Designing Conditions for Disruptive Innovation Ecosystems

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The concept of disruptive innovation ecosystems relates to a type of ecosystem capable of delivering disruption in underserved markets. This idea can create serendipity for disruption through new ways of thinking and leveraging resources across businesses. However, scant research exists on what and how to design conditions for disruption utilising resources and capabilities at the boundaries of businesses. Based on network theory and characterisation, we evoke an alternative design mode using visuals and speech to generate rich data with participants in makerspaces. The qualitative and visualisation data is analysed using thematic and visual network analysis techniques, respectively. Our findings suggest three main conditions that may be satisfied to create serendipity for disruptive innovation ecosystems to emerge: Navigating high risks, creating new markets, and generating new roles. Our findings also highlight factors under these three conditions that may be promoted to create disruption. Combining the thinking "through design" approach using visuals and speech with network theory and characterisation, we demonstrate the significance of coupling conversations with drawings, thus moving past abstractions and helping participants to see and better understand the inner workings of their ecosystem attributes. Using theoretical constructs embedded in visualisations can help design researchers and ecosystem practitioners design conditions for disruptive innovation ecosystems. The originality of this work is in linking network theory and characterisation with speech and visual data capture and analysis, thus presenting a strategic asset and alternative way of thinking and acting on boundary spanning resources and capabilities in local ecosystems.

Keywords: thinking through design; disruptive innovation ecosystems; makerspaces; social network theory; ecosystem attributes

1 Introduction

This paper explores thinking "through design", evoking an alternative design mode for generating and analysing local ecosystem data. We investigate makerspaces as ephemeral spaces for entrepreneurs and makers and how these spaces design conditions for disruption, thus cultivating conditions for disruptive innovation. We are interested in makerspaces because they can change economies from the local to a global scale (Bolli 2020). Thinking "through design" is related to the

existing literature on research through design (RtD) (Frayling 1993; Buchanan 2001; Cross 1999; Forlizzi et al. 2009; Zimmerman et al. 2010). In RtD, prototypes play a key role in confronting the real world "because the theory is not hidden in abstraction" (Sanders and Stappers 2014, p. 6). Based on the concept of thinking “through design”, which in this article is about using design visuals to support thinking about disruption in local ecosystems, we want to convince the design innovation community that visualising ecosystem characteristics can be useful as rigorous heuristics to help us both think, understand, and design conditions for disruptive innovations. We discuss how collecting data through network visualisations can help reveal important ecosystem attributes, e.g. clusters, bridges, structural holes, weakties and role structures, thus evoking alternative design thinking modes.

Challenges exist in how businesses think about resources that reside at the boundaries of a system (Zulu-Chisanga et al. 2020). How actors analyse, plan, and decide about these boundary-spanning resources and capabilities remains a complex issue (Schutte and Direng 2019; Motoyama and Knowlton 2017; Jacobides et al. 2018). According to Nthubu et al. (2019, p. 632), “A disruptive innovation ecosystem is an ecosystem capable of delivering disruptive innovations”, where innovation is identifying new opportunities (connections, resources, and markets) across businesses and acting upon them. Disruption is the process whereby a new or smaller firm with fewer resources successfully challenges established firms (Christensen et al. 2015). In this article, disruption is about an ecosystem rather than a firm. Using visuals and speech as an alternative mode of thinking at the ecosystem boundaries is important to help actors leverage resources and capabilities outside their businesses.

An innovation ecosystem is defined as a set of actors and processes that cooperatively and competitively interact to co-evolve and innovate (Christensen 2013). Some researchers emphasise the need to understand interrelationships and complementarities between different ecosystem actors and how these might be leveraged to create shared value (Adner and Feiler 2019; Dedehayir et al. 2017; Iansiti and Levien 2004; Jacobides et al. 2018; Rosli et al. 2017). Uber and Lyft appear as examples of disruptive innovation ecosystems in the taxi business, where they identified an underserved transport market and exploited it. Airbnb and Breather targeted the lower-end customers in the hotel business (Libert et al. 2014; Smith 2016). It would be vital to design conditions for disruptive ecosystems from scratch (Nthubu et al. 2019), but the dynamic behaviour of ecosystems can be challenging to manoeuvre (Roundy et al. 2018). Microsoft Zune is a good example of a failed ecosystem that was expected to disrupt the iPod ecosystem by offering cheaper and competitive pricing (Woody 2013). Users had little motivation to opt for Zune.

Design research has a role to play in developing conditions for disruption in ecosystems. Cruickshank (2014) argues that a designer's role as a gatekeeper and a central figure in creating new products, services, and systems is ebbing away. Others also demonstrate that design can help us understand interactions between key actors in a system better (Karadima and Bofylatos 2019; Ballantyne-Brodie and Telalbasic 2017; Pérez et al. 2019). This thinking mode affects how design research is evolving towards empowering non-designers to engage in innovation effectively (Lee 2008; Sanders and Stappers 2008; Manzini 2015; Cruickshank et al. 2016). This form of empowerment also depends on how ecosystems' whole network of relations changes (Zamenopoulos et al. 2019, p. 4). In this messy world of ecosystems, practitioners are challenged to characterise and exploit ecosystem attributes defining value in networks (Bianchi and Vignieri 2021; Nthubu et al. 2019, p. 633). Therefore,

thinking “through design” using speech and visuals to capture and analyse data may allow for the construction of knowledge with participants in unconventional ways, thus empowering them to think through words and space dimensions to navigate ecosystem complexities. This paper aims to understand conditions for disruption and the role that makerspaces can play in local innovation ecosystems by answering the following questions:

- What are the main conditions for thriving disruptive innovation ecosystems in the UK makerspaces, and how can thinking “through design” shape these conditions?
- What is the role that different makerspaces play in the ecosystem of disruptive innovation?

To explore the above questions, section 2 highlight the context, network theory and characterisation to help us identify and understand conditions for disruption. Section 3 discusses the methods used to construct data and how this data is analysed. Section 4 present key findings and discussions, and finally, section 5 conclude the article by outlining key contributions, limitations, and future work.

2 Context and theory

This paper focuses on makerspaces as local ecosystems. We are interested in how makerspaces cultivate conditions for disruption. The concept of makerspaces is about promoting open design and fabrication through co-learning, co-working, co-creation, and sharing ideas (Vuorikari et al. 2019). Makerspaces promote access to digital fabrication tools for community users and entrepreneurs to create solutions and experiment with different business models (Marsh et al. 2018; Elhoussamy and Rizk 2020). This idea is important to stimulate risk-taking behaviours and actions without substantial loss of revenue. Although makerspaces are democratising innovation (Smith 2017, p. 14), little is known on how these ephemeral spaces shape conditions for disruption. We use visuals to capture perceptions in interesting ways as an alternative mode of thinking about ecosystem attributes. Using visual probes responses from ecosystem actors to think and utilise the space as the second dimension of communication (Zweifela and Van Wezemaela 2012; Norman 2016, p. 347).

2.1 Understanding conditions for disruption

Not all new technologies are disruptive (Christensen et al. 2018), but the business models that the technology shape sometimes creates disruptions (Hopp et al. 2018). Christensen argues that disruption can be achieved by providing simpler, cheaper, and good-enough alternatives to underserved markets. We know that innovation has been opening and becoming democratized by engaging lead users in the design development process (von Hippel 2005; Chesbrough 2010). This is now in part proliferated by the growing advent of digital technologies, e.g. 3D printers, allowing more people access to digital fabrication and personalisation. Van Holm (2015, p. 30) also reported that "makerspaces are the latest expansion of access and opportunity and have the potential to push society over a tipping point of engagement with design". Therefore, empowering people with tools to think and understand markets is becoming a key condition for disruption. In line with this, disruption is about smaller businesses combining their resources and coordinating their capabilities to successfully challenge large ecosystems for markets.

Nevertheless, this is not the only condition for disruption, and it might also depend on the opening of new opportunities, varied by the customers' positions and behaviours in the local social networks (Mahto et al. 2020). We are interested in how local networks present alternative design modes which might lead to disruption and what is required to understand these networks. According to

Mahto et al. (2020, p. 4), entrepreneurs who are unafraid of pursuing high risk can pursue disruptive innovations. Makerspaces often produce accidental innovations through experimentation (Von Holm 2017, p. 165). Examples of ground-breaking innovations that came out of makerspace activities are MakerBot 3D printers and Oculus Rift (Hui and Gerber 2017; Smith and Light 2017). Before makerBot, 3D printers were expensive and only available to large firms. MakerBot made it possible for small businesses and communities with fewer resources to access these digital technologies.

Furthermore, markets with scarcity and low social cohesion present a suitable environment for disruption (Lee and Tuselmann 2013). Investigating makerspaces through design (engaging ecosystem actors through speech and visualisations) might reveal new conditions for disruption. We use network theory and characterisation to think "through design" and reveal ecosystem attributes that may shape conditions for disruptive ecosystems.

2.2 Network theory and characterisation

Visualising ecosystems enable communication of new opportunities in networks and offer an alternative mode of thinking about complex systems (Vink et al. 2019; Zweifela and Van Wezemaela 2012). This approach has advantages because it enables people to create network images that they can see and use to think, analyse and identify opportunities for innovation (Padilla et al. 2018; Lurie and Mason 2007; Burnay et al. 2019; Evans 2011). Drawings as artefacts enable useful discussion and communication because they reveal previously hidden information (Sanders and Stappers 2014).

2.2.1 Clusters and bridges

Revealing clusters and bridges in makerspace networks may lead to new conditions for disruption. Clusters are actors in a specific sector who may be connected or disconnected, cooperating, or competing (Porter 1998). Clusters in local ecosystems have an advantageous role anchored on geographic and social proximity. However, clusters of actors in an ecosystem are often hidden from sight, making it difficult to plan and use this advantage. In Musial and Juszczyszyn (2009), bridges connect clusters with the peripheral nodes or clusters and the rest of the network. We present bridges as key actors or clusters that connect distant actors or clusters in the ecosystem to exchange resources. Using ecosystem visuals can also effectively reveal bridges by observing the visual density or cohesion of nodes. For example, Bridge-1 (a node) connects cluster A and C, while bridge-3 (a cluster) connects cluster A and B (Figure 1). Visualising clusters and bridges in makerspaces may be useful in promoting conditions for disruption.

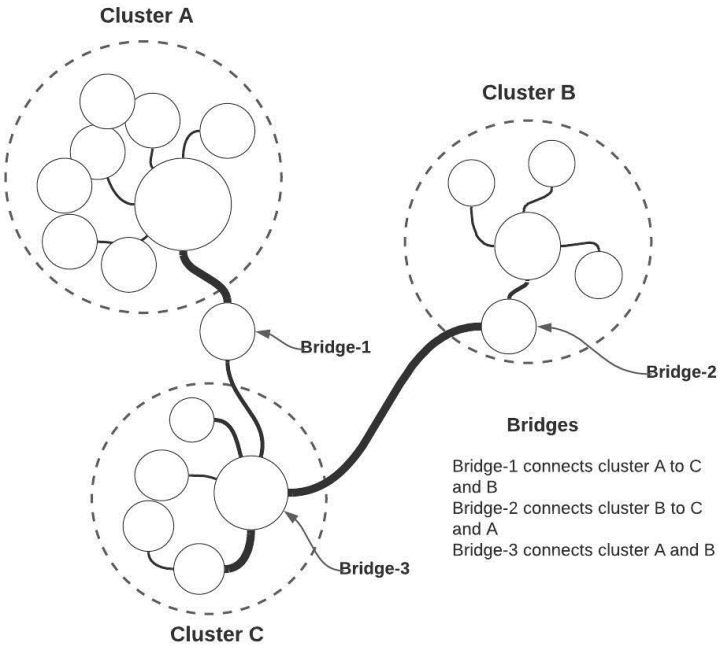

Figure 1. Visual display of clusters and bridges

2.2.2 Structural holes

Structural holes are opportunities for promoting access to new information, which may lead to disruption. Ahuja (2000, p. 431) defines structural holes as follows; "gaps in information flow between alters linked to the same ego but not linked to each other" (Figure 2). Structural holes in this paper are opportunities for entrepreneurs to leverage social capital, i.e. resources embedded and hidden in ecosystem structures. Social capital is not just about closeness (Latora et al. 2013) but also about leveraging information and resources from disconnected environments. This formed the key arguments by Robert S Burt, who highlighted the advantage of occupying bridging positions between separate entities (Burt 1992). While cohesion may lead to social capital through increased trust levels between actors (Coleman 1988), it can also lead to limited exploitation of innovative ideas because of redundant information embedded in closed networks. Knowledge of structural holes is an opportunity to access new information. Understanding structural holes give actors greater exposure to the novelty of information.

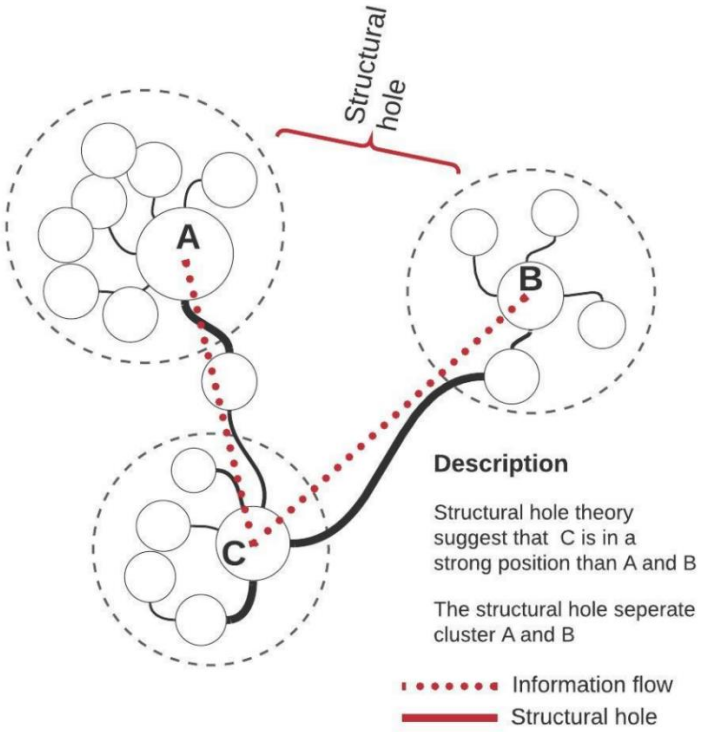

Figure 2. Visual display of structural holes

2.2.3 Weak ties

Nthubu et al. (2019) argue that revealing weak ties in ecosystems may help actors design conditions for disruption. Weak ties link actors from different groups better than strong ties (Granovetter 1973). This is also important to gain access to new information for innovation. We emphasise that combining strong (internal resources) and weak ties (external resources) might be key in promoting disruption (Chesbrough et al. 2014; Cruickshank 2010). This paper reveals the strength of ties by observing connections between nodes. Whether nodes and clusters are directly or indirectly connected (Figure 3) can impact the quality of information between actors. We think through design by visualising ties and using visuals to probe responses from actors.

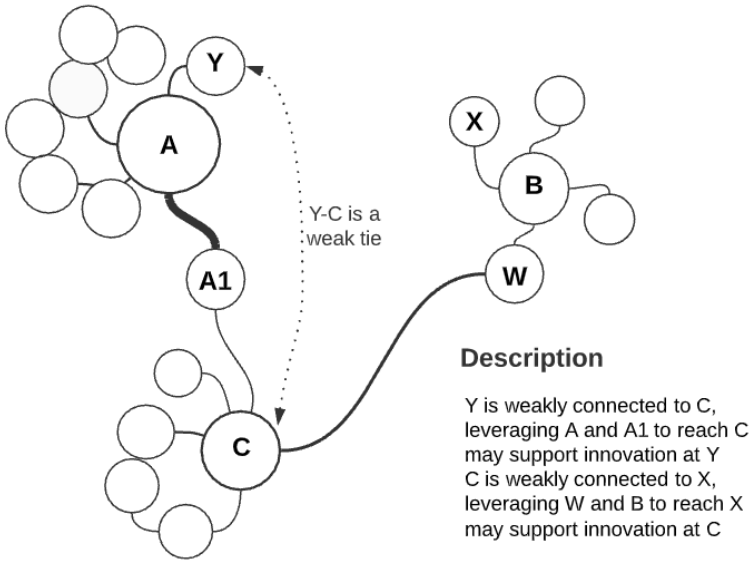

Figure 3. Visual display of weak ties

2.2.4 Roles structures

Role structures are structures showing how actors are arranged in a network. This discussion defines roles in terms of keystones, dominators, hub landlord or niche actors (Figure 4) (Iansiti and Levien 2004). Keystones occupy few positions yet have a profound influence in promoting stability through the provision of key resources. Dominators occupy both value-creating and extraction positions. Hub landlords occupy a central position in the network where they maximise on value extraction only. Niches occupy value creation positions in a keystone network and focus on innovation. These ecosystem roles' constructs are important in understanding conditions for disruption in networks. Identifying and understanding ecosystem roles may affect decision making, thus influencing how disruption occurs in local ecosystems.

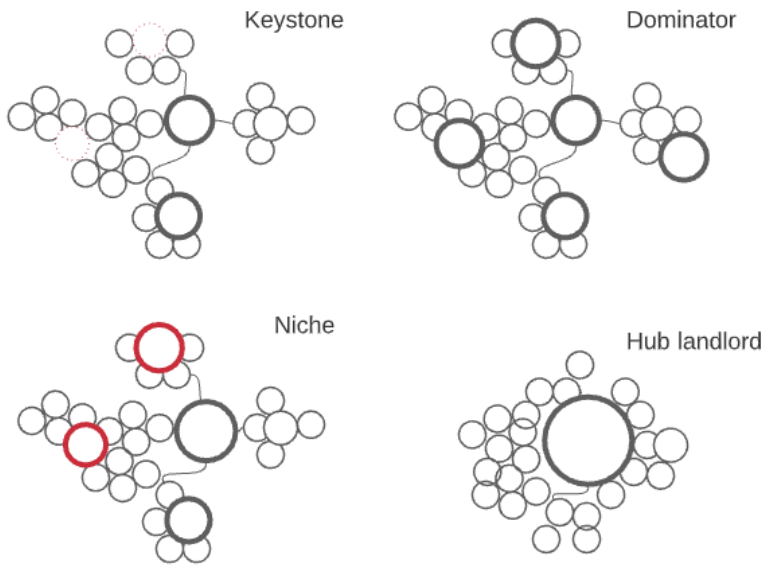

Figure 4. Visual display of role structures (redrawn from Iansiti & Levien 2004)

3 Methods

We engaged managers and entrepreneurs to capture visuals and narrative data about the state of local ecosystems, and these datasets were analysed to create new knowledge about conditions for disruption. According to Bolland and Collopy (2004, p.4), managers are designers and decision-makers in organisations. Therefore, assuming the role of designers, managers can develop new solutions rather than being stuck in default alternatives. Gathering data through design actions plays a formative role in generating new ideas that can lead to disruption because visuals and mapping processes prompt the emergence of new and unexpected data across firms (Sanders and Stappers 2014). The knowledge of existing systems inhibits new thinking (Huang et al. 2018, p.248), hence the need for thinking “through design” to move past these abstractions. Using research through design enable actors to create mental models of their tacit knowledge as maps or drawings, then analyse them and discuss new ideas (Padilla et al. 2018).

Our design visualisation approach is based on the idea that visualisations can shape conditions for disruptive innovation ecosystems (Nthubu et al. 2019, p. 634). This is important to better understand disruptions in makerspaces from the collaboration of researchers, makerspace managers and entrepreneurs' perspectives. The thinking “through design” approach combines speech and

drawings to generate, capture and analyse rich tacit data with participants (Figure 5). Visuals are not just products in a piece of paper but a result of production, reflection, and evaluation, triggering discussions and curiosities (Zweifela and Van Wezemaela 2012, p.5).

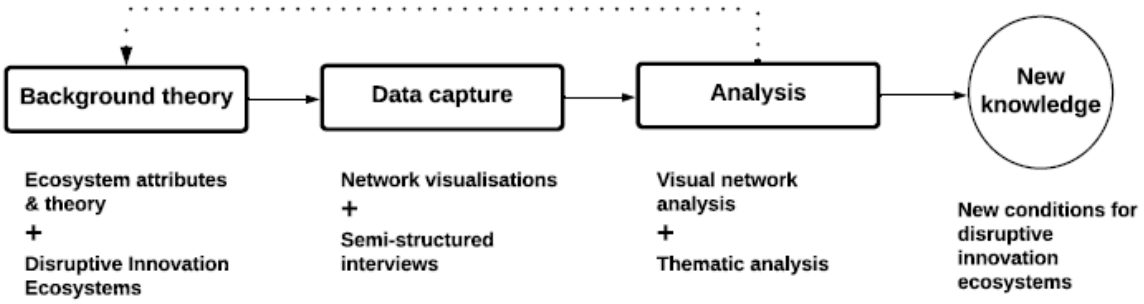

Figure 5. Research approach

A purposeful sampling strategy was adopted to select makerspaces in the Northwest of England for several reasons. First, because we are in the Northwest of England, making it convenient to visit and conduct in-person interviews and visualisations. Second, we selected experienced makerspaces with over eight years in operation to provide rich data. Third, we also considered experienced managers. Specifically, we interviewed makerspace directors (n=3) and entrepreneurs (n=6) affiliated with these spaces between 2018 and 2019. Below is a brief description and rationale for selecting each ecosystem case.

"Successful Makerspace" was considered for this present research for several reasons. First, because it exhibited characteristics of a successful makerspace model, with less dependence on external grants and loans. Second, it attracted a range of users, i.e. hobbyists, professionals, students, and young people. Third, it is self-funded, and the makerspace profit is invested back into the space. Forth, it has strong links with local universities and colleges.

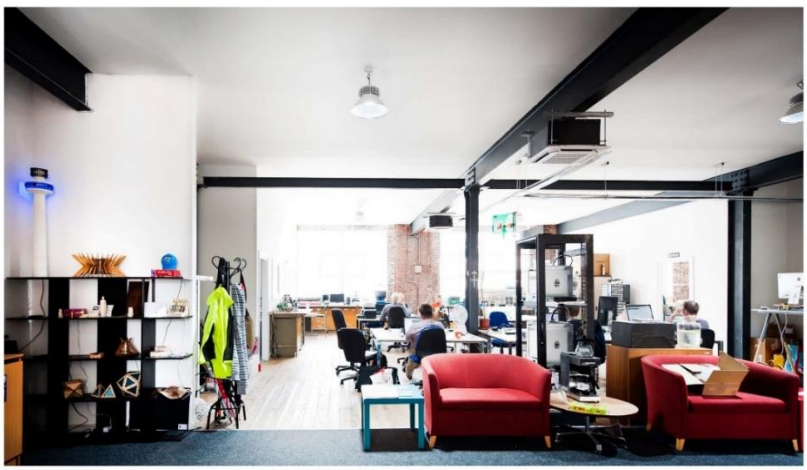

Figure 6: Inside the "successful Makerspace"

"Failed Makerspace" was considered because it exhibited some highlights of a failed model of a makerspace, hence crucial and interesting to study. Second, the makerspace no longer has a dedicated community space, making this an interesting case for insights.

Figure 7: Inside the "Failed Makerspace"

"Emerging Makerspace" was selected because it combines an incubator, accelerator and the FabLab models located within a bank environment, thus making this an interesting case to explore. Second, the makerspace is owned and run by the commercial bank, thus presenting a different approach for a makerspace setting.

Figure 8: Inside an "Emerging Makerspace"

We conducted semi-structured interviews and visualisations concurrently to facilitate thinking "through design" and create ecosystem objects to help us think about conditions for disruption. This involved asking questions about why makerspaces thrive or not and how makerspaces promote openness, creativity and innovation or not. We also visualised network relationships using drawings on paper-based A3 paper tools (Figure 9). Visuals helped identify key actors and roles and analyse, locate, and determine relationship strength. We used three open-source visualisation tools, i.e., *Gephi, Chord Snip* and *OmicsNet*. Gephi force-directed layout algorithm characterises clusters, bridges, and role structures in the ecosystem better. The Chord Snip layout algorithm characterises

nodes and ties' hierarchies better. Finally, the OmicsNet 3D layout algorithm was selected to characterise structural holes better because of its interactive features.

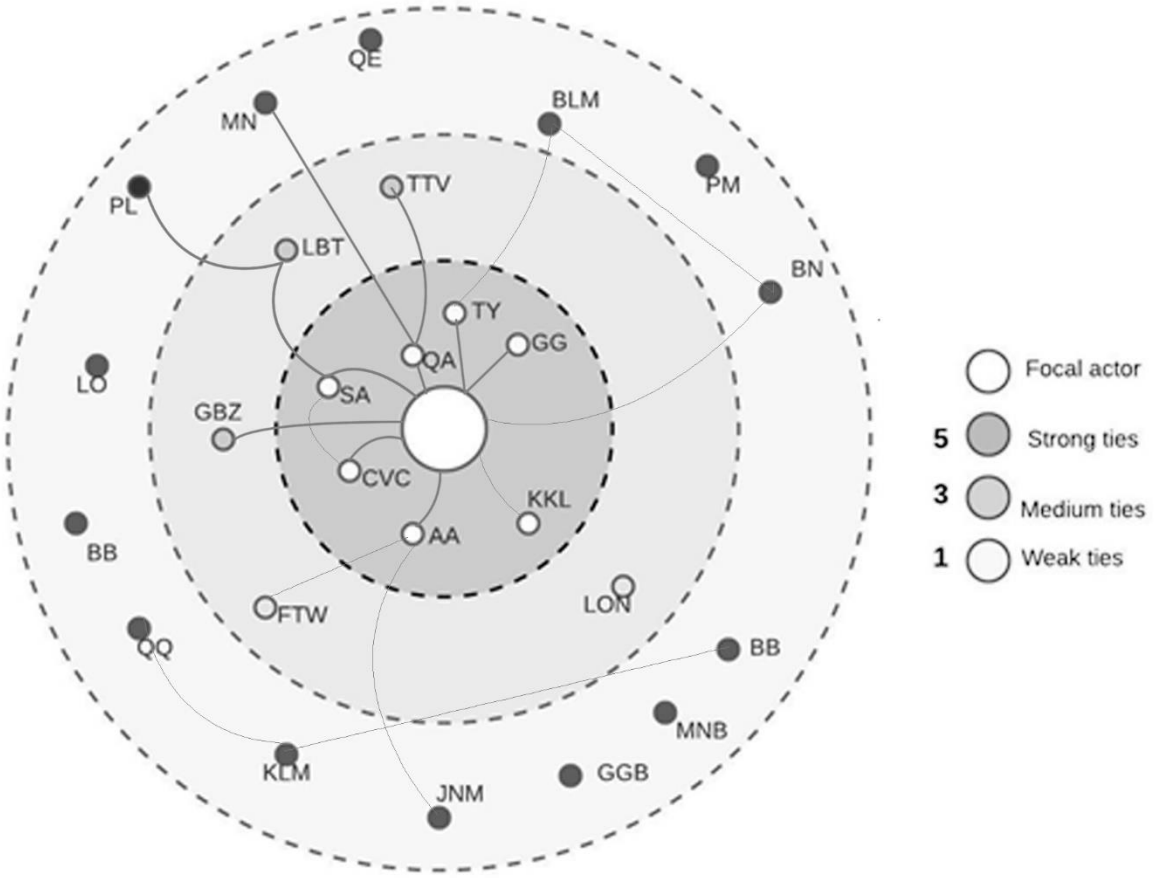

Figure 9. Mapping tool used to generate visualisations with participants

The semi-structured interviews captured actors' experiences about makerspaces, how these spaces can influence disruptive innovation, and what conditions can be cultivated to cause disruption. All interviews lasted between one to two hours and were recorded, transcribed and coded to generate themes following a five-step process, i.e. data familiarisation, code generation, theme generation, theme revision and theme definition (Braun and Clarke 2006). This process is useful for capturing the complex meaning of textual and visual data (Boyatzis 1998). The thematic and visual data were aggregated into three main dimensions, as shown in Figure 10.

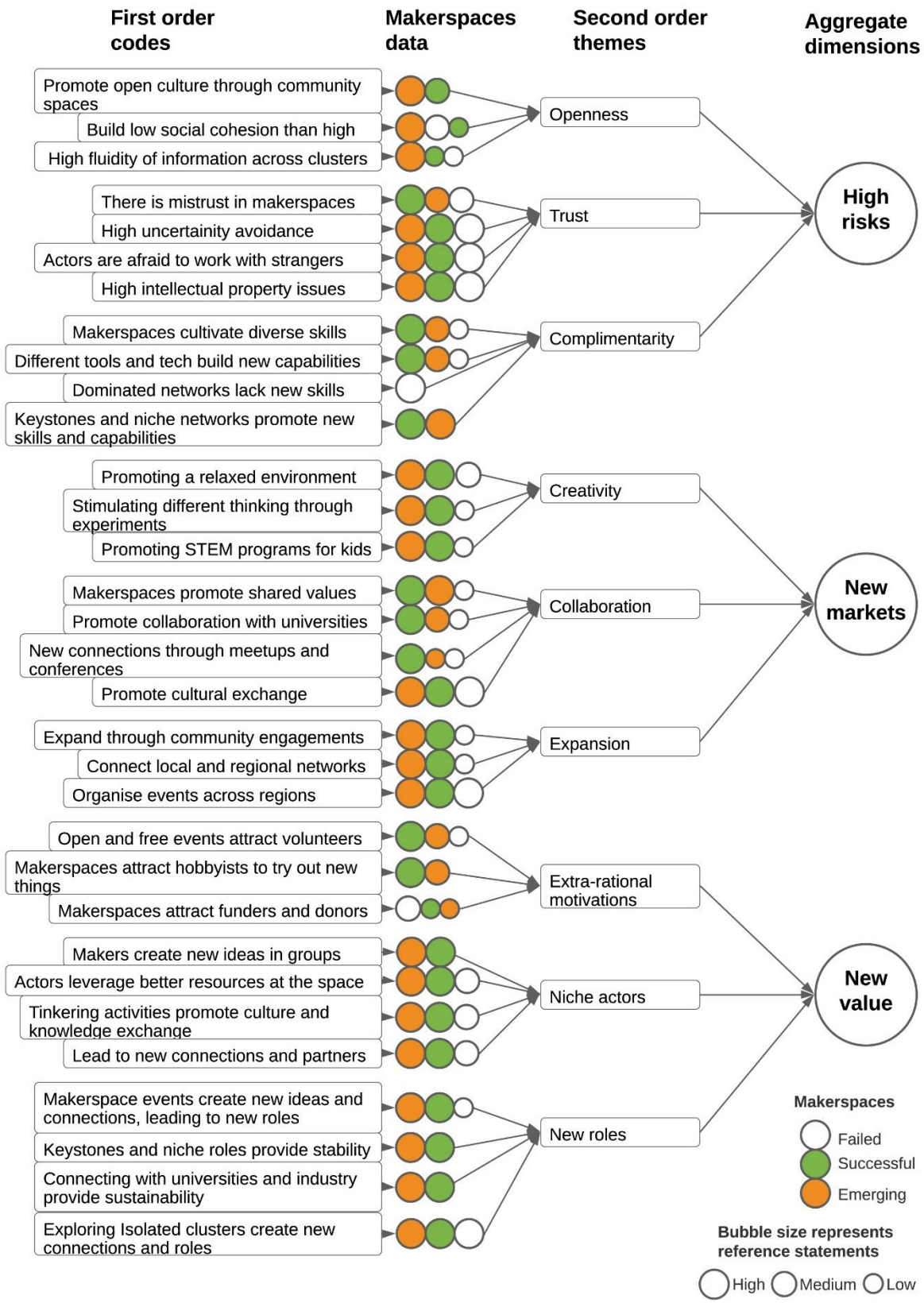

Figure 10. Final data structure from codes to themes to aggregate dimensions

Before engaging human participants in their workplaces, ethical approval was applied for and granted by Lancaster University Ethics Committee. This was important to ensure that their privacies and identities were protected (Bell 2019).

4 Findings and discussions

Nine themes came out of the thematic and visual network analysis, defining conditions for promoting disruption in makerspaces (Figure 11). These factors are classified under three aggregate dimensions defining disruption, i.e. High risks, new markets, and new value. As indicated by the arrows between factors, there is a significant reciprocal relationship between these dimensions.

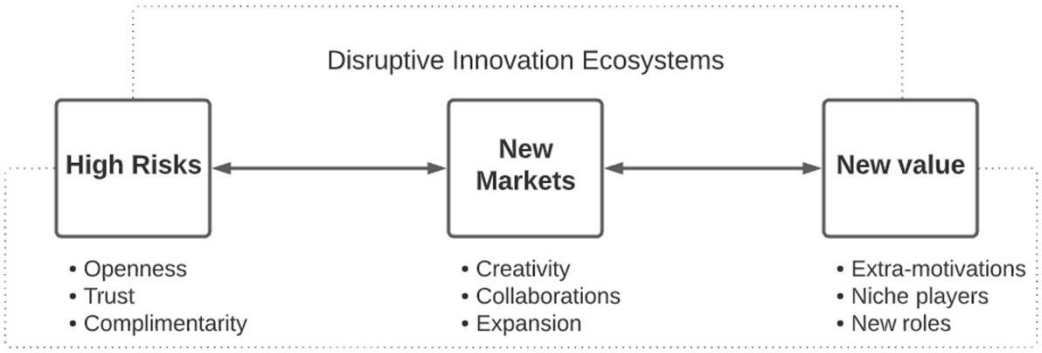

Figure 11. Second-order themes and aggregate dimensions representing conditions for disruption in makerspaces

4.1 Navigating high risks

High-risk environments in makerspaces include high failure rates, intellectual property conflicts (Radniecki 2018), and an underdeveloped market. Participants indicated the danger of venturing into untested territories where incumbent ecosystems are reluctant to go, highlighting the exorbitant costs associated with these actions. Since pursuing high risk has been identified as a condition for disruption (Mahto et al. 2020), participants emphasised that makerspaces promote access to different fabrication tools to stimulate risk-taking behaviours. Three conditions for navigating a risky environment came out of the analysis: Openness, trust, and complementarity (Figure 11).

4.1.1 Openness

Openness promote sharing of information and resources across actors. This is important to build an open environment for collaboration (Sheridan et al. 2014; Marsh et al. 2018). Participants indicated that the UK makers are less open to sharing ideas than other parts of the world, e.g. the USA.

> "I think, sometimes its culture challenges. Us the British are quite reserved, whilst Americans are more open to collaboration, as Brits we are much more closed, I think culturally as a nation, that could be quite a challenge" (Emerging makerspace).

Although previous research indicates that makerspaces promote an open culture of sharing (Benkler and Nissenbaum 2006), we found that different cultures play a significant role in how people view makerspaces. This is also supported in (Bolli 2020, p. 74), highlighting Shenzhen's fast production and export orientation, opening the city, and fluidising social networks to drive a maker culture, creativity, and innovation. To further investigate the openness of makerspaces in the UK and how that fluidises the cities, we used relational data from the field to observe connections between actors. Juxtaposing the visualisation results using a chord layout (Figure 12), the "Emerging and

Failed makerspaces" have a low social cohesion indicated by large gaps and weak ties between actors, while a "Successful makerspace" has high social cohesion. Observing Figure 12 (C), the ecosystem structure has many weak connections on the left side. Implications for this are that exploring the weak ties may present new information to build conditions for disruption than in other cases. This is in line with findings in (Lee and Tuselmann 2013).

Based on the theories of weak ties and structural holes, opening "Emerging makerspaces" to connect with new actors and ties present more fluidity to create disruptions than in "Successful and Failed makerspaces" because of high redundancy and a very low social cohesion. Using these visuals as ecosystem artefacts might help practitioners with new information. This information can be practically applied (Weber and Hine 2015) to design conditions and ecosystem networks for disruption because visuals probe responses from actors better. Lack of openness in ecosystems leads to redundancy, low fluidity, and no disruption, as shown in a "Successful makerspace".

Based on these results, we argue that the first condition for navigating high-risk environments is to promote openness and fluidity for actors to share risks. This argument is in line with findings in (Bolli 2020), where the emergence of makerspaces has opened the city of Shenzhen and led to growth in personal networks and entrepreneurship.

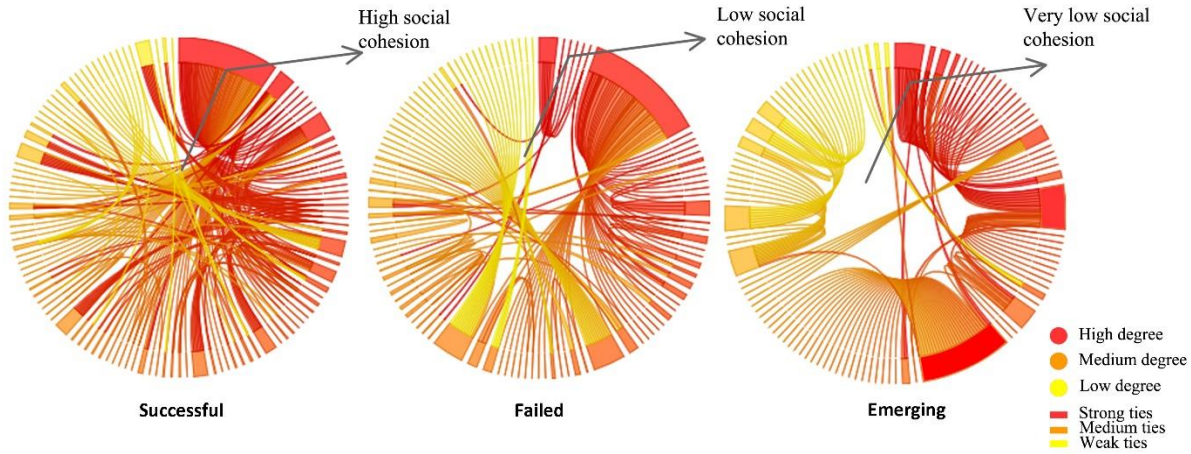

Figure 12: Example of Chord layout results between makerspaces (Successful, Failed and Emerging makerspaces)

4.1.2 Trust

High-risk environments require a high need for trust (Von Stamm and Trifilova 2009, p. 248). As discussed earlier, this study found that most UK makerspace users are less open to collaborations partly because of mistrust. Previous research shows that mistrust is associated with uncertainty avoidance (Hofstede 1984). Using structural holes help us see opportunities to build trust and reduce uncertainty avoidance. For example, using a 3D layout (Figure 13), structural hole-1 separates the co-working desks users with Arduino activities, meaning that these actors are not working together. From the interview, actors attributed their uncertainty avoidance to intellectual property conflicts, and some highlighted a lack of interest in working with strangers. However, visual information provides an alternative design mode to see bridges that may close holes to enable trust and experiments across distant actors, leading to disruptive ideas. Other structural holes are shown (Figure 13), which might enable trust and risk-taking behaviours.

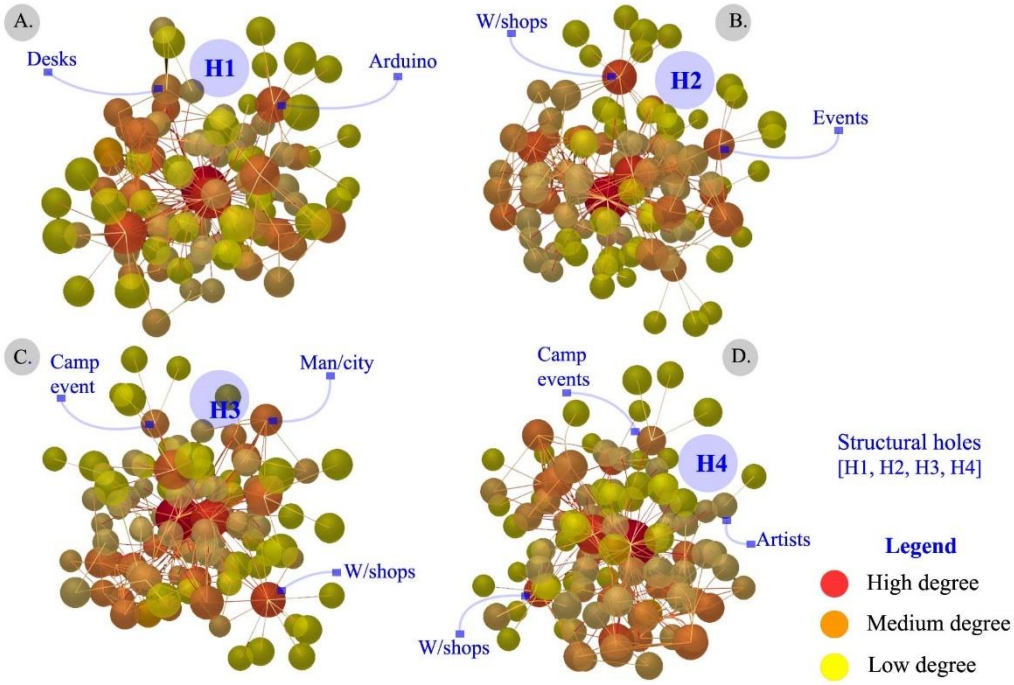

Figure 13: Example of a "Successful Makerspace" structural holes

4.1.3 Complementarity

We found that navigating high-risk environments also require understanding a set of roles, tools, and actors and how they are related. For example, a "Successful makerspace" director highlighted that open-source hardware components such as Arduino kits, laser cutters and MakerBot 3D printers attracted more users to experiment with ideas they later developed into businesses. We also observed that makerspace activities mostly evolved around digital technologies (3D printers, laser cutters, routers, 3D mills), electronic art and pottery work. These tools provide complementarity to navigate high-risk experimental stages of businesses (Valkokari 2015, p. 21). Observing clusters formed across makerspaces (Figure 14), a "Successful makerspace" has close-knit clusters compared to "Failed and Emerging makerspaces". This is because the "Successful makerspace" has strong relationships with the local university and community leaders, thus acting as a keystone player in the local ecosystem. The makerspace as a keystone provide certainty to other actors to leverage resources through strong ties. A "Failed makerspace" resembles a dominator, having less room for exploration, while an "Emerging makerspace" resembles a niche-based network adding to value creation. Keystones and niche-based networks provide complementary roles that may help actors navigate high-risk environments for innovation, but dominated networks lack the complementarity necessary for sharing risks and increasing serendipity for disruption. These observations are in line with Granstrand and Holgersson (2020, p. 8), where the authors highlight how Apple opened its ecosystem to complementary innovators in apps and content development, allowing them to make huge profits from its ecosystem.

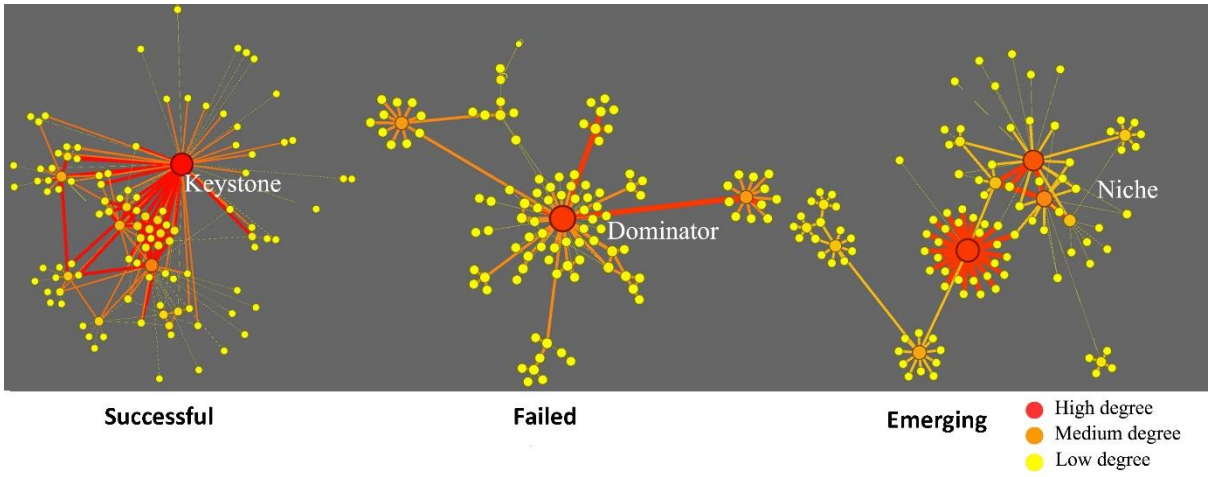

Figure 14: Examples of the role structures between makerspaces

4.2 Creating new markets

Most participants highlighted the need to disrupt existing markets through leveraging new connections and roles in local ecosystems. Participants emphasised the advantage of a close-knit community that accelerate a critical mass of makers and tinkerers through physical activities, e.g. workshops and social events.

> "Also, it [referring to the makerspace] allows us to work very closely with disruptive companies that allow us or the way they operate get us thinking differently as well to expand the ecosystem" (Emerging makerspace).

Based on the above quote, the “Emerging makerspace” is influenced by how disruptive firms operate, emphasising new markets and confronting risky environments to develop conditions for disruption. Most participants identified the following factors as key: Creativity, collaboration, and expansion.

4.2.1 Creativity

Makerspaces provide a relaxed environment to tinker with new tools and business models. However, participants highlighted that bringing actors together to experiment with strangers is often difficult to achieve. The “Successful makerspace” leverages partnerships with universities, pubs, and other community spaces like public libraries. This is key in increasing the makerspace creativity, capacity, and ultimately new markets. We found that weak ties can be leveraged to promote collective creativity between distant actors in a “Failed makerspace” (Figure 15). For example, the UK research and innovation fund could be explored to connect STEM kids with digital tools and entrepreneurs. Blum-Ross et al. (2019) also support STEM programs integration into makerspaces to promote collective creativity. Combining young people's creative prowess with entrepreneurial minds can promote disruptive ideas.

Based on the theory of weak ties and the idea of leveraging bridges, the university can act as a bridge to provide spaces for workshops, connecting digital makers and local councils. These connections may help the local government recognise makerspaces as an alternative ground to promote regional innovation and development. Inviting some SMEs, i.e. freelancing artists, and others in co-working spaces at subsidised fees may increase their presence in the ecosystem, leading to new markets. Participants highlighted that creating an environment where strangers intermingle

may lead to the emergence of disruption through collective creativity. This is in line with previous literature (Nthubu et al. 2019, p. 632).

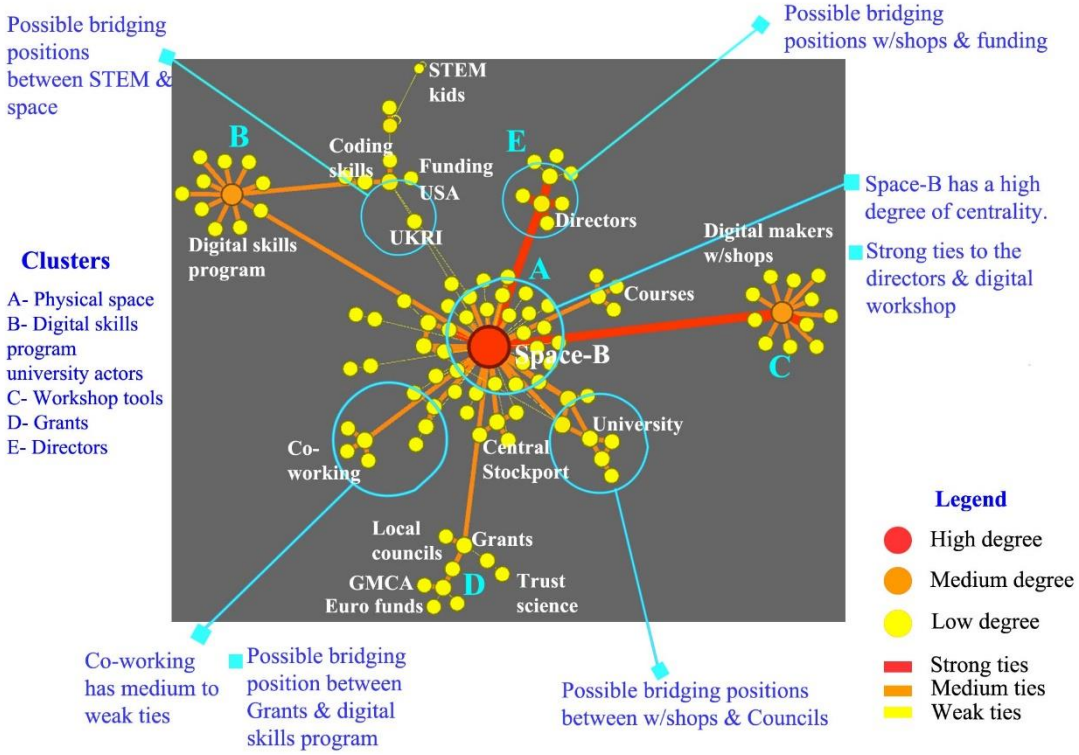

Figure 15: Examples of important clusters and bridges in a "Failed makerspace"

4.2.2 Collaborations

Collaborations promote shared value in makerspaces, which may lead to disruption. Innovation is not limited to one actor; it is about collective effort (Nylund et al. 2019). This study found that makerspaces are collaborating with knowledge centres with better fabrication tools to promote co-creation. For example, the "Successful makerspace" director mentioned that their meetups were moved from the pub to the university workshops to support co-creation with 3D printers, laser cutters and Arduino kits because it was impossible to make things at the pub.

> "When we started running the Maker night, we had Arduino kits, and the university had laser cutters, so people planned to do some Arduino stuff, and others planned to do laser cutting. That's kind of got us to try and get more people because meeting at the pub, we weren't getting many people coming along because we couldn't make stuff" (Successful makerspace).

A combination of 3D printers, laser cutters and milling machines attract makers to collaborate better through making than just having conversations. Using ecosystem visualisations (Figure 16), there are opportunities to find new connections based on the structural hole theory (Burt 1992). For example, layout view (B) shows structural hole (H3) separating grant agencies with the makerspace; exploring these agencies can increase the funding opportunities to start the community lab, which may provide serendipity for new connections. Layout view (C) reveals a structural hole (H4) separating the digital skills program and the British council. Collaborating with the British council to promote digital skills program for Kids might contribute to innovation in local ecosystems. Structural hole (H5) in layout view (D) shows a gap between the university students and co-working spaces. Marketing

spaces at discounted fees may open new markets amongst students, leading to collaborations with entrepreneurs. Previous literature shows that developing interconnections between different cultures and competencies can lead to "entrepreneurial solutionism", which is about developing a certain field for solving social and economic problems (Bolli 2020, p. 72). This could lead to the cross-pollination of ideas and ultimately disruptive innovation ecosystems.

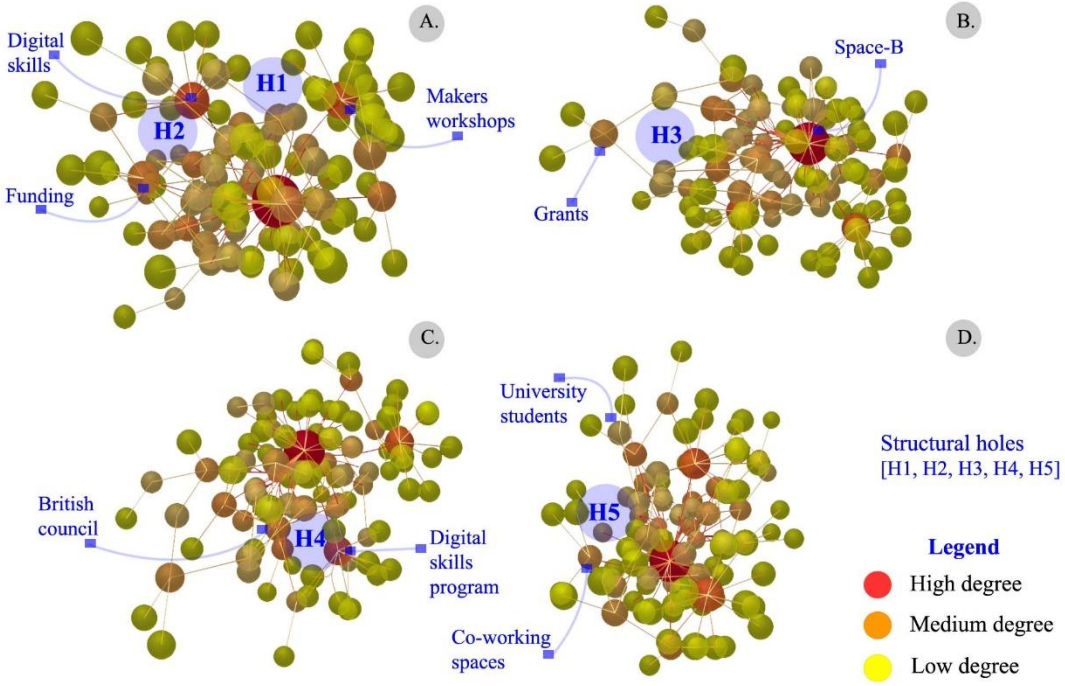

Figure 16: Examples of important structural holes in a "Failed makerspace"

4.2.3 Expansion

Based on creating social benefits for communities and network effects in local ecosystems, makerspaces depend on a critical mass of entrepreneurs and hobbyists to expand the local ecosystem.

> "There are people who come in the evening who aren't running a business and aren't thinking about running businesses, they also provide useful stuff because some of them fix machines which helps the businesses that are here to run their businesses. The business would be like oh… I like that idea; I can use it for my business" (Successful makerspace).

The above quote demonstrates that a "Successful makerspace" is expanded by hobbyists and volunteers who are not entrepreneurs but derive satisfaction in contributing value to the ecosystem. From the "Emerging makerspace" (Figure 17), cluster B appears to be the main community in the ecosystem. This is so because it represents a network of other makerspaces spread across the UK. In contrast, cluster A represents a local ecosystem (makerspace, the FabLab, SMEs, Investors, and others). In cluster A, the "Emerging makerspace" has a high degree of centrality, signalling its high influence in the cluster. There are visible bridges in the ecosystem that might connect these isolated clusters to promote openness, i.e. the UK Government may be used as a bridge to connect technology industries and cluster C through innovation funding. Other makerspaces across the UK may also be used as bridges to connect the "Emerging makerspace" to other UK cities to expand the

ecosystem from local to national level. Therefore, we argue that creating local and national links that extend to other cities can increase regional disruptive innovation ecosystems.

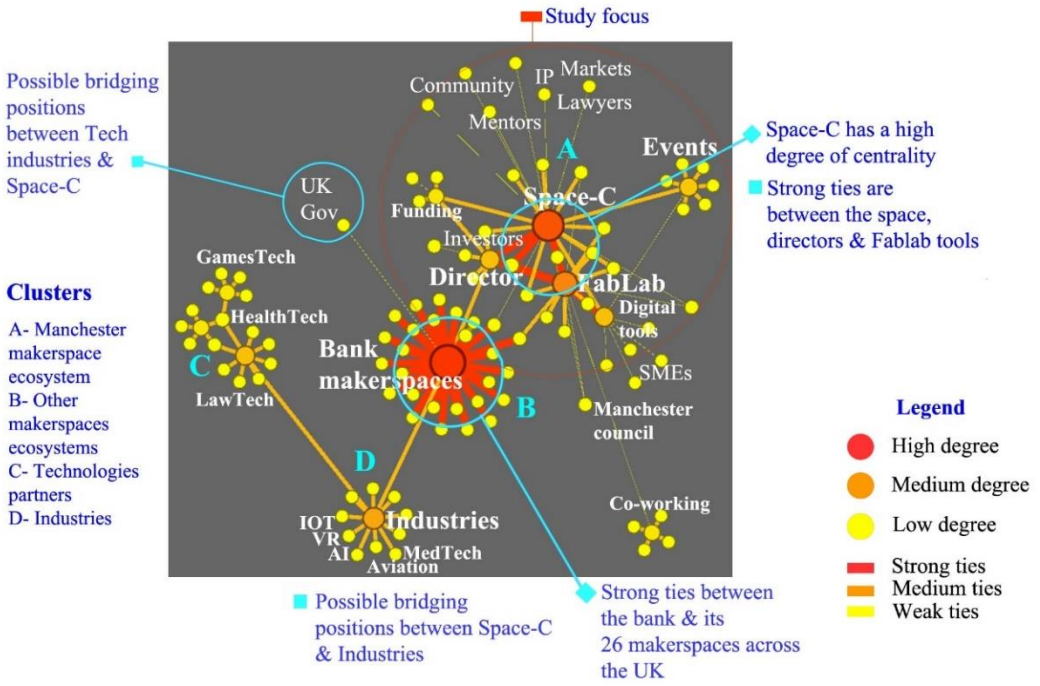

Figure 17: Examples of important clusters and bridges in an "Emerging makerspace"

4.3 Creating new value

Smith and William (1977) argued that although entrepreneurs act in pursuit of profit, they may generate value for society. We also argue that creating value in makerspaces is about maintaining the ethos of co-creation to benefit the community and rejuvenate local enterprises. Makerspaces combine different competencies leading to "entrepreneurial solutionism". From the analysis of the results, the meaning of value varied based on the type of business models adopted across three makerspaces.

> "We only survive through freelancing; none of us gets any money from XX [referring to the makerspace]. It is a company that has shares, it could pay dividends, but it all goes back into the space. We don't ever intend to take any money from it" (Successful makerspace).
>
> "We don't maintain a public community side. We decided to close that, we didn't want to be paying money at the landlord's pocket" (Failed makerspace).
>
> "We got a particular shared value growth ambition which is that if we work closely with the community, and then they grow, we will grow also" (Emerging makerspace).

The above quotes highlight different makerspace views about creating new value. To maintain the ethos of co-creation and open access while pursuing profit, three things emerged from the analysis of the results that can help create new value to promote disruption: Extra-rational motivations, niche players and new roles.

4.3.1 Extra-rational motivations

To support community and enterprise growth, a group of self-motivated people, e.g. hobbyists and funders, are important to contribute to the socio-economic condition of their localities. Hwang and

Horowitt (2012) highlight that promoting extra-rational motivations is a huge challenge. Our findings indicate that makerspaces that promote free open events attract altruistic people to create shared value than closed makerspaces. For example, analysing the “Emerging makerspace” (Figure 18), layout view (D) reveals the structural hole (H2) separating events and digital tools from makerspaces elsewhere. Based on this analysis, creating coffee events between these communities promotes social interactions, attracting volunteers or funders to the space.

> "Because we have been doing this for seven years, so we got a lot of people coming from the community to help out with assembling of stuff and putting things together. Many came to volunteer their time from the community without expecting anything in return" (Successful makerspace).

The significance of having volunteers and people not motivated by money is the willingness to try out new things with others without the fear of loss of profit. This is important to sustain local ecosystems (Presenza et al. 2019). Wolf and Troxler (2016) add that it might be useful for corporates to infuse makerspace values in their strategies to open innovation to the community. Mortati et al. (2012) also highlight that socialisation activities can lead to new connections.

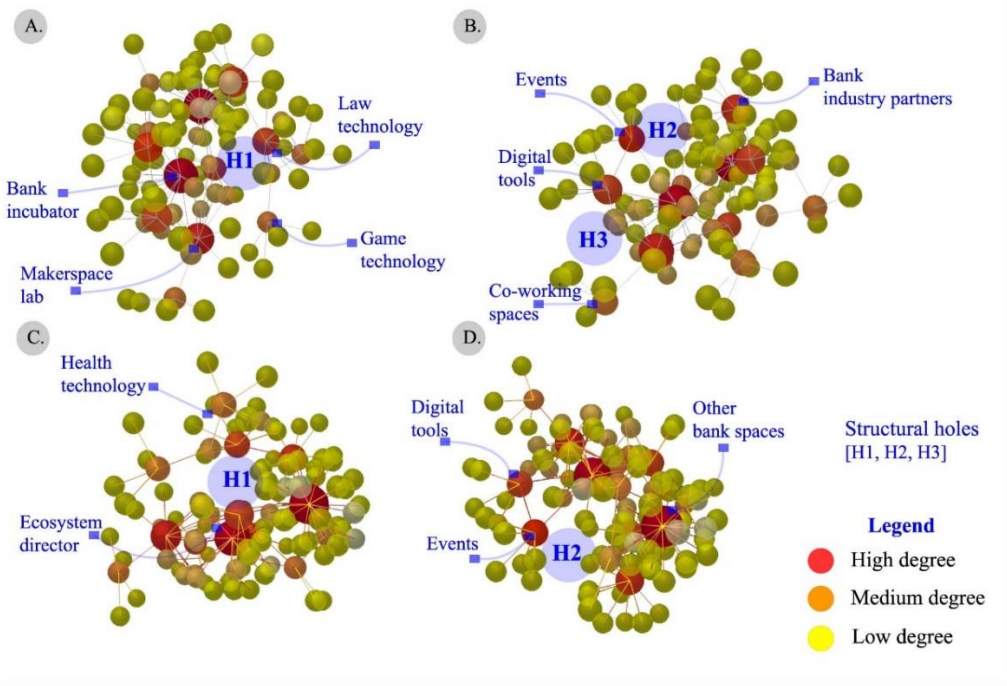

Figure 18: Examples of important structural holes in an “Emerging makerspace”

4.3.2 Niche players

Niche actors in a makerspace compliment the space by bringing in new ideas. This is important in creating value for the community and enterprises seeking to disrupt the market. Niche roles and actors may develop disruption through leveraging keystone support (Elena and Avasilcai 2016). A niche actor has a meagre physical presence but can contribute more to innovation (Figure 14). Having a critical mass of niche players in the makerspace might lead to new ideas, innovations, and ultimately disruptive innovations. For example, funding STEM programs and increasing more activities to find new connections between students and entrepreneurs may lead to more niche

ideas, as discussed earlier. These ideas can be commercialised into viable businesses, which may later replace existing markets with new ones.

4.3.3 New roles

The study found that most makerspaces play keystone and niche roles in providing basic resources for makers and driving innovation initiatives in the community. Connecting different actors with different roles leads to "new roles" that ecosystem actors may assume. This is important to create new value (in terms of new information and resources) different from the existing one. Thus, providing stability and driving innovation.

Analysing connections in three makerspaces (Figure 12), the “Successful makerspace” has strong ties with the local universities, researchers and students, a “Failed makerspace” has strong ties with funders, and an “Emerging makerspace” has strong ties with key industry players. However, there is less evidence of new roles arising from these strong ties. This finding suggests that it is important to explore isolated clusters, bridges, and weak ties to create new roles which can create new value. As shown in Figure 11, the more creative, collaborative, and expanded the ecosystem, the better chance to create new roles, which may lead to disruptive innovation ecosystems.

5 Conclusions

This paper aimed to understand conditions for disruption and the role that makerspaces play in triggering disruptive innovations. We have discussed how thinking “through design” using a combination of visuals as subjective models and speech in gathering qualitative data can help design researchers, ecosystem actors, and policymakers characterise network attributes related to different ecosystems. Exploring makerspaces through the lens of network theory provided a framework to fragment and characterise real-world ecosystems, which may provide actors with a model to evaluate and activate their local ecosystems for disruption. In adopting a thinking “through design” approach, we demonstrated the significance of using visuals to support thinking modes in identifying the main conditions for “Successful”, “Failed”, and “Emerging” ecosystems. Three conditions were discussed as key: i) Navigating high risks, ii) Creating new markets, ii) Creating new value.

This paper amplifies the value of thinking “through design” to elaborate on the role of makerspaces in designing conditions for disruption. This is important to provide ecosystem managers with a framework to co-create disruptive ideas across firms. We have discussed that “Successful” and “Emerging” makerspaces can yield disruptive innovations. This is so because makerspaces are predominantly used by smaller firms with fewer resources. Therefore, with access to keystone (makerspace) resources, these smaller firms can successfully work together to challenge and displace established firms for markets. Unlike incremental innovations, where firms make improvements based on existing products or services (Shi et al. 2020), disruptive innovations are about creating a new market different from the existing one, providing new value and serendipity for disruption.

Even though most makerspaces are open spaces by design, they do not guarantee openness amongst makers. Our approach provides the means and framework to reveal important conditions for disruption in makerspaces. Makerspaces are taken as key strategic environments for economic development in the UK. Although this paper discussed how makerspaces might be utilized to promote disruption, it is limited by using a small sample in the UK. Further empirical work is needed to support and empower ecosystem actors with visualisation tools in other ecosystem contexts to define the value of open environments for disruptive innovation.

This paper opens important debates on how makerspaces can shape conditions for disruptive innovation ecosystems. We hope to engage further with the design innovation community to extend the value of design in promoting disruptive innovation ecosystems.

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References

Adner, R & Feiler, D 2019, 'Interdependence, Perception, and Investment Choices: An Experimental Approach to Decision Making in Innovation Ecosystems', *Organization Science,* vol. 30, no.1**,** p. 109.
Ahuja, G 2000, 'Collaboration Networks, Structural Holes, and Innovation: A Longitudinal Study', *Administrative Science Quarterly*, vol. 45, no. 3, pp. 425-455.
Ballantyne-Brodie, E & Telalbasic, I 2017, 'Designing local food systems in everyday life through service design strategies', *The Design Journal*, vol. 20 (sup1), pp. S3079–S3095.
Bell, E 2019, *Business research methods*. Fifth edition / Emma Bell, Alan Bryman, Bill Harley. ed., Oxford University Press, Oxford.
Benkler, Y & Nissenbaum, H 2006, 'Commons-Based Peer Production and Virtue', *Journal of Political Philosophy,* vol. 14, no. 4, pp. 394-419.
Bianchi, C & Vignieri, V 2021, 'Dealing with "abnormal" business growth by leveraging local area common goods: an outside-in stakeholder collaboration perspective', *International Journal of Productivity and Performance Management,* vol. 70, no. 3, pp. 613-634.
Blum-Ross, A, Kristiina, K & Jackie, M 2019, *Enhancing Digital Literacy and Creativity: Makerspaces in the Early Years*, Routledge, New York.
Boland, R & Collopy, F 2004, *Managing as designing*, Stanford Business Books, Stanford, California.
Bolli, M 2020, 'Innovators in urban China: Makerspaces and marginality with impact', *Urban Planning*, vol. *5*, no. 4, pp. 68-77.
Boyatzis, R.E 1998, *Transforming qualitative information: thematic analysis and code development*, SAGE Publications, California, United States.
Braun, V & Clarke, V 2006, 'Using thematic analysis in psychology', *Qualitative Research in Psychology*, vol. 3, no. 2, pp. 77-101.
Buchanan, R 2001, 'Design research and the new learning', *Design Issues*, vol. 17, no. 4, pp. 3–23.
Burnay, C, Dargam, F & Zarate, P 2019, 'Special Issue: Data Visualization for Decision-Making: An Important Issue', *An International Journal,* vol. 19, no. 4**,** pp. 853-855.
Burt, R. S 1992, *Structural Holes: The Social Structure of Competition*, Harvard University Press, Cambridge, Massachusetts, and London, England.
Chesbrough, H 2010, 'Business Model Innovation: Opportunities and Barriers', *Long Range Planning,* vol. 43, no. 2-3**,** pp. 354-363.
Chesbrough, H. W 2003, *Open innovation: The new imperative for creating and profiting from technology,* Harvard Business Press, Boston, Massachusetts.
Chesbrough, H, Kim, S & Agogino, A 2014, 'Chez Panisse. Building an Open Innovation Ecosystem', *California Management Review,* vol. 56, no.4**,** pp. 144-171.
Christensen, C. M 2013, *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail*, Boston, Massachusetts.
Christensen, C. M, Mcdonald, R, Altman, E. J & Palmer, J. E 2018, 'Disruptive Innovation: An Intellectual History and Directions for Future Research', *Journal of Management Studies,* vol. 55, no. 7**,** pp. 1043-1078.
Coleman, J. S 1988, 'Social Capital in the Creation of Human Capital', *American Journal of Sociology,* vol. 94**,** pp. S95-S120.
Cross, N 1999, 'Design Research: A Disciplined Conversation', *Design Issues*, vol. 15 no. 2, pp. 5–10.
Cruickshank, L 2010, 'The Innovation Dimension: Designing in a Broader Context', *Design Issues,* vol. 26, no. 2**,** pp. 17-26.
Cruickshank, L 2014, *Open Design and Innovation: Facilitating Design in Everyone*, Ashgate, Farnham.
Cruickshank, L, Coupe, G & Hennessy, D 2016, 'Co-Design: Fundamental Issues and Guidelines for Designers: Beyond the Castle Case Study', *Swedish Design Research Journal,* vol. 10**,** pp. 48-57.

Dedehayir, O, Ortt, J. R & Seppänen, M 2017, 'Disruptive Change and the Reconfiguration of Innovation Ecosystems', *Journal of Technology Management and Innovation,* vol. 12, no. 3**,** pp. 9-21.
Elena, G & Avasilcai, S 2016, 'Framing the Competitive Behaviors of Niche Players: The Electric Vehicle Business Ecosystem Perspective', *Procedia - Social and Behavioral Sciences,* vol. 221**,** pp. 342-351.
ElHoussamy, N & Rizk, N 2020, 'Innovation practices at makerspaces in Egypt, Tunisia and Morocco', *The African Journal of Information and Communication*, vol. 26, pp. 106-130.
Evans, M 2010, 'Design Futures: An Investigation into the Role of Futures Thinking in Design', PhD Thesis, Lancaster University, Lancaster.
Forlizzi, J, Zimmerman, J & Stolterman, E 2009, 'From Design Research to Theory: Evidence of a Maturing Field', *In Proceedings of the Conference on the International Association for Societies of Design Research,* Seoul, Korea.
Frayling, C 1993, 'Research in Art and Design', *Royal College of Art Research Papers*, vol. 1 no. 1, pp. 1–5.
Granovetter, M. S 1973, 'The Strength of Weak Ties', *American Journal of Sociology,* vol. 78, no. 6**,** pp. 1360-1380.
Granstrand, O & Holgersson, M 2020, 'Innovation Ecosystems: A Conceptual Review and a New Definition', *Technovation*, vol. 90-91, no. february-March, p. 102098.
Hofstede, G 1984, 'Cultural Dimensions in Management and Planning', *Asia Pacific Journal of Management,* vol. 1, no. 2**,** pp. 81-99.
Holm, E. J. V 2015, 'Makerspaces and Contributions to Entrepreneurship', *Procedia, Social and Behavioral Sciences*, vol. 195, pp. 24-31.
Hopp, C, Antons, D, Kaminski, J & Oliver Salge, T 2018, 'Disruptive Innovation: Conceptual Foundations, Empirical Evidence, and Research Opportunities in the Digital Age', *The Journal of Product Innovation Management,* vol. 35, no. 3**,** pp. 446-457.
Huang, T.T, Aitken, J, Ferris, E & Cohen, N 2018, 'Design thinking to improve implementation of public health interventions: an exploratory case study on enhancing park use', *Design for Health*, vol. 2, no. 2, pp. 236-252.
Hui, J & Gerber, E 2017, 'Developing Makerspaces as Sites of Entrepreneurship', *CSCW '17: Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing, Portland, Oregon, USA,* 25 February 2017- 1 March 2017, pp. 2023-2038.
Hwang, V & Horowitt, G 2012, *The Rainforest-the Secrets to Building the Next Silicon Valley*. (2 ed), Regenwald, California.
Iansiti, M & Levien, R 2004, *The Keystone Advantage: What the New Dynamics of Business Ecosystems Mean for Strategy, Innovation, and Sustainability*, Harvard Business School Press, Boston, Massachusetts.
Jacobides, M. G, Cennamo, C & Gawer, A 2018, 'Towards a Theory of Ecosystems', *Strategic Management Journal,* vol. 39, no. 8**,** pp. 2255-2276.
Karadima, D & Bofylatos, S 2019, 'Co-living as a Means to Re-engagement. A Literature Review', *The Design Journal,* Vol. 22, pp. 751-62.
Musial, K & Juszczyszyn, K 2009, 'Properties of Bridge Nodes in Social Networks', In *International Conference on Computational Collective Intelligence*, Springer Berlin Heidelberg, Berlin, pp. 357-364.
Latora, V, Nicosia, V & Panzarasa, P 2013, 'Social Cohesion, Structural Holes, and a Tale of Two Measures', *Journal of Statistical Physics,* vol. 151, no. 3-4**,** pp. 745-764.
Lee, R & Tuselmann, H 2013, 'Entrepreneurship, occupational division and social capital differentials', *Journal of Small Business and Enterprise Development,* vol. 20, no. 3, pp. 661–680.
Lee, Y 2008, 'Design Participation Tactics: The Challenges and New Roles for Designers in the Co-Design Process', *CoDesign: Design Participation(-s),* vol. 4, no. 1**,** pp. 31-50.
Libert, B, Wind, Y. J & Fenley, M. B 2014, 'What Airbnb, Uber, and Alibaba Have in Common'*, Havard Business Review,* 20 November. Available at: What Airbnb, Uber, and Alibaba Have in Common (hbr.org)/ [Accessed 25 October 2018].
Lurie, N & Mason, C 2007, 'Visual Representation: Implications for Decision Making', *Journal of Marketing,* vol. 71, no. 1, pp. 160-177.
Mahto, R. V, Belousova, O & Ahluwalia, S 2020, 'Abundance – A new window on how disruptive innovation occurs', *Technological Forecasting & Social Change*, vol. 155, p.119064.
Manzini, E 2015, *Design, When Everybody Designs: An Introduction to Design for Social Innovation*, The MIT Press, Cambridge.
Marsh, J, Arnseth, H. C & Kumpulainen, K 2018, 'Maker Literacies and Maker Citizenship in the Makey (Makerspaces in the Early Years) Project', *Multimodal Technologies and Interaction,* vol. 2, no. 3, p. 50.
Mortati, M & Cruickshank, L 2012, 'Nets: A Design Tool for Activating Social Networks', *International Journal of Entrepreneurial Behaviour & Research*, vol. 18, no. 4, pp. 509-523.

Norman, D. A 2016, 'When You Come to a Fork in the Road, Take It: The Future of Design', *She Ji: The Journal of Design, Economics, and Innovation*, vol. 2, no. 4, pp. 343-348.
Nthubu, B, Richards, D & Cruickshank, L 2019, 'Disruptive Innovation Ecosystems: Reconceptualising Innovation Ecosystems', *In Conference Proceedings of the Academy for Design Innovation Management,* London, vol. 2, no. 1, pp. 629-644.
Nylund, P. A, Ferras-Hernandez, X & Brem, A 2019, 'Strategies for Activating Innovation Ecosystems: Introduction of a Taxonomy', *IEEE Engineering Management Review*, vol. 47, no. 4, pp. 60-66.
Padilla, L, Creem-Regehr, S, Hegarty, M & Stefanucci, J 2018, 'Decision Making with Visualizations: A Cognitive Framework across Disciplines', *Cognitive Research: Principles and Implications,* vol. 3, no. 1**,** pp. 1-25.
Pérez, D, Hands, D, McKeever, E & Whitham, R 2019. "Design within Social Entrepreneurship. A Framework to reveal the use of Design in interdisciplinary spaces." *The Design Journal*, vol. 22(sup1): pp. 229-241.
Porter, M 1998, 'Clusters and the New Economics of Competition', *Harvard Business Review,* vol, 76, no. 6**,** pp. 77-90.
Presenza, A, Abbate, T, Cesaroni, F & Appio, F. P 2019, 'Enacting Social Crowdfunding Business Ecosystems: The Case of the Platform Meridonare', *Technological Forecasting & Social Change,* vol. 143**,** pp. 190-201.
Radniecki, T 2018, 'Intellectual Property in the Makerspace. *Journal of Library Administration*, vol. 58, no. 6, pp. 545-560.
Rosli, A, Beltagui, A & Candi, M 2017, 'Understanding Disruption in Innovation Ecosystems: An Effectuation Perspective', *Annual meeting proceedings (Academy of Management),* vol. 1**,** p. 16803.
Roundy, P. T, Bradshaw, M & Brockman, B. K 2018, 'The Emergence of Entrepreneurial Ecosystems: A Complex Adaptive Systems Approach', *Journal of Business Research,* vol. 86**,** pp. 1-10.
Sanders, E. B. N & Stappers, P. J 2014, 'Probes, toolkits and prototypes: Three approaches to making in codesigning', *CoDesign*, vol. 10, no. 1, pp. 5-14.
Schutte, F & Direng, T 2019, 'Incubation of Entrepreneurs Contributes to Business Growth and Job Creation: A Botswana Case Study', *Academy of Entrepreneurship Journal,* vol. 25, no. 3**,** pp. 1-17.
Sheridan, K. M, Halverson, E. R, Litts, B. K, Brahms, L, Jacobs-Priebe, L & Owens, T 2014, 'Learning in the Making: A Comparative Case Study of Three Makerspaces', *Harvard Educational Review,* vol. 84, no. 4**,** p. 505.
Shi, X, Zheng, Z, Zhang, Q & Liang, H 2020, 'External Knowledge Search and Firms' Incremental Innovation Capability: The Joint Moderating Effect of Technological Proximity and Network Embeddedness', Management decision, vol. 58, no. 9, pp. 2049-2072.
Smith, A and William, L 1977, *The Wealth of Nations*, London, Dent.
Smith, A 2017, *Social Innovation, Democracy and Makerspaces Working paper Series SWPS 2017-10*, Science Policy Research Unit. Available at: SSRN-id2986245 (1).pdf
Smith, A & Light, A 2017, 'Cultivating Sustainable Developments with Makerspaces Cultivando Desenvolvimento Sustentável Com Espaços Maker', *Liinc em revista,* vol. 13, no. 1, pp. 162-174.
Smith, A. G 2017, Social innovation, democracy and makerspaces (SSRN Scholarly Paper No. ID 2986245), viewed 20 March 2020, Retrieved from https://papers.ssrn.com/abstract= 2986245.
Smith, J. W 2016, 'The Uber-All Economy of the Future', *The Independent Review,* vol. 20, no. 3**,** pp. 383-390.
Valkokari, K 2015, 'Business, Innovation, and Knowledge Ecosystems: How They Differ and How to Survive and Thrive within Them', *Technology Innovation Management Review,* vol. 5, no. 8**,** pp. 17-24.
Van Holm, E. J 2017, 'Makerspaces and Local Economic Development', *Economic Development Quarterly*, vol. 31, no. 2, pp. 164-173.
Van Holm, E.J 2015, 'Makerspaces and contributions to entrepreneurship', *Procedia-Social and Behavioral Sciences*, vol. *195*, pp. 24-31.
Vink, J, Edvardsson, B, Wetter-Edman, K & Tronvoll, B 2019, 'Reshaping Mental Models – Enabling Innovation through Service Design', *Journal of Service Management,* vol. 30, no.1**,** pp. 75-104.
von Hippel, E 2005, *Democratizing innovation,* The MIT Press, Cambridge, Massachusetts.
Von Hippel, E. 1986, 'Lead Users: A Source of Novel Product Concepts', *Management Science,* vol. 32, no. 7**,** pp. 791-805.
Von Stamm, B & Trifilova, A 2009, *The Future of Innovation*, Gower Publishing Limited, Surrey.
Vuorikari, R, Ferrari, A & Punie, Y 2019, *Makerspaces For Education and Training-Exploring Future Implications For Europe*, Publications Office of the European Union, Luxembourg.
Weber, M. L & Hine, M. J 2015, 'Who Inhabits a Business Ecosystem? The Technospecies as a Unifying Concept', *Technology Innovation Management Review*, vol. 5, no.5, pp. 31–44.
Wolf, P and Troxler, P 2016, 'Community-based business models: Insights from an emerging maker economy', *IxD&A*, vol. 30, pp.75-94.

Woody, L 2013, 'Microsoft's 13 Worst Missteps of All Time', *InfoWorld*. 14 January. Available at: Microsoft's 13 worst missteps of all time | InfoWorld/ [Accessed 20 November 2020].
Zamenopoulos, T, Lam, B, Alexiou, K, Kelemen, M, De Sousa, S, Moffat, S & Phillips, M. 2019, 'Types, obstacles and sources of empowerment in co-design: The role of shared material objects and processes', *CoDesign*, pp. 1-20.
Zimmerman, J, Stolterman, E & Forlizzi, J 2010, 'An Analysis and Critique of Research through Design: Towards a Formalization of a Research Approach', *DIS '10: Proceedings of the 8th ACM Conference on Designing Interactive Systems,* Aarhus, Denmark , August 16 – 20, pp. 310-319.
Zulu-Chisanga, S, Chabala, M & Mandawa-Bray, B 2020, 'The Differential Effects of Government Support, Inter-Firm Collaboration and Firm Resources on Sme Performance in a Developing Economy', *Journal of Entrepreneurship in Emerging Economies,* vol. 13, no. 2, pp. 175-195.
Zweifela, C & Van Wezemaela, J 2012. Drawing as a qualitative research tool an approach to field work from a social complexity perspective. *Tracey Journal: Drawing Knowledge*, vol. 5, pp. 1-16.