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WEAR Sustain Network: Wearable Technology Innovation

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Abstract

Purpose: As wearable technologies and eTextile sectors mature they are being increasingly used in couture and high street fashion. However, much of the innovation in this space has been driven by technological and commercial imperatives. It is time to re-consider this technological landscape in the bigger picture of a sustainable human-centred world.

Approach: This paper reports on initial findings from 48 projects supported through the EU funded WEAR Sustain network to examine sustainable and ethical approaches to wearable technology design. Case studies of collaborations between artists and technologists in designing and realising sustainable and ethical wearable technologies are presented.

Findings: An initial set of themes emerging from detailed analysis of WEAR Sustain network project updates are outlined highlighting the importance of cross-disciplinary hubs, mentors, and networks. A survey of wearable and eTextile stakeholders highlights the challenges faced in ethical manufacturing and production of wearable and eTextile products which blur the boundaries between digital and physical.

Value: This paper offers the reader insight into challenges and opportunities in the emergent Creative Economy sector of wearables and eTextiles which have the potential to transform the fashion industry. By reporting on case studies of recent near-to-market projects this paper grounds concerns of ethics and sustainability in wearable and eTextile design and production in real-word experience.

Keywords: Wearables, eTextiles, sustainability, ethics, network

Article Classification

Technical paper

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WEAR Sustain Network: Wearable Technology Innovation

As wearable technologies and eTextiles mature they are being increasingly used in couture and high street fashion such as Levi's Commuter smart jacket. However, much of the rush into the new markets of wearables and eTextiles has been driven by technological innovation and commercial imperatives of being first to market. In this rapid development concerns of efficiency, techo-fetishism, and commercial return have outweighed discourses on sustainability, privacy, and quality of life, often leading to fragmented sectors of innovation (Bazalgette, 2017). Indeed, the majority of research into eTextiles has been funded for military and medical sensor applications (Ryan, 2014). As the wearables and eTextile markets mature it is time to consider this technological landscape in the bigger picture of a sustainable human-centred world.

This paper reports on initial work of the WEAR (Wearable technologists Engage with Artists for Responsible innovation) Sustain network funded by the European Commission Horizon 2020 Research and Innovation initiative to promote collaborations between technologists and designers/ artists to develop sustainable and ethic wearables. For 18 months the network has operated as a Europe wide catalyst for 46 projects in wearable technology design and development to the point of market and investment readiness. This has been explored by running two Open Calls to select and fund projects innovating in the wearables and eTextiles areas, working with artists/ designers and technologists, and focussed on the challenges of ethics and sustainability in this sector. Projects funded under the two Open Calls lasted 6 months and received vouchers for expert services offered through the WEAR Sustain network. The aim of the vouchers was to support the development of fully functional prototypes in the projects by providing expertise to complement existing team skills and experience given the inherent challenges of working across arts and technology. Vouchers could be used to for mentor consultations and hub services on the topics of: Ethics & Sustainability; Design & Aesthetics; ICT Technology; Prototyping Textile & Fashion; Data & Data Models; User-centred Design; Business; Legal; Validation Trials/Living Lab Experiments; and Business & Marketing. In this way the projects explore innovation through typical early stage Creative Economy R&D practices (Bakhshi and Lomas, 2017) and consider broad societal and cultural implications of new technologies. Crucially, the WEAR Sustain network prioritises:

1. Engagement with alternative discourses in the conceptualisation and design of wearables and eTextiles by prioritising artist-technologist synergies;
2. Addressing issues of sustainability in both production and end-of-life wearables and eTextiles;
3. Foregrounding ethical issues of privacy and ownership of personal and embodied data.

In building a network of 700+ like-minded actors in the sustainable and ethical wearable space from hubs to individual artists and technologists WEAR present a unique and compelling cross-section of the contemporary landscape which aim to shape a more sustainable and responsible future for wearables.

In addition to the network itself WEAR Sustain is developing a Sustainability Strategy Toolkit (SST, reported in Baker et al., 2018) to synthesize the sustainability knowledge and know-how gathered through the network and to provide opportunity for companies to self-assess their sustainability footprint and areas for improvement.

In this paper we first reflect on the growth of the wearables an eTextiles sectors of the Creative Economy and highlight potentials for growth. We then present two case studies from the WEAR Sustain network to illustrate close-to-market wearable innovation. Following these case studies we summarise progress reports from teams in the WEAR Sustain network and conclude by highlighting sustainability and ethics challenges faced by companies working in these sectors.

The Growth of Wearables and eTextiles in the Creative Economy

The Creative Industries contribute a significant part of global GDP accounting for $547 billion in 2012 (UNCTAD, 2015), contributing, for example, 8.2% of UK's economy (UK Govt, 2016), and continue to grow with growth of 8.6% from 2003 to 2012 (UNCTAD, 2015). The Creative Economy itself encompasses a broad range of activities and stakeholders and is generally accepted to be "those industries which have their origin in individual creativity, skill and talent and which have a potential for wealth and job creation through the generation and exploitation of intellectual property" (DCMS, 1998, p.3). The UK Skills Council defines Creative Economy sectors as "Advertising, Fashion, Textiles, Film, Television, Radio, Photo Imaging, Interactive Media, Publishing, Animation, Content for Computer Games, Software, Commercials and Promos, Corporate Production, Post Production and Visual Special Effects and Other Specialist Facilities, Craft, Cultural Heritage, Design, Literature, Music, Performing Arts and the Visual Arts, and Architecture" (Alliance, 2011). However, emerging sectors such as wearables and eTextiles are not explicitly included in this categorisation, most likely due to their recent emergence at a confluence of existing sectors such as Fashion, Textiles, Interactive Media, Software, and so on. Furthermore, there is a "dearth of interpretive and critical literature on WT [Wearable Technologies]" (Ryan, 2014), reflecting the relative lack of research in this area. In this paper wearables refer to computational devices which can be worn on the human body, and eTextiles refer to textiles which are created to be used with wearables, for example as part of the input/ output system as sensors and/ or displays. Wearables and eTextiles are typically used together in the fashion industry to create garments which are capable of computation, interaction, and communication. In terms of the Creative Economy, wearables and eTextiles are typical of emerging fields in the Creative Economy where the contemporary digital era of ubiquitous digital communications technologies (Bakhshi, 2013) provides an "enormously exciting opportunity for a further wave of growth and innovation" (Bazalgette, 2017) for digital sectors of the Creative Economy.

Whilst still nascent sectors, it is clear that the global eTextiles (smart textiles) market is growing rapidly, rising from USD 795 Million in 2014 to a predicted $4.72 Billion by 2020 with a predicted growth of 33.58% between 2015 and 2020 (PRSNewswire, 2015). Similarly, the global wearables market is estimated to reach a value of $19 Billion in 2018, more than ten times its value five years prior (Statista, 2018). Indeed, in 2015, three time as many wearables were shipped than in the same quarter in in 2014 (Wired, 2015). Lymberis (2017) notes even higher expected growth with wearable devices predicted to prise to $160 Billion by 2026, and noting that the European Parliament Scientific and Technology Options Assessment Panel identified wearables as one of the top ten technologies that will change lives. Whilst the market for wearable devices such as smart watches and fitness trackers has now matured to major consumer acceptance the challenge for the remaining emergent parts of sector such as fashion is now to move beyond pragmatic technological concerns (software to user experience) and exploration of materials (textiles to eTextiles) and turn to creating wearables as fashion items and everyday pieces of clothing (Wired, 2015). As suggested by Buechley and Eisneberg (2008) "E-textiles present an alternative look at computation—pervasive, soft, flirtatious, playful, theatrical", offering an innovative, paradigm shifting, and alternative view and use of computational technologies.

A key differentiator between wearables and other sectors of the Creative Economy is the necessary combination of both physical and digital innovation and production. As noted by Weiss (2016), there are "trends towards increased digitalisation continue to blur the boundaries between physical and digital". Whilst this offers opportunities for market growth it also presents barriers and challenges to rapid innovation due to the financial cost and time involved in physical innovation versus digital innovation. Specifically, digitally native Creative Economy companies make use of digital platforms such as social networks, search engines, online marketplaces, and content distribution help to generate new products and services and to transform their creative processes (Bakhshi, 2013). For those concerned with physical objects, digital platforms provide opportunities through the 4th industrial revolution a digital revolution characterised by a "fusion of technologies blurring the lines between the physical, digital and biological spheres" (Weiss, 2016). For example, digital platforms provide opportunities for innovation through using new materials and production techniques, they facilitate greater and closer access to markets and customers, and provide opportunities to include customers more in the design process (Weiss, 2016). However, here has to date been a concentration of interest in those sectors which produce or consume digital content. For example, the "IT, software and games sub-sector contributes almost 40% of the GVA of the Creative Industries" (Bazalgette, 2017). Furthermore, when research has been undertaken in the Creative Industries on the role of digital platforms it has tended to focus on digital consumption and production. For example, in (Bazalgette, 2017), Boston Consulting Group's desk research examined government interventions across the Creative Industries but focussed on the "audiovisual, music and video games sectors." (Bazalgette, 2017). Similarly, there has been extensive research on how digital platforms have changed Creative Industry sectors such as

music production and consumption, for example Wikström et al.'s book (2016) catalogues extensive studies on innovation in the music industry as a result of the introduction of digital platforms, but there is no similar detailed research into wearables and eTextiles design in the Creative Economy. This is despite the opportunities wearables offer to explore "our relationships with our bodies and how we move them" (Ryan, 2014), and that artists and performers have been exploring the expressive and artistic potential of wearables since the 1950s (ibid).

A brief survey of research into the Creative Industries suggests that in terms UNESCO's Framework for Cultural Statistics Domains (UNESCO-UIS, 2009), the Cultural Domains which involve physical object production, consumption, and archival are least well investigated despite the emergence of wearables and eTextiles as drivers of growth within the Creative Economy. Furthermore, even within the well researched domains of Performance and Celebration; Books and Press; Audio-visual and Interactive Media; and Design and Creative Services there are major issues of fragmentation and lack of sustainability as noted by (Bazalgette, 2017) for the Music Industry which would likely also occur in less research domains such as wearables and eTextiles:

> "The data infrastructure for creative content is not harmonised. Artists are finding ever more innovative and creative ways of getting digital content to their fan base and new formats and streaming services continue to come online to distribute this content. But whilst there has never been so much choice at all levels of the value chain, the growth in new streaming services and platforms, each with their own methods of managing data, means that there is a potential for error and conflict and a growing threat to an artist's ability to gain attribution and remuneration for their works. In order to develop the right environment for the market to create new and sustainable business models, we need data to be robust, reliable, transparent and accessible. In many parts of the Creative Industries, in particular the Music industry, this is not currently the case" (Bazalgette, 2017).

Prototyping Wearables and eTextiles

One of the main challenges to innovation in wearables and eTextiles is the difficulty of prototyping devices which must be robust, lightweight, connected, interactive, and reliable. Unlike software which can be rapidly prototyped, deployed, and refined, wearable prototyping takes time and often physical material skill. Rapid prototyping of electronics with microcontrollers became increasingly accessible through the introduction of the open source Arduino electronics platform which offered low cost ways for people to quickly connect sensors and output devices to small form factor microcontroller circuits. Following the introduction of Arduino, Lilypad (Buechley and Eisenberg, 2008) was developed specifically for wearable and eTextile prototyping, offering ways to work with soft materials such as conductive threads and flexible sensors. As part of the open source maker scene the Lilypad pad offered a low-cost entry point to prototyping wearables and eTextiles. As noted by Baker (2018), Lilypad made

electronics accessible to a wider group of people, notably including fashion designers and crafts through sewn connectors and circuits. However, the DIY nature of the open source movements of Arduino and Lilypad make them unsuitable for developing high fidelity commercially oriented product prototypes. Typically such prototypes are bulky (even if sewn into fabric the Lilypad is 50mm in diameter with additional space required at least for batteries) and have low processing power with limited displays resulting in typically single function development. The WEAR Sustain Network is particularly interested in how such early stage wearable prototypes which might be created using platforms such as Arduino and Lilypad might be translatable into commercial ready prototypes at a development stage which might attract serious commercial investment and funding.

Beyond the challenges of prototyping wearables and eTextiles there are key issues of the sustainability and ethics identified by the WEAR Sustain network which need to be considered within the design and development process as they become embedded into the technologies that we produce. As discussed by Kuusk et al. (2014) smart textiles present a bigger risk to the environment than conventional textiles as they increase the consumption of scarce raw materials and are hard to recycle due to the intertwining of multiple kinds of materials. Ethical concerns with the development of wearables and eTextiles are both in terms of the personal and often private data collected by wearable devices, and also the ethical implications of the manufacturing processes involved in mass productions of both textiles and technology.

Given the opportunities for innovation when artists and technologists innovate together as well as the inherent challenges such creation across disciplines brings (Mamykina et al., 2002) this paper presents case studies of collaborations between artists and technologists in designing and realising sustainable and ethical wearable technologies. These highlight the opportunities and challenges for cross-disciplinary work in this sector and how they may potentially shift dominant techno-centric discourses on wearables and eTextiles – that is, moving from a focus on functionality for sports and fitness to explore richer forms of human-computer interaction.

Case Studies

The 46 projects supported by the WEAR Sustain network covered topics ranging from engineering more recyclable and expressive eTextiles, to projects which use eTextiles and wearables to help improve people's wellbeing and personal health. To give an idea of the kinds of wearables and eTextile projects supported by the WEAR Sustain network we present two illustrative case studies of projects supported by the WEAR Sustain network: Wisp and Mi.mu.

Firstly, Wisp is a startup established in 2016 which is developing sensual wearables. On joining the WEAR Sustain network the project was reported as Technology Readiness Level (TRL) 4 - the Solution

has been developed and tested in a closed environment (ie lab, atelier etc.). Starting with several Arduino prototypes and designs for more sophisticated products the challenge for Wisp was to undertake further user testing of the prototypes and concepts and to develop the product to a stage that could be produced in short runs in China for wider scale testing and to attract both customers, PR, and investment.

In contrast, the Mi.mu project established in 2014 is a wearable gesture control interfaces for live music that was reported as TRL 7 on joining the network – Prototype demonstration in operational environment. Whilst Mi.mu already had 30 early-adopters using Mi.mu in their professional music practice the labour intensive production of Mi.mu make scaling the product to mass production financially prohibitive. The challenge for Mi.mu in the WEAR Sustain network was to develop new versions of Mi.mu which could be more cost-effectively mass produced in an ethical and sustainable way (e.g. in the UK or EU) with an aim to significantly reduce production costs thereby increasing potential market demand.

Fig. 1. © Wisp from wisp.me.uk

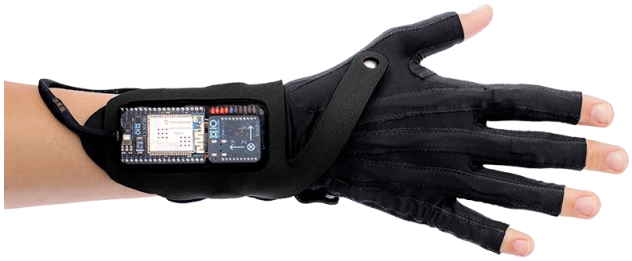

Fig. 2. © Mi.mu gloves from mimugloves.com

At the end of their six month project with WEAR Sustain Wisp had developed crowd funding business models, and developed two prototypes with a Chinese electronics design studio partner and were waiting for a third version to be delivered after delays due to manufacturing errors. Wisp highlighted that whilst collaboration mostly went well there were challenges in the production process as they had to split the development of hardware, electronics and software between Italy, China, and the UK respectively which made it difficult to manage the integration. Furthermore, difficulties in communication were encountered as there was no one shared language between the partners.

Furthermore, although most collaboration happened online, it was felt that more in-person collaborations would have made the development work smoother, though this would have added cost and logistical issues.

By the end of six months Mi.mu had successfully developed a new production version of their Mi.mu gloves which it was estimated could be sold for less than half the original Mi.mu glove costs. In addition, Mi.mu had undertaken extensive user testing of the new gloves and developed business models and branding to launch the new version of the gloves. As with Wisp, Mi.mu encountered some development and testing delays due to manufacturing errors highlighting the challenges of rapid prototyping and product development. In contrast to Wisp, Mi.mu is solely produced within the EU meaning that the sustainable and ethical practices in production could be more easily audited. Good levels of communication between production partners was especially important for Mi.mu as a novel heat-bonding process was developed for the gloves which required not only developing a heat-bonding process, but also selection of appropriate materials for bonding.

In terms of Mamykina et al.'s (2002) model of art-tech collaborations it is interesting to note that both Wisp and Mi.mu showed evidence of tight integration between the artists and technologists. In contrast to the predominant model of collaboration found by Mamykina et al. (ibid) – the "assistant model" – in which "collaborators assume the responsibility for different phases of the project", Wisp and Mi.mu showed signs of the "full-partnership model" in which "complementary interests exist even where the outcomes by each individual party may differ" and where "partners are able to achieve mutual benefit but at the same time, retain ownership of their individual achievements" (ibid.). Indeed, Wisp's way of working with their Chinese design studio partner strongly fits into the full-partnership model. In keeping with the findings of Mamykina et al. (ibid) both Wisp and Mi-mu encountered difficulties in communication within their projects. As Mamykina et al. (ibid) note: "ability to communicate and exchange creative ideas is an essential part of the creative process", and so it may be that implementing some of Mamykina et al.'s guidelines may have helped to address the communication challenges encountered in these projects: "Devising a Shared Language"; "Developing a Common Understanding of the Artistic Intentions and Vision"; "Engaging in Extensive Discussions and What-if Sessions"; and "Sharing Knowledge Resources".

Project Progress

Throughout product development all WEAR Sustain projects were required to report monthly on their progress and challenges faced to the WEAR Sustain network. An initial review of the monthly feedback reports highlights a number of common themes raised by projects undertaking sustainable and ethical wearable design and production projects. The primary purpose of such an analysis is academic research into what happened on the projects. It may be useful for feeding into WEAR Sustain's Sustainability

Strategy Toolkit in terms of giving an overview of the kinds of challenges and innovation that people reported happened during development of their prototypes.

As found with Wisp and Mi.mu, schedule delays were the most frequently cited challenge for projects, followed by slow production processes, problems of integration, and communication problems. These issues may partly be due to the pan-European nature of the WEAR Sustain network which specifically aimed to bring together partners from across Europe to work on projects, or it may simply be that the cross-disciplinary nature of the projects (business, arts, design, technology, manufacturing) meant that the necessary skills were inevitably distributed across hubs of expertise. There were also challenges faced within the teams such as low availability of team members which may be due to the early stage of the teams meaning that teammates had multiple competing commitments, and lack of necessary skills which highlights the need for hubs of expertise and mentoring support for such early stage innovative projects. Materials and rapid production were another challenge face by projects including difficulties of material ordering and delivery, and difficulties in finding materials to be used. Again, this points to the value of open hubs and networks which can provide advice and guidance of material selection. However, in projects such as Mi.mu where new production techniques were developed it is inevitable that deep levels of expertise are needed which may not be realistically provided through networks and online forums. Interestingly, whilst 3D printing was frequently mentioned teams also highlighted the disadvantages of 3D knitting/ printing technology suggesting that more sophisticated physical prototyping solutions beyond 3D printing would be valuable resources for hubs to offer.

The WEAR Sustain network required projects pay particular attention to the sustainability and ethics of their products. Sustainability was predominantly mentioned by projects in terms of manufacturing and material with only brief mention of other aspects of sustainability such as economic sustainability, sustainable business models, or ensuring healthy lives. In terms of manufacture, the predominant concerns were local manufacturing as illustrated by the Mi.mu project, and eliminating waste. Simplifying the manufacturing process was also mentioned in relation to sustainability. Natural materials and recycled materials were the most mentioned materials with reference to sustainability. Interestingly the recyclability of prototypes and materials used in the prototyping processes were often mentioned indicating a concern for the ecological implications of a rapid prototyping process in which many prototypes may be produced and then disposed of it there is no way to reuse them.

In terms of ethics, the primary concern of projects was data protection in particular privacy issues and anonymising data. Some projects such as Mi.mu did not collect personal data in their device meaning that it was not a concern of all the projects. Concerns about good treatment and payment of workers were raised more times than mentions of open-source design indicating that ethical production was more of a concern than the sharing of design work. The practicalities of signing Non Disclosure

Agreements and informed consent forms for user studies were also mentioned indicating that practical advice in these areas would be of benefit to such projects. Broader ethical concerns such as equal pay or women's empowerment and rights were mentioned less frequently which may indicate a focus on ethics within the projects themselves rather than a consideration of the broader impact of taking an ethical stance in product design and development.

Individual Views

In parallel to asking WEAR Sustain projects to report on a monthly basis we undertook a small online survey of individuals working in the wearable design space with twenty four respondents, sixteen of who were in the WEAR Sustain network. Half of the respondents had been involved in more than 5 wearable development projects, and in total there were fourteen fashion/ textile designers, one product designer, one installation artist, six engineers/ technologists, and two consortium leads. Designers/ artists rated social sustainability, environmental sustainability, and ethical labour practices more highly in terms of importance than engineers/ technologists who rated economic sustainability more highly. This suggests that the results of the project reports above reflect more of a designer/ artist interest than an engineering/ technology focus. In contrast, both designer/ artists and engineers/ technologists rated prototyping and technical development as the most important stages of wearable development, and follow-on funding as the most challenging stage of a development process. The challenge of securing follow-on funding is reflected in frequent mentions of fund raising mentioned in the project reports and mentions of business plans, but in the survey follow-on funding was rated as one of the lowest levels of importance by artists/ designers.

In the survey most respondents reported finding it challenging to find information about business models, environmental impact, social impact, economical impact, ethical data, and ethical labour practices. This may partly explain why these topics were not reported frequently in the project reports – the lack of readily available information may lead to less consideration of the topic in the projects given their very short timelines.

Results from these surveys were then used within the WEAR Sustain network to inform the iterative prototyping of the Sustainability Strategy Toolkit. In particular, the surveys were used to inform persona generation as part of the requirements gathering for the design of the interactive prototype for the Sustainability Strategy Toolkit.

Discussion

Reflecting on the project progress reports and survey of wearable and eTextile practitioners it is clear that the optimism of blurring "boundaries between physical and digital" (Weiss, 2016) is still far off. Whilst open-source Maker platforms such as Lilypad (Buechley and Eisenberg, 2008) and ready

availability of 3D printing offer opportunities to explore wearable interaction and use of eTextiles as input and output, there still remain significant barriers to moving from ideation to near-commercial production. Production delays and misunderstandings reported in the WEAR Sustain projects will block routes to growth in the Creative Economy. Indeed, in the survey most respondents, whether artists or technologists, highlighted the issues of prototyping and technical development as most important in the development of new wearable and eTextile products. Compounding the challenge of moving from early prototypes to production runs were concerns about ethical and sustainable production and manufacturing similar to those noted by Kuusk et al. (2014). These concerns resulted in some teams choosing to locate production within the EU to ensure ethical production and manufacture, however, this can increase production time and cost. Ethical, sustainable, and traceable global production and supply chains would need to be developed if the environmental impact of wearables and eTextiles highlighted by Kuusk et al. (2014) are to be mitigated.

As noted by Mamykina et al. (2002), "creative pursuits in industry involve interdisciplinary teams working together to develop a product that cannot be created by a single individual alone". However, the reality of working in SMEs and their inherently small teams means that many of the WEAR Sustain projects found it difficult to secure sufficient breadth of expertise. This was compounded by problems of availability of experts which caused difficulties of communication and delays in production due to lack of face-to-face meeting. For SMEs the challenge for innovating at the blurring of digital and physical is how to find and engage with sufficient breadth of expertise across disciplines for example from material engineers, PCB manufacturers, and software engineers, to business and logistic experts, and to fashion designers and textile weavers. The WEAR Sustain network attempted to support cross-disciplinary working by offering vouchers which could be used for expert advice and guidance. For such cross-disciplinary approaches to be sustainable in the future they need to be self-sustaining and move beyond reliance on such voucher incentives. Models for micro-consulting by experts through networks of expertise and hubs as developed in the WEAR Sustain network are one possible ecosystem approach to addressing the challenges of inter-disciplinary working necessary for wearable and eTextile innovation and production.

Summary

In this paper we outlined the WEAR Sustain network and briefly introduced two projects in the network. Wisp and Mi.mu both demonstrate that artists working with technologists can produce product innovation, manufacturing innovation, and develop economically viable and attractive business models. Initial analysis of all monthly project reports combined with a short survey of individuals working in the wearable technology design field suggests that, as with any project, project management is complex but that the distributed combination of artists, technologists, and production brings additional communication and collaboration issues. Not least the challenges of rectifying manufacturing errors

and negotiating NDAs in multiple languages and disciplines. In terms of sustainability the predominant concern of projects was the sustainability of their production process and materials which in itself brings challenges when working with international partners who may not have comparable approaches to sustainability. The reports point to the importance of hubs as resources of skills, expertise, and production equipment, especially in terms of sourcing materials and technologies with suitable properties. However, concerns were raised about the environmental impact of rapid prototyping without suitable recycling or reuse, and the utility of 3D printing was also questioned which challenges the dominant narrative of maker spaces as the solution to low-cost low-carbon local manufacturing. Ethical implications were considered within the projects and their development process rather than broader ethical impact of the products developed. This may in part be due to the difficulty of finding information about ethical and sustainable aspects of wearable technologies. One way to address this may be for hubs to become centres of excellence for particular aspects of sustainable and ethical wearable design along with a content rich and easy to navigate online resource on sustainable and ethical wearable design.

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