singapore, Germany, Italy, Greece, France, and others. We couldn’t have done it without the production and team increase that the Creative Impact Fund programme enabled us to do. The successful application of our materials in a real-world setting not only showcased their functionality but also demonstrated market acceptance. Quantitatively, this is reflected in the revenue generated from these products, validating our economic strategy of creating a sustainable revenue source for the next years. Based on this market success, we have set higher production and revenue goals for the next year. We have also kick-started further international marketing campaigns and we’re currently expanding our reseller network.

To scale impact required us to scale and grow as an organisation

In 2022, we had two co-founders in the team, and by the end of 2023, we had around 10 people joined, including scientists, marketing and business people, production hands, and interns from various fields of study. The Creative Impact Fund programme had a direct cause and effect here as it allowed us to finally increase the team. In the early phase, the team is the key factor of both the direction and pace of the young organisation’s development. We are lucky to have these smart and ambitious people join us and work on the same vision to bring mycelium as a material to the market. We have now launched new hiring campaigns to expand our team by at least double within 2024. In addition, the project has affected many other people including the workshops that we’ve given during the project and we’ve also worked with international students to support their mycelium-related research activities. We’ve also had 3 interns

specialising in design and biology, enhancing our efforts to actively raise public awareness about mycelium materials.

Optimisation of material properties for different use cases

The extensive research and development activities conducted during the project have yielded quantitative milestones. We conducted tens of material and growth tests, providing a comprehensive understanding of mycelium materials. The sheer volume of analyses conducted, ranging from species selection to exploring the potential of industry leftovers to carrying out various material properties tests, quantifies the depth of our insights and the knowledge gained. Based on these results, we could create the new recipe that was used for the pilot projects proving to have better properties than our previous materials.

Establishing international logistics and supply chain

As a part of our adaptation process, a quantitative impact is evident in the successful management of production and logistics processes. The timely delivery of materials for pilot projects and the scalability achieved in production processes are quantifiable indicators of our operations and prove that we are capable of producing mycelium materials in larger quantities. It has also been a great source of learning as we've established the necessary mix for logistics including packaging and cost-efficient international logistics partners. It might seem trivial, but this process takes time and resources to work out. Additionally, it was important to secure reliable raw material partners who would have consistent sources of leftovers that would secure us reliable test results over the whole R&D phase. To explain this better then the mycelium material properties can change whether we use different fraction-size leftovers, or if it's hay, hemp, or sawdust.

Qualitative Impact

Impact as customer satisfaction and feedback to development from partners

Beyond quantitative indicators, the qualitative impact of stakeholder engagement is significant. Collaborations with external partners, universities, and consultants have allowed us to move faster and save time by tapping into external knowledge. End-user feedback from pilot projects,

captured through testimonials and cases, paints a qualitative picture of how our materials integrate into real-world scenarios, impacting not just the physical space but also the experiences of those inhabiting it. For example, our reseller in London brought out that this is the highest quality mycelium material and products that they have seen on the market. And we've heard the same feedback from international architects that we are working with. In general, the feedback on our materials has been very positive showing great promise for further market adoption.

Knowledge Sharing and Interdisciplinary Collaboration

Internally, the impact of our project on the team is evident in the heightened culture of knowledge sharing and interdisciplinary collaboration. The initial stages of our project coincided with the formation of a new team. The knowledge-sharing efforts required to bridge the gap between disciplines, such as biology and architecture, have cultivated a collaborative spirit that extends beyond the confines of the project. It was really important for the team members from different fields of study to educate each other maximally about the topics that they knew about. For example, our material scientists, with their expertise in engineering and building materials, emphasised the importance of achieving specific material properties. Concurrently, the mycologists and biologists contributed insights on how to modify the recipe. This collaboration ensured that while the mycelium continued to grow, the material remained biodegradable. The business people needed to make analyses whether the recipe and additives would be cost-efficient and the engineers analysed how and if the substrate mix would affect the defects and growth of the materials. All in all, there are tens of parameters when producing and scaling up the mycelium material production, hence it is super critical to share as much knowledge as possible between the team members.

Goal Setting and Strategic Vision

The impact internally is also reflected in the meticulous goal-setting and strategic vision. Setting clear objectives for weeks and months ensured that the team operated with a shared vision. The achievements of milestones, such as the initiation of pilot projects, signify the alignment of the team towards common goals. Equally important is to communicate this to the team as well, for example at the beginning of the project we had cases when the strategic vision was not clear to everybody and it caused confusion. As soon as this was clarified then the

monthly goal and weekly task setting became much easier for everybody – they understood why it was necessary.

Team Resilience and Agile Approaches

The internal impact extends to the resilience and agility instilled in the team. Learning from tests, analyses, and setbacks, and adapting strategies in response to evolving challenges have cultivated a resilient team culture. The iterative learning process, guided by the Build-Measure-Learn methodology, has become ingrained in the team's approach to problem-solving. This is a supercritical understanding and base for further team growth and faster involvement of new team members. For example, when our latest full-time member, Sabina, and the interns joined the team in the second half of the project, the innovation processes were much clearer to them, we had already project management in place, etc. All in all, it meant that we could start quality work with new team members straight away.

E. Learnings

The journey of developing mycelium materials and overseeing pilot projects has been a great experience, marked by numerous challenges and successes. Our reflection encapsulates the lessons learned throughout the project, focusing on the key factors that supported our impact, areas that needed improvement, and advice for teams that venture into similar fields or innovation processes. Furthermore, it explores the strategies to internalise these learnings into our future processes and the next steps in extending the CIRCE initiative.

Achieving Impact - Key Factors

One of the most important contributors to our project was the comprehensive approach to material testing. We conducted a wide array of tensile, compressive, and durability tests on mycelium-based materials. This thorough testing not only validated the viability of mycelium as a sustainable material but also provided invaluable insights into its structural characteristics, enabling us to fine-tune its properties for specific applications. For teams that undertake material development (or any other development process), it is crucial to put a plan together where you map out the most important features you need to get to and plan the tests for weeks and even months ahead because you'll soon find out that time is running by very fast.

Regarding mycelium materials the tests will take altogether weeks, therefore if you have 7-8 months like we had in this project then it means that we had very limited time to get to results. What helped to mitigate this risk was to run several tests and assumptions in parallel.

Team and its management

Effective team management emerged as another critical factor. Given the interdisciplinary nature of our team, fostering effective communication and collaboration was challenging yet essential. Regular cross-disciplinary workshops and team-building activities played a critical role in breaking down silos, enhancing mutual understanding, and promoting a collaborative spirit. For example, developing mycelium materials required collaboration from diverse fields like biology, mycology, architecture, design, business, and engineering. Assembling a new team for such a project meant encountering an initial learning curve, where team members needed to understand each other's backgrounds and share their expertise. We saw that having frequent team meetings, where team members discussed aspects of mycelium, engineering, and biology helped align them toward the common goal. From a practical point of view, you will see that the early phase of the project will go slower compared to a few weeks and months later when your team members already know each other, have a shared understanding of the material, and know what to do next.

Furthermore, it is important, that one creates a product that the market needs. In the startup world, there is a specific term for this – product-market fit (PMF). PMF is a concept that shows the alignment between a product or service and the demands of the target market. Achieving product-market fit implies that the product not only satisfies the needs of the customers but does so in a way that distinguishes it from competitors, creating a unique value proposition. In the realm of mycelium material products, understanding and actively engaging with the market and architects is important for achieving product-market fit. The market for sustainable and eco-friendly materials is dynamic and continually evolving, shaped by factors such as consumer preferences, regulatory requirements, and technological advancements. Regular and direct communication with potential users, stakeholders, and architects enables a better understanding of the evolving needs and expectations within the industry. In our case, the architects play a crucial role as they are instrumental in specifying and selecting materials for construction projects. Engaging with architects provided us the insights into the specific requirements, performance expectations, and design preferences that influence material

choices in construction. It also meant that we were carrying out pilot projects for verified market needs.

Areas for Improvement and Lessons Learned

Despite our successes, several areas for improvement surfaced during the project. First and foremost was the need for enhanced scalability in pilot projects. The transition from small-scale laboratory experiments to larger production processes revealed unforeseen challenges. Streamlining and optimising these processes are crucial for the successful deployment of mycelium materials on a commercial scale. Scaling up our processes on the one hand saved us a lot of manual work, but on the other hand, we understood the next bottlenecks and that for a factory scale production, we will need further automated production processes.

Additionally, communication gaps persisted for some weeks at the start of the project, particularly for team members to understand each other's knowledge base and bridge the knowledge gap. Bridging this divide required more streamlined reporting structures and regular knowledge-sharing sessions to ensure that technical advancements align with broader project goals and that a shared knowledge base would be created.

Advice for Teams in Similar Fields

Drawing from our experiences, our advice for teams embarking on similar ventures involves emphasising collaboration, investing in comprehensive material testing, and anticipating scalability challenges. Establishing a culture of open communication and knowledge sharing is important. Furthermore, maintaining a balance between technical innovation and strategic project management is essential for success – this includes setting team meetings, project goals, monthly goals, and weekly targets.

Iterative testing is also crucial in the developmental phase, enabling teams to adapt and refine their materials based on real-world feedback. Embracing a mindset of continuous improvement and remaining adaptable in the face of unforeseen challenges will be instrumental in overcoming hurdles along the way. This was very much supported by the Creative Impact Fund programme itself, which was very welcomed by our team and gave us mental support that

failing sometimes is accepted – it's important to move towards the goals and make improvements for the next iteration.

Talking to customers and users is crucial to bringing a product or a service to the market that people need. We advise you to start talking to potential users straight away as they give you insights as well as become paying clients for you. For further steps of the project, it's super important to have case studies so that the market, investors, and supporters would believe in your capability to follow through the innovation process.

Working on your current and future funding is as important as successfully delivering the current project. The moment you run out of funds only the founders stay in the organisations if they are very driven. In our case, we started working on the next year's budget and financial means mid-way through the project, and fortunately, the goals that the CIRCE's Creative Impact Fund programme align with our future steps, such as increased production and revenues, new products, team growth, etc. We advise other teams and organisations working in the field to look into both investors as well as grants and funds. There are numerous options for ventures in cleantech and creative industries. Most importantly, one should ensure, that the project continues seamlessly beyond the conclusion of any specific funding source.

Internalising Learnings and Future Steps

Internalising the lessons learned from this project involves incorporating a culture of continuous improvement into our organisational management. This includes regular retrospectives, where team members can openly discuss challenges and propose solutions. Knowledge-sharing platforms and documentation will be further emphasised to ensure that insights gained from material testing and pilot projects are seamlessly integrated into our ongoing work. Practically, we take more efficient project management learnings with us as we increase the team size and the team communication concepts – when and how to make team meetings, how to set realistic development goals and weekly targets based on tasks at hand.

As we extend the Creative Impact Fund programme, our future steps will focus on scaling up production processes, refining material properties based on market feedback, and expanding the scope of interdisciplinary collaboration. Strengthening partnerships with research institutions, industry experts, and regulatory bodies will be prioritised to enhance the project's

overall impact and facilitate its integration into mainstream markets. We will also start hiring further specialists in the team.

All in all, the development of mycelium materials and pilot projects has been a transformative experience, full of valuable lessons on how to create something that doesn't exist in a structured way. From the importance of comprehensive material testing to the challenges of interdisciplinary team management, every aspect of the project has contributed to our growth. In 2024, should everything proceed as planned, we aim to at least double our team size and expand our operations by two to threefold. By internalising these learnings and taking strategic steps forward, the project initiative gave us an important lesson on how to manage these processes as our team and ambitions grow.

Myceen's product in an exhibition being presented to the Estonian president

F. Linking back to CIRCE's Creative Impact Fund

We have found several topics where our project's and the Creative Impact Fund's goals and approach meet.

Iterative Innovation

The iterative learning methodology that underpinned our mycelium material development aligns with the ethos of Creative Impact Fund. By testing and analysing mycelium materials, building product prototypes, and learning from the results for the next iterations, we saw that this method worked very well in our project's context. We therefore strongly support that the Fund will continue to use this practice for future projects and we are happy to share our learnings personally for the next teams should they be interested in this.

Deepening economic relations between the UK and the EU as one of the CIRCE's initial goals of mitigating the negative effects of Post-Brexit

Our project not only exemplifies the impact of creative economic innovations but also highlights a significant EU-UK connection. Our initial major pilot project served as a bridge between the two regions. Notably, the UK has shown substantial interest in our products, prompting us to strengthen and expand this link. In 2023, we've established a partnership with a London reseller and several UK architects, and we're looking forward to collaborative projects with UK universities and museums in 2024. This development directly addresses CIRCE's original founding mission of fostering collaborations and deepening relationships between the EU and the UK in CCE post-Brexit.

European cross-disciplinary Collaboration and know-how transfer on Creative Impact

CIRCE as an interdisciplinary think tank with research labs in various European cities, has many similarities with our mycelium material development project. The diverse expertise within our interdisciplinary team resonates with the fund's network of academics and practitioners across Europe – our team boasts Ph. D.s, masters, and interns in different fields from biology to engineering to material science, and from different backgrounds and countries. We are mostly working with architects and potential collaborators from different countries than

our local environment and continue to push for the industry's popularisation and collaborations. Our approach to external collaborations with universities, consultants, and partners for validation and testing is similar to CIRCE's approach of engaging with a network of experts. For example, during the project, we directly collaborated with 6 universities and research institutions in four countries, we had multiple interns who learned about mycelium materials, carried out workshops for a wider audience, and established potential collaborations with several architecture companies in various European countries.

Learning from Setbacks and Building Resilience

The iterative learning process, where failures are embraced as opportunities for improvement, aligns with Creative Impact Fund's commitment to responding to current and future crises. Mycelium material development faced challenges in scaling up production processes and adapting to diverse environmental conditions, mirroring the unpredictable nature of external forces that the fund works on. The resilience that we've got through the iterative learning process is a shared strength.

Contributions to Creative Impact and CCE

The insights derived from mycelium material development contribute to the discussion on Creative Impact and CCE. By innovating sustainable biomaterials, we address the environmental impact of construction practices, aligning with the broader sustainability goals of CCE. The interdisciplinary nature of our team and collaborations speak to the diverse talents and perspectives that are crucial for fostering creativity and innovation within the creative economy. Our case is a great example of combining Creative Impact and creativity in general with novel materials that help to turn around polluting industries.