**3d modelling for the 99%:**

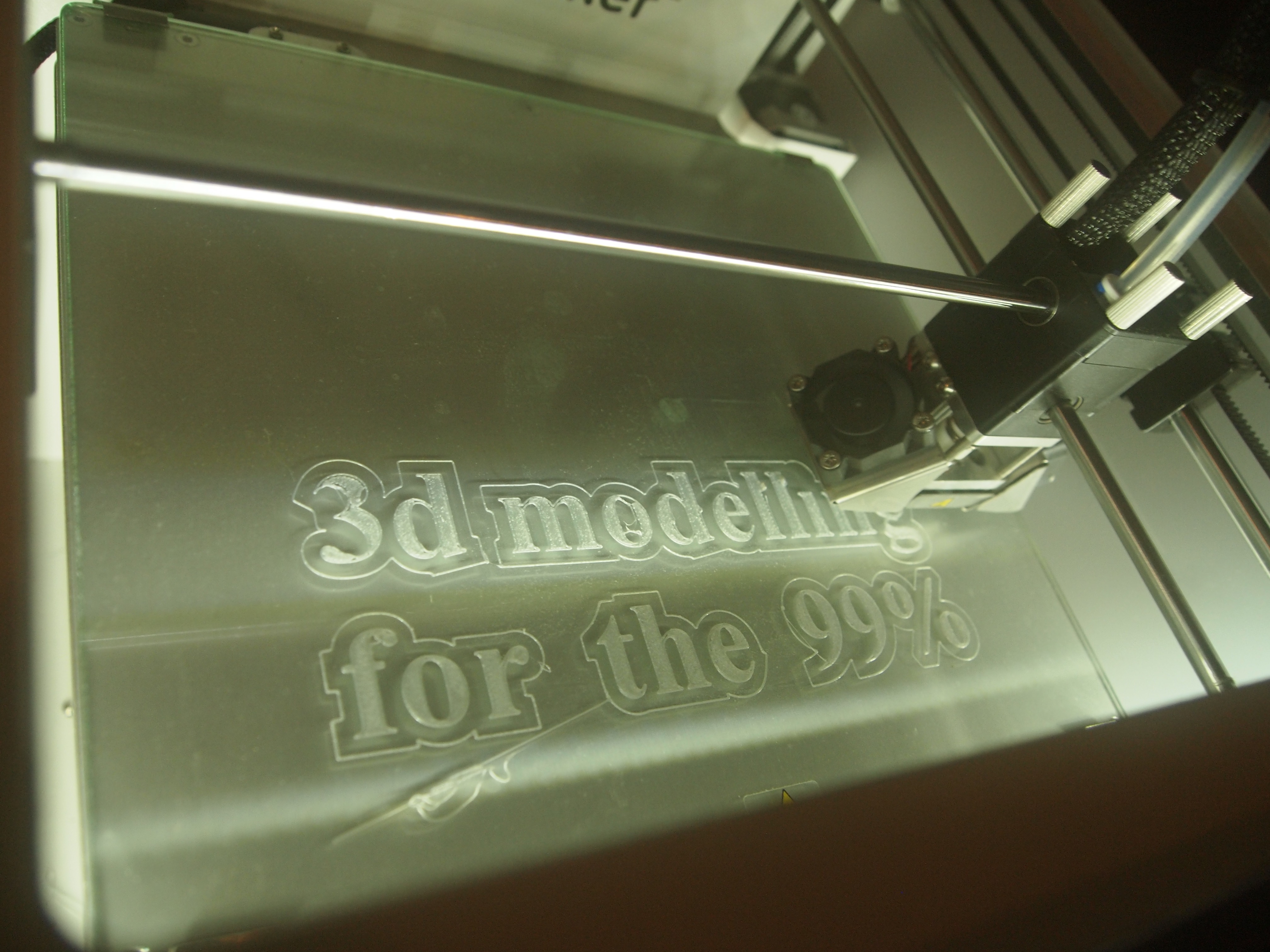
**Enabling the public to benefit from 3d printing and modelling**

**by**

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Thesis submitted in partial fulfilment of the requirements for the degree of

Master of Arts (Design Management)

in the

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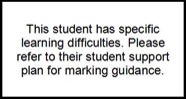
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# Preface

This paper, my Design Management Masters Degree thesis, develops an approach to introducing novices to computer-aided design (CAD). I delivered this course to people with disabilities as a part of the ‘In the Making’ project.

I first met Dr Hurley at an event at Salford University where researchers presented their projects to students who were choosing master’s degree dissertation subjects. Dr Hurley was involved with a project hoping to introduce disabled people to 3d printing. I was keen to get involved as the project had worthy and practical aims and I felt I would be far more motivated doing something useful than writing a dry academic piece. I shaped my dissertation proposal to dovetail with the project taking input from the team and Fiona Velez-Colby, my academic tutor. I delivered CAD training to five groups and was delighted to receive positive feedback from both the team and the attendees. I designed this project to develop my teaching skills in an academically rigorous way, in order to present myself as a strong candidate for academic teaching and research roles; we shall see how this transpires.

Combining the project with running *Daedalus Design* (my retail design consultancy), renovating my house and fatherhood has been very challenging. I work with design agencies and shop-fitters on brands including *Harrods*, *Nike*, *Adidas*, *Christian Laboutin, Annoushka, John Lewis* and *Geox*, developing retail interiors and furniture. There have been numerous times when I have had to turn down contracts and miss family events in order to work on my dissertation and conversely times when I have had to put my academic work on hold to pay the bills. Despite all this I have found the process very rewarding and it has done nothing to dampen my enthusiasm to combine professional practice with academic teaching and research.

I would like to acknowledge the support I have received from Ursula, Nick, Philip, Fiona Anne whose contributions have all been invaluable. Finally, thank you to my family for their boundless support and patience; Matilda and Verity should be able to spend more time with their daddy now.

# Introduction

This thesis is a development of an earlier piece of research by the author entitled ‘Barriers to participation in 3d print making’ (MacLeod-Iredale, 2015). The earlier paper identified 3d computer modelling as the most significant barrier to participation in 3d printing for non-designers (other than the socio-economic causes of disenfranchisement and disadvantage). This research will develop and test an approach to introducing the layperson to generating 3d digital content.

Until very recently, 3d content has been the exclusive remit of professional designers and dedicated amateur enthusiasts. The public are beginning to have access to the much-vaunted technology (Kirkby 2015), with the nascent democratisation of 3d printing via organisations including the *FabLab* movement, libraries and schools (Compton and Walker 2014, Chung 2014, Griffey 2014, Moorefield-Lang 2014). Others can debate exactly how 3d printing may affect the public (Chan and Smith 2013, Flanders 2011), it is clear however, that it has the potential to provide a plethora of opportunities, especially for those with needs poorly served by mass manufacturing (Manyika et al 2013; NASA 2014; McCue 2015).

If the public are to benefit from these opportunities, then they must be able generate 3d content confidently; this project introduces complete novices to 3d modelling. In a short period of time the project aims to equip these neophyte designers with the basic skills and the confidence to enable them to develop their own ideas independently.

The aim of this project was to engagingly introduce lay-people (the ‘99%’ who are not professional designers) to 3d modelling for printing. The primary objective to achieving this aim was to develop a short, introductory workshop-based course. This was delivered to small groups to train and inspire the attendees to develop these skills so they can harness 3d printing technology for practical or expressive purposes.

## Aims and objectives

As ‘In the Making’ provided the context for this project’s primary research it is important to first understand the aims and objectives of the project with which this piece has a symbiotic relationship. As ‘In the Making’ is run by two academics and a political lobbyist one must understand their individual aims in order to understand the agendas informing the project.

* Dr Nick Taylor, University of Dundee: Dr Taylor’s research locus is in ‘how aspects of maker culture can be applied to different communities.’ (Taylor 2015).
* Philip Connolly, Disability Rights UK: Philip sees the project as a means for disabled people to develop skills and access to a new technology (*see quote on page 6*). His hope is that these skills will address some of the physical challenges this group experiences. He is also hopeful that the project may inspire some attendees to develop further and enhance their employability.
* Dr Ursula Hurley, University of Salford: Dr Hurley is using the project to study the creative processes of members of the public and the form that this creative expression takes.

These aims complement one another in the execution of ‘In the Making’, although it is too soon to assess their success as Dr Hurley and Dr Taylor have yet to publish papers relating to the project.

This matrix of aims informs ‘3d modelling for the 99%’. The fact that this piece must serve many masters could initially be seen as a burden as it could easily result in lack of clarity of vision. In practice, the opposite is true. These restrictions necessitate a focused and pragmatic approach. Consequently, the aim of the project are dictated as:

To engagingly introducing lay-people (the ‘99%’ who are not professional designers) to 3d modelling for printing.

This aim, the methodology detailed below and the details of the content to be delivered, were discussed with the key stakeholders and their input heavily influenced the approach taken. As a good deal of this discussion was informal and verbal, it was impractical to capture these discussions in a formal manner; consequently some developments in the process have been paraphrased.

The above aim translates into a primary objective of developing a short introductory workshop-based course. This is broken down into more detailed secondary objectives:

* **Format**: What type of delivery would be most effective for a very diverse group of novices? How best to maintain engagement and ensure optimal retention.
  + What is the best way to impart effective 3d modelling skills in a quick and engaging way?
* **Content:** What skills and knowledge must be imparted to satisfy the project’s aim?
  + What level of computer literacy can realistically be expected from interested amateurs?
  + What 3d data is required to interact with 3d printers on a basic level?
  + What are the key skills required to create 3d models suitable for printing?

The indented points above are the research questions explicitly examined below. These questions must be provisionally addressed prior to the delivery of the first course. The other objectives were initially tackled by the ‘In the Making’ team and the steering group. These ‘provisional’ answers will inform the approach taken for the initial session, which will then evolve in response to reflections and feedback gleaned from this and subsequent workshops.

Beyond these objectives there are other factors affecting the success of the course that must be addressed. These will vary between implementations of the course being developed, with a very different course being delivered for example, to prisoners as opposed to a Women’s Institute meeting. There are, however, common themes uniting even such diverse implementations. These factors are:

* **Target group:** Who are the people that the course will serve? What common factors can be identified to enable the content and format to resonate with the target group?
* **Venue:** What factors define a venue’s suitability?
* **Equipment:** What equipment and software are required to deliver the above content?
* **Facilitator:** Some consideration is given to the traits of a successful facilitator (although in this project the facilitator is the author).

The primary research has been presented as a series of reflective pieces; each deals with a single delivery of the course. Each reflection is followed by a discussion of session outcomes, elucidating what went well, where there was scope for improvement and how subsequent sessions were improved as a result. This approach highlights the iterative nature of the process, demonstrating how solutions to problems in early sessions are tested.

## Background

The primary research for this piece took place within the ‘In the Making’ project, an Arts and Heritage Research Council (AHRC) ‘Connected Communities’ project jointly run by Disability Rights UK and the Universities of Salford and Dundee (Hurley, Taylor and Connolly 2015). These organisations were represented respectively by Philip Connolly, Dr Ursula Hurley and Dr Nick Taylor. The input and advice from these three and many others has been invaluable to this project.

The ‘In the Making’ project aims to offer access to 3d printing to people with, and those affected by, disability in a variety of locations within their community (Hurley, Taylor and Connolly 2015). This piece of research takes place within the initial pilot project, delivering six workshops across Salford.

What if, as the computing revolution was taking off in the 1980s, there had been a concerted effort to get disabled people involved? By the 1990s and 2000s the disabled community would likely have seen significant benefits from this effort. So if we are on the cusp of a revolution in digital fabrication, can we do the same thing now?

Hurley, Taylor and Connolly (2015)

This project takes place as a part of the *Fab-Lab* ‘movement’ (MIT 2015), this is a service giving members of the public free access (other than material costs) to cutting-edge design and manufacturing tools so that they can develop and make their own projects.

As cited above, ‘In the Making’ strove to involve the disabled community in the early stages of an emerging technology with the potential to offer them a uniquely significant portfolio of benefits (Koslow 2015], McCue 2104).

Whilst not central to this piece of research that project attendees are people with disabilities and their carers, this consideration offers a number of benefits. On a superficial level they are simply a representative cohort of individuals with a wide spectrum of IT and design skill-levels. However, the demographic makeup of the groups is extremely valuable, ensuring inclusivity for the public as a whole. The approach taken has been tested with people with a vast spectrum of different challenges, including those with learning difficulties, limited communication ability and severely restricted mobility and dexterity, as well as those with disabilities that do not affect their operation of computers or interaction with the facilitator.

This resulted in a robust and pragmatic approach that suits a far broader swathe of the population than one developed for non-disabled people with a nod to inclusivity. This inclusivity ensures that the course can be delivered to almost any group with basic IT skills (with the possible exception of those with limited or no sight).

### The workshops

‘In the Making’ is run by a steering group consisting of:

* Dr Ursula Hurley: Senior Lecturer in English & Creative Writing, University of Salford.
* Dr Nick Taylor: Dundee Fellow and Lecturer specialising in Human–Computer Interaction and Interaction Design, University of Dundee.
* Philip Connolly: Policy and Communications Manager, Disability Rights UK.
* Fiona Velez-Colby: Programme Leader MA Fashion Innovation, University of Salford
* Joe MacLeod-Iredale (the author), Retail Furniture Design Consultant and MA Design Management student.
* A number of people with disabilities and carers for those with disabilities.

The steering group decided that the sessions should be two consecutive days. The first day was a creative workshop focusing on inspiration and primarily using clay as the medium, facilitated by *Arthur + Martha*, an arts and poetry outreach project working with a variety of disenfranchised groups (Arthur + Martha 2015). The second day was an interactive workshop introducing the entry-level computer-aided design (CAD) package *Sketchup* to the attendees, facilitated by the author. The sessions ran from 10am to 3:30pm including a lunch break. The aim of the second session was that the attendees model and 3d print an object. The hope was that the participants should then either develop their 3d modelling skills on their own, attend a future ‘In the making’ session or visit one of the three *Fab Lab* locations in and around Manchester. The group organised six events, to be held at a variety of accessible venues throughout Salford.

### Why Sketchup?

*Fab Lab*, *Ultimaker* and the author recommended *Sketchup* (previously *Google Sketchup*, but sold to *Trimbl*e in 2012 [Sketchup.com 2015]) following discussions at the launch event for six key reasons:

1. Both *Fab Lab* and the author have successfully trained absolute 3d modelling novices with this software. Some trainees only had basic levels of computer literacy. The software’s relative simplicity will ensure that those who may not feel comfortable with frequently intimidating software packages are not excluded.
2. Whilst relatively simple to use, *Sketchup* is a professional design package used for architecture, interiors, games, engineering and woodworking industries amongst others. It is possible to create complex, dimensionally accurate objects suitable for manufacture (*Sketchup* 2015).
3. SketchUp is the second most prevalent piece of CAD software (after *AutoCAD*, which is entirely unsuitable) used in the UK, with 20.81% of designer using it in their current job (CADAgency 2016).
4. It interfaces well with the *Cura* software used to prepare (‘slice’) models for the *Ultimaker* 3d printers chosen for the project (*Ultimaker* 2015).
5. *Sketchup Make* (the entry level variant) is free to download and use for non-commercial projects, meaning that course attendees can download and install it on their own computers. This is important; the steering group are keen that attendees can go on to develop their 3d modelling skills independently. They also have a policy of issuing free *Sketchup Pro* licences to educators, allowing the project to import and export a far wider range of file types and to access professional features that may allow our participants to make versatile use of their models.
6. Both the author and *Fab Lab* have considerable experience with *Sketchup*, ensuring that participants can continue to receive support following ‘In the Making’ and that relatively complex problems can be solved quickly and easily without unduly holding up the participants. *Sketchup* also has a large community of users, ensuring that they are far less likely to get stuck and demoralised when modelling on their own.

The use of *Sketchup* as the key modelling tool should be reviewed for suitability in the planning stages of phase 2 of the ‘In the Making’ project.

### Questions

Some of the questions identified in the aim and objectives (*above*) require an answer prior to the delivery of the first course. The initial answers to these questions allowed a ‘prototype’ course format and content to be developed. This prototype was subsequently tested and improved in response to experience and feedback from the five delivery sessions:

* What level of computer literacy can realistically be expected from interested amateurs?
* What 3d data is required to interact with 3d printers on a basic level?
* What are the key skills required to create 3d models suitable for printing?
* What is the best way to impart effective 3d modelling skills in a quick and engaging way?

The rationale behind each one of these questions are discussed below:

#### What level of computer literacy can realistically be expected from interested amateurs?

It is critical to understand the level of basic computer literacy that it is realistic to expect. If the content delivered assumes too high a level of computer literacy, then it may leave trainees lost and over whelmed; if it is pitched too low, then the participants may feel patronised and become disengaged and frustrated.

In order to effectively deliver content it is also necessary to gain an understanding of the target groups’ demographic makeup. This will inform choices of content, tone and approach. However, as ‘In the Making’ is for the 16.6% of the UK population (ODI 2014) who ‘identify as disabled’. As disability is the sole commonality within this group the only other factors beyond this that can be deduced are a propensity for poverty, low educational achievement and poor cultural and social engagement (DWP 2014, ODI 2014). Consequently, in this context, the content must be as broadly accessible as possible.

#### What 3d data is required to interact with 3d printers on a basic level?

This project aimed to develop attendees’ skills to a stage where they can see meaningful results by the end of their first session, ideally having constructed a 3d model that the team were able to print for them to take home. It is hoped that this early success has enthused some attendees to develop their own skills and projects further on their own, at future session or at one of the established *Fab Labs*.

In order to answer this question, a thorough understanding of the data requirements of the *Ultimaker* 3d printers must be achieved and an assessment made of the most effective way in which novices might be able to satisfy these requirements.

#### What are the key skills required to create 3d models suitable for printing?

The project allotted a single session from 10am to 3:30pm in order to deliver 3d modelling training. As a result the choice of techniques, tools and approaches were extremely stringent. This necessitated a tight focus on the key tools and techniques required to generate some very simple 3d geometry suitable for printing. It was essential to identify all these key techniques and from this, to build the course content around them. Initially it was hoped that attendees would be able to grasp the basics to a level sufficient to express themselves or develop a product to address a practical need.

#### What is the best way to impart effective 3d modelling skills in a quick and engaging way?

It is vital to discover how best to impart the skills identified by addressing the above cited research questions in order to most effectively use the limited time of the tutor. It is also crucial that the participants find the process engaging, enjoyable and non-intimidating, as this will be a major factor in whether they continue to develop their skills. These questions will also clarify the optimum class size. The answer to the above question will help to define the requirement for a posited phase 2 of the ‘In the Making’ project.

## Impact

This research hopes to develop an inclusive way to engage with basic 3d design for the layperson, primarily so they can benefit from the opportunities presented by burgeoning public access to 3d printing.

The immediate intent of this project is to impart basic 3d modelling skills in the pilot stage of the project, delivering the benefits cited above. The findings will contribute to the planning and bid-writing for follow-on and phase two funding for ‘In the Making’. In the broadest terms this research should also be useful to those delivering content within organisations such as *Fab Lab*, American public libraries and others offering public access to 3d printers. It may also offer insight to educators and those developing entry-level 3d modelling software.

## Methodology

As discussed above, this project will use ‘In the Making’ to iteratively test its content on this representative sample of the public. This forms the primary research element of the paper.

The fact that the group consists of disabled people is not significant to this research; they are simply a convenient group of interested amateurs. However, they are likely to manifest a wider spectrum of difficulties than a cross-section of the broader public, allowing for a more rigorous testing of the approach developed, resulting in a far more inclusive end result.

The core of the primary research methodology is ‘evolution’; beginning with an imperfect approach and refining it iteratively by cyclical delivery, coupled with a repeated but stringent collaborative review process. This evolutionary approach allows for ‘the survival of the fittest’ elements of the training and, for elements identified as weak, the trial of new approaches.

The iterative process is inspired by the ‘Agile’ cyclic model of product development, frequently used in the software industry (*Bitzesty* 2011, *Agile* 2015). This process should enable the development of an effective ‘field-tested’ approach to delivering CAD training to members of the public. The model also closely resembles the design process prevalent in the author’s industry, in which cycles of increasingly refined design are revised in response to client feedback, only being released for manufacture when both client and manufacturer are satisfied.

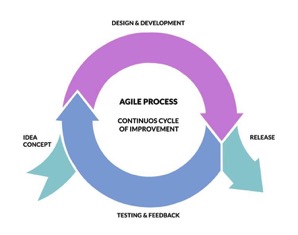


Figure from Bitzesty (2011)

The above approach was implemented as follows:

1. **Idea/ concept:** An outline approach was discussed at the steering group.
2. **Design / development:** An outline approach was developed based on initial secondary research and discussion at the steering group.
3. **Testing and feedback:** Initial contact was made with the disabled community at the launch event of the project, where a brief survey of skill-levels, expectations and specific areas of interest was conducted. This data was collated with that collected by the event’s organisers.
4. **Design/ development:** This data was synthesised with the secondary research into a prototype course content.
5. **Testing and feedback:** Consultations with industry experts informed a more nuanced and rigorous version of the workshop to be delivered.
6. **Testing and feedback:** Content was delivered to the first ‘In the Making’ workshop.
7. **Design/ development:** The content was updated in response to informal feedback, critical self-reflection and discussion with members of the steering group.
8. **Testing and feedback/ design and development:** The cycle of refinement and delivery was repeated a further four times.
9. **Design/ development:** The final version of the course was documented and discussed.
10. **Release:** Recommendations for further improvements were made in including how the approach could be applied outside the ‘In the Making’ project.

The primary research gathered by this project comprises reflections and feedback on the delivery of a series of training courses. An initial ‘prototype’ approach to delivering the course was developed by using secondary sources and consulting experts, prior to the commencement of the practical element of this project. This prototype course established a baseline upon which improvements could be made and enabled the attendees to have a useful and enjoyable, although imperfect, experience. The initial research also defined an informal reflective framework with which to structure the outcomes of the sessions. Each successive session imparted added layers of depth and nuance to the approach and tested the validity of the secondary research, expert opinions and operating assumptions.

### Literature review

Initial research uncovered little relating to levels of 3d modelling literacy amongst the public (Chester 2007; Allen 2015 and Kowalski 2015 all noted its paucity). Broader research indicated very low levels of general computer literacy (BIS 2012). The modest literature that relates to the adoption of 3d modelling outside the design professions consists of companies such as *AutoDesk* (2015) and *Trimble* (Sketchup 2015). They respectively advocate their entry-level products: *TinkerCAD* to children and adults interested in the maker community and *Sketchup* to amateur architects and interior designers.

As a consequence of this modest body of peer-reviewed academic literature, the secondary research has consisted of less formal blogs, *YouTube* videos, *TED* talks and industry press releases, largely produced by the 3d printing community. The research questions have substantively been addressed using a combination of primary research methodologies, mainly encompassing course delivery, supplemented by expert assistance and interviews.

### Ethics

All the primary research conducted by this project (other than expert interviews) took place within the context of ‘In the Making’. The team were aware of all contact with individuals involved as such, this research is covered by that project’s ethical approval. This approval was granted to Dr Hurley by the CASS Research Ethics Panel in May 2015 (*see appendix 9*).

*The application documentation is available via the link to supporting documents in appendix 10*.

## Timeline of project

* First steering group: 24th April 2015
* Second steering group: 23rd July
* BBC launch event: 29th to 30th July.
* Irlam session: 4th September.
* Salford Angel centre session: 17th September.
* Eccles session: 9th October
* Walkden session: 12th November.
* Swinton session: 26th November.
* Deadline for this paper: 15th January 2016
* Start in Salford session: 15th January
* Conference: June 2016.

## Launch event questionnaire design

Two of the initial research questions were broached with a questionnaire distributed at the launch event held at the *BBC.* These questions were:

* What level of computer literacy can realistically be expected from interested amateurs?
* What is the best way to impart effective 3d modelling skills in a quick and engaging way?

The other two research questions were informally discussed with representatives present from *Fab Lab*, *Ultimaker*, and the other members of the project team present at the event.

### Levels of IT confidence

In order to approach the first question is was apposite to consult the literature pertaining to introductory ICT training. Anglim (2012) raises the discrepancy of ‘actual’ versus ‘reported’ levels of literacy. A weakness of self-reported assessments is that peoples’ self-evaluations are frequently distorted, as they are subjective. Ability-based measures do not suffer from this axiomatic flaw.

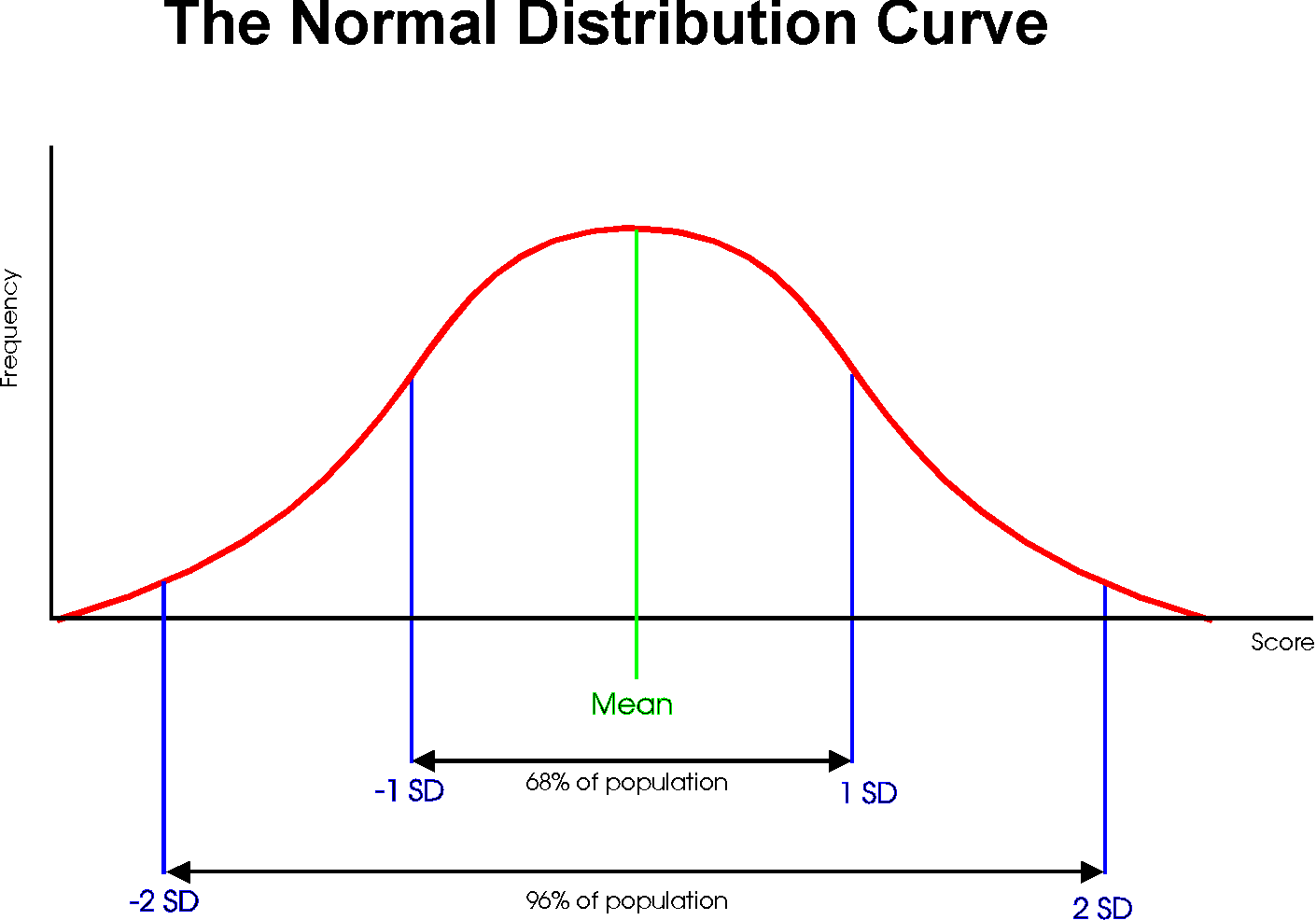
Both Foggarty (2001) and Wilkinson et al. (2010) (see Appendix 6 for their question sets) discuss the assessment of computer literacy in its broadest sense. Their batteries of questions require yes/no responses to vague and subjective statements including, ‘I have used computers for leisure’ (Wilkinson, 2010) and ‘I am not what I would call a computer person’ (Foggarty, 2001). It is not clear how useful the responses to these questions would be to this project as it sought to develop ‘a very particular set of skills’ (Taken, 2010). The questions asked focus on the creative use of computers.

The experience of Kontos (2007) who gathered data regarding levels of computer literacy (prior to commencing a community college ‘Introduction to Computing’ course) is perhaps the most similar in intent to this project. He asked the participants to rate themselves from one to five in the following area: Computer Vocabulary, *Microsoft Word*, *Microsoft Excel*, *Microsoft PowerPoint*, *Microsoft Access*, e-mail, web searches and networks. Whilst Kontos states that this is not the most rigorous of tests and acknowledges the perils of self-reporting, his approach allowed a quick and simple way in which to ensure that the course was pitched at an appropriate level for his students.

In this case the respondents’ level of confidence was of at least the same import as their level of skill. As their confidence affected their responses to questions regarding personal skill level attention had to be dedicated to their level of confidence as well.

### Learning styles

The first step in answering the question ‘what is the best way to impart effective 3d modelling skills in a quick and engaging way? ‘ is to establish how the learners learn. In order to provide the most satisfying and effective learning for the attendees it is necessary to takes advantage of their learning-style aptitudes. As the course is delivered to small groups, the ‘average’ learning style of the cohort must be identified. A questionnaire was distributed at the launch event to gather the learning preferences of the attendees. This ‘average’ does not constitute the target skill level for the course content; it defines the centre of the normal distribution curve and the data’s standard deviation dictates the ‘flatness’ of the curve.



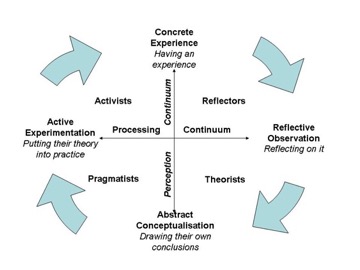
Normal Distribution Curve (University of Oregon 2015)

This knowledge allows the content to be aimed at as broad a section of the public as possible, ensuring the highest possible levels of inclusivity.

Clark (2000) suggests that Honey and Mumford’s (2000) learning style questionnaire builds successfully on Kolb’s (1984) learning model, developing it into a more usable and engaging training tool. The author first encountered this typology in a management-training course and found it to be a powerful reflective tool. Pragmatically, the questionnaire is also quick and simple to complete, making it ideal for the target audience.

* **Reflector** - Prefers to learn from activities that allow them to watch, think, and review what has happened. Likes to use journals and brainstorming. Lectures are helpful if they provide expert explanations and analysis.
* **Theorist** - Prefer to think problems through in a step-by-step manner. Likes lectures, analogies, systems, case studies, models, and readings. Talking with experts is normally not helpful.
* **Pragmatist** - Prefers to apply new learning to actual practice to see if they work. Likes laboratories, fieldwork, and observations. Likes feedback, coaching, and obvious links between the task-on-hand and a problem.
* **Activist** - Prefers the challenges of new experiences, involvement with others, assimilation and role-playing. Likes anything new, problem solving, and small group discussions.

Clark (2000)



Clark (2000)

The ‘learning styles’ model is not without critics. Guterl (2013) cites Coffields’ (u.d) meta-analytical study into learning styles research. Coffield found, ‘no sign pointing to an overarching model of learning styles.’ Guterl also refers to Willinghams’ (u.d) assertion that learning styles are nothing more than a manifestation of a varying makeup of cognitive strengths. If indeed the ‘learning style’ is simply a manifestation of one’s relative cognitive strengths, it is still a useful tool with which to gauge how best to deliver to a group or individual. This position was reinforced by Andrew Goose, who stated that whilst the learning styles model may be based on a flawed model is has proven effective and is widely adopted in industry (paraphrased).

Respondents were asked to rate their ‘computer confidence’ on the following scale:

* 0: Very unconfident.
* 1: Somewhat unconfident.
* 2: Somewhat confident.
* 3: Very confident.

This approach is subject to a number of limitations:

* As discussed above (Anglim, 2012), there are often discrepancies between reported and actual levels of skill.
* The questions assume that the respondent understands terms used.
* The small number of questions asked and the four categories of response result in crude data with relatively poor depth.

Additionally, two respondents were overheard discussing their answers; they had interpreted the question as meaning ‘how confident are you about having a go at 3d design?’ As a result their answers will not be a realistic measurement of skill level. Despite these limitations, the approach taken was the most practical and realistic method to gather data from the launch event. Any other approach would have been unwieldy and impractical (*the questionnaire used is attached as appendix 2*).

### Launch event questionnaire data

Data from the launch event questionnaires addresses two key questions:

1. What is the correct level to pitch the training to ensure that the attendees are neither patronised nor confused?
2. What delivery method would best suit the learning style of the majority of the attendees?

Data from launch event questionnaires (Appendix ???)

Whilst it is predictable that most respondents had little or no confidence with 3d modelling packages or 3d computer games (0.9 out of 3), the level of confidence with ‘basic’ computer literacy is consistently high across the area of “logging on, creating folders, finding things on your computer, accessing websites, writing e-mail, looking up information, ‘googling’” (2.87 out of 3, standard deviation 0.46). This enables the training to focus on basic 3d modelling, as only a few outliers will require assistance with basic computer operation. It is likely that this is due to the technical nature of the subject matter appealing to people who share an interest in technology and make use of computers in their day-to-day lives.

Respondents reported generally low levels of confidence in the allied creative disciplines of photograph editing (average 2.00, standard deviation 1.00) and sculpting (average 1.15, standard deviation 0.95). It is worth noting however, that the standard deviations are considerably higher in these areas as a few respondents reported considerable confidence. Greater levels of associated skills suggest that the training should allow the attendees to progress at their own speed where possible to prevent those who may progress far faster from becoming disengaged due to boredom. It may be possible for these attendees to act as teaching assistants (*see Goose interview above*), helping those less confident to manifest their creativity. This would have the ancillary effect of allowing the facilitator to focus their efforts on those experiencing more complex difficulties.

The second section of the questionnaire gathered details of the respondents’ learning styles, as described in Clarke’s (2000) version of Honey and Mumford’s (2000) typology. The aggregated responses of learning style questions indicated a moderate preference towards ‘doing’ and ‘feeling’ as opposed to ‘watching’ and ‘thinking’:

Data from launch event questionnaires (Appendix ???)

Andrew Goose (*see interview*) was consulted on the significance of these preferences. It was his opinion that the above data represented an appreciable preference for ‘doing’ and ‘feeling’ and is fairly representative of the broader public.

Clarke (2000) categorise this set of preferences as the ‘organising’ category. He describes the key traits of this group as:

* Good at adapting to changing circumstances and solving problems in an intuitive, trial-and-error manner, such as discovery learning.
* Tending to be at ease with people.
* Prefering the challenges of new experiences, involvement with others, assimilation, and role-playing.

This maps onto Honey and Mumford’s (???) category of ‘activists’:

‘Activists are those people who learn by doing. Activists need to get their hands dirty, to dive in with both feet first. Have an open-minded approach to learning, involving themselves fully and without bias in new experiences.’ (Mobbs 2015)

The preferred learning activities of this group are listed as:

* Brainstorming.
* Problem solving.
* Group discussion.
* Puzzles.
* Competitions.
* Role-play.

This set of preferences clearly suggests that the participants would respond well to ‘getting their hands dirty’ as soon as possible. As a result the ‘taught’ element of the course will be kept to a minimum; the key features and concepts of the software will be explained and then the attendees will be let loose to play with their new toy. Support will be offered to those who need it and extra time may need to be dedicated to individuals who manifest other learning style preferences.

It must be noted that whilst the groups aggregated scores show a significant preference for the ‘activist’ learning style, the data shows significantly higher standard deviations (Doing/Watching 1.83, Thinking/ Feeling 1.73). Consequently, the training style must be able to accommodate individuals who express other learning style preferences. In the small groups envisaged for the project, this can be achieved by individual attention. However, larger groups would necessitate a different approach in order to best accommodate these individuals.

The questionnaire data suffers from two significant weaknesses: the small sample size of 20 respondents may lead to outliers skewing the results and the cohort attending the launch event may not be representative of those who go on to attend the courses. Clearly it is not practical to address these weaknesses within the current project however, it is important to highlight these weaknesses and not to treat the data with undue confidence.

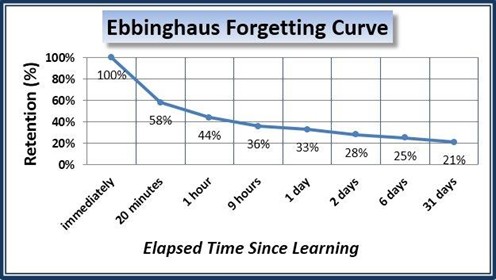
## Interview with Andrew Goose – Global Learning Advisor (Offer to Cash)- Shell

Andrew Goose, (OTC) Global Learning Advisor, delivers vice-presidential level training and mentoring support in order to pervade customer-service strategies to Shell’s 4,000 customer-service operatives based in Manila, Jakarta, Cape Town and Krakow. As such, he is a valuable source of insight from outside academia’s ‘ivory towers’. His training must deliver quantifiable results to short timescales.

Goose is a strong advocate of Jennings’ (2011) ‘70:20:10 principle of learning’. Jennings was the Chief Learning Office at Reuters from 2002 to 2008 before founding his own company, *Dutroon Ltd*. Jennings states that 70% of learning is achieved by the trainee performing the activity, 20% through mentoring and expert support and only 10% by formal teaching. The process of combining these approaches is ‘blended learning’ and it is considered the most effective way to deliver learning retention (‘stickiness’).

Whilst delivering training, the appointment of a ‘lieutenant’ to assist other learners in the absence of the SME (Subject Matter Expert) can aid both the ‘lieutenant’ and fellow learners. Once learners have received initial training, this principle can be extended into a ‘peer learning’ model. A mutually supportive community of learners is likely to make far more progress than a diaspora of unconnected individuals.

Goose also felt that learners need to make use of the imparted skills immediately; stating that expecting a learner to retain the majority of what they have been taught runs contrary to Ebbinghaus’ work on memory (Jennings 2011), (*see the ‘curve of forgetting’ below*). In order to make the training ‘sticky’ one must make use of ‘repetition based on active recall’ (*TrainingIndustry* 2014). For practical skills this means ‘doing it’. This can take the form of traditional ‘homework’ exercises, a team challenge or most effectively, a month of 5-minute daily challenges. This final approach has the added benefit of transforming the activity into a habit. Another valuable technique to enhance long-term retention is follow-on material for instance, a five minute ‘highlights’ video circulated some weeks after the training event.



Ebbinghaus’ forgetting curve (TrainingIndustry.com 2014)

Goose is also heavily involved in ‘generational learning’; the study of how different age groups learn most effectively. Generations Y and Z (*see Appendix 7: Generational demographics*) are most effectively trained in short 10-minute bursts, ideally through video. This approach is however, not as effective with baby boomers and generation X, who were educated within a book-based learning paradigm and as such, are frequently more comfortable with text-based instruction.

He felt that this was an important factor to consider when structuring training. As ‘In the Making’s’ only stipulation for attendance is that one ‘identifies as disabled’, this is not a tool that can be used in this particular situation. To focus on a single age group’s preferred learning style would negatively impact inclusion by disadvantaging other demographics.

# In the Making: course delivery and iteration cycle

As the foundation of this research is the delivery of practical workshops, the ‘data’ section will comprise a series of reflections, written as soon as possible after each session to best capture the veracity of the events. Each of these reflections will be followed by a ‘modifications’ section. The modifications will discuss the changes and improvements highlighted by the delivery experience, which will be incorporated into subsequent sessions. Consequently the iterative evolution of the training will be captured in a semi-narrative form.

Reflective writing is formatted in italics to distinguish it from the body of this work. The reflections contain the opinions of the author, the technical facilitator. These opinions contain value judgements of the author and others. These value judgements inform decisions taken to improve the course content; as such they are pertinent to this paper. Whilst these will inevitably colour the findings of the project, it is important for the purposes of academic rigour to distinguish these subjective reflections from the factual findings discussed in the non-reflective sections.

## Launch event – Media City UK: BBC Quays House, 29-30th July 2015

*In the lead up to the launch events at the BBC, the team were a little anxious about potential attendance levels. This proved unnecessary, as due to the tenacity of Margeret Tullet, the project’s volunteer organiser, both days were fully booked. The venue, a hospitality suite ancillary to the BBC’s canteen at Media City, Salford was perfect, offering plenty of bright comfortable space at the heart of the national institution but set apart enough that we did not feel in the way. It would not be a surprise if some people attended just to have a look inside the BBC!*

* *

*After a brief opening address by the three main organisers of the event, Phillip Connolly of* Disability Rights UK*, Dr Ursula Hurley of Salford University and Dr Nick Taylor of Dundee University, we divided the attendees into four groups. Each group participated in one of four presentations:*

* ***3d scanning:*** *This was facilitated by Tony Terry from* Fab Lab *Manchester, demonstrating the technology by scanning participants.*
* ***3d printing:*** *Two representatives from* Ultimaker *(the suppliers of the hardware used by the project) talked the participants through the 3d printing process and enthused about the myriad of uses to which their customers put the technology.*
* ***‘Ideation’:*** *Another* Fab Lab *facilitator, Michael Walsh, discussed the process of developing a need into an idea then into a design. (CHECK???)*
* ***Commercialisation:*** *The final group, led by David Armson, also from* Fab Lab, *gave a brief overview of how one might take a product to market.*

*Each group attended each of the presentations and then had lunch in the BBC canteen. We were victims of our own success: many of the sessions overran due to in-depth discussions between the attendees and presenters. As a result the first day’s session overran and the team were less able to garner feedback from the group than would have been ideal.*

*One of the attendees on the first day was the BBC’s Disability Affairs Correspondent Nicki Fox. She was extremely enthusiastic and quick to grasp how helpful the technologies could be to people with disabilities. On the second day she filmed a piece for BBC News (Fox, 2015), speaking to both the experts about the technology, and the attendees about how they could use the technology to solve everyday problems. Unfortunately for the project, we were not explicitly mentioned in the report that aired but the fundamental reason for the project was clearly and enthusiastically expressed.*



*Both days took the same format and whilst the second day was a little less packed than the first, it was every bit as successful. Across the two days I collected 13 survey forms, which should be sufficient to gain an understanding of the appropriate level and learning approach of the training I will be delivering. I spoke at some length with the representatives of both* Fab Lab *and* Ultimaker *about the technical challenges I might face delivering the workshops – the consensus was to limit expectations and that* Sketchup *was a compelling entry point into 3d modelling.*

*A wide range of disabilities was represented including sensory, learning difficulties, wheelchair users, Alzheimer’s sufferers and people on the autistic spectrum. The project was not focussed on the attendees’ actual disabilities but rather the fact that disability disadvantages people, frequently preventing them from fully engaging in all aspects of society. Consequently we were keen to treat the attendees as people with individual needs rather than as a set of symptoms and as such, did we not seek to record details of the disabilities. As someone with little contact with the disabled community it was heartening to explain how the technology could help people and for this to be received with such enthusiasm. We all left feeling that the project had as strong a launch as we could have hoped for.*

### Discussion of launch event

Each discussions section will begin with short list of the positive outcomes of the session and also the areas to be improved upon at subsequent sessions:

* Positive outcomes:
  + Enthusiasm of all involved.
  + Attendance levels.
  + Attendee diversity.
  + Location.
  + Media attention.
* Areas for improvement:
  + Haphazard workshop timekeeping.
  + Lack of ‘name-check’ in BBC report.

The launch event highlighted the breadth of skill, experience and disability of those interested in participating. This may prove problematic for the project, as there is as risk that the ‘ends of the bell curve’ may feel neglected, as facilitation is likely to be pitched to the level of the average attendee.

Discussions with representatives of both *Ultimaker* and *Fab Lab* reinforced that *Sketchup* was indeed the most appropriate 3d modelling tool, being comparatively simple; capable of generating relatively complex geometries; compatible with all the mass-market 3d printers and crucially- free.

## 1st session - Irlam: Princess Park Garden Centre, 4th September 2015

*When I initially arrived at the venue Dr Taylor and Dr Hurley expressed a feeling that the previous day could have gone better. I had little time to dwell on this as the laptops acquired for the project were not equipped with mice, meaning that navigating the 3d environment within* SketchUp *would be very cumbersome. Luckily there was a large supermarket very close to the venue so I was able to purchase a couple of mice for our participants to use.*

*When I returned, the participants had arrived: two people with disabilities and their carers. I shan’t attempt to categorise their disabilities as this is an area in which I have no expertise and as mentioned earlier the nature of the participants’ disability is of little import to this research. One woman lacked dexterity using a mouse; the other’s disability did not affect her computer use. One of the carers had long ago worked as a draftsman using* AutoCAD *and was familiar with many of the concepts I was trying to convey. The outcome of this was simply that he got stuck on more complicated problems than the less experienced participants.*

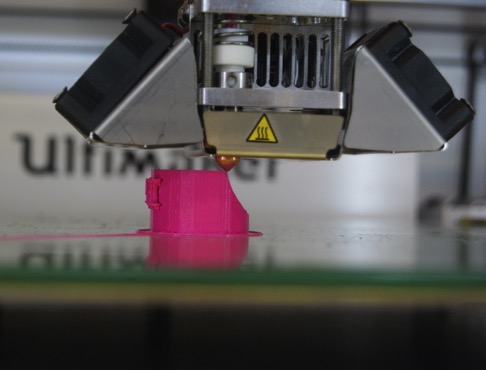
**

*I began by introducing myself as a retail design consultant delivering the training as part of my Design Management Masters Degree at Salford and then asked briefly if they had ideas about what they would like to make. One woman was keen to make a brace to support a weak finger joint. The mass-produced options are too large for her hands and her occupational therapist had told her that she would have to do without as a result. The other attendee just wanted to have a play to see how the technology worked.*

*I then talked the attendees through a* Sketchup *model of my house, explaining that none of the things that they could see were individually terribly complicated to model and that complex shapes can be built up using a small number of basic techniques. To demonstrate this I opened a blank* Sketchup *document and made a basic 3d shape, demonstrating a few basic modelling tools, describing what I was doing and then introducing the process of navigating around the virtual space.*

*The attendees proceeded to use the tools I had demonstrated to model a basic house shape and to practise navigating the virtual space (which I found the most challenging aspect of 3d modelling when I was first introduced to* Solidworks *at university more than a decade ago). I circulated amongst the attendees, answering questions and making sure that they did not get too stuck. The participants naturally transitioned into modelling their own things once they had reached a basic level of comfort with the software.*

*Of the four attendees one was happy to just tinker, two required frequent assistance as they got stuck on their own projects. The final attendee (who wanted a custom finger brace) was struggling with the mouse and it was clear that this was a little complex for a beginner to model in their first session. As I was concerned that she may become dispirited, I modelled if for her, involving her and her carer in the process as much as I could. Once the models were complete, Nick ‘sliced’ (translating the models from data usable by the modelling software, in this case* SketchUp*, to a format suitable for the 3d printers) them and set the* Ultimakers *printing. On this occasion the printers behaved perfectly and both disabled attendees were able to take two versions of their designs with them (initially one was too small and the other did not print quite correctly).*

**

A finger brace being printed.

*As the session came to an end we asked the attendees for some feedback about what they had liked and what could have been improved. The attendees agreed that the second day, my* Sketchup *training as described above, was the more satisfying of the two days and they were happy with the progress that they had made. Three of the attendees expressed an interest in attending a future session and two were keen to spend their own time getting to grips with the software. No negative feedback was offered about the* Sketchup *training – this is a mixed blessing as some constructive feedback would have been useful in order to deliver a more polished course next time!*

*Once the participants had left, Phillip Connolly, Dr Taylor and Dr Hurley each expressed satisfaction and relief regarding how the day went and thanked me for my efforts. In subsequent e-mail feedback (*see appendix 4a*) Dr Hurley suggested I introduce myself a little more fully and try opening with a discussion of people’s ideas.*

*It is difficult for me to take anything but positive reinforcement from this inaugural session. I am aware that the subsequent sessions are likely to be busier and as such a more formal approach may be necessary. This may be more of a challenge as this session was not vastly different in character to the workplace mentoring I have previously delivered.*

### Discussion of Irlam session

* Positive outcomes:
  + Positive feedback.
  + Attendees expressed satisfaction on the progress they had made and left with a printed object.
* Areas for improvement:
  + Informal and inadequate introduction.
  + Lack of forethought led to rush to supply adequate equipment.
  + One attendee required a level of assistance impractical in a larger group in order to develop a simple assistive device.

Such positive feedback as was received above can prove problematic for development as it can encourage complacency. As a result the reflections written from this point onwards will be deliberately self-critical and circulated to the key project members to attempt to capture even superficial opportunities for improvement.

The next session has a larger number of attendees booked; consequently a slightly modified approach will be required. The use of a projector will ensure everyone is able to see the initial demonstration of the software, as well as potentially aiding engagement for any attendee with sight problems. Dr Hurley is seeking additional facilitation for the busier sessions; this should allow the same high level of personal support that was possible initially. This will be invaluable to those who have practical problems that they are seeking to address, as it is simply unrealistic to expect a novice to be able to design functional objects after such a short time.

The rush to buy mice before the attendees arrived highlights the need for thorough preparation – it was only the ready availability of mice local to the venue that prevented this becoming a real problem – if a vital part of the printers was missing it could seriously impact the attendees’ experience.

Dr Hurley suggested a little more formal introduction from the facilitator might be helpful; the benefits of this should be compounded in a busier session as discussing the same basic things with each attendee simply becomes impractical in larger groups.

## 2nd session: Salford: Angel Centre, Chapel St, 16-17th September

*Upon arriving at the venue there I spoke with Dr Taylor and Dr Hurley who informed me that there would be substantially more people attending than last time due to the centre not passing on bookings until the day before the event. Consequently I hurriedly connected my laptop to the projector after finding a Mac adapter and rushed to set things up correctly. Whilst I was sorting this out twelve people arrived (including about 4 carers, although I am not comfortable treating the carers and assistants differently to the disabled attendees). We were unable to allot a laptop to each individual and even with the mice previously purchased, a number of people had to struggle with inadequate pointing tools. As a result of this influx and my struggles with the projector I was less prepared for the start of the session than I would have liked.*

*Dr Hurley opened the event with a short introduction and handed over to me. Due to my slight flustering I rather rushed through the introductory tour of* Sketchup *and did not show examples of my commercial work as I had planned (my laptop was not cooperating) and went directly to the introductory exercises. Following this rushed introduction I was confronted with even more varied levels of computer confidence than previously, ranging from one client who had ‘done his homework’, arriving with a computer model he had worked on, a (lapsed) product design graduate to individuals who spent a good deal of the day becoming familiar with navigating the three dimensional ‘canvas’.*

*Due to the large numbers of people, I was limited to spending short periods of time with each person helping them with their immediate issues, which frequently felt inadequate. This issue was compounded by the more confident and outspoken attendees requesting help whilst the more shy and withdrawn had to spend longer waiting for assistance. This led to some people not making as much progress as I would have liked, although I believe that only two attendees left without at least handing in files to be printed after the event. The first of these was the product design graduate, a wheelchair user who runs a company designing and developing wheelchairs for developing markets. He attended in order to see 3d printing in action to gauge its viability for his company; as such it was perhaps less important that he left with a printed ‘knick-knack’ than some of the other attendees.*

*The other person who did not leave with something was David Riley, a man with severely limited mobility and communication abilities due to muscular dystrophy, who was not able to interact with the computers. He was keen to develop a method by which he could control his wheelchair using limited arm and head movements. Fiona Velez-Colby spent some time talking to David about this aspiration and I took over once she was called away. I am very concerned that David’s expectations may not have been met and that the amount of time it will take to meet his needs is not something that I can offer. I hope that we will be able to signpost him to someone who will be able to assist him.*

*Ultimately I believe that the total number of attendees was around seventeen including six carers. Whilst it was wonderful to have such a high level of interest, ultimately the experience of the attendees was compromised by the small amount of attention each participant could be allotted.*

*This negativity aside, the feedback at the end of the event was broadly positive with the main points being an appetite for more in-depth time spent with the software. One attendee mentioned that some sort of ‘cheat-sheet’ could be useful as the icons confused him. The best feedback was from a man with hearing and communication difficulties. When the team was soliciting feedback he was rocking and vocalising – we took this to mean that he wanted to contribute but when his carer was asked if he wanted to contribute she responded ‘He doesn’t want to say anything, he is just happy’.*

*Personally I am finding it very rewarding to spend time working with the disabled participants as other than a couple of exceptions I have little experience interacting with people with disabilities, especially those affecting communication.*

*Following the session we received extremely positive feedback from attendee John Abbott: ‘…todays atmosphere lifted me; everyone’s creative juices were flowing. The relaxed atmosphere and informative tuition was sublime … Joe was amazingly helpful, this guy deserves a medal (Thanks Joe)’ (*see appendix 2b*). Whilst I acknowledge that this reflection is intentionally hypercritical in order to highlight areas ready to be improved, it is heartening and a little humbling to hear what a productive and meaningful experience John had.*

### Discussion of Angel Centre session

* Positive outcomes:
  + Overwhelming popularity of session.
  + Engaged attendees.
  + Positive feedback.
* Areas for improvement:
  + Impractically high attendance levels.
  + Insufficient equipment for large group.
  + Flustered introduction.
  + Inadequate level of technical facilitation due to high numbers.
  + Inability to help with complex practical problems.
  + More assertive attendees monopolising tutor time.

The most outstanding modification highlighted by this session was the necessity of limiting numbers to a more manageable level. Both Dr Hurley and Dr Taylor raised this issue; they felt that they were unable to pursue their own research agendas as they were acting as supplemental facilitators due to the weight of numbers. The consensus was that it was important to rigorously enforce the cap on the number of attendees to six (including carers) to ensure that all the projects’ objectives could be met.

The delivery of the introduction was felt to be a little rushed and superficial. This was to due hurried and inadequate planning. For future sessions a more explicit ‘lesson plan’ should help the introduction stay on-track. Discussions with Dr Hurley highlighted a need for a fuller introduction to the facilitator (the author). Consequently, the introduction to the next session will be structured as follows:

* Brief introduction of facilitator, explaining:
  + Who I am.
  + What I do for a living.
  + How I am involved with the project.
* A brief explanation of what we will be doing today – playing with *Sketchup*, designing something and then 3d printing it.
* A little introduction to *Sketchup* – what it is, who it is for (amateurs and professional).
* Demonstration of *Sketchup*
  + Draw a rectangle – explain about vertices.
  + Pull into a cube – explain about faces (delete a face then replace it).
  + Show how to navigate the 3d space, explain axes.
  + Draw on surface; use the push tool, circle, rectangle and move.
  + Scale – inputting dimensions
* A tour of a sample *Sketchup* model (the authors house).
* Time to play!

The core of this approach is an adaptation of the beginners’ user guide on *help.sketchup.com* (REF), mainly ‘Designing in *Sketchup*’ and ‘Drawing quickly’. It has been adapted to suit a demonstrator-led environment as it is a written guide. The modifications also take account of the competency evidenced at the two workshops delivered thus far.

One of the attendees mentioned that some sort of ‘cheat sheet’ would have been helpful as he was getting a little confused by the profusion of buttons on screen. Other attendees also occasionally needed support to help them identify the correct button. For the next session the attendees will be given the ‘*Sketchup Pro* Quick Reference Card’ (*Appendix 8*), downloaded from *Sketchup.com*. If this proves useful it will be used in future session. However, a less comprehensive version may need to be developed in order not to intimidate beginners, as the published reference card includes far more than the limited palate of tools presented initially.

As stated in the above reflection many of the attendees struggled with inadequate pointing devices. Although many had brought their own laptops, few had thought to bring a mouse and some of these were not equipped with a clickable scroll wheel – essential to efficiently navigating the 3d space in *SketchUp*. This issue has simply been addressed by the purchase of three additional wired mice.

Finally, the above feedback was circulated to the directors of the project as a way to encourage their own feedback.

## 3rd Session: Eccles: Gateway Centre, 8-9th October 2015

*After a frustrating quest in search of change for parking, I arrived slightly late to the Eccles Gateway Centre. The number of attendees was reassuringly lower than at the Angel Centre previously, with 4 attendees expected and three actually attending. Once I had set up the laptops, involving moving all the tables to a corner of the room (we were not permitted to use an extension lead) our guests arrived.*

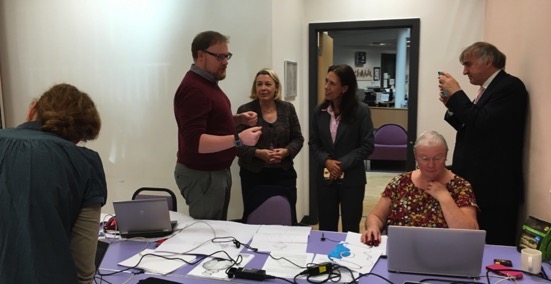
*Barbara Keeley (Member of Parliament for Worsley and Eccles South and Shadow Minister for older people, social care and carers) and Debbie Abrahams (Member of Parliament for Oldham East and Saddleworth and Shadow Minister for disabled people) arrived, far less dramatically than I expected. I spoke to each of them before I realised who they were! They both showed a great deal of interest in the project, staying for about least two hours. Barbara Keeley was particularly fascinated with the printing technology; it was a real shame that we were unable to demonstrate them in action. It was good to be able to explain the project and my research to such influential people and I hope that our enthusiasm and the value of the work made an impression.*

**

From left to right: Dr. Nick Taylor, Margeret Tullett, Car crash chap, Barbara Keeley MP, the author, Phillip Connoley and Debbie Abrahams MP

*As we only had three attendees, the disruption caused by our visitors was not significant. I was able to pop over and support Daphne (a sculptor and repeat attendee) whenever she got stuck tracing a sketch she wanted to convert to a three dimensional object. Whilst we broke for lunch I traced the rest of her sketch, as it is a fiddly process and laborious for beginners, especially as Daphne’s condition affects her energy levels. Once this was complete we sat together as she converted the profiles into a 3d shape (see below for image) that she was happy with. We then passed this over to Dr Taylor to import onto the 3d printer. When the print had finished Daphne was very pleased with the end result although in hindsight I would have cautioned against printing in translucent PLA material.*

*Of the other two attendees one was happy to be there to chat and generally get involved. I asked him explicitly whether he would like to have a go with the software and make something. He said that he would not have time to design anything although I suspect that this was due to a lack of confidence at odds with his gregariousness throughout the session. The final attendee was working with Dr. Hurley to produce models directly from his sketch work. Both of these other attendees wanted bracelets, which I threw together on* Sketchup *as they had shown no inclination to model them themselves.*

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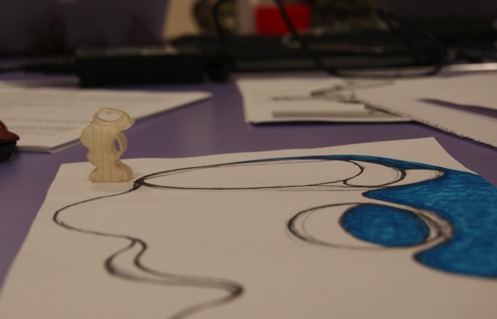
*The most frustrating element of this session was that I was unable to deliver my initial presentation that was shown to be so necessary at the previous session because once the guests had left the attendees were happily getting on with their individual projects. This led to a somewhat fragmented session with little interaction between the attendees and I feel that I was not fully utilised. It would have been helpful to test the presentation (detailed above) but it is clear that a measure of flexibility is required.*

### Discussion of Eccles session

* *Positive outcomes:*
  + *Interest and enthusiasm from prestigious guests.*
  + *Happy attendees.*
* *Areas for improvement:*
  + *Disruption due to guests.*
  + *Unachievable expectations from attendee.*
  + *Printers initially not working.*

The prime issue with this session was the lack of working printers to show the guests. This was caused by the vagaries of an emergent technology, exacerbated by the teams’ lack of experience. It is unclear how this could be addressed in future sessions other than by setting up earlier and by the increasing expertise of the team that will develop over time.

Another frustration was being required to move all of the desks to allow access to power sockets. An extension lead was not forthcoming from the venue’s reception and the group was not permitted to purchase one, as it would not be PAT (Portable Appliance Test) compliant. This is at odds with the HSE’s (Health and Safety Executive) stated advice: ‘New equipment should be supplied in a safe condition and not require a formal portable appliance inspection or test.’ In addition, ‘The law simply requires an employer to ensure that their electrical equipment is maintained in order to prevent danger’ (HSE 2015). Consequently, it would be advisable to take a suitable multi-gang power socket to the next session.



The disruption caused by the visiting MPs was minimised by the small and diverse cohort of attendees. If there had been more attendees the visitors would have substantially impacted the participants’ experience. Consequently, in future sessions, efforts will be made to adhere to the timetable regardless of guests. It would also have been useful for the guests to see elements of the presentation, as many of their questions about the technology were the same as those fielded by the attendees.

### Response to Phillip Connolly’s questions about what phase 2 should consist of:

In a lull during the Eccles session Phillip Connolly (*Disability Rights UK)* solicited input from the author on a mooted phase two for the ‘In the Making’ project. What follows is the author’s input on this subject:

*I see the project’s overarching aim as to enable those with disabilities to both express themselves and to address the specific physical challenges that their disabilities present by harnessing the emergent technology of 3d printing. I see these two aspirations as equally valuable for a disenfranchised group poorly served by mass manufacturing.*

*There seems to have been a lot of interest so far, most importantly from the target group. It feels that we need to serve a range of interest. This includes:*

* *Those who just want to see 3d printing, find out what it is and make a knick-knack as a memento.*
* *Those with something specific they would like to make.*
* *Those for whom it may develop into a hobby, novel approach to an existing activity or commercial tool.*

*We are lucky to have* FabLab *as a resource to which people can progress but we need to appreciate that it can be a fairly intimidating environment for many of our attendees. Some sort of bridging session may ease this transition (perhaps we could offer an additional, final session in one of the* Fab Labs *for those wanting to take things further?).*

*I am very aware that there is only so far I can progress an attendee in one session and it is unlikely that they will be able to make what they want to make with that level of skill. As a result it feels sensible to build a model that allows people to attend repeatedly to build their skills.*

*Dr Hurley mentioned that she was struggling to find further facilitation help – I was a little surprised by this and feel that the ideal situation would be for me to train members of the disabled community to a level at which they would be comfortable supporting beginners. This could potentially provide them with a source of income and marketable skills. It would also reduce the facilitation cost for the workshops, as professionals like me are rather expensive (I am charging the project a fraction of my consultancy rate).*

*I would suggest that we aim to book eight attendees per session to allow for attrition to the ideal six attendees. We need to allow for the variable nature of our clients’ disabilities.*

*Regarding the method of delivery, I would propose regular sessions across a number of accessible community spaces and possibly* Fab Labs *where people could come to work on their projects and print things. So we would possibly organise a regular activity at a number of sites, which could expand as we train our cohort to facilitate.*

*As I have not attended the first part of the workshop I cannot really comment on it other than asking how it will fit in with the more resolved aims for phase two – I am hoping to be able to attend the next one dependant on work commitments.*

*As I have mentioned, it is my ambition to combine professional practice with developing an academic career. To this end I would be very interested if phase two might include funding that would allow me to continue my involvement and undertake a PhD on some aspect of the project.*

## 4th Session: Walkden: Gateway Centre, 11-12th November 2015

*On the weekend preceding this session, my wife and I came down with a relatively serious strain of flu. As I write this, a week and a half later, I am still not well although not incapacitated as I was.*

*I had committed to delivering the equipment to the venue (which Dr Hurley had previously dropped at my house) and providing technical facilitation on the first of the two days of the session, in addition to the second day as usual. This was because* Fab Lab *Manchester was unable to cover the first day as previously. Once I had loaded the car, not generally a strenuous process, my head was spinning and I felt far from safe driving; I persuaded my wife to drive me to Walkden even though she had called in sick. Once we had delivered the equipment I allowed myself to be persuaded by both my wife and Phil Connolly that I really needed to go home and get better, despite feeling bad about leaving the group without a technical facilitator for the day. With hindsight this was clearly the correct decision as I spent the rest of the day bundled in a duvet dosed on paracetamol playing a particularly undemanding computer game.*

*The following morning I was feeling a little better and felt safe to drive to the venue. I was the first to arrive, rearranging the room to allow access to power sockets. I was grateful to have a chance to sit down and let the room stop spinning after this. There were six attendees at this session:*

* *Greg, a man who experiences a number of physical challenges with a lot of ideas for objects to help him overcome them.*
* *Tessa, an artist visiting from London, interested in understanding how 3d printing could contribute to her creative practice.*
* *Jay, a carer, supporter of the project and member of the steering group.*
* *Ken, a man whose indistinct speech and read-back software suggest some form of learning difficulty, who was interested in seeing 3d printers and making something he could take away with him.*
* *Lynda and her assistant, who attended the first session in Irlam.*

*Daphne was unable to attend this second day due to an unexpected hospital appointment, which is a shame as I am keen to see how she has progressed – hopefully she will make it to one of the two final sessions.*

*Shortly before we were due to start, Simon from* Fab Lab *Manchester arrived at the request of Philip Connolly in case I was not able to make it due to my illness. Throughout the day he was extremely helpful and highlighted how much more we were able to achieve with additional technical facilitation (though he was also unwell!).*

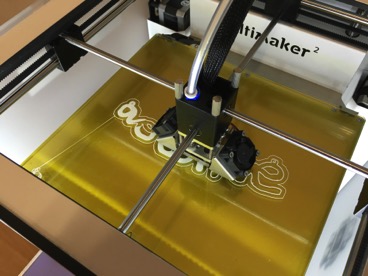
*I delivered the opening presentation; I skirted over the details about me a little and did not show any examples of my commercial work but it went very smoothly and sustained the interest of the group. It would have been challenging presenting to a larger group without a projector. After this we moved on to a discussion about what the participants wanted to make. Ideas ranged from practical assistive devices to artistic statement pieces and just wanting to play with the technology – the full gamut we have come to expect from the project.*

**

*This session really benefited from having more facilitation than before. Tessa and Jay enjoyed working, together playing with the software and discussing ideas. Simon focussed on helping Linda produce the ‘Overcome’ necklace pictured below – I suspect that Lynda is not terribly confident with computers and may be deterred from having a go by her limited dexterity. Dr Hurley worked with Ken to help him articulate and make a plaque saying ‘Going out weekends’. In addition to supporting Tessa, Dr Hurley and Jay with* Sketchup, *I spent a good deal of my time working with Greg; he had a lot of ideas and was keen to make progress with them.*

*I was a little concerned that Greg was ‘trying to run before he could walk’ although I have been guilty of the same on many occasions. I quickly modelled him a brush-rest he had sketched and we were able to print this off before it was time to pack up. Frequently, attendees with more ambitious and developed ideas have left without an object they can take with them. I feel we are running the risk of disenchanting people due a lack of concrete progress and that a little time spent moderating expectations at the start of the session may mitigate this disillusion. I hope that Greg has managed to install* Sketchup *on his machine and has spent some time working on his ideas prior to his attendance at the next session. It would be a real shame for him to miss out on the benefits his ideas could bring him.*

*Once we had packed up, I gave Philip Connolly a lift to his friends’ house on my way home. We were discussing our feelings about the project and shared a concern that those participants with ideas for pieces of assistive technology were not progressing to a usable object that actually addressed their needs. Whilst it is clear that there is a lot of interest in the project and the attendees are enjoying themselves, this concern prevents either Philip or I considering the project a full success and started us questioning how we might better address those needs.*

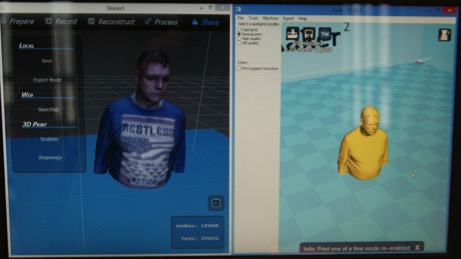
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*In the days following this session I have been tinkering with one of the 3d printers and struggling to get it to successfully print. This highlights a ‘training need’ for me, as if I am to continue delivering the workshops, it is not acceptable that I should rely on others to operate the printers and focus solely on teaching the design software.*

### Discussion of Walkden session

* *Positive outcomes:*
  + *Diverse group, representing the full scope of the disabled community.*
  + *Efficacious introduction.*
  + *Extra technical assistance.*
  + *Engaged attendees.*
* *Areas for improvement:*
  + *Highlights the project’s over-reliance on the author.*
  + *Inability to provide adequate support to develop assistive devices.*
  + *Unrealistic expectations from attendees.*
  + *Lack of projector.*

The prime weakness of the project highlighted this week was its reliance on a very limited pool of technical facilitators provided by *Fab Lab* Manchester and the author. Whilst this is not a single point of failure (Simon from *Fab Lab* helped facilitate on the second day in case the author was too ill to attend), it is cause for concern that will need to be addressed in the proposal for phase two, as a larger scale project will need to be more resilient. The intention of the initial project was that members of the disabled community would be trained to a level at which they would be able to deliver the introductory training. Thus far no one has shown interest in following this path; hopefully the project will find suitable candidates however, finding skilled and enthusiastic people may prove challenging.

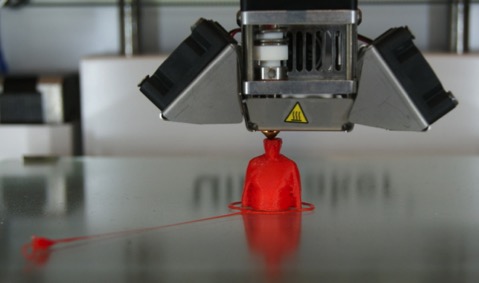


Whilst it was not a significant problem on this session, it is clear that a laptop screen is only useable for a handful of people and a projector is required for larger groups. As there are only two more sessions planned for the pilot stage of the ‘In the Making’ project, it is not realistic to acquire a projector at this stage however, it should be considered a requirement for phase two.

The sessions delivered so far have proved that it is realistic for most participants to design and ‘print’ a very basic object (i.e. a name tag, bracelet or small abstract object) in a single day. The examples of assistive therapeutic objects including Lynda’s finger splint and Greg’s brush-holder required a lot of one-to-one input from facilitators, which is not possible during busier sessions. There are other examples of assistive objects (including David’s wheelchair controls, Greg’s lectern and some wheelchair addments) that would provide a lot of benefit to the individual but require far more development than is practical in the project as currently delivered. There is clearly a requirement for more in-depth help for some individuals. A discussion with Phillip Connolly developed this need into a possible proposal to be included into phase 2: that a certain number of participants in phase two might be given access to a designer for an extended period of time in order to develop more complex and potentially life-changing therapeutic objects. There are three possible variants to this approach:

* As an escalation point for a mobile *Fab Lab* model. To pair the individual with the assistive technology need with a practising designer.
* To form a partnership with a university product design or engineering course and develop a module where each student is assigned a person with an assistive technology need as a customer with a live brief.
* To provide custom design services as an escalation path for occupational therapists.

The relative cost and benefits of these approaches will be discussed below. The lack of consultation with occupational therapists in the scoping stages of this project could be a possible oversight as they form a vital part of the eco-system within which this project operates.



The short-term impact of these larger development needs (far beyond the scope of this pilot project) is that attendees sometimes manifest expectations far beyond those that can currently be met. For the final two sessions there are two complementary approaches that can be undertaken to avoid disappointment and disillusionment. The first is simple, stating that the session is a ‘taster’ session to enable participants to understand what is possible and to show them that they are capable of picking up the software and making use of the 3d printing technology. The second is to signpost them to the *Fab Labs* in and around Manchester so they can develop their ideas into something useful.



## 5th Session: Swinton: Gateway Centre, 25-26th November 2015

*As I had custody of the projects’ equipment, I took it to the* Gateway Centre *for the first day of the course. It was my intention to deliver the equipment and spend the day at the centre writing and keeping half an eye on the facilitation as I have yet to see the first half of the course. As I drove in I received a message from Dr Hurley asking if I could help Phil (the facilitator from* Arthur + Martha*) as his partner was ill and Dr Hurley was unable to attend due to teaching commitments. I agreed to help as I was concerned that the participants’ experience might be less than satisfying with an overwhelmed facilitator.*

*I shan’t go into too much detail over the first day as this piece deals with the training that I have been delivering on the second day of the course. The attendees enjoyed the activities that Phil led them through which began with a little poetry writing exercise and then involved creating something with the dry leaves he had brought. There was a little tension as Phil had expectation of the software and hardware that were not realistic without prior preparation and he had given us no notice of what he intended to do. Dr Taylor addressed this and the attendees left happy with a 3d printed relief model of a leaf with their text on.*

*Day two could have had a more auspicious start as I had left my workbag at home, which contained all my notes, laptop and mouse! Despite this, my introduction to* Sketchup *went very smoothly and I covered all the ground that I wanted to other than showing my commercial work (as this was on my laptop). One of the attendees asked a number of technical questions I would not normally address in an introduction. I was concerned that this might test the patience of the other attendees but it didn’t seem to cause a problem. It was again clear that a projector would be extremely helpful as the attendees needed to crowd around me. Liam, who had limited vision, could not follow what was happening on screen. It may have been helpful that I had attended the previous day as I had already built up a rapport with the attendees. It is a shame that I was not able to show any of my commercial work as I feel it gives my practice a context and may instil confidence in the attendees.*

**

*Five attendees and two carers seems to be around the ideal number of people, enough that it feels like a cohesive group and not too many to keep track of. The group (representing the full spectrum of people the project is hoping to help) consisted of:*

* ***Lorna*** *– A wheelchair user with a lot of practical ideas for adaptations: demountable basket for the front, rucksack mount/dog rail for the back; these were made far more complex by the need to get them on and off easily. She had previously tried to learn* Autodesk Inventor *in order to model these and had struggled, as it is by no means an entry level CAD package. Lorna would benefit greatly from attending* Fab Lab *and I helped her book onto a CNC furniture-making course at their Ancoats site.*
* ***Daphne*** *– A repeat attendee mentioned above, became dispirited before lunch, saying that she could just not ‘get’ the software. I tried to encourage and reassure her that she had made good progress in previous sessions but she had lost confidence and we ended up giving her a non-CAD based creative project to work on.*
* ***Liam*** *– A quiet chap happy to work on his own. He initially started working on a* Minion *that he wanted to adapt into a spectacle holder. This proved a little complex so he made a supermarket trolley token with a grip as he kept losing coins due to poor sight and dexterity. I hope that Liam persists with the software as his ideas were interesting and he seemed comfortable with the technical aspects of 3d printing.*
* ***Phil and his carer*** *– A jovial chap with learning difficulties who was more than happy to play with the software and be the groups’ DJ. He and his carer produced a key fob and in common with previous attendees with similar conditions, he left when his key fob was printed.*
* ***Kevin and Claudia, his wife/carer*** *- Kevin had suffered a stroke and had limited language and mobility. Initially it was difficult to assess how well he would cope with the training but he took to the software well. I suspect that he did something technical prior to his stroke. Initially they designed a rather complex key-fob, which we printed, then started making a helicopter! I hope they will make it to the next session as they were lovely people and seemed to get a lot of enjoyment from the process.*
* ***Greg*** *– Our second repeat attendee. Greg arrived with even more ideas! We worked on his literature stand (which we did not have time to print on-site) and then began working on a chock to stop wheeled chairs moving as he rises. Greg is unusual amongst the attendees in that he arrives with a sheaf of sketches of his ideas. I feel he is the ideal candidate for the more intensive help envisioned for the follow-on funding.*

*It would seem that those who attend with carers request less help. This may be due to ‘two heads being better than one’ or possibly the nature of the conditions that require carers. It should be noted that this is an impression based on a small sample size but it would suggest that when calculating numbers we don’t have to count carers when calculating appropriate levels of attendance.*

*Dr Taylor, Dr Hurley, Philip Connolly and I went for lunch together to discuss the future of ‘In the Making’. This is beyond the scope of this project but it was fascinating to hear Philip Connolly’s insights into how we should approach the meeting with the Minister for Disabled People scheduled for early next year. The other members of group felt the sessions lacked a cohesive flow between day one and two and that they were not entirely satisfied with* Arthur + Martha *or the support provided by* Fab Lab*. I was heartened to be told that my involvement would be welcome in whatever form the project takes.*

**

*I was satisfied with how the session went and felt that whilst there remains room for improvement, my approach and delivery have become far more polished and professional since the ones earlier in the programme. After the session I went for a drink with Lorna (one of the attendees) and Jay, a committed member of the steering group. It was a lovely way to end the day and their enthusiasm for the project was very encouraging.*

*I’d like to acknowledge the* Gateway Centre *staff; they quickly and courteously sorted out every request*

### Discussion of Swinton session

* Positive outcomes:
  + Flow from day one to day two.
  + Slick presentation.
  + Optimism of project team.
  + Engaged and enthusiastic team members.
* Areas for improvement:
  + *Martha + Arthur’s* technical expectations.
  + Lack of laptop and notes.
  + Attendee expectation of what can be achieved.
  + Projector.
  + Parking ticket.

There were many aspect of the project that worked well this time: The introduction flowed smoothly and covered all the ground intended without any of the participants disengaging. The size of the group was perfect and whilst there was a wide range of ages and disabilities represented; none of the participants were left behind.

As previously, the introduction would have worked better with a projector. Dr Hurley, Dr Taylor and Philip Connolly are aware of this and will include an allowance for one in the proposal for phase 2, if the sessions are to be delivered in a similar fashion. Again, the facilitator’s commercial work was not shown (due to the absence of the laptop).

A significant issue highlighted by the author, attending for both days for the first time, was the lack of continuity between day one and day two of the course. Philip Connolly, Dr Hurley and Dr Taylor will have to refine the aims of the project in order decide what to deliver in order that the sessions do not feel disjointed.

It has become clear over the last few sessions that it is not possible for a novice to create a practical object in the 5 hours that the course allows. In this time, a novice is able to grasp the basic tools in *Sketchup*, understand how to navigate around the 3d space and create some shapes that we can print. ‘Design’ is a separate, related skill from learning to operate the software, and is a far complex and more nebulous skill. As such, it is not realistic to convey anything more than a taste of what is possible in such a short time.

Finally, as many of the participants have practical needs that they wish to address, it would enrich phase two to recruit an occupational therapist to the steering group as there is a natural overlap between this project and their area of expertise.

## 6th Salford: Start in Salford, Broad St, 14-15th January 2016

This session is unfortunately after the submission date for this paper and thus cannot be discussed here. However, reflections will be captured that can contribute to future work and the introduction recorded.

## Article: Disabled entrepreneurs and new technology by Katie Parker

The *Institution of Engineering and Technology* contracted Katie Parker (a freelance journalist) to write an article for their magazine. Katie contacted people involved with delivering the project (including the author) initially exchanging e-mail (*see appendix 4c*) followed by a telephone interview. In the article, Parker (2015) introduces 3d printing, citing examples of how the technology has been used to make assistive objects. She then describes the project and the sessions (that had taken place at the time of writing), focusing on the practical aspects of the project and mentioning other projects in the same sphere. The conclusion details the overarching agenda of the project.

Parkers’ (2015) piece is followed by a call for volunteers to assist the project. Robert Roberts answered this call (*see appendix 4d*), a recent design graduate who identifies as disabled. Rob will be assisting the author to deliver the final session in Salford (following the deadline of this piece), which should enhance the attendees’ experience greatly.

# Discussion

The iterative approach taken has allowed the secondary research and assumptions made in the planning phase to be rigorously and repeatedly tested. This section discusses how the findings answer the research questions prosed above and the implications of these answers.

### What level of computer literacy can realistically be expected from interested amateurs?

The levels of computer literacy exhibited by the attendees of ‘In the Making’ events matched or possibly exceeded those identified by the survey conducted at the launch event. Few struggled with general computer operating tasks and a large number arrived having installed the software on their own laptops. This factor allowed the technical facilitator to focus the limited time available on teaching the CAD software, rather than helping attendees struggling with lower level IT issues. It is expected that individuals who are interested enough to enrol in and attend a 3d printing workshop, share an interest in other technical and technological areas. This predilection results in a cohort far better equipped with ICT skills than could be expected from the broader public. As a result of this finding, it is possible to assume a competent operating knowledge of computers when delivering future training of a technical nature.

### What 3d data is required to interact with 3d printers on a basic level?

The hype surrounding 3d printing suggests that ‘if you can imagine it you can make it’ (Flanders D. 2011 and Moorefield-Lang 2014). Superficially, any 3d model can be exported into an .STL (stereolithographic) file, imported into ‘slicing’ software (*Cura*) and exported to a 3d printer. Few of these objects will successfully print, especially on an FDM (fused deposition modelling) printer, the technology that comprises all but the highest-end units. The factors affecting what will and will not print are contingent on the technology, size, make and model of printer and the material to be printed.

Whilst the technical facilitator (the author) is a veteran designer and expert in many manufacturing methods, 3d printing is a new endeavour for him. As the other members of the team have no manufacturing experience at all, the group as a whole is made up of novice 3d print users. This contributes to why the project has been producing two categories of object:

1. Variations on objects proven to work: key fobs, bracelets, plaques etc.
2. Other custom objects with a high failure rate, even when the team follows the approaches that they believe should maximise the object’s ‘printability’.

This knowledge gap will be addressed as the group gains experience and knowledge however, until that point they will only have incomplete expertise to impart to attendees. It is likely that other factors contribute to this problem: the type and model of printer; printers being moved to new locations for each session and the stability of the tables on which the printers are placed. The inexperience of the group prevents these and other unknown factors from being adequately addressed, compounding the problem.

### What are the key skills required to create 3d models suitable for printing?

There are two fundamentally different answers to this question: the level of skill required to produce a ‘knick-knack’ is an order of magnitude lower than those needed to produce an object of any practical use. Almost every attendee who designed a geegaw managed to complete at least one object and have it printed to take home (other than on the second, heavily oversubscribed session when many objects were printed after the event). In stark contrast, no attendees independently completed the design of a practical object at the session. Those assistive, practical objects produced were modelled by the technical facilitator, working closely with attendees.

This divergence of outcomes highlights differences between basic CAD *skills* and design *knowledge*. Imparting basic *Sketchup* skills has proven realistic within the short time allowed by the project, which is all that is required to model a simple trinket. In contrast, developing the knowledge required to design functional objects takes years of study and experience.

### What is the best way to impart effective 3d modelling skills in a quick and engaging way?

In response to Jennings’ (2011) 70:20:10 principle (*see above)* the formal ‘taught’ section of the course was kept as brief as possible, ranging from 15 to 30 minutes. This range puts the taught proportion of the course at between five and ten per cent of the five hour session. It is more difficult to quantify the ‘mentoring and expert support’, as this varied dramatically between individuals. Some people required little input and only requested help a handful of times in the day, whereas others made little progress on their own and relied heavily on technical help. The second group were disproportionately those attempting to develop an assistive object rather than just a souvenir, reinforcing the ‘skills verses knowledge’ factor discussed above.

As Jennings’ 70:20:10 principle was adhered to throughout the project, it is not possible to state that it is the *best* approach, having not been tested against alternatives. It is possible however, to conclude that it was an effective and engaging way to introduce beginners to CAD software. It did not prove as successful at imparting design knowledge in the short time available, which is an unrealistic expectation whatever approach is used.

### Age

One of the key factors when designing a training approach, as specified by Andrew Goose, is the age of the cohort. As the course was aimed at everyone identifying as disabled, it was not possible to pitch the offering at a particular age range. There was no discernable difference in outcome between the different age groups, suggesting that the approach was broadly appropriate. However, if subsequent sessions are to be delivered to a specific age group, this factor should be revisited. As the interview with Mr Goose was conducted after the launch event, no age data was logged as part of the survey.

### Group size

In chronological order the number of attendees was 4, 15, 3, 6 and 8. It was invaluable to start with a small group, allowing for a less intensive first trial of the course content. The second session (due to the venue not communicating bookings to the project team) was vastly oversubscribed. Whilst this imposed a great deal of pressure on the staff, the positive feedback from attendees indicated that the session was a success. Whilst it was very challenging, the oversubscription proved useful in developing the teaching approach, demonstrating that increasing numbers dilutes the attention that each attendee can receive. It may have been more helpful to ‘stress test’ the approach on a later session however, it would be unfair on the attendees to intentionally overload the facilitator. The final two sessions were an ideal size, with the attendees all receiving appropriate levels of support. As noted above, attendees who brought carers imposed less of a burden on staff time than those without. Consequently, for future sessions carers should not be formally counted as ‘attendees’.

### Disability

It was made clear in the aims and objectives that the attendees’ disability was incidental to the project. It would however, be remiss not to discuss its impact, especially as this piece will be used as a consultation document for planning subsequent project phases. The impact of the attendees’ disabilities on their participation ranged from ‘none’ to ‘significant’, with the most significant caused by severe physical challenges and learning and communication difficulties. Counter-intuitively, those with communication and learning disabilities required markedly less technical assistance than those with physical issues. The first group frequently attended with carers and had far more limited expectations than their physically disabled classmates. The non-technical staff members were also frequently able to assist this group. The second group arrived with higher expectations, often hoping to make assistive objects (Greg and Lorna both arrived with a portfolio of devices and objects they wanted to develop). As a result, this group required a far greater level of technical input and infrequently completed their practical projects.

A non-disabled attendee is less likely to have niche needs than the physically disabled who are frequently poorly served by mass manufacturing. Consequently, they are likely to be more frequently satisfied by producing knick-knacks rather than having a specific object in mind. The evidence for this is not overwhelming however, being based on the limited experience to date of the able-bodied team members, who have shown no inclination to make their own objects.

### Time

The technical portion of the course took place on the second day, running from 10:00 to 15:30 with a half hour lunch break. At every session those participants who designed non-practical trinkets completed their designs and on every occasion (other than the oversubscribed second session) left with their printed object. As discussed above, attendees with more ambitious projects only completed them with intensive technical help. This repeated result demonstrates clearly what content can be delivered in the five hours assigned to the project. As the attendees were not working on an assigned project, the more confident attendees did not finish their designs first, they simply completed more complex designs to the same time scales as their less confident classmates.

### In the Making

The aims of this project remained complementary to those of ‘In the Making’ throughout. Philip Connolly, Dr Taylor and Dr Hurley were consistently helpful and supportive. They were keen to provide as effective a course as possible for the attendees. To this end they were sent drafts of the reflections (*above*) and responded with their constructive feedback. As a result, the iterative process by which the course was developed was collaborative and included diverse perspectives. Phillip Connolly has concluded that he considers the project a partial success as we have struggled with the attendees more practical projects.

# Conclusions

This paper describes the successful development, and the single implementation of a course ‘engagingly introducing lay-people to 3d modelling for printing’. There is further work to do before this course can be ‘packaged’ in order for it to be implemented by any suitably qualified design tutor. However, the research performed includes all of the elements required to develop this ‘package’.

To reiterate, the project’s objectives are:

* **Format**: What type of delivery would be most effective for a very diverse group of novices? How best to maintain engagement and ensure optimal retention.
* **Content:** What skills and knowledge must be imparted to satisfy the projects aim?

The objectives have been achieved as follows:

### Format/ Content

Over the five instances of the course delivered, the initial ‘prototype’ course was iteratively refined into the format detailed in *Appendix 11: Course schedule*. The reasons for these choices are elucidated below:

#### Setting up

On every session there were issues to resolve prior to beginning. These included rearranging the room to enable the participants to plug in their laptops, connecting to projectors, buying mice and batteries, requesting seating suitable for a particular client’s needs and even finding change for parking meters. It proved essential to allow at least half an hour for addressing these unforeseeable factors as well as setting up the presentation.

As many of the attendees did not know one another it was a useful ‘ice-breaker’ to have a 3d printer working when they arrived. This also saved time explaining how the technology works as it is largely self-explanatory and therefore engaged and enthused the attendees.

#### Introduction

Prior to delivering the actual content it was apposite to formally begin the event and explain the structure of the day. Dr Hurley called the session to order and introduced the team before handing over to the facilitator. In order to convey context and credibility to the facilitator, their introduction included a brief description of the type of design they normally undertake. The author listed some prestigious clients that attendees were likely to be aware of. This instilled confidence in the attendees and therefore conveyed that the facilitator would not struggle with their design ideas. The facilitator also explained how he was involved with the project, although this seemed a little less interesting to the attendees.

In the early sessions the attendees were given a brief tour of a detailed *SketchUp* model of the facilitator’s home; this was dropped in later sessions as it was felt that it intimidated the participants.

This introduction was followed with a brief outline of how the day was to be structured. It was presented at this point as the attendees were settled. It gave them an opportunity to address concerns prior to the demonstration in order that they could focus.

#### Demonstration

The demonstrations began with a brief description of the chosen CAD tool *SketchUp*, explaining that it is a simple 3d design package suitable for amateurs but also a widely adopted professional tool used primarily by architects and interior designers.

This was followed by a practical demonstration, introducing the attendees to all of the basic features that they would need to use in order to make their first model to print. This is only a small sub-set of the tools that *SketchUp* offers (*see Appendix 8: SketchUp reference card*). It was clear that any more detail than this would overwhelm novices.

* **Draw a rectangle:** explain that everything is made from lines and vertices.
* **‘Pull’ into a cube:** explain about faces (delete a face then replace it).
* **Navigation:** Show how to navigate the 3d space, mentioning the importance of the scroll wheel on the mouse. This was one of the main stumbling blocks.
* **Axes:** Explain what these and other objects on screen are (many attendees were confused by these and tried to delete them).
* **Draw on surface:** use the push tool, circle, rectangle and move.
* **Scale:** Explain that the scale they draw to is not important for creative objects, as the object can be rescaled prior to printing but that scale is very important for practical objects.
* **Dimensions:** Show how to force a line, circle and rectangle to be a specific size, for those intending to make a practical object.

Scale, Dimension and Axes were added to session three as participants were getting stuck and confused about these elements in the earliest sessions.

Whilst the presentation was in progress other team members ensured:

* The attendees own laptops had a working version of *Sketchup* installed.
* All the attendee’s specific needs were dealt with. These included assigning mice, laptops, supportive seating and any assistive devices needed.
* That everyone could see and hear the demonstration. Some attendees needed to sit close to the presentation screen, see the presenter’s mouth in order to lip read or see their sign-language interpreter as well as the presentation.
* The environment was comfortable for everyone, addressing temperature, light levels, glare from window, drafts etc.

When drawing the demonstration to a close, the participants were encouraged to ‘play’ with the software, familiarising themselves with all of the tools demonstrated. Participants who did not heed this advice frequently focussed on one tool and subsequently required help as they forgot how to use the other tools.

In line with Jennings (2011) 70:20:10 principle advocated by Goose (*see interview above*), the introduction and demonstration section was kept to less than ten per cent of the total course time. In practice this section took roughly 20 minutes and attendee engagement was maintained.

*(See appendix 10 for a recording of the introduction to the final, Start in Salford session)*

#### Workshop

Throughout the workshop section, during which the attendees work on their own projects, the facilitator’s main role is to circulate, responding to requests for help from the attendees. If they are stuck then it is important to guide them towards working out the solution for themselves. This approach encourages the participants to solve their own problems; if they work the solution out themselves it is far more rewarding than the expert stepping in. If this approach fails, particularly if they find themselves in a very complex tangle (a frequent occurrence even with CAD experts) then one must intervene and fix their problem, explaining what is being donw and what caused the problem. This will help them to avoid getting stuck in the same way again.

It is imperative to pay attention to all of the attendees. Frequently the quieter attendees are reticent in requesting help, instead waiting for it to be offered. Similarly, it is important to avoid being monopolised by the more confident and vocal members of the group as this will lead to neglecting those who are less confident.

It is also vital to take care not to overload the attendees, remembering that they are taking in a lot of new information.

#### Printing

Participants require quite a lot of assistance once they are ready to print; each model took roughly ten minutes to prepare. The process is as follows:

* **Check:** When attendees are ready to print their object, inspect the model for holes, flipped face, orphan geometry or features that will prove difficult for the printers. Explain the process.
* **Optimise:** Some objects required adapting to make them quick and practical to print, most frequently adding voids within the part.
* **Scale:** Check with the attendee if there is a particular size they want their object prior to scaling it to fit the print bed.
* **Slice:** Save the file as an .STL and open in the slicing software, explaining that this converts their model into a tool path for the printer. Save the file onto an SD card.
* **Colour:** Encourage the attendee to pick a colour of filament to print their object and show them how to change the filament on the printer.
* **Print:** Ask attendee to insert the SD card into the printer and select their model to print. Explain that the printer needs to warm up, which is why nothing happens for a few minutes.

Where practical, participants were encouraged to perform as much of this process as possible, consistent with the learning style shown by the questionnaire data. Involving the attendees in operating the printer will equip them to take advantage of the facilities at Fab Lab, whose staff are very helpful but overwhelmed at busy times.

Whilst the attendee’s models are printing they should be encouraged to monitor the printer and alert the team if their print is failing. Tell the attendees that their prints will be hot when they are finished and not to try to remove them from the bed themselves.

#### Closing the session

Usually attendees will start modelling something else whist their model prints. At the end of the session make sure that they can take their files with them on a USB key, e-mail or saved on their own laptop. If attendee’s prints are not finished when they leave, take their address and send it on once it is complete.

#### Additional observations

Clearly elements of this programme are specific to a mobile course involving 3d printers but most should prove relevant to anyone introducing novices to 3d design.

Throughout the introduction it is important that the attendees feel comfortable asking questions and requesting clarification, because if they lose track of what it going on they are likely to feel very lost when it is time to begin using the software. It is also important to maintain some levity, as without this the process can feel intimidating for attendees, few of whom have seen CAD before.

### Supporting factors

There were a number of aspects of the course specific to its delivery within ‘In the Making’. These factors are discussed below:

#### Target group

Whilst the project was open to everyone ‘identifying as disabled’, it was clear from the launch event onwards that those interested in attending were more technically savvy than average. This is supported by the high levels of confidence with basic IT reported by respondents to the survey as contrasted with both Foggarty (2001) and Wilkinson’s (2010) findings. This enabled everyone to focus on the task at hand rather than struggling with more pedestrian computer issues.

No age data was captured either as part of the sign-up process or at the events. Consequently, any discussion of attendee age is based on the author’s subjective impression. With this proviso, there were a few impressions worth sharing. The average age of the attendees appeared to be mid-forties; those with learning difficulties were generally a good deal younger than this. There was no obvious correlation between attendee age and their IT literacy. Finally, those with physical disabilities who appeared to be of working age were the most likely to design assistive objects.

As with age, no data was gathered on the nature of attendee’s disabilities; it was felt to be both invasive to ask and the team lacked the knowledge to interpret this data in any but the most superficial way. There were a broad range of disabilities represented, encompassing many different learning, communication, sensory and physical difficulties.

This wide range of learners allowed the course content to be tested in a far more rigorous way than with almost any other approach. This has led to true inclusivity. Everyone can benefit from the course from a deaf man with learning difficulties to a wheelchair-bound company director with very limited dexterity - both finding the second session rewarding.

#### Venue

The team running ‘In the Making’ went to great pains to ensure the suitability of the course locations. As the Policy and Communications Manager of *Disability Rights UK*, Philip Connolly is exceptionally well qualified to assess venue accessibility. When combined with the exhaustive audit the team conducted on proposed venues, the project was provided with a consistently high standard of venue. The initial venue was a little cold upon arrival and Wi-Fi was not available at every venue. Other than these minor niggles, this aspect of the project ran smoothly. The essential factors to consider when choosing a venue are:

* **Seating and tables:** Sufficient comfortable and ergonomic seating, given participants will be seated for extended periods of time.
* **Power:** To charge laptops, run 3D printers and, vitally, to make hot drinks.
* **Accessibility:** Both to and within the building, for those with disability or infirmity.
* **Security:** In order to leave equipment at the venue overnight or at lunchtime.

#### Equipment

A substantial quantity of equipment is needed to successfully deliver the course described above:

* **Pencils and paper:** Most designers (amateur and professional) prefer to begin the design process on paper.
* **Laptops:** One should not assume that every attendee owns, or is willing to bring, their own computer. Many own a desktop computer and one attendee owned a laptop but was not able to carry it around as an able-bodied person could. Where possible, the laptops should have large bright screens to accommodate both those with impaired sight and older attendees, whose eyes are likely to have lost accommodation (the ability to focus unaided on near objects). In practice, a little less than half of the attendees brought their own laptops.
* **Mice:** All the major CAD design software uses the middle mouse wheel for zooming and orbiting the model. It is possible to operate the software using a track-pad but this is very limiting and will compromise their experience. Very few of the attendees brought a suitable mouse with them. As these are available very cheaply, it is advised that the facilitators provide a mouse for every participant.
* **Software:** *Sketchup* and *Cura* are essential; *Photoshop*, a web browser and *Solidworks* are helpful.
* **3D printer:** The *Ultimaker II* printers (which are entry-level professional FDM machines) used by the project were suitable for purpose. A ratio of one printer per four attendees worked well.
* **SD card:** For transferring the ‘sliced’ files onto the printer/s.
* **USB key:** Useful for both installing *Sketchup* onto attendees’ computers and also for moving files between machines for ‘slicing’, tidying up etc.
* **Projector:** It is impractical to present to more than about four people using a laptop screen, especially if any have sight problems. ‘In the Making’ did not have a projector, the lack of which was keenly felt. It should be considered essential for phase two.

#### Facilitator

It is not possible to draw objective conclusions on the traits required for a successful facilitator with any academic rigour, as the author led all of the technical facilitation. The author’s subjective impression of the traits required are:

* Mastery of software.
* A facility to explain technical information to non-technical people.
* Patience.
* Enthusiasm.
* Empathy.
* An interest in the attendees and their projects.

These conclusions should be treated only as opinion, rather than invested with any objective credibility.

## Critique

It has been more difficult than expected to assist the attendees in making practical objects as teaching even the rudiments of design has proven unrealistic in the time available. It is clear that if subsequent projects are to deliver practical results then a very different approach must be taken. This approach must either take the form of a longer term programme of sessions (in which attendees develop their own design knowledge, supported by expert tuition) or attendees must have the individual attention of an experienced designer who can lead them through the process.

The ideal scientific method of enquiry is the double-blinded, randomised controlled trial (IAN 2015). As this research was carried out under the auspices of ‘In the Making’, we were obliged to deliver a functional course to all attendees; as such this ‘gold standard’ approach would not have been ethical. This is frequently the case with studies in the ‘softer’ social sciences. Whilst not ideal, it is simply unethical to treat volunteer attendees as guinea pigs, delivering what one believes to be a worse ‘session’ in order to collect rigorous data.

Project aim is:

To engagingly introducing lay-people (the ‘99%’ who are not professional designers) to 3d modelling for printing.

The course developed has been a qualified success. The project has introduced thirty complete novices to 3d modelling; the vast majority of whom took a 3d print of their design home with them. There has been overwhelmingly positive feedback from attendees; the only dissatisfaction expressed being a desire to spend more time with CAD (the second day of the workshop delivered by the author) than with the more creatively focused first day.

Whilst not fundamental to the premise of this research, the disabilities of the attendees enabled the development of a far more inclusive approach.

# Recommendations

The recommendations for subsequent stages of ‘In the Making’ are stated below. The next stages for the author are detailed in the afterword as they are of a more personal nature.

## ‘In the Making’: Further research

‘In the Making’ will be seeking both follow-on and phase two funding due to high levels of interest that were evidenced by over-subscription and repeat attendance. The project also uncovered real shortcomings in the assistive technology marketplace, evidenced by the thirst for tailored and custom designs shown by the participants with physical challenges. The exact nature of these proposals is under discussion at the time of writing.

The follow-on project is likely to be a much more intensive, individual form of the initial project. It is proposed that a number of disabled people will be recruited from phase one. They will individually be given access to a design professional for an extended period of time in order to develop an assistive product far more fully than has been possible for phase one.

Phase two is a little more distant and thus more indistinct and will be shaped by the 26th January 2016 meeting with the Parliamentary Under Secretary of State for Disabled People, Justin Tomlinson MP. The current aspiration for phase two is that it should be on a far larger scale and deliver the best and most effective aspects of phase one to a far wider swathe of the disabled community. This paper has a number of proposals for phase two of ‘In the Making’ to be raised at the next management group meeting (*agenda in appendix 4e*):

* A mobile *Fab Lab* model as delivered in phase one with the addition of an escalation route in which an individual with an assistive technology need is paired with a dedicated practising designer for a more substantial period of time. This will allow their concept to be developed into a working prototype.
* Form partnerships with university product design and engineering departments and develop a module in which each student is assigned a person with an assistive technology need as a customer with a live brief.
* Develop and an entry level course in assistive technology design. This would be targeted at people identifying as disabled and would support them for a longer period of time to address their own needs as well as providing them with a qualification and the beginnings of a portfolio.
* To provide custom design services as an escalation path for *NHS* occupational therapists. This would require substantial efforts to raise the profile of the project but could potentially provide the most effective practical assistance. This approach will not satisfy the project’s aim of developing individual people with disabilities.

These proposals may not be consistent with the aspirations of the management team but will be presented for their consideration.

# Afterword

At the time of writing ‘In the Making’ is still running. I have a single session still to be delivered, a conference to help organise and follow-on planning to which I am contributing. As a result, my research will continue in concert with the ‘mother’ project. I intend to deliver a paper detailing the ‘packaged’ course and my experiences introducing people with disabilities to computer-aided design and 3d printing at this conference. I am keen to publish elements of my research in due course, possibly with one of the project team members.

I am excited to be meeting the [Parliamentary Under Secretary of State for Disabled People](https://www.gov.uk/government/ministers/parliamentary-under-secretary-of-state-minister-for-disabled-people), Justin Tomlinson MP, with Dr Hurly and Phillip Connolly on the 26th January. This meeting is to raise awareness of the project, gauge which way the ‘political wind is blowing’ and hopefully to garner support for phase 2.

In parallel with, this I will seek further opportunities to teach and to secure funding for further research. It is my intention to write a PhD on this, or an allied subject. This is dependant on securing funding as to do otherwise would shirk my responsibilities to support my family. This will serve my ultimate ambition of combining academic teaching and research with my professional practice.

I will need to address a number of skill deficiencies in order to deliver similar courses to the highest standards in the future:

* **3d printing:** There were many occasions, particularly when the shadow ministers visited, when my lack of expertise with 3d printers caused problems.
* **3d Scanning:** I must make a far more concerted effort to make use of 3d printing’s emergent sister discipline of 3d scanning. The project has thus far failed to take advantage of this technology, missing out on many ways by which our attendees could generate 3d data.
* **Managing expectations:** In future sessions I need to focus people on starting projects that they have a realistic chance of successfully completing. Too often I have encouraged attendees to pursue projects that are too complex for an absolute novice, which engendered disappointment and disillusionment.

Developing and delivering the training has been both interesting and rewarding and has done nothing to dampen my ambition to teach. Initially, the participant’s disabilities made me a little nervous as I had little contact with the disabled community. It took very little time to realise that the participants were just people like any other but for the few extra challenges they face. I feel that this realisation has made me a slightly better person.

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# Appendices

## Appendix 1: Research proposal

**Democratising 3d Design – Enabling the public to benefit from 3d printing.**

**Research Proposal - Joe MacLeod-Iredale**

**1. Objective of the Research**

This piece is a development of an earlier piece of research by the author entitled ‘Barriers to participation in 3d print making’ (MacLeod-Iredale, 2015). This research identified 3d computer modelling as one of the most significant barriers to participation for members of the public (other than broad socio-economic causes of disenfranchisement and disadvantage). This piece will develop and test a curriculum to introduce the layperson to generating 3d digital content.

Until recently generating 3d content has been the exclusive remit of professional designers and dedicated amateur enthusiasts (REF). With the nascent democratisation of 3d printing via organisation including the FabLab movement, the US library service and school design and technology departments the public are starting to be able to access the much vaunted and debated technology. Others can debate exactly how 3d printing may affect the public, it is however, clear that it will provide opportunities, especially for those with needs poorly served mass manufacturing. If the public are to benefit from these opportunities then they must be able generate 3d content confidently. 3d modelling skills can also be used for interior design, creating game assets, animation amongst others.

**2. Background/Review of the Literature**

Initial research uncovered little relating to levels of 3d modelling literacy amongst the public and described very low levels of general computer literacy. The modest literature relating to the adoption of 3d modelling outside the design professions is mainly companies such and AutoDesk and Timble respectively pushing their entry level product TinkerCAD to children interested in the maker community and Sketchup to amateur architects and interior designers.

Further in depth research is required to exhaust other avenues of enquiry to fully inform this piece.

Questions:

* What level of computer literacy can be expects from interested amateurs?
* What level of 3d modelling skill is required to interact with 3d printers etc. on a basic level?
* What are the key skills that will need to be imparted to gain these skills?
* How best to impart these skills in a quick and engaging way.

**3. Hypotheses and Predictions**

A description of the questions you are examining and an exploration of the claims. List the **specific** question(s) that you are exploring.

* What level of computer literacy can be expects from interested amateurs?

It is critical to understand the level at which the people will be. The pitch ‘training’ too high will leave trainees lost and overwhelmed, too low will leave them disengaged and frustrated.

* What level of 3d modelling skill is required to interact with 3d printers etc. on a basic level?

The aim is to get people to a stage where they can see meaningful results which will hopefully enthuse them to develop their own skills further. If a the ‘training’ is too comprehensive prior to the ‘trainees’ having a pay off to their efforts then attrition will likely be high and the resources that must be dedicated to their training may be prohibitive.

* What are the key skills that will need to be imparted to gain these skills?

As there will be limited time in which to deliver the ‘training’ it is crucial to focus on the elements that will enable the ‘trainees’ to gain the most benefits. To this end it is important to understand the process of idea 🡪 3d print in some detail.

* How best to impart these skills in a quick and engaging way.

The final stage is how best to deliver the above skills, finding the right balance of time spent per learner and the best way to ensure that people are engaged and enjoying the process.

**4. Method and Design**

The research will use the ‘In the Making’ project as a platform for the research. ‘In the Making’ is a pilot initiative or Disability Rights UK and Salford University bringing 3d printing workshops to interested disabled people in Salford.

The fact that the group will consist of disabled people is not significant to this research; they are simply a convenient group of interested amateurs. However, they are likely to manifest a wider spectrum of difficulties than a cross section of the broader public, allowing for more rigorous testing of the approach developed resulting in a far more inclusive end result.

* Initial contact will be made with the cohort at the launch event of the project where a brief survey of skill levels, expectations and specific areas of interest will be conducted. This will be collated with the data collected by the events organisers.
* These findings will be digested and synthesised with deeper research into a prototype approach.
* This approach will be delivered to the first ‘In the Making’ workshop.
* The approach will be iteratively improved using subsequent ‘In the Making workshops’, gaining informal feedback where possible.
* All the finding will collate into a final report.

**5. Significance and Conclusion**

This research hopes to develop a non-intimidating way to engage with basic 3d design for the layperson, primarily so they can benefit from the opportunities presented by widening availability of 3d printing.

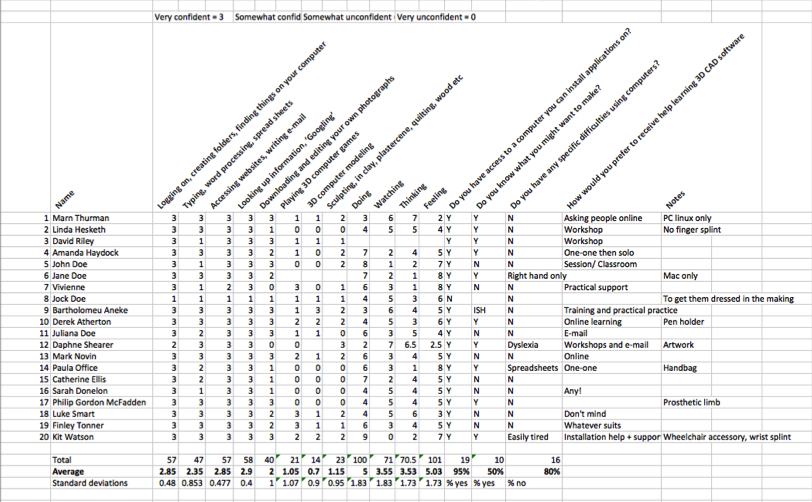
The project will be of immediate benefit to people taking part in the pilot stage of the ‘In the Making’ project and to a wider rollout that may take place. It should also be of use to those using organisations such as FabLab, American public libraries and others offering public access to 3d printers. It may also offer insight to educators and those developing entry-level 3d modelling software.

## Appendix 2: Launch event questionnaire

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Name | | |  | | | | |
| **Computer confidence** | | | **Very confident** | **Somewhat confident** | **Somewhat unconfident** | **Very unconfident** | **NA** |
| Logging on, creating folders, finding things on your computer | | |  |  |  |  |  |
| Typing, word processing, spread sheets | | |  |  |  |  |  |
| Accessing websites, writing e-mail | | |  |  |  |  |  |
| Looking up information, ‘Googling’ | | |  |  |  |  |  |
| Downloading and editing your own photographs | | |  |  |  |  |  |
| Playing 3d computer games | | |  |  |  |  |  |
| 3d computer modeling | | |  |  |  |  |  |
| Sculpting, in clay, plastercene, quilting, wood etc. | | |  |  |  |  |  |
| Circle either **"Doing"** or **"Watching"** below, depending upon the part of the statement you most closely relate to . | | | | | | | |
| **Doing** - I often produce off-the-cuff ideas that at first might seem silly or half-baked. **Watching** - I am thorough and methodical.  **Doing** - I am normally the one who initiates conversations. **Watching** - I enjoy watching people.  **Doing** - I am flexible and open-minded. **Watching** - I am careful and cautious.  **Doing** - I like to try new and different things without too much preparation. **Watching** - I investigate a new topic or process in depth before trying it.  **Doing** - I am happy to have a go at new things. **Watching** - I draw up lists up possible courses of actions when starting a new project.  **Doing** - I like to get involved and to participate. **Watching** - I like to read and observe.  **Doing** - I am loud and outgoing. **Watching** - I am quiet and somewhat shy.  **Doing** - I make quick and bold decisions. **Watching** - I make cautious and logical decisions.  **Doing** - I speak fast, while thinking. **Watching** - I speak slowly, after thinking. | | | | | | | |
| Circle either **"Thinking"** or **"Feeling"** below, depending upon the part of the statement you most closely relate to. | | | | | | | |
| **Thinking** - I ask probing questions when learning a new subject. **Feeling** - I am good at picking up hints and techniques from other people.  **Thinking** - I am rational and logical. **Feeling** - I am practical and down to earth.  **Thinking** - I plan events down to the last detail. **Feeling** - I like realistic, but flexible plans.  **Thinking** - I like to know the right answers before trying something new. **Feeling** - I try things out by practicing to see if they work.  **Thinking** - I analyze reports to find the basic assumptions and inconsistencies. **Feeling** - I rely upon others to give me the basic gist of reports.  **Thinking** - I prefer working alone. **Feeling** - I enjoy working with others.  **Thinking** - Others would describe me as serious, reserved, and formal. **Feeling** - Others would describe me as verbal, expressive, and informal.  **Thinking** - I use facts to make decisions. **Feeling** - I use feelings to make decisions.  **Thinking** - I am difficult to get to know. **Feeling** - I am easy to get to know. | | | | | | | |
| Do you have access to a computer you can install applications on? |  | Do you have any specific difficulties in using computers? | | |  | | |
| Do you know what you might want to make? |  | | | | | | |
| How would you prefer to receive help learning 3d CAD software |  | | | | | | |

## Appendix 3: Launch event data

(Also available via link in appendix 10)



### Appendix 4: E-mail correspondences

Below are the key correspondences dealing with the authors’ contribution to the ‘In the Making’ project:

#### 4a: First session feedback from Dr Ursula Hurley

On 10 Sep 2015, at 13:46, Hurley Ursula <U.K.Hurley@salford.ac.uk> wrote:

Hi Joe,

Everyone was delighted with what you did last week. I think the thing to consider is how we will cope with more people – there are 8 participants potentially signed up for next week’s session. It was clearly the individual attention that helped Lynda’s fantastic outcome with the splint.

Perhaps we could begin day 2 with an introductory discussion about what you do, and what designs people have in mind?

Fiona will be there to help, and she’s hoping that one of our technicians will also be allowed out for the day, so potentially there’ll be 3 people equipped to give expert support. I’m certainly happy to talk to people and offer non-expert support. But we can think about whether we need to increase the number of facilitators for future sessions.

Also worth noting that two of the participants are Deaf and will communicate via their support worker.

Also, shall we ask Fiona to bring her projector so that people can see what you’re doing on screen?

Do shout if you’d like to discuss anything. I’m on leave until Tuesday but you can get me on 07933 718172.

All the best,

Ursula

Dr Ursula Hurley

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t: +44 (0) 161 295 2851

Email address | [u.k.hurley@salford.ac.uk](https://uos-portal.salford.ac.uk/owa/redir.aspx?C=919406b100e549629cfabcb156f2ad61&URL=http%3a%2f%2fwww.salford.ac.uk)

<http://www.seek.salford.ac.uk/profiles/UHURLEY.jsp>

#### 4b: 2nd Session feedback from John Abbott

From: John Abbott [[abbottjohn77@gmail.com](mailto:abbottjohn77@gmail.com)]

Sent: 17 September 2015 18:55

To: Hurley Ursula

Subject: 3d Printing Project

Hi Ursula,

I would like to say a very big Thank you to you and the Team.

Today has inspired me to progress my deflated creativeness. Having a non visual disability can't half get in the way and stop the things we aspire too... but todays atmosphere lifted me, everyones creative juices were flowing. The relaxed atmosphere and informative tuition was sublime... it helped me interact with people on all levels, sharing ideas and inspirations. Joe was amazingly helpful, this guy deserves a medal (Thanks Joe). I would most certainly recommend this project and would defiantly attend future programs like this. Thank you so much.

Could you please forward Fiona's contact details. She was ever so helpful and inspiring.

And If possible could I have Joe and Phillips email address those too would be great to keep in touch with and maybe the typographer chap you talked about. It'd be great if I could meet with him.

I have attached the skp files below and will try and make a trip over to FabLab as you suggested. Sounds like a really cool place.

Hope to see you again

Kind regards

John Abbott

#### 4c: Communications with Katie Parker

The majority of the communications with Katie were informal phone conversations, see the e-mail exchange below:

From: macleod.iredale@googlemail.com

Subject: Re: 'In the making' project

Date: Fri, 16 Oct 2015 12:37:58 +0100

CC: n.x.taylor@dundee.ac.uk

To: kpparker@live.co.uk

Afternoon Kate,

As long as your readers can cope with such a detailed shot of my ears then your welcome to use it!  I’d describe myself as a 'retail design consultant', my company is called Daedalus Design and my most recent projects have been for Harrods, Adidas, John Lewis Anoushka and Christian Laboutin.  'In the Making' is the subject of my Design Management Masters thesis, in which I am developing an approach to delivery of entry level CAD training to people with a range of disabilities.  Lynda’s project was to produce a brace to support a weak finger joint - her hands are too small for any of the off-the-shelf’ braces  (including the Oval-8) to fit so we modelled one to her measurements in a CAD package called Sketchup and printed it out on the Ultimaker 3d printer.  Nick or Ursula may have photographs of the finished brace they could send over.

Let me know if there is anything else I can help with,

Joe.

On 15 Oct 2015, at 15:02, Kate Parker <[kpparker@live.co.uk](mailto:kpparker@live.co.uk)> wrote:

Hi Joe,

Nick Taylor has emailed the attached photo of yourself to me to use with an article I'm writing for the Institution of Engineering & Technology E&T magazine website about the 'In the making' project.

Are you happy for me to use it? If so, can I just check some info? - you're a product designer, a professional practitioner as well as a masters student, is that right? Can I say where you work and where you're studying?

Also, did you help Lynda Hesketh with her finger splint prototype? I wondered if you could briefly describe the process (literally a few sentences so I get the gist!). I've attached another image, from Lynda's project - is Oval-8 the name of the product?

Thanks for your help.

Kind regards,

Kate Parker

Freelance Journalist

07787815066

#### 4d: E-mail exchange with Rob Roberts

Rob, Sue,

My name is Joe, I have been providing technical facilitation for the In the Making project.  I should really have contacted you earlier, I have been a little distracted with family Christmas, running my business and my masters thesis is due in two weeks.

I am delighted that your interested in helping out - if we have learnt anything from the project so far it is that the more technical expertise we have then the more we can help people.  Perhaps we should aim to get the Salford session a little early so we can say hello and work out how best to use your help.

I can really empathise with the struggle to get into design, it took me a good few months to find my first role and I had to relocate to take it.  All I’d suggest is to put together a good portfolio, start networking (start with connecting with me on LinkedIn) and keep designing to your own briefs.  If you have a portfolio then I’d love to see it.  When you do manage to get into a design role it is a very satisfying way to make a living!

Anyway, I’ll see you in a couple of weeks,

Joe.

Dear Sue and Rob,

You are most welcome to attend our 14th - 15th January course. We are always in need of people with the skills to support our participants as they take their first steps in 3d design.

Please sign up here:  <http://www.inthemaking.org.uk/salford-events/>

We look forward to meeting you then, and we will indeed keep Rob in our plans for further developments with the project.

Very best wishes,

Ursula

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

From: Susan Roberts [[sue.roberts.eu@btinternet.com](mailto:sue.roberts.eu@btinternet.com)]

Sent: 25 November 2015 10:40

To: Hurley Ursula

Subject: Re: Interested

Dear Ursula,

Thank you so much for replying, and Rob thanks you too.

He apologises that he won't be able to attend this week as I've talked him into taking advantage of a job application support course at his Uni. He would however be very interested in coming along in January.

He was very heartened by your email, and we too wish we'd heard about you earlier as it's right up his street! Oh well, if you can, as you mentioned, keep Rob in mind for the future, that would be great!

If you could, when you can, email details of the January dates, I will share this with Rob.

Again, our thanks,

Sue and Rob.

On 24 Nov 2015, at 14:43, Hurley Ursula <[U.K.Hurley@salford.ac.uk](mailto:U.K.Hurley@salford.ac.uk)> wrote:

Dear Sue,

Many thanks for your message - I'm delighted that news of our project has reached you and Rob.

We would love to involve Rob in whatever way works best for him. Unfortunately our practical making sessions are coming to an end for this phase of the project. If only we'd heard from you earlier - we could have offered paid facilitation work for the whole of this stage!

However, we already have our facilitators in place but we would still welcome Rob if he wished to attend as an observer/helper.

These are the dates/venues still to happen:

25 & 26 November, 10 - 3, Swinton Gateway (tomorrow is short notice but if Rob could get there on Thursday he'd be most welcome). We can pay travel expenses.

14 & 15 January, 10 - 3, Start in Salford, Brunswick House, Salford Crescent

Following this, the project enters a period of evaluation, culminating in a celebration event at MediaCityUK in June 2016. Again, Rob is most welcome to attend that.

We are planning to bid for further funding to expand the work we're doing and we will bear Rob in mind for any opportunities that arise.

Very best wishes,

Ursula

-----Original Message-----

From: Susan Roberts [<mailto:sue.roberts.eu@btinternet.com>]

Sent: 23 November 2015 12:14

To: Hurley Ursula

Subject: Interested

Dear Ursula

I'm writing on behalf of my disabled son, Robert. He has asked me to contact you after  I shared with him the article published recently. Rob graduated from LJMU last summer, gaining a 2.1 in his BSc. Product Design Engineering. He has Aspergers, ADHD and dyslexia and has problems with laxity of joints. We are immensely proud of his achievements but also frustrated that despite all the barriers and hard work (and student debt!) he has been unable to get any work in his chosen field. He was most interested in the work you are doing and is proficient and knowledgeable (as a computer buff) in SolidWorks, 3dS Max, 3d Printing, Photoshop and Google SketchUp, as well as the product design, materials and manufacturing processes involved. He thrives on finding innovative solutions to people's everyday problems in an innovative and out-of-the-box way. His own comment was that, at last, a place where real things are made to happen, and they, unlike most, would understand my disabilities and talents.

Is there any way at all that Robert could somehow be involved in your work? The lack of application of his talents is leaving him in a worsening state each day, mostly because the whole routine and structure of his life ended with uni.

I'm sorry if I have contacted you inappropriately, but I hope you understand.

Kind Regards

Sue Roberts.

#### Appendix 4e: Agenda for ‘In the Making’ management group.

Dear Friends

I appreciate that we will meet at the final fab lab and I hope we might have a meeting of the reference group on the afternoon of the Friday to capture their input. I wanted to briefly touch on our meeting on January 26th.

Suggested schedule:

* Meeting with Minister of Disabled People Justin Tomlinson MP 10.30 to 11 am at Caxton House, Tothill ST, St James’
* Project evaluation to date against milestones – at Can Mezzanine 11.30 – 12
* Budget evaluation – Ursula 12.00 – 12.30
* Identification of costs committed to and budget available until June 2016
* Document lessons learnt
* Lunch 1 pm to 2 pm
* Conference planning 2pm to 3.30 pm
* Break
* Future collaboration - identifying USP
* Preparation for future bidding and what do we know regarding timetable, amount etc
* Finish – 5pm

Naturally this is a draft.

Please could you send me your thoughts especially for planning the 30 minute meeting at the beginning..

Today is my last day in the office.

Merry Christmas and a Happy New Year

Philip

## Appendix 6: Computer confidence questions

ICT skills

* I know how to create a folder
* I feel confident closing down a software program
* I do not feel confident attaching a file to an email
* I can use a word processing application
* I know how to save a document to a folder
* I would not recognise a PDF (Portable Document File)
* I would have difficulty finding a web site∗
* I feel confident making selections from popup menus∗
* I would find it difficult to search a database of references to journal papers
* I need help with using computers for learning
* I feel confident using a computer to write a letter or essay
* I do not know how to find an article in an e-journal

Experience with computers

* I have used computers at work/school∗
* I feel disadvantaged by my lack of experience with computers
* I communicate with people using email
* I have used computers to look for information for example: Library catalogue/books
* I have used computers to support my learning
* I have used computers to find out about careers
* I have used computers for leisure

From Wilkinson et al (2010)

The following statements refer to your confidence when using computers.

* I have less trouble learning how to use a computer than I do learning other things.
* When I have difficulties using a computer I know I can handle them.
* I am not what I would call a computer person.
* It takes me much longer to understand how to use computers than the average person.
* I have never felt myself able to learn how to use computers.
* I enjoy trying new things on a computer.
* I find having to use computers frightening.
* I find many aspects of using computers interesting and challenging.
* I don’t understand how some people can seem to enjoy spending so much time using computers.
* I have never been very excited about using computers.
* I find using computers confusing.

I’m nervous that I’m not good enough with computers to be able to use them to learn mathematics.

From Fogarty (2001)

## Appendix 7: Demographic groups

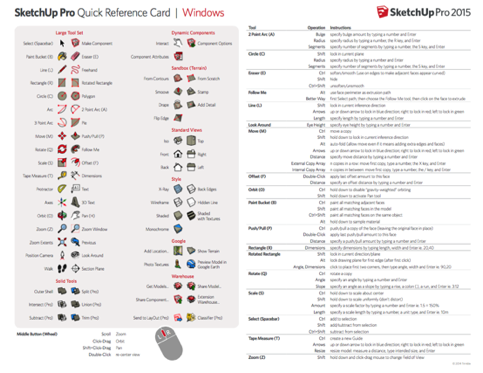
Demographic group as defined by birth year:

* Depression era :1912-1921
* World War 2: 1922-1927
* Post war cohort:1928-1945
* Boomers 1: 1946-1954
* Boomers 2: 1955-1965
* Generation X: 1966-1976
* Generation Y: 1977-1994
* Generation Z: 1995-2012

Schroer (2004)

## Appendix 8: *Sketchup* reference card

Acquired from <http://help.sketchup.com/en/article/116693>



## Appendix 9: Ethical consent approval

Macintosh HD:Users:Joseph:Library:Containers:com.apple.mail:Data:Library:Mail Downloads:C10E13E5-D6B4-482E-B59E-A14643877A00:Ethics formal letter - approval 140036.pdf

## Appendix 10: Link to supporting documentation

Follow the below link below to access a number of the key supporting documents and data impractical to add as appendices:

https://www.dropbox.com/sh/togmhztqbycxrr2/AACOJuZxpw5IZNAXms\_S-keTa?dl=0

## Appendix 11: Course schedule

* **Setting up (30 minutes):**
  + Arrive at least half an hour before the event is due to begin.
  + Set up the room so that attendees are able to plug in their laptops.
  + Connect presentation computer to a projector if available and queue up *Sketchup*.
  + Set the printers printing.
* **Opening (20-30 minutes):** Once the attendees have all arrived and settled, frequently some time after the scheduled start time, people are welcomed by another member of the team who hand over to the author for his introduction.
  + **Introduction:**
    - Introduce yourself.
    - Explain what you do for a living.
    - Explain briefly how you became involved with the course.
  + **Outline:** What we will be doing on the course – playing with *Sketchup*, designing something and then 3d printing it.
  + **Introduce *Sketchup:*** Explaining that it is a simple piece of 3d design suitable for amateurs but that it is also a professional tool used primarily by architects and interior designer.
  + **Demonstration of *Sketchup:***
    - **Draw a rectangle:** explain that everything is made from lines and vertices.
    - **‘Pull’ into a cube:** explain about faces (delete a face then replace it).
    - **Navigation:** Show how to navigate the 3d space, mentioning the importance of the scroll wheel on the mouse.
    - **Axes:** Explain what these and other objects on screen.
    - **Draw on surface:** use the push tool, circle, rectangle and move.
    - **Scale:** Explain that the scale they draw to is not important for creative objects.
    - **Dimensions:** Show how to force a line, circle and rectangle to be a specific size, for those intending to make a practical object.
* **Whilst the presentation is in progress:**
  + A member of the team ensures that all the attendees own laptops have a working version of *Sketchup* installed.
  + Ensure that all the attendee’s specific needs are dealt with. These could be for object such as assistive devices, mice, laptops, seats or practical considerations: Some attendees may need to sit close to the presentation screen or be able to see the presenters mouth in order to lip read. Even the temperature of the room can distract the attendees.
* **Workshop (5-8 hours):**
  + Encourage all of the attendees to go and play, cautioning against trying to design anything specific initially.
  + Circulate, responding to requests for help from the attendees. If they are stuck then try to guide them towards working out the solution for themselves. If this does not work then fix their problem, explaining what you are doing and what they did.
  + Pay attention to all of the attendees, frequently the quieter attendees are reticent to request help, instead waiting for it to be offered.
  + Try not to be monopolised by the more confident vocal members of the group as this well lead to neglecting those less confident.
  + Be careful not to overload the attendees, remember that they are taking in a lot of new information.
* **Printing (within later stages of workshop):**
  + **Check:** When an attendee is ready to print their object inspect the model for holes, flipped face, orphan geometry or features that will prove difficult for the printers. Explain what you are doing and why.
  + **Optimise:** Some objects may require adapting to make them quick and practical to print.
  + **Scale:** Check with the attendee if there is a particular size they want their object and scale so it fits the print bed.
  + **Slice:** Save the file as an .STL and open in the slicing software, explaining that this covets their model into a tool path for the printer. Save the file onto an SD card.
  + **Colour:** Encourage the attendee to pick a colour of filament to print their object.
  + **Print:** Get the attendee to put the SD card into the printer and select their model to print. Explain that the printer needs to warm up, which is why nothing happens for a few minutes.
  + **Observe:** Keep an eye on the printer and show attendees how to pause a failed print.
  + **Completion:** Make sure that attendees know that the print will be hot and not to try to remove it from the bed as soon as it is finished.
* At the end of the session make sure attendees take their files with them, on a USB key, e-mail or saved on their own laptop.
* If attendee’s prints are not finished when they leave, take their address and send it on once it is complete.
* **Packing up (20 minutes):** Ensure that the room is neat and tidy and that the furniture is returned to its’ previous positions before leaving.