Monograph:

Barriers to women's involvement in hackspaces and makerspaces

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Abstract

This report uses interviews and - in the absence of a substantial body of empirical studies - existing informal research and media in order to elucidate the reasons underlying an observed gender-imbalance in the users of organisations known as 'hackspaces' and 'makerspaces'. We frame this phenomenon in the wider context of a similar imbalance in the number of girls and women pursuing study and careers in STEM and computing subjects, and the benefits of achieving a more egalitarian community, for the individual, the organisation, and society in general. We identify several distinct 'barriers' to engagement, and provide suggestions for possible solutions. In the absence of empirical research, we suggest that organisations wishing to make change to improve the gender-balance of their user base should do so with caution and continuous feedback from their existing and target audiences in order to ensure efficacious change without disruption, and call for more research into this issue to verify or challenge the conclusions which we draw here.

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Women in STEM

The problem

It is well known and well documented that women are under-represented in 'STEM' subjects - science, technology, engineering, and mathematics. Though computing is not specifically included in this group, women are also suffering in this field, with numbers of women in computing industries having actually fallen dramatically from the mid 1980s (Henn, 2014; Mitchell, 2013). This is despite growing efforts to encourage girls and young women to study and engage with male dominated fields and activities, including the WISE Campaign, ScienceGrrl, STEMettes and Young Rewired State, among many others.

This imbalance is often self-perpetuating, with male-dominated environments becoming both increasingly unappealing to women and simultaneously more difficult for women to enter, for reasons including 'homosocial reproduction'; where, put simply, men hire other men because they remind them of themselves. Mumby (2013) writes that, 'In this context, it becomes extremely difficult for women to assimilate into a culture where they do not immediately understand the taken-for-granted meanings at work, and where the "in-group" perceives them as "alien" before they have even had a chance to prove themselves' (p210). Though such biases may be deliberate, it is generally more likely to be due to unconscious mechanisms in the recruitment process, combined with pressure on women to conform to approved societal roles, which generally do not include those in male-dominated fields.

Exacerbating this is that the lack of women in these industries results in a lack of role models for younger generations (*Girls' Attitudes Survey: What girls say about equality*, 2013; Zecharia, Cosgrave, Thomas, & Jones, 2014), and a subsequent difficulty for girls to imagine themselves working in these industries. The prevalence of an 'it's not for girls' message is causing girls to reject these subjects at a young age, such that their ability to enter these industries later in life becomes further restricted.

Why is it a problem?

It is important to understand the wider context in which this issue is situated. The gender imbalance in STEM fields is not solely a problem for women wishing to enter such domains, either socially or professionally, and finding it difficult to do so, though this is indeed a problem. Rather, a more complex but more widely relevant problem is that this results in a huge, untapped resource in the female population that could otherwise be contributing to these important sectors and industries.

This problem is itself twofold; first, this almost halves the potential workforce in these sectors, likely also reducing the average ability and quality of that workforce. Second, this necessarily reduces the diversity of the potential workforce, though it is known that diversifying work environments increases the creativity and innovation of industries, thus creating more and better paths to improved output, be that manufacturing, theoretical research and development, or practice (Ali, Kulik, & Metz, 2011; Herring, 2009). Improving access to these fields for women is thus important not only for those individual women who may wish to enter these fields but also has implications for the economy and wider society.

This is a particularly important issue at a time of high unemployment, a rising number of insecure jobs and zero-hour contracts, particularly for women (*Contracts with No Guaranteed Hours, Zero Hour Contracts*, 2014), and severe austerity measures which have also disproportionately affected women and the poor (Poinasamy, 2013). It is vital that individuals are enabled to exploit any resources available to them for personal development.

Work done

A great deal of work is currently being carried out to address problems in this area. There is great momentum in campaigns to redress the gender balance in academia and industry. For example, the Athena Swan Award scheme is encouraging science and technology departments at universities to actively engage with this issues, in terms of both students and staff (Donald, Harvey, & McLean, n.d.). Increasing numbers of science and technology outreach volunteers are working with schoolchildren, particularly girls, to engage them with these industries. Organisations like Girlguiding UK are working to show girls that these are futures that are open to them, and grassroots campaigns such as ScienceGrrl are devoted to representing and promoting women in STEM fields and encouraging more young women

and girls to study these fields.

Lost groups

Though there are concerted efforts ongoing to increase the numbers of girls and young women studying STEM subjects, there is little focus, if any, on the opportunities and potential in retraining adults who are not currently working in those fields.

Adult education has the potential to play an extremely important role in reducing unemployment by giving unemployed, working age adults a broader skill set, and one that not only applies to in-demand and growing industries, but that also better equips people to self-employ through freelancing or developing independent small business.

The route to employment via retraining is particularly important for groups such as the long-term unemployed, disabled, single parents and return-to-workers. Though such retraining in STEM can be vital to economic development, there is little research on the gender-balance of those retraining within STEM fields, entering STEM as a career change or attempting to enter STEM via adult education. We believe there should be the same efforts to understand the gender balance in these environments as in the typical education and career environments. We believe there should be increased work to engage these groups with the science, computing and technology related resources available to them in order to maximise the number of people able to exploit these resources.

The gender-balance controversy

Are women just 'less interested'?

Though we support an expansion of the support of women in STEM to these environments, we note that this movement in professional and early educational environments has been met with a certain degree of controversy, largely from groups and individuals who see these attempts to redress the gender-balance 'for its own sake'. Among these groups there appears to be a belief that males and females have intrinsically different talents and interests, and regard attempts to improve the gender balance in STEM as a futile effort to force girls and women into fields that they generally do not wish to enter and/or are unable to offer the same quality of work as boys and men. This view is frequently perpetuated in the popular press and opinion publications (Marks, 2015; Kenny, 2014).

This is an extremely controversial issue, and one that receives a great deal of attention in the popular media, particularly with regard to neuroscience and biology, with a fondness in the media for reporting hardwired differences or a 'genetic' basis for men and women being interested in or skilled in different things (Connor, 2013), even when those scientists conducting neuroscientific research state that any observed differences are due to environmental factors (Rippon, 2014).

We do not wish to comment on the reasons for any real or perceived difference, but note two important points:

- We acknowledge that although there may be a perceived tendency for women as a group to simply choose not to engage with certain fields activities out of preference, this does not mean that individual women choosing to pursue those activities should not be supported in their efforts to do so in an educational, social or work environment in which it is difficult for them to do so.
- We note that society is likely to play a large role in shaping peoples preferences; as such, any apparent differences in patterns of mens and womens preferences and skills may be due to historical and ongoing social influences. Therefore it is entirely plausible, even likely, that more women may begin to show more interest in the future as societal influences on gendered behaviour change. It is important to make these fields accessible so that future generations will be more easily engaged.

Target groups

The two sections above lead us to define those that we are interested in focusing on with the current research. These can be broken down into four distinct groups:

- Those women who are already interested but find the environment inaccessible.
- Those women who might be interested but are unaware of routes to education or engagement.
- Those women who have not had the opportunity to discover an interest.
- Those women who would benefit from skill learning as a means to an end (greater employment prospects etc.), rather than necessarily satisfying an interest in itself.

It is also important to note those who we are specifically not targeting:

- Those women who are sufficiently interested and confident that they don't feel they need assistance accessing these resources.
- Those women who genuinely have no interest and would thus be unlikely to benefit from increased accessibility or inclusion.
- Those women who are secure in other fields who would not noticeably benefit from the skill development opportunities afforded by improved accessibility.

Non typical routes to learning and skill development

Formal education is, unfortunately, often inaccessible to those groups who most stand to profit from it. It is usually expensive and demanding in terms of the time required for study and commitment to meeting deadlines. Additionally, it usually involves the earning of a formal qualification, which may be off-putting for many adults, not wishing to re-enter a school- or university-like environment. Even relatively flexible, distance learning programmes, which have long been identified as being important to women's development (Evans, 1995), suffer from many of these problems for key groups, particularly those with financial restrictions. Other, non-typical routes to self-education and skill-development may be more useful in realising the potential of key groups.

Hackspaces and Makerspaces

In recent years the UK has seen a rise in the number of organisations typically known as Hackspaces and Makerspaces (see Stokes et al., 2015, for a useful overview), which have the potential to serve as a non-traditional route to skill learning and personal development which may assist in the improvement of access to STEM fields for adult women, particularly technology and computing. This has particular relevance for those in key groups unable to access formal education.

These tend to be non-profit organisations that operate primarily on a membership basis but often also offer standalone courses or workshops open to non-members. In exchange for a membership fee, members receive access to space, tools, technologies and staff time and expertise to allow members to develop skills in a wide range of areas relevant to manufacturing, digital arts and computing. These spaces can be seen as combining the features of workshops, studios and digital labs in order to provide an integrative and collaborative environment in which members with interest in computing, digital arts, technology, science, machining and similar areas are able to meet, create, and learn from each other as well as access the necessary tools to realise projects which would otherwise be difficult or impossible to complete.

'Maker and Hacker Organisations' (MHOs) tend to emphasise knowledge exchange as a primary resource, providing a facility whereby members can not only exploit the space and tools available, but also have access to other members', staff and volunteers' knowledge and guidance in using new technologies. Many MHOs provide not only access to members, but also run workshops, courses and other, more structured events. Several MHOs also request only a 'pay-what-you-can' membership fee, rendering them more accessible to many people than more traditional routes to learning. Additionally, they are informal spaces, often with a social element or emphasis, in which members may learn specific skills at

their own pace without the pressure of a formal educational environment.

Clearly, MHOs can provide an excellent resource for those with an interest in increasing their skills in these areas. This in turn has implications for employability, entrepreneurship and access to further opportunities. However, like more typical routes to education and skill development in these typically male-dominated areas, MHOs frequently suffer from gender imbalance, such that they tend to attract predominantly male members; ratios currently stand at about 80:20 on average according to NESTA's recent 'digital makers' report (Stokes, Stewart, & Sleigh, 2015). This imbalance can powerfully affect women members of MHOs; indeed, one female blogger and hackerspace user describes having to 'fix' the environment before being able to enter and take part:

> *'The environments where I was trying to "learn about nerdy stuff" were sociotechnically broken in a way that made it hard for me (as a disabled minority woman, among other things) to join in. If I wanted to even start being part of the technical community, I had to start by fixing the technical community ... It's almost as if I could only enter the makerspace as a janitor.'* (Chua, 2015).

Access Space

Access Space is a Sheffield hackspace and digital media lab and registered charity. They provide a 'refab space' in which participants are able to make use of digital manufacturing machines including a 3D-printer and laser cutter, amongst others. There is also the facility to pre-book access to a computer lab, which is available to members and non-members. Membership is set at £25 per month. This provides 2 free hours of access to machines, tools, space and staff advice and guidance. Further hours for members are set at £5 per hour. Non-members are able to access the same as members for a flat rate of £25 per hour.

The organisation has reported historic difficulty appealing to potential women users and members in the community, particularly within their computer lab space, though they have found that their refab space has a generally higher take-up amongst women. Perhaps more significantly, however, they report a particular difficulty encouraging women to integrate in the space's community, and retaining their membership once they have become involved. Rather, women users have tended to exploit the space for particular tasks related to individual projects, and tend not to return once those projects are complete.

This is undesirable on at least two levels. Firstly, because it prevents those women who do become briefly involved for a particular purpose from capitalising on a fuller range of the facilities offered, which may be of future benefit to them. Secondly, because it maintains a less diverse long-term community within the space, where those women's presence could be an extremely positive force, both in terms of diversifying the space and increasing collaboration and creativity, and also because it is likely to have a perpetuating effect on the numbers of women members and users.

Access Space is in the process of relaunching, and in doing so is keen to implement measures to address the gender gap in users of their facilities. In this report we hope to provide Access Space with insights into the barriers to engagement and participation facing potential women members and users, and offer practical advice based on the experiences of other spaces, users and experts in supporting and representing women in STEM fields.

Relaunch and re-conceptualisation

We aim to work in a complementary fashion to the existing approach of Access Space as they relaunch and re-conceptualise. It is thus important to understand their unique focus and find ways of improving the appeal to diverse audiences without fundamentally altering their core programme or character.

Access Space differs in some respects to many other similar spaces, according to Jake Harries, Artistic Director of Access Space, who emphasises its non-member focused approach, with Access Space being open to the public for commitment free one-off sessions and design and manufacturing advice. Their focus is on encouraging people to come in with ideas and discuss ways in which to realise them. They are particularly arts focused, and concentrate on integrating digital technologies into the arts in a creative

way.

Given the ongoing reorganisation of the space, there is currently no strongly integrated user community, though there is a view to opening the main part of the space as a 'collaborative discussion lounge', while Access Space drives the formation of collaborations with other similar and complementary organisations. This should be seen as an ideal opportunity to create a space which is engaging and appealing to a diverse audience including women, without disruption to an existing community to which the introduction of such measures may appear intrusive.

Discussions with Access Space staff revealed that there is no current recruitment strategy, but that there is a keenness to develop one which addresses some of the main issues that may be off-putting to women and other under-represented groups. These issues have been largely self-identified by the staff at the space, with acknowledgement of factors such as the intimidating nature of a heavily male dominated user base, a functional and utilitarian feel which may seem uncomfortable, and the apparent lack of community and accessibility resulting from the loss of a free, open computer lab. Moreover, the staff are aware that their user base is relatively narrow in terms of background, interests and skills, with many of its users being technically oriented. The space hopes that by increasing its appeal to people with a broader range of interests, the gender gap will naturally begin to decrease.

In developing its member base, Access Space hopes to encourage a sense of community and collaboration, and hopes to attract return-to-workers and the long term unemployed who will benefit from the facilities the space has to offer. Particularly, they hope to build a community of individuals who are not only benefitting from the space from a self-development perspective, but are also contributing to the short- and long-term future of the space through regular participation, volunteering, skill-sharing, collaboration and creation of innovative projects.

A note on feminist hackerspaces

Access Space is not alone in struggling to attract a gender-balanced user base, and one approach has been to focus on creating spaces either exclusively for women or with an explicitly feminist agenda. Most specifically, these spaces tend to reassess and redefine what is meant by 'openness' - a concept held dear to the hacker/maker movement. Emphasis is put on not only openness but on an environment in which female safety is paramount, and in which male-domination is not only acknowledged but constantly challenged (Toupin, 2014). Similarly, Henry (2014), writes in response to online commenters claiming that women are not interested in hacking,

> *'If we aren't at hackerspaces, it isn't because we don't make things, don't code, or aren't technical enough. It's because men act like the space is theirs. Women face harassment ranging from assault to much milder, but more constant, come-ons and innuendos. Our geek cred is constantly challenged or belittled. You might be there coding, and you want to stop for a while and draw in your notebook and think, but if you're not staring at a black and green screen or, like, melding your brain with an Arduino every second, some dude is going to come up to you and act like you need his expert lessons in how to hack.'*

Whether or not a particular organisation suffers from these problems (there are certainly no reports that Access Space has presented a negative environment for its female members), if the perception is that such spaces tend to be plagued by these issues, women who might be otherwise keen to participate could well be put off investigating a particular space.

However, though this is clearly an important issue, Access Space is not and has no plans to become a women-only or women-focused organisation, thus we are not focused on measures necessitating the exclusion or demonisation of men. Also, we regard the issue of safety as one so fundamental that it is not exclusive to MHOs, therefore not one that we will focus on here. We do note, however, that this is a key factor that may be off-putting to potential members of any gender, and one that all MHOs should prioritise for the benefit of all members.

Understanding the barriers

We conducted interviews with users of MHOs, as well as several individuals with experience working with and for girls and women in male dominated fields to try to understand the root causes of the gender imbalance at Access Space and other similar organisations. Their opinions and advice were extremely useful and varied. Many of their comments, however, could be seen as relating closely to one of a few core issues, which we now discuss in turn.

Women *are* 'just less interested'... at the moment.

The overriding feeling was that women and men generally do differ in their interest in maker and hackerspaces and the activities that go on there. There was also a general feeling that women members tend to engage in different types of activity from men out of preference, rather than some sense of being unwelcome from participating in other, more male-dominated activities.

This is an important point and should be respected; we do not wish to pressure potential or current women members into engaging with aspects of the space with which they have no interest, simply to reduce the size of the gender gap.

However, it is also important to understand the cause of this divide. People do not develop skills and interests in a societal vacuum; it is likely that women and men develop generally different skills and interests based on their opportunities to experience particular activities, the societal approval and encouragement of their engagement with those activities, and the visibility of gender consistent role models in those activities. Indeed, as one male hackspace user stated, 'I'd say "less interested" implies more than I'd like to. The space reflects society.' Heather Williams, founder and director of Science-Grrl, discussed the possibility that a certain amount of the disinterest felt by women and girls is born of ignorance about the environment and opportunities, rather than a genuine disinterest in the possible activities to be engaged in and skills to be learned. Moreover, Rachael Turner, co-founder and director of MadLab, a makespace based in Manchester, stated,

> 'I think we have this imbalance because, clearly, the playing field is not level. There are tons of stats out there about lack of access to IT opportunities which are only just starting to be addressed now (with Code Clubs, Coder Dojos, IT Curriculum etc) so we're dealing with the remnants of a historical imbalance.'

As discussed earlier, it is likely that numbers of women naturally preferring to engage with historically male-dominated activities will increase, as young women and girls who are successfully engaged with by the considerable efforts to reduce societal gender stereotyping grow older and begin engaging with facilities like MHOs as adults. As a result, this 'barrier' to participation should be acknowledged as transient, but seen as sufficiently important to address in the current environment.

It's not about women vs men it's about techies vs non-techies.

This is closely related to point 1, but is noted separately since it is related more strongly to the appeal and accessibility of spaces to those who do are not already involved in 'hacker' culture or do not already have a set of skills which are clearly useful or usable in the space.

Because involvement in hackerspaces and makespaces usually involves a spare time commitment, it is likely that an element of fun or entertainment is required in order to attract those who are not exploiting the space's facilities for a clear, distinct project. For those whom the primary potential benefit of these spaces is one of general skill learning and personal development, without an existing skill set that has a clear purpose or utility within the context of the space, involvement may be 'too much like hard work'.

If, in order to exploit the space in any way, a new skill set needs to be learned from scratch, this may lack the requisite element of fun required for involvement, even if the longer-term benefits are clear and well defined for a particular individual. Emma Mulqueeny, founder and CEO of Young Rewired State, an organisation for young people interested in technology and digital 'making', noted that involvement

in MHOs for non-techies can feel like 'working in your spare time'.

It is likely that the group of people for whom this initial hurdle feels too large is disproportionately composed of women, due to the historical reasons outlined above regarding social pressure around traditional male and female roles and activities. Following from this, several of our interviewees involved in MHOs including Rachael Turner and Al Bennett (a user of Edinburgh Hacklab) noted that existing women members often tend to engage in different activities to men, often having more of an arts/design focus as opposed to 'pure' tech, where Sarah Simmonds (a user of London Hackspace) suggested that 'culturally safe hacks, such as arts and crafts' might be likely to encourage more women members.

Heather Williams told us that for her is seems that,

> *'It's totally natural for an engineer or computer scientist to hack for fun, as they already have a lot of the skills! Mostly, these are men. It's just too big a jump for non-techies for it to seem like fun.'*

Heather goes on to make the important point that compounding this problematic jump in skills required, there is a powerful consumer culture which dominates our society, encouraging us to buy, not to make. She suggests that we need to encourage an inclination amongst people towards 'hacking' in the broadest sense, in order to popularise the concept of the spaces, making them feel more accessible to more diverse audiences.

A related issue is one brought up in previous research, whereby even if new members or participants are interested in learning new skills in digital arts and technology, if they arrive without the skills and knowledge necessary to complete a certain project or task, they may not be shown or taught, but rather have the task completed for them. As Schultz (2015) writes,

> *'How are people like me, whove never been particularly techie, supposed to join in? And what if the "hackerspaces" - the central institutions of the maker movement, where makers gather to build, collaborate, and learn - tend to be dominated by white guys whose first reaction to someone new is, "Here, Ill do it for you"?'*

This can be done with the very best of intentions, but may cause the new participant to feel unwelcome and inadequate, with the result that they may be very unlikely to return.

It's too intimidating

Popular opinion amongst those we spoke to was that the male domination of the spaces was a self-perpetuating problem, with that very aspect of the space likely to be off-putting to new women members. Ange Taggart, a user of Nottingham Hackspace, goes further, suggesting that a male-dominated environment may be even *more* intimidating with the presence of only one or two very confident female members; rather than acting as role models and assisting women to see themselves as part of the community, this may further exaggerate the perceived level of expertise and confidence required for a woman to be accepted into such a community. Related to this, Heather Williams suggests that girls and women perhaps need to already be a part of a maker 'culture' before feeling comfortable or able to participate in MHOs, gain suggesting a certain 'catch 22' - potential members may feel too uncomfortable to participate without being involved in the culture, but cannot access the culture without participating.

One user suggested a large contributing factor to this problem of discomfort or intimidation is that women and men often communicate in different ways, bonding over things and events (men) or interpersonal and emotional responses (women) with the result that 'Male dominated environments can be remarkably lonely places for women' (Sarah Simmonds). Anne-Marie Imafidon, co-founder of girls-in-tech organisation 'STEMettes', said that it can feel like 'going into the wrong pub.'

Emma Mulqueeny points out that learning a new skill in any environment, even a familiar and comfortable one, can be a challenging process. Since, as noted in point 2 above, involvement in MHOs for women can often involve a greater degree of skill learning from scratch than for men, it is likely that this is compounded by the intimidating nature of a male-dominated environment in the context of MHOs. Indeed, anecdotal evidence suggests that this is frequently the case; Emma notes that even when many girls and women sign up for tech events, there tends to be a high drop-out rate between signing up and actually attending. It is likely that this relates to broader issues regarding women's confidence and self-esteem; notoriously, in the workplace women are far less likely to apply for promotion or payrises (Babcock, Laschever, Gelfand, & Small, 2013); in the context of MHOs, women seem to feel less confident simply 'tinkering' with an existing project or device, as described by Janet Gunter, founder of the Restart Project (Fink, 2014). This pattern seems to hold from a young age, where girls tend to have less confidence in their own abilities than boys do from school (Zecharia et al., 2014). While this is evidently a much wider, societal issue, it is important to be aware of such factors in making MHOs appealing to women in order to find ways of reducing their impact in that context; to make initial participation feel like a smaller step out of one's 'comfort zone'.

It's not a pleasant place to be

Several interviewees also noted that MHOs are often housed in spaces which are physically and/or aesthetically unappealing or off-putting for many women. Why this particular factor appears to affect women more than men is beyond the scope of the project; however, it is important to note since so many of our respondents - both male and female - commented on it. As an example, one anonymous user pointed out that the ladies' toilet light switch was located so high on the wall that it was out of reach for most women! Similarly, an interviewee of a previous examination of women hackerspace members instructed MHOs to 'clean your damned bathrooms' in order to attract more women (Baichtal, 2011). Similarly, in a further study, one interviewee said,

> *'As a woman in technology, it's like, I'm already part of a like a 10, 20 percent group so it doesn't really take a lot to turn me off. So I think like I'm just more sensitive to like things like the space sucking and being dark and gloomy.'* (Fox, Ulgado, & Rosner, 2015)

Emma Mulqueeny described a MHO in California which had a lot of success with attracting women members had a decor which brought the 'outside inside', with outdoor-themed areas and murals depicting the sky. Such consideration of the feel of MHOs can contribute significantly to its general aesthetic and sense of welcoming, and help reduce the discomfort associated with integrating into an unfamiliar place. Emma suggested that most MHOs, by contrast, tend to feel like 'someone's garage', where Anne-Marie Imafidon said that it can feel like 'coding in someone's bedroom'; unlikely to appeal to those not already familiar with the atmosphere and clientele of a given space.

There's often no goal

Simple self-driven membership of MHOs generally requires a general interest in hacking and 'tinkering' for its own sake. The absence of a particular goal or outcome from this process is likely to emphasise the skill-learning aspect of involvement and thus exacerbate the feelings of intimidation. The ill-defined outcome of simply 'learning a skill' may be insufficient to drive women to participation when the perceived barriers (intimidation) or costs (time, money) are so great.

It is likely that by emphasising a clear application of any newly learned skills, or by focusing skill-development towards a particular project or problem, more women may begin to participate in a given space. We found that it was frequently observed that when women do become involved in MHOs, it is often to gain assistance with or access to tools for a particular project; indeed, Access Space themselves have observed this, with most women involved in the space engaging for only a short period of time in order to conclude a project. Similarly, one male hackspace user stated that 'retention is tougher than getting people through the door', and Al Bennett of Edinburgh Hacklab states that women 'tend to be looking for a solution to a problem they're trying to solve'. Emma O'Sullivan, a member of Build Brighton, also observed that women tend to be more involved in projects focused on building something tangible rather than simply tinkering. Delphine Dallison, a member of staff at Glasgow MAKLab, herself

became involved through a defined digital arts project. Delphine, however, disagrees that women are intrinsically more project focused than men, suggesting rather that the lack of women role models in MHOs may dissuade women from participating without a clearly defined outcome.

There's no easy way to get in

A further theme that was common in our conversations was that women would be more likely to become involved if there was a clearer means of introduction and/or induction to a given MHO. This is related to opportunities to access, as pointed out by Rachael Turner (above), and feelings of intimidation; in an unfamiliar place where the social etiquette is unknown, a more well defined route to participation may reduce feelings of discomfort and unfamiliarity by providing a clearer role as an official 'beginner' for new members. Delphine Dallison suggested that without a structured introduction to a space, the self-learning and integration process may be stifled through feelings of uncertainty, and self-confidence within the space less easily developed. Al Bennett pointed out that 'It also helps if newbies (male or female) are willing to just dive in and get involved. It can take a while to get to know people', highlighting the potential difficulties in getting involved if one is not comfortable 'diving in'. Emma Mulqueeny similarly pointed out that for women, involvement often has a social element and women who have had a positive experience within a given MHO will often return with like-minded friends. Those friends thus have a clearer, better-defined route to involvement through an existing member; by developing a clearer means of involvement for those who do not have friends already involved, this 'second wave' of recruitment is more easily reached.

In an extension of this, several interviewees said that the practical barriers to participation can often be greater for women; Heather Williams emphasised that difficulty finding time is particularly true for women with young families. Anne-Marie Imafidon said that cost of classes, events or taster sessions can be an issue, particularly for people who are just trying to find out more about a given MHO, pointing out that it can come across as though a space is 'charging people so you can introduce them to the things *you* love', which may be off-putting, particularly for those in key groups with limited financial resources. One interviewee and MHO member even said that 'I couldn't even afford to join for a while, and after I did there were some months where I went hungry to maintain my membership', underlining the hiuge significance of this particular barrier.

It's not clear what the spaces are or what they offer

It became apparent through our conversations with interviewees that often, spaces operate within relatively closed circles, whereby only those already part of the 'maker/hacker culture' are aware of them and what it is that can provide and facilitate. Diana Probst of Cambridge Makespace states that 'I *think* that people invite engineering types along to makespace more often than they invite artists and writers, and I think that the number of engineers available as members is high. So,people who are not engineers or scientists don't hear about it so much.' This not only makes reaching new audiences difficult, but can give an impression of 'cliquey-ness', further fostering a sense of intimidation among new or potential members. Indeed, Emma O'Sullivan suggested that much of the problem is rooted in the way MHOs represent and market themselves. Again, this makes the gender-balance problem a largely self-sustaining one, with self-selecting, primarily male groups continuing to dominate the market.

Views about why this was the case varied strongly amongst interviewees, however. Some suggested that advertising was largely ineffective where others emphasised its vital importance, particularly within online social media. Where advertising is used, however, the impression was often one that it contained too much jargon; even the term 'hackspace' or 'makerspace' is relatively meaningless to those outside of the culture. Heather Williams noted that often, MHOs and other organisations that engage in 'outreach' activities can make the mistake of advertising to 'people already like us', which is futile to the extent that those groups will already be involved; it is thus important to avoid alienating the target audience by presenting a given space in a way to which they are unable to relate.

It challenges an adult sense of self

It was agreed by many of our interviewees that adults are much harder to reach with new ideas than young people. Emma Mulqueeny stressed the role of social anxiety, which she sees far more in older

children and young women than in young children; she stressed the importance of developing non gender-stereotypical skills and interests before this age in order to truly begin to break down socially enforced gender roles. This, of course, relates strongly to the theme of intimidation that has been central to several of the barriers we have discussed.

Heather Williams suggested that a deeper issue may be significant, that adults have a well developed sense of self and personal 'narrative', and that participation in a culture that is perhaps very far from any existing aspect of their self-concept is extremely challenging; people are perhaps reticent to adapt their self-image around a new activity, particularly one which might contrast with existing notions of oneself. This is likely to be particularly problematic for women in MHOs since the degree of required learning is often greater (see point 2). Emma Mulqueeny notes the importance of feeling comfortable in oneself and how they learn new things before being at ease participating in MHOs - it is likely that this sense of comfort involves seeing oneself intrinsically as a 'learner', or someone interested in skill development.

Working towards solutions

Clearly, the previous section outlines many and varied potential issues as to why women may not be accessing MHOs. In the present section, we use advice from those interviewees with experience in targeting and recruiting women into male-dominated environments, including MHOs, in order to generate suggestions for measures to address each of the potential barriers discussed above.

Women are less interested

This in itself is impossible to address within the restricted context of MHOs as it is intrinsic to the target group and, as discussed above, relates directly to broader, societal issues. Rather, we would suggest three main measures to begin to tackle this as a 'barrier' to the extent it is perceived rather than accurate.

1. Tackle women's *own* perceptions that they're not interested.
   By this, we mean that MHOs can make the effort to present facilities and activities in a way that more women can relate to. Ways in which to begin might include:

   - Showcasing successful people and projects from the space in order to illustrate the potential endpoints and/or benefits of membership
   - Reframing the facilities offered by the space in terms of activities that may be more familiar or typical for potential women users. For instance, as Anne-Marie Imafidon suggested, present the space as providing a forum for 'arts and crafts for the digital age.'
   - Have more women volunteers and members of staff wherever possible to facilitate potential women users to envisage themselves taking part.

2. Tackle existing users' perceptions that women aren't interested.
   By this, we mean that MHOs can take measures to discourage this perception amongst existing members in order to foster a generally more welcoming environment. Ways in which to begin might include:

   - Inviting women guest speakers to talk about their work in other spaces.
   - Inviting women from other organisations to run one-off sessions to showcase or demonstrate a new or interesting skill or technique.

3. Make the space and its activities seem more accessible. Emma Mulqueeny stressed the importance of appearing mainstream and compelling, and also noted that women often step further out of their comfort zone for a good and relatable cause. This might include:

   - Hosting events that appeal to a wider user base to showcase the space, such as fusion digital/conventional arts & crafts fairs and exhibitions.
   - Combining arts- and tech-based activities with entertainment and socialising; for instance, film nights or live music events.

- Host fundraisers or charity events that involve opportunities to engage with the space's facilities - for instance, by donating a certain amount in order to make a small item with a specialist tool such as a laser cutter, or by producing items for a charity to use or sell.

It's about techies vs. non-techies

This is similar to the previous issue in that in itself this is a problem intrinsic to the user, and can only be tackled to the extent that it is a perception rather than a reflection of reality. To this end, we suggest taking measures which provide potential members with an accessible introduction to the activities and technology provided by a given space, in order to support them to discover their own interests therein. To do this, we suggest the following:

- Incorporate a wide range of activities and, crucially, show where and how these can overlap to produce new and exciting projects and products. Use collaborations with other organisations in order to facilitate this. Though some spaces may balk at the notion of introducing activities seen as more 'feminine' or generally accessible for women for that reason alone, as Sarah Simmonds noted, 'accommodating crafts to bring in more women sounds terribly cliche, but I guess if you want to trigger a cultural revolution you need begin somewhere, right?' However, Heather Williams warns against making activities seem overly 'girly', so a fine balance is important here.
- Emma Mulqueeny suggests that at events and courses, activities should be project-based with different tasks and roles, so that guests and attendees are able to try a range of things to maximise the chance of discovering a task or activity they are interested in pursuing further. Moreover, this can foster a sense of camaraderie, community and belonging, which should improve retention rates.
- Reframe activities within a context of application - demonstrate why a particular skill may be useful and what it might allow and lead to, through talks, demonstrations or exhibitions.
- Have staff on hand to support self-learning and skill-development based around the user's own creative ideas.
- Anne-Marie Imafidon stressed the importance of avoiding jargon, particularly when recruiting and with new members. Use simple, everyday language to explain tools, techniques and processes.
- Emphasise the creative element of activities in the space and make it clear what a total beginner would be able to achieve in the space - emphasise collaboration and skill development to realise ideas, not about coding or engineering for its own sake.

It's too intimidating

This is one of the barriers that is most easily under the control of the spaces themselves. There are many measures that can be introduced to make the space seem more friendly and welcoming. Our interviewees focused heavily on this particular barrier and suggested a variety of ways in which to do this.

- Have regular open days or evenings aimed around new people with planned activities or taster sessions for prospective members to experience the space in a structured context. These can be used as an opportunity to showcase the space, demonstrating some of the work that is carried out and promoting workshops and courses.
- At such events, make sure there is a 'meet-and-greeter' whenever the space is open to new members or the public. Open evenings and similar can become negative if not actively led; potential new members should be greeted, and conversation encouraged. Interaction should be driven by the existing team and members, rather than left to the guest. A greeter could be responsible for showing prospective members around the space, explain what the space is, what they can do while they're there, the ways they can get involved and what sort of support they can expect.
- To help counter the dual sources of intimidation of both learning a new skill and entering a new and unfamiliar environment, consider working with other organisations to run guest courses elsewhere in more familiar environments. By giving potential members a skill set that can be used in the space in advance, there may be a clearer role for them within the space.
- Discourage 'cliquey-ness' among existing members. This could be achieved by:
  - Assigning established members as mentors for new members.

– Have regular, structured 'skill sharing' sessions to encourage integration.
– Have dedicated socialising spaces to help encourage a sense of community.
– Focus on the improved integration of existing female members to help bring about more long-lasting and genuine change.

- Ensure new people understand the dynamic of the space, what they can do there and who to come to for guidance.

- Aim for a mixed-gendered team of staff or volunteers present whenever new members are being recruited to foster a sense of inclusion and inspiration; Delphine Dallison stresses the importance of women role models.

- Target courses and activities appropriately; as Heather Williams discussed with us, if courses are for total beginners it is critical that they are pitched correctly and do not assume a higher level of knowledge than the audience is likely to have.

- Emma Mulqueeny emphasises that if people sign up to take part in events and courses, ensure they are kept in touch with until the event; send emails and updates regarding what activities will take place, what opportunities there will be, have online groups or forums for attendees, and if possible ask for suggestions and feedback to encourage a sense of welcoming and participation from the beginning.

It's not a pleasant place to be

Again, this is entirely within a given MHO's control, and a measure that all members of any gender or background are likely to appreciate. Though workspaces themselves are often by their nature dusty, oily or noisy, depending on the equipment used and the purpose of the precise space, this should be kept within designated workspaces and not spill into social or reception areas, desk spaces or kitchens and bathrooms. Particular measures that should be taken include:

- Make sure the space is clean, particularly bathrooms and kitchens.

- Try to make the space comfortable and relaxing - if possible, include lounge areas and dedicated social spaces - make it somewhere people want to spend their spare time.

- Consider including a small 'library' of books and other resources for leisure and reference on issues relevant to the space.

- As far as possible make it warm, bright and airy, keep decoration inoffensive and gender neutral.

- Keep it tidy - reduce clutter, make sure each part of the space has a clear purpose and that all equipment has a home.

There's often no goal

Though the goal for an individual member or potential member will be unique, a given MHO can take measures to make it more obvious what the benefits of involvement in a space can be. Again, this can be part of a structured introduction to a space to allow potential members to find a concrete purpose for involvement. Particular measures to emphasise outcomes and applications include:

- Run courses for learning particular skills, or how to use particular tools or techniques and show attendees how those skills, tools and techniques can be used creatively.

- Run sessions for learning how to create a particular product or object.

- Showcase existing or past members and what they have achieved through membership, and illustrate the kinds of creative and arts projects that MHO facilities can assist with. This might be achieved through open evenings and exhibitions as already suggested, or remotely through advertising and social media.

- Again, work with charities and non-profit organisations to ground certain events or causes in philanthropy in order to contextualise skill learning.

There's no easy way to get in

This point relates to appearing accessible to people prior to being introduced to the space as a prospective member. It is important to project externally an image of openness and inclusivity and engage with the public in order to attract members. Key here is to make people feel confident of being welcomed and included should they choose to become members or casual users in the future, and to give people an opportunity to meet staff and existing members and ask about the space. Measures that may help achieve this include:

- Hosting one-off events without the feeling of obligation of a long term commitment. Use a varied programme of events to reach a wide audience of different skills and backgrounds, and make events as interactive as possible.

- Hosting events at different venues that may have higher footfall, and that wider audiences may be more familiar with and thus aware of their event schedule; for example, museums, galleries and community halls.

- Co-hosting events with other local organisations, particularly those with high takeup amongst women and other under-represented groups. This may be a particularly powerful way of reaching new audiences, and, as Anne-Marie Imafidon points out, can help to 'neutralise' a space and begin to shed any image of exclusivity or cliquey-ness. This can also provide an opportunity to demonstrate overlap and fusion of activities in which prospective members may have an existing interest.

- Emma O'Sullivan stresses the importance of having a presence at local 'Maker Faires' which attract an extremely diverse set of 'makers' including those from more arts and crafts backgrounds. This should help improve both the size and diversity of the potential audience and allow the opportunity to showcase the activities facilitated by the space.

- Run activities for pairs and groups - this may not only encourage people to attend with friends, but may also provide a forum for meeting and common ground for conversation for those who come alone.

- Delphine Dallison suggests running events for children, and if possible include concurrent activities or courses for adults, providing an easier route for parents to get involved whilst similarly reaching out to younger generations

- Promote a clear, structured introduction for new members. This may include, for example, free taster sessions of all available equipment in order to allow new members to discover new skills and interests.

- As far as possible, make courses, particularly introductory courses, free.

- Run events at different times of the day and week in order to be accessible to as wide an audience as possible.

It's not clear what spaces offer

Many spaces rely primarily on word of mouth, which can restrict knowledge of a given space and what it offers within a self-selecting and relatively small community. Spaces with greater visibility such as a 'shop front', in contrast, seem to do better at attracting more new members than those that are more closed off. This obviously isn't possible for most or even all MHOs, but online and local media can be used to a good effect to promote a space and its ethos and facilities.

- Make sure you have a user friendly website. This is one that is not only simple and easy to navigate but one that introduces the space in clear terms without using jargon. Again, use this as an opportunity to showcase existing members and work that goes on in the space.

- Have an active presence on online media, but target your audience effectively. E.g., facebook, twitter and instagram all have generally different core user bases. Understand what groups you are likely to reach with different media and how to target your key groups effectively; as Anne-Marie Imafidon points out, use twitter to attract professionals, use instagram to attract youth groups, etc.

- Many people might not use online media - use flyers and local publications to advertise.

- Make contacts with other organisations to help promote your space, or reciprocal advertising agreements. Examples may include parent and child groups, art galleries, museums, colleges and universities, job centres, WI groups, craft circles, and so on.

- If possible, have a dedicated 'outreach' person or team to oversee these efforts and critically, to gain feedback from members, prospective members and the public about the ways in which they have been successfully reached.

It challenges a sense of self

This barrier is again extremely difficult for MHOs as it is intrinsic to individuals in the target audience. However, again we would suggest taking measures which help people view themselves in the context of the space in the ways that have previously been discussed, including reframing activities in order to help prospective users to draw parallels between the facilities on offer and their existing interests, and envisage themselves in the space in a way that is consistent with their self concept. Again, we stress the potential power of collaborations with contrasting organisations to support this process, and showcasing those existing members who are able to demonstrate concrete benefits from involvement and engagement with the space.

Resistance to change: one final barrier?

Though the above suggestions, if implemented faithfully, may help MHOs - Access Space in particular - work towards driving positive change in the gender-balance of their user base, it is important to note one particular theme that arose during our conversations with MHO staff, volunteers and users. It became clear that, within the organisations, there is often a hesitance to explicitly drive change to make the spaces more appealing to women. Ange Taggart insightfully suggested that in order to begin making change, one must first accept that there is a problem; this may be difficult for existing staff and users of MHOs to do, as it may challenge a strongly held existing perception that the space is perhaps more open and welcoming than it may in fact be. Indeed, previous examinations of the rates of women's involvement in MHOs have revealed similar findings (Baichtal, 2011).

Users in particular seem to believe strongly that women are genuinely less interested in the facilities and activities afforded by MHO participation. Following from this, many interviewees stressed that they disagreed with the notion of attracting more women 'for its own sake', believing that targeted recruitment might lead to a dilution of the ethos of the space and an 'artificially' balanced user base. In particular, there was a worry that a space which felt safe and comfortable for the existing user base might become less safe and comfortable through the artificial introduction of a more mainstream community. That said, all were positive towards having more women members in principle, as long as it was for reasons of genuine interest and commonality with existing users.

While there may be some truth to the perception that 'women are less interested' as has been discussed, we suggest that this belief in itself causes some difficulties. Within the status quo, a space that is male dominated will only be successful in recruiting those women who are extremely confident in themselves and their interest and skills in those male-dominated arenas. The presence of any women, no matter how few, may lead to the false impression that a space is accessible to women in general. It is more likely, however, that there is a larger community of potentially-interested-but-nervous women who might otherwise be keen to participate in MHOs whom we do not see, as they are put off by the reasons discussed above. The perception that women aren't interested, if it leads to a lack of explicit effort in improving accessibility to women, may thus exacerbate the problem.

As a particular example, one interviewee, a user of MHOs, said of explicitly targeting women,

> 'I personally think this is missing the point completely. The lab exists to serve the members' needs, it is essentially a members club and anything we do that's "outreach" is a side effect, not a core part of the organisation. Interests like knitting are well covered by other organisations [...], so there's absolutely no point in trying to cover the same ground. [...] we need to concentrate on what our members and other interested parties want. If you want to stick an Arduino in something, we can help with that. If you want to light up LEDs and spin motors, we can help there.'

This is a valuable and not uncommon viewpoint, and one that should be taken into account when considering if, when, and how change should be pursued. It would be missing the point indeed to make a space accessible to a new group if the measures taken to do so excluded members of its existing user base.

However, we make the point that it is likely that there are women who do want to 'stick an Arduino in something', or 'light up LEDs and spin motors', but they don't know it yet - because they don't know what an Arduino is, what it does, how it works, or perhaps even possess the right language to describe what they need to people who could help. These people could benefit enormously from MHOs, but need assistance with reaching the point where they can appreciate what MHOs can offer them. We argue that such people are worth 'reaching', both for their own benefit and for the diversification of MHO user bases.

Resistance to driving change within MHOs is not ubiquitous, however. Indeed, many users are passionate about it. As Janet Gunter states, "We need to do whatever it takes to bring women in." MadLab's Rachael Turner stresses that they believe strongly in addressing the gender-balance and have taken many measures to do so, to the extent that it is now staffed predominantly by women (not through policy), and has a 50-50 ratio of male to female members for many of its activities, though women remain more under-represented in some of its more 'pure tech' activities. Importantly, Rachael says that 'we're seeing more and more women getting involved as opportunities to access maker activities/spaces are opening up. And some of the most active makers I know are women', highlighting the possibility that underlying the imbalance are reasons more complex than just 'women aren't interested'. Although correlation is not causation, MadLab has grown rapidly since its inception in 2009 and is one of the country's biggest and most successful MHOs, suggesting that actively making spaces more appealing can have successful results beyond artificially equalising the gender-balance.

Similarly, Delphine Dallison of Glasgow MAKLab observes a relatively high proportion of women members, and credits this to their diverse range of activities and the fact that MAKLab has always had a significant number of female staff members whom she sees as role models for members. Delphine emphasised the importance of diversifying the membership base of the space and hopes to begin running apprenticeships and a mentoring scheme, in order to appeal to a wider range of people, both male and female. Interestingly, both MadLab and MAKLab consider themselves to be 'non-typical' MHOs, but both enjoy a higher female to male ratio than the usual rate of about 20:80. Both Rachael and Delphine, as well as STEMettes' Anne-Marie Imfidon, and Sarah Simmonds, a user of London Hackspace, all explicitly pointed out that a more diverse and cross-disciplinary user group leads to more interesting ideas and more creative collaborations. Indeed, this has been shown to be the case in the workplace (Ali et al., 2011; Herring, 2009), and even those users averse to explicitly attempting to recruit more women mentioned the benefits of more diversity in general. Janet Gunter further emphasises that 'Everybody brings something to the table; we need to create spaces where there is a dialogic learning... and both are benefitting from that relationship.' Importantly, Emma O'Sullivan also points out that the lack of gender-diversity can also be problematic for men, particularly those interested in learning more stereotypically 'female' crafts and technologies. These reasons alone, we argue, are sufficient to actively pursue a more diverse user base. Though this project has been focused on the gender-balance, diversification should be a broader aim beyond the domain of gender.

Wisely, however, existing members warn of tokenism, and the inclusion of women for 'box ticking' purposes (Baichtal, 2011). Indeed, Diana Probst says that 'I have seen studies that show that if you tell women that there are few women in a space, you get fewer of them wanting to join.' Any attempts to address gender imbalance should maintain a vision of the real goal; to allow women to partake in the space as valued participants with something to give as well as something to gain. Tokenism is likely to be more destructive than taking no action at all, increasing stereotyping amongst the dominant group, and making any women who are recruited quickly feel unwelcome and isolated, which is likely to further discourage more women from getting involved (Settles, 2014).

In order to avoid such superficial efforts to address the gender-balance, we suggest that an important starting point is to establish a consensus that change is indeed necessary, and an understanding of the reasons why. This is, however, likely to be the most challenging step; as Ange Taggart points out, the support of those leading MHOs is critical to change, and reflective of the overall male:female ratio, these leaders are often men. The demographics of our willing interviewees would suggest that currently, far more women are recognising this issue and are interested in discussing and tackling it than men. In order to win this support, it is vital to begin a more conspicuous conversation about these issues and

engage with those who do not believe gender imbalance to be a problem. We hope that this report will help begin this process on a wider scale.

Summary

We have drawn together existing work and the viewpoints of several named and anonymous interviewees regarding the involvement of women in hackspaces and makerspaces and derived a set of 8 defined 'barriers' that appear to be preventing more women from engaging with such organisations. For each, we have provided a set of suggestions for ways to tackle those barriers and we believe that the majority of these suggestions are achievable in the short-medium term. However, in order for these to have the desired effect it is important that existing staff and users are convinced of the benefits of change. This may be the largest hurdle to overcome, and is likely to be an important starting place for those MHOs that are considering a concerted effort to work towards a more gender-balanced organisation. To do this, it is important to recognise the benefits beyond a more politically correct user base statistic. The benefits to productivity and creativity of a more diverse community are clear, and it is this which should be emphasised when considering change.

However, we note the importance placed by our interviewees on maintaining the ethos, purposes and focus of MHOs. As such, we stress that any measures taken to improve the gender balance should not compromise those core and fundamental values and atmosphere that are so important to the existing user base.

Access Space & future work

Access Space has already reached a point where it feels ready for a certain degree of change in order to address its gender-balance. We feel that it is in a position to begin leading the way for other spaces which may also struggle to recruit women, and demonstrate through positive action how modifications can be made without sacrificing the ethos or atmosphere of the space that its current users value.

With the above general suggestions for longer-term change in mind, in order to launch a new approach to diversifying Access Space, we suggest an initial event to 'trial' a set of these approaches. This should provide the opportunity to begin to target wider audiences, and gain important feedback on the efficacy of the approaches and gain further suggestions for future development from target users.

Though we have compiled a substantial set of views, it is important to point out that although we contacted staff and users from many different relevant organisations, those that agreed to talk to us were predominantly women, and there were several organisations from which no-one chose to be interviewed. As such, it should be noted that the findings outlined in this report are reflective of the views of a small, largely self-selected group, and as such should be interpreted with some caution.

However, it was noted during the completion of this project that there is little, if any, empirical research on issues of gender diversity in organisations like MHOs; thus, the findings presented here constitute an important starting point for a more in-depth programme of research into these issues. We believe it is important for such large-scale and systematic research to be carried out to scientifically verify or challenge the views and issues that have been raised in the current research. We also note that, although we have focused exclusively on gender-balance in the present report, many of the benefits we describe of improving this aspect of a space rely on a broader 'diversity'. Indeed, some of our interviewees pointed out that they would like to see more generalised diversity along lines of race, ethnicity, socio-economic background, occupation, and more. We agree that diversification in all these areas is equally important and urge for similar research on the involvement of other minority groups in MHOs.

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- Sarah Simmonds: User of London Hackspace
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