CREATIVE CAPACITY BUILDING: ENHANCING PARTICIPATORY DESIGN WITH RURAL CAMBODIAN FARMERS

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ABSTRACT

The development of technology to address challenges faced by underserved communities in developing countries has become the focus of many engineers and designers in the Western world. However, to date, such technologies have not had the level of positive impact and long-term adoption predicted. Research shows this is due to contextually-driven factors not being taken into account, such as a lack of locally available materials and skills, harsh environmental conditions and a lack of buy-in from the community. Projects which include the community in the process of identifying and prioritizing the challenges they face, generating ideas and building prototypes, have been proven to be more effective at creating solutions that are accepted and maintained. This process, known as Participatory Design (PD), is growing in popularity. However, PD practitioners still struggle to facilitate true collaboration with communities with documented challenges focusing on communities having a lack of understanding of design, problem solving and creativity as well as a lack of confidence and motivation to contribute to a long-term PD project.

This study aims to resolve this challenge by utilizing knowledge from the field of Creative Capacity Building (CCB); an education-focused field that looks to improve an individual's ability to independently problem solve and innovate through structured, hands-on training sessions. Based on literature, a CCB programme was designed, to be completed at the beginning of a long-term PD project. This aimed to be succinct, engaging and socio-culturally appropriate to the specific community. A six-month, multi-case study was undertaken with several partner organizations in rural Cambodia. The study aimed to collaborate with rural people with disability, to create technology that improved their ability to engage in agricultural practices.

Results showed that the implementation of CCB positively affected the community's ability to contribute contextual insights to the project as well as their understanding of the design process and motivation to contribute. CCB was not found to improve the community's ability to critique existing designs or their ability to create prototypes, competencies that were already strong; nor their ability to generate ideas, a competency that was weak. Other findings included a positive relationship between the use of making-style activities and community motivation, an inverse relationship between group size and community ability to express opinions and a new conceptual model to describe the collaborative partnership between designer and community.

Keywords: participatory design; capacity building; agriculture; developing context; humanitarian technology development; humanitarian engineering

Summary of Publications

Four papers have been published and one paper is under review as part of the doctoral research presented in this thesis. Parts of all five papers have been integrated into relevant thesis sections.

Paper I:

Drain, A., Shekar, A., & Grigg, N. (2017). 'Involve me and I'll understand': creative capacity building for participatory design with rural Cambodian farmers. CoDesign, 1-18. doi:10.1080/15710882.2017.1399147

Paper II:

Drain, A., Shekar, A., & Grigg, N. (2018). Participatory design with People with Disability in Rural Cambodia: The Creativity Challenge. The Design Journal. doi:10.1080/14606925.2018.1488923

Paper III:

Drain, A., Shekar, A., & Grigg, N. (2018). Insights, Solutions and Empowerment: a framework for evaluating participatory design. CoDesign. doi:10.1080/15710882.2018.1540641

Paper IV:

Drain, A., Shekar, A., Grigg, N., & McCreery, M. (2018). The collaborative design of a low-cost, accessible rice seeder for rural Cambodia: Trade-offs and challenges. IEEE Catalog Number: CFP18GHT-ART. : IEEE Global Humanitarian Technology Conference

Paper V:

Drain, A., & Sanders, E. (2018, Under Review). A Collaboration System Model for Planning and Evaluating Participatory Design Projects. International Journal of Design.

Acknowledgements

I began this research journey as a commercial product developer, with little understanding of the world and little understand of how to collaborate with other cultures. I am thankful to say, I am now a participatory designer with *some* understanding of the world, and a great deal more understanding of how to collaborate with others. While this transformation may seem subtle to the outside world, it has been life changing, and I am extremely grateful for the opportunity.

This research documents the collaboration of dozens of individuals, both designers and community members, from New Zealand, Australia, Cambodia, the Netherlands, Poland and the United Kingdom. Thank you to all collaborators directly involved in my project work: Melissa, Longhan, Dalen, Khim, Sokmeas, Natalia, Nick, Nora, Emily, Sreypov and Virak. I am also grateful to the community of Kampong Tralach, Cambodia. Collaborating with them has been inspiring, eye opening and challenging. They welcomed us into their community and gave everything to the project, thank you. I am sorry we have not yet reached final, implemented solutions; this will be my focus in the immediate future.

Agile Development Group, Light For The World and Engineers Without Borders Australia have all been important partners throughout the project. The support I have received from their staff, in the Netherlands, Australia and Cambodia has been invaluable. I have been welcomed into a network of diverse practitioners and have received opportunities I could not have imagined at the beginning of this journey. Thank you for all of the discussions about humanitarian engineering, ethics, community development, participatory design and life in general. While it is too difficult to name you all, I would like to make special mention of Ian Jones, David Curtis, Alanta Colley, Jenny Turner, Bianca Anderson, Nick Brown and James Ayers. You have all helped to shape this research and I am very grateful for the support.

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To Georgie – thank you for your constant support over the past three and a half years. Thank you for enduring months of time apart, and even encouraging me to travel to other countries to work and learn. Your kind, adventurous nature has kept me grounded and ensured I still took time away from my work to enjoy our life together. Thank you for not getting too angry when I drifted off into my thoughts or checked emails at 11pm. We are a team, and this research belongs to both of us.

Thank you to everyone I have worked with along the way. I am the product of my experiences, and this research reflects the journey we have travelled.

List of frequently used abbreviations

PD	Participatory Design
HTD	Humanitarian Technology Development
HTD-using-PD	Humanitarian Technology Development using Participatory Design
CCB	Creative Capacity Building
PwD	Person with Disability
ADG	Agile Development Group
LFTW	Light For The World Cambodia
EWB	Engineers Without Borders Australia
D(n)	Designer (n)
P(n)	Participant (n)

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CHAPTER ONE

INTRODUCTION

1.1 The Research Topic and Context

Participatory design (PD) is a process that aims to both create technology and empower participants through collaboration during a design project (Holmlid, 2009). Massachusetts Institute of Technology (MIT) researchers describe these two outcomes as the *impact of the product* and *impact of the process*, respectively (Budzyna, 2017). During PD, designers aim to involve marginalized or underserved communities in the process of planning, designing and testing potential technological solutions in a collaborative way (Greenbaum, 1993; Schuler & Namioka, 1993). Originating in 1970's Scandinavia, during the computerization of industries in the 1970s, this practice looks to utilize mutual learning, trust and empowerment to understand complex contextual issues and in turn create more sustainable technology solutions (Sundblad, 2010). PD has proven successful in the design of technologies in Western contexts (Wilkinson & De Angeli, 2014) and shows promise as a method for humanitarian technology development (HTD) in developing contexts (Moraveji et al., 2007; Reinders et al., 2007; Molapo & Marsden, 2013). In the present thesis, the use of Participatory Design for Humanitarian Technology Development is referred to as Humanitarian Technology Development-using-Participatory Design (HTD-using-PD).

However, while HTD-using-PD can deliver effective impact, its application in developing contexts has resulted in many documented challenges (Kam et al., 2006; Winschiers, 2006; Hussain et al., 2012; Molapo & Marsden, 2013; Godjo et al., 2015; Mazzurco, 2016). In such contexts, studies have noted challenges due to cultural and societal differences, logistical and geographic difficulties, and education and design experience (Burgess & Steenkamp, 2006; Kam et al., 2006; Winschiers, 2006; Chandra & Neelankavil, 2008; Zeschky et al., 2011; Schafer et al., 2011; Hussain et al., 2012; Sianipar et al., 2013). It is the latter of these challenges that the present research focuses on.

Challenges relating to design experience have been documented in several studies. For example, in the design of English language software for rural Indian school children, Kam et al. (2006) found that "*they [children] have very little exposure to high technology which may limit their ability to envision prospective designs*" (p. 1). Furthermore Kam et al. "*discontinued low-tech prototyping on the last day of Phase II since participants found low-tech prototyping to be frustrating*" (p. 5). A second example is that of Hussain et al. (2012), working with rural communities in Cambodia to design prosthetic limbs. Hussain et al. posed the question "*What happens when participatory design approaches are transferred to cultures that have much stronger social hierarchal structures than Scandinavian* *societies and have greater variations in education and income level than in Western countries?*" (p. 92). Their study encountered challenges with participant motivation, power structures between stakeholders (children and parents) and a lack of understanding of the design process. Ultimately Hussain (2011) stated "*it is first now, after completing all the work in the four field studies, that the designer and participants are ready to undertake a participatory design project together*" (p. 28). This statement relates to participants lack of confidence and familiarity with the concepts of problem solving, idea generation and divergent thinking. These barriers are restricting the widespread use of HTD-using-PD, and in turn reducing the long term impact each project could make. These findings indicate a need for greater attention to the process for introducing PD projects into communities.

Similar to Hussain, Molapo and Marsden (2013) ask the questions "*how can we co-design new technologies with users who have little to no technology experience?"* (p. 1) and "*what methods can be used to conduct participatory design in such a manner that users' limited technology exposure does not become a hindrance to their ability to contribute to the design process?"* (p. 1). These questions were asked in relation to the design of software solutions and the challenges of co-designing using software-focused prototypes. Again, this stresses that more needs to be done to contextualize PD in developing contexts (Wang et al., 2016). Byrne and Sahay (2007) support this view stating that practitioners need to be aware that community members are not automatically skilled and confident to perform creative activities. While being overlooked in the past, this is now becoming an important focus as HTD-using PD is refined.

This PhD research investigated the effectiveness of using creative capacity building (CCB) workshops, as defined by the MIT D-Lab (Taha, 2011), to build participants capacity in creative activities at the beginning of a HTD-using-PD project. The research utilized a case-study methodology focused on a collaboration between development practitioners and a community of people with disabilities (PwD) in rural Cambodia. The focus on PwD is important as individuals of this marginalized group are poorly included in Cambodian society.

PwD in Cambodia are excluded from many aspects of life and, regardless of impairment, there is a stigma that these individuals have cognitive disabilities and are "*emotionally erratic and unaware of the social norms of behavior*" (Gartrell, 2010, p. 294). This social exclusion, coupled with an individual's mental or physical impairments create a damaging cycle of reliance and workplace exclusion. While all countries are home to PwD, Cambodia is unique due to its high levels of physical disability, dependence on labor-intensive agriculture and poorly developed infrastructure (outside of the capital city Phnom Penh). Because of this, two major outcomes need to be addressed: social empowerment and assistive technology development. Firstly, opportunities for empowerment need to be provided to PwD in Cambodia. The Disability Action Council of Cambodia (DAC) state that initiatives should aim to meet objectives such as poverty alleviation, equal access to education, ability to participate in political life and enhanced access to the physical environment (Sauth, 2014).

Secondly, focus must be placed on designing assistive technologies that allow PwD in rural areas to gain access to agricultural livelihoods. This will allow individuals to enter the local workforce, provide subsistence produce for their families, or farm produce for selling at local markets. While many Western organizations have designed technology to address needs in developing contexts, many have been unsuccessful. Burgess and Steenkamp (2006) attribute this to differences in cultural and social structures, between Western design teams and foreign communities. Others highlight access to communities, resource constraints and a lack of inherent understanding for the community as some of the issues faced when designing products for communities in developing contexts (Radjou & Prabhu, 2012; Hall et al., 2014; Ramani & Mukherjee, 2014). PD is a promising approach for overcoming these design hurdles, while also aiming to empower PwD through inclusion in a PD project.

This thesis reports upon how a new stage in the PD process, CCB, can be used at the beginning of a project to improve aspects of designer-community collaboration.

1.2 Current Knowledge Gap and Need for Research

The traditional HTD approach has focused on building infrastructure and utility. Replacing this with a participatory approach, focused on community involvement, co-operation and emancipation (Holmlid, 2009) has proven to be an effective shift that results in both the empowerment of local communities and the creation of better solutions.(Scarf & Hutchinson, 2003). This sentiment is summarized well by Mumford (1984) who stated "*participation is viewed pragmatically and ideologically – something that helps efficiency, satisfaction and progress, but which is also morally right*" (p. 103). However as Hussain et al. (2012) state "*few studies address the real-life challenges of doing participatory projects in developing countries*" (p. 91). Furthermore, little attention has been given to the ability of community members in a developing context to collaborate in a process originally designed for Western industrial workers. In fact Kam et al. (2006) argue that community members may lack an understanding of the role of abstract prototyping and become "*highly frustrated throughout this phase*" (p. 5).

Research is needed to understand the enablers and barriers of conducting HTD-using-PD projects with marginalized communities and to investigate how the PD process might be enhanced to ensure sustainable, contextually-appropriate solutions and community empowerment can be delivered by all HTD practitioners.

1.3 Value of Research

The present research is valuable to academic researchers, field practitioners and aid organisations as it aims to understand the underlying factors behind successful and failed PD projects and use this as input in the development of a contextually appropriate HTD-using-PD process. This research provides a detailed account of the implementation of CCB sessions and undertaking of a new PD project. From this, value has been created through the identification of key aspects of designer-community collaboration and the documenting the capacity building content development process and full PD project. Furthermore, a practitioner handbook, including CCB, PD activities and monitoring and evaluating tools has been created and disseminated through several humanitarian engineering networks.

Many researchers have stated that, while being a step in the right direction, current HTD-using-PD practices do not align well with the cultural and societal differences present in developing contexts around the world (Kam et al., 2006; Winschiers, 2006; Hussain, 2010). As such, it is important that research is conducted that investigates how to enhance the PD process and achieve more effective impact. Other studies have aimed to do this by refining the tools and techniques a designer uses, as well as developing ways of minimizing Western bias in the process. The value of the present research is in investigating whether CCB could add value to a PD project by enhancing the community's creative competency. This competency provides community members with the *capacity to participate* in a meaningful way, resulting in better technology development and local empowerment (Byrne & Sahay, 2007).

1.4 Research Questions

To guide the present research, four research questions were developed. These aimed to guide the process of defining the research domain (designer-community collaboration during HTD-using-PD), developing appropriate project content (CCB and PD activities) and evaluating the effectiveness of CCB on enhancing designer-community collaboration during HTD-using-PD. The following section briefly explains the rationale behind each research question. A more detailed discussion can be found in Section 3.1.2.

Research Question 1 - How are individuals from underserved communities currently involved in HTD-using-PD?

This question guides the research to investigate the current state of HTD-using-PD. This ensures that enablers and barriers from previous research are utilized in the design of CCB, PD activities and decision making during the case study.

Research Question 2 - What are the key competencies required to enable individuals from underserved communities to participate effectively in HTD-using-PD?

This question guides the identification of key traits and skills that result in high-quality collaboration. These competencies can be used in designing focused, appropriate CCB content, PD activities and monitoring and evaluation tools.

Research Question 3 - How can CCB be utilized to build the required competencies in participants?

This questions ensures that the CCB content development process is well documented to allow for future research to utilize the process for projects in different socio-cultural environments. It also ensures that a rigorous development process is followed during the design and piloting of CCB content.

Research Question 4 - Does the implementation of CCB enhance the quality of collaboration between designers and participants during HTD-using-PD?

This question ensures the PhD research is outcome-focused by explicitly focusing on the effectiveness of CCB implementation. This involves evaluating the impact of CCB as well as understanding other factors which influence collaboration throughout a PD project.

Furthermore, the aim of present research can be stated through the following objectives:

1. Understand the current state of HTD-using-PD, including enablers and barriers to success
2. Investigate whether existing design process and collaboration conceptual models are adequate for guiding successful HTD-using-PD
3. Identify the key competencies required for participants from underserved communities to participate effectively in HTD-using-PD
4. Develop CCB workshops to build participants ability to participate effectively in HTD-using-PD
5. Evaluate whether implementing CCB workshops results in better quality collaboration between designer and participant during HTD-using-PD
6. Provide a detailed account of the process utilized to add to the growing research field of HTD-using-PD with underserved communities

1.5 Outline of this Thesis

The present research consists of four stages:

1. Design of CCB
2. Implementation of CCB
3. Completion of PD project
4. Mid-term community revisit.

A full methodology is presented in Chapter 3. The present chapter has introduced the focus of the research, rationale and importance and the research questions. Stage 1 will be presented through literature review (Chapter 2) and CCB content development process (Chapter 4). Stages 2, 3 and 4 are presented in Chapters 5, 6 and 7. Firstly, Chapter 5 provides a summary of the CCB and PD project stages, focusing on practical aspects such as technology development and socio-cultural insights generated. Next, Chapter 6 provides a detailed analysis of each of the cases across CCB and the PD project. This analysis focuses on the collaboration between designer and community as well as the impact generated. Finally, Chapter 7 presents the key findings identified from the present research. These findings include a new PD collaboration conceptual model, practitioner handbook and an understanding of exactly how CCB has impacted collaboration in the case study. The outline of the thesis is shown in Figure 1.

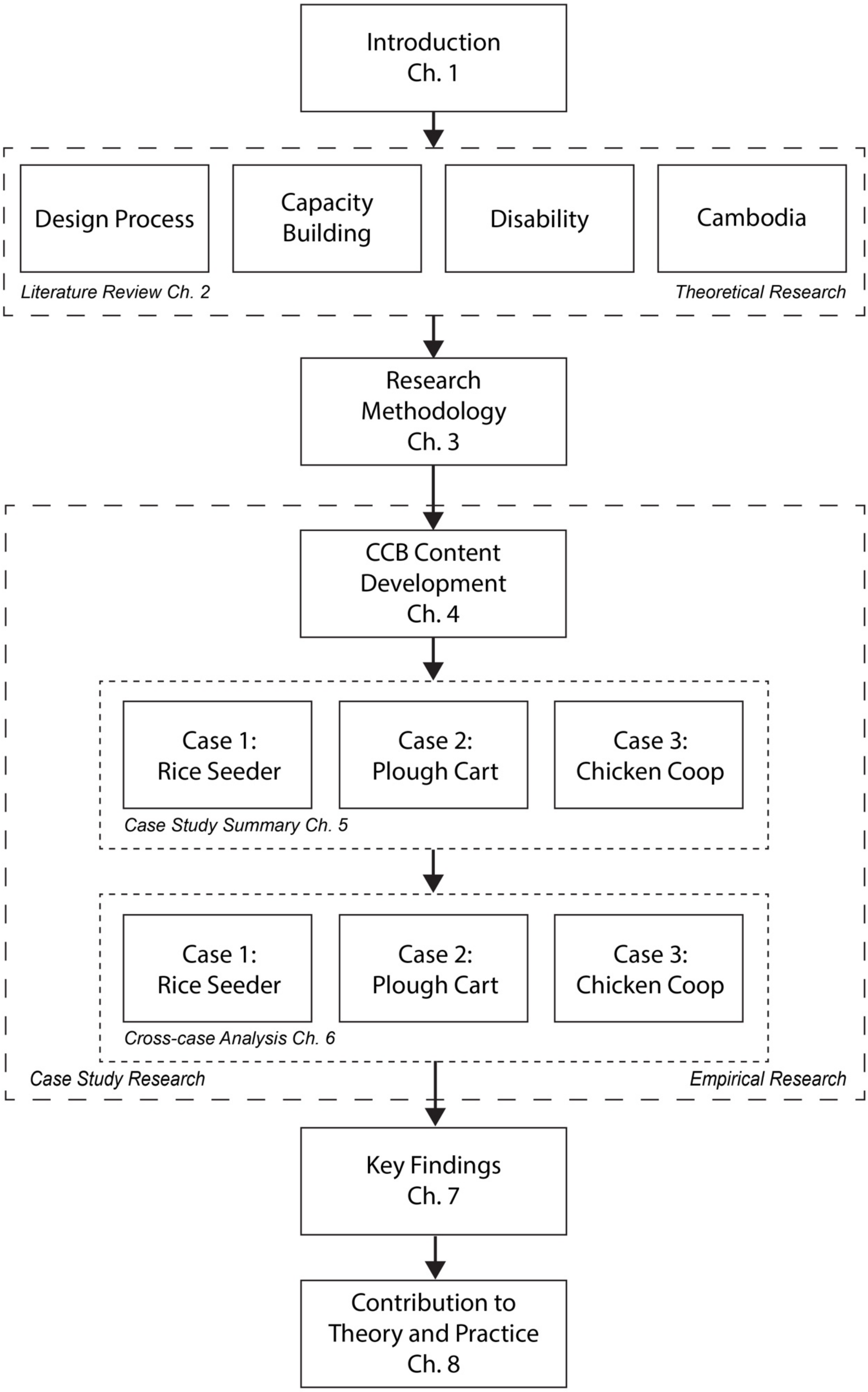


Figure 1 - Outline of the thesis

CHAPTER TWO

LITERATURE REVIEW

CHAPTER OVERVIEW

This chapter presents a review of the academic literature relevant to the present PhD research. Firstly, new product development in Western markets is introduced as a way of explaining the fundamental aspects of the design process. Next, an overview of product development for developing contexts is discussed to show the current research landscape and highlight the deficiencies of current commercial approaches. HTD and participatory approaches are then discussed as these represent more philanthropically-focused approaches to technology development for developing contexts. PD methodology is discussed in detail as it is the main field in which the present research is grounded. This discussion includes the origins and ideology of PD and its adaptations and associated limitations when applied in developing contexts. Capacity building theory is reviewed as a technique of addressing limitations documented in PD literature. Next, the context in which the present research is based is presented. This includes a review of literature on Cambodia, including its history, culture, geography and people, and disability, including conceptual models, definitions and previous research. Finally, important research from the above research fields is explicitly stated to ensure the reader is aware of the main inspiration of the present research.

2.1 The Design Process

2.1.1 New Product Development

The New Product Development (NPD) process is defined as "*a disciplined and defined set of tasks and steps that describe the normal means by which a company repetitively converts embryonic ideas into saleable products or services*" (Schirr et al., 2013, p. 472). New products increase the stream of revenue for companies contributing to 27.3% of company sales on average over the three year period studied in the USA (Cooper, 2013). Notable models are the Stage Gate Model (Cooper, 2008), see Figure 2, and the British Design Councils *Double Diamond* framework (Council, 2007), see Figure 3, which represent high level guidance in which to use a number of lower level tools and techniques.

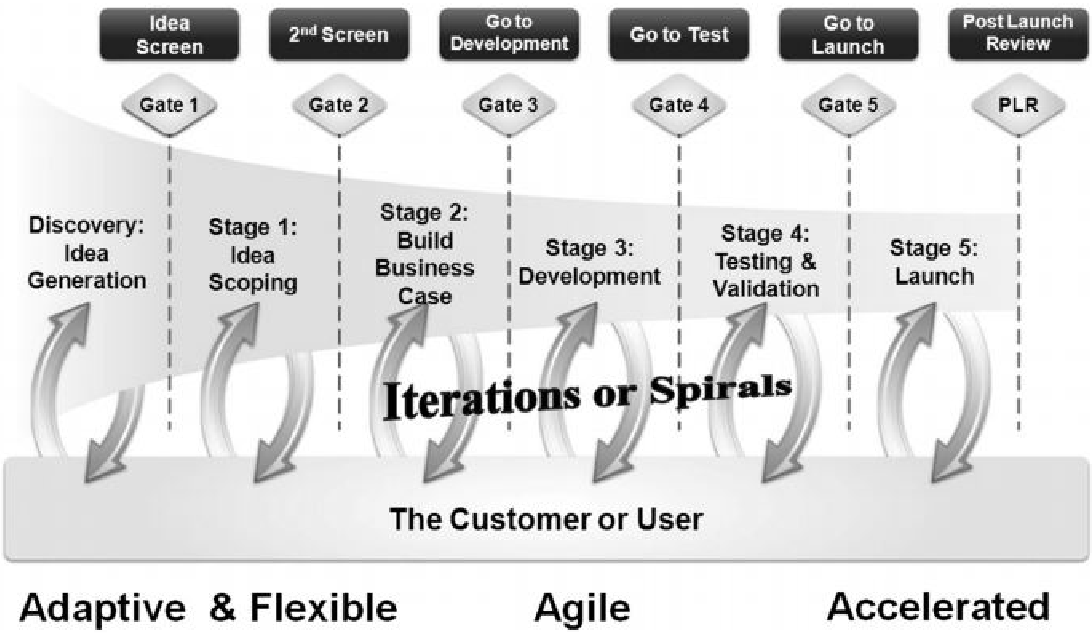


Figure 2 – Stage-Gate Process (Cooper, 2014).

The Stage-Gate Process identifies key stages in the process of developing a concept from an idea to a commercially viable product. The funnelling shape of the diagram also represents the converging nature of the process, with a large number of possible solutions being reduced down to one final product. It suggests that the customer or user are consulted throughout the process; however, it is often through intermediary means, such as marketing and product testing.

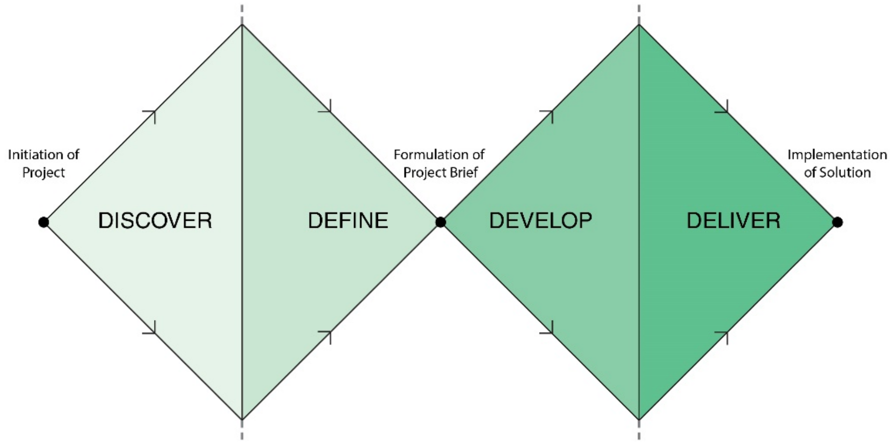


Figure 3 - Double Diamond Design Process (Clune & Lockrey, 2014)

The Double Diamond Design Process, developed by the UK Design Council, follows a similar idea-to-market process with the main difference centring on the conceptual description of the product development process (UKDesignCouncil, 2007). While Stage-Gate highlights a converging process in which ambiguity and multiple potential solutions are slowly focused onto one final solution, the Double Diamond Design Process shows the importance of multiple converging and diverging points to encourage creativity and redefinition of the specific problem definition. This has resulted in the Double Diamond becoming a popular design process for more creatively driven product development Projects.

While NPD processes are now considered standard practice in Western contexts, they are relatively new to developing contexts and have not resulted in the same success rates. One study highlights this disparity by stating the product success rate of new product concept generation in Western markets is 1 out of 6.6 while in developing markets this figure drops to 1 out of 46.1 (Ozer, 2006). A second study shows that less than half of the companies releasing products in developing contexts meet their goals, compared to around two thirds of new product companies in Western contexts (Austin-Breneman & Yang, 2013). This difference highlights the ineffectiveness of Western practices to produce commercially viable solutions to developing context issues (Chakravarthy & Coughlan, 2012). Driven by inherent differences in culture, geography, available resources and other factors (Prahalad, 2012; Payaud, 2014) a number of models specific to developing contexts have been developed. These are discussed in the next section.

2.1.2 Product Development for Developing Markets

Commercial interest in this area stemmed from the work presented in the book *The Fortune at the Bottom of the Pyramid* (Prahalad, 2009), originally published in 2004. In essence, Prahalad stated that large multi-national companies should be interested in providing products for the poor people of the world as it was profitable and noble (Schafer et al., 2011; Prahalad, 2012). It was estimated that this market, referred to as the base-of-the-pyramid (BOP), would be worth approximately $5 trillion in purchasing power parity (PPP). PPP is used as a way of considering different countries cost of living in order to derive a comparative income between countries. Prahalad and Hart (2002) also stated that 4 billion people had an annual income of less than $1,500 USD PPP, 1.5 – 1.75 billion people had an annual income of between $1,500 and $20,000 USD PPP and only 75-100 million people had an annual income over $20,000 USD PPP. While these estimates resulted in a large amount of interest from both academia and industry they were also criticized by some researchers who argued that the romanticised notion of empowering consumers would actually result in the uneducated being exploited (Karnani, 2009). Others also argued the estimates generated were exaggerated and used a poverty line as high as $6USD per day (Landrum, 2007). The studies mentioned are two of a limited number disputing the BOP movement. However, the overall sentiment, that developing contexts should benefit from newly developed products and technologies, is widely supported.

The present research will use the term *underserved community*, or in some cases *community*, to describe the communities and market, described above. This is because the present researcher believes this best describes the resilient people who are not adequately served by products, services, infrastructure, education or opportunity. Furthermore, from this point forward the present researcher will refer to the individuals of the communities that will receive the designed solutions as *community members.* While much of the research reviewed to this point has used the term *end-user*, this is a commercial term that positions the individual as a recipient of something from a designer. The present researcher argues that this terminology creates a barrier to discussing approaches that utilize collaborative relationships between designer and community. The exception to this rule will be when the specific community involved in the case study is discussed. In this instance, the present researcher will refer to the community members as *participants*, as this is the standard terminology in the PD research field. The terms *developing context* or *developing country* will be used to compare countries to Western contexts. However, it must be noted that this terminology presents a dichotomy of definition which the present researcher does not agree with. The scale should be viewed as a spectrum with many complex criteria; the United Nations Sustainable Development Goals provide a good overview of these criteria (UNDESA, 2015).

Why are different development methods needed for underserved communities in developing contexts?

The need for design processes that are specific to developing contexts is supported by Burgess and Steenkamp (2006) who state that differences in cultural and social structures, between Western and developing contexts, means generalizability of current marketing knowledge, based on high income, industrialized countries, may not be accurate for all markets. This was evident in a separate study which highlighted the One Laptop Per Child (OLPC) program, which is a non-for-profit venture aiming to use donations to build and distribute computers to children in developing contexts. This program aims to deliver laptop computers to impoverished communities for $175USD per unit (Nakata & Weidner, 2012). However, it was highlighted as an example of how a poor understanding of the user can result in consumer rejection. Initial issues with product acceptance were resolved through the identification of poor aesthetic design causing a stigma around what was perceived to be a *poor-person* product.

Although product development for developing contexts still seems to follow a logical structure it is very complex due to the large number of inputs needed for decision making, many of which are taken for granted in Western markets (Nakata & Weidner, 2012). Access to communities during development, resource constraints, lack of inherent understanding for the specific user group, complex distribution models, dissemination of product information and cross-cultural design projects are examples of some of the issues faced when designing products for a developing context (Radjou & Prabhu, 2012; Hall et al., 2014; Ramani & Mukherjee, 2014). This section of the literature review has focused on commercially driven product development research. This is not the only way that underserved communities receive new technologies. In fact, much of the implementation of technologies into underserved communities has been through humanitarian activities, such as those funded by the New Zealand Government (MFAT, 2015). This approach tends to be driven by philanthropic, not commercial, aims and aligns closely with the work of government aid agencies and non-government organisations (NGO). The next section focuses discussion on humanitarian approaches to technology development.

2.1.3 Humanitarian Technology Development

The terms *product development for developing markets* and *humanitarian technology development* (HTD) can be viewed as very similar in their methods but with a difference in the underlying rationale. Product development suggests commercial interest in designing products, which not only address issues faced by communities but also provide profit to the organisation involved. While the exact definition of HTD is the subject of much recent discussion, the present researcher believes it removes this underlying commercial interest, as defined by Schirr et al. (2013), and instead approaches ethically driven international development activities through focusing on technological development. The term HTD could also be replaced with *humanitarian engineering* or *engineering for social good*. However, the present researcher has aligned with the term HTD as it clearly defines the focus of the research, to design technology for humanitarian purposes. Schneider et al. (2008) summarize this sentiment well stating "*humanitarian engineering is design under constraints to directly improve the wellbeing* *of underserved populations*" (Schneider et al., 2008, p. 312). The exact beginning of this paradigm is difficult to determine as many technology-focused development activities occurred under different names. Mazzurco (2016) provides a detailed review of the conception of humanitarian engineering using 1992 as a starting date, because the first Engineers Without Borders (EWB) chapter was founded in this year. EWB are a network of NGOs specializing in humanitarian engineering.

Several HTD design processes have been developed. One of these is the Co-Design and Implementation Process (Murcott, 2007). This focuses on the relationship with community and the relational, knowledge-sharing, learning process. This model presents four main themes of egalitarian partnerships between experts and communities, utilization of local resources, real-world testing and open source innovation and dissemination. This model, developed through action research in Nepal, improves upon commercial product development models as it gives detailed guidance for a practitioner while also explicitly highlighting the importance of community consultation throughout the design process. However, the research suggests there are still challenges related to the promotion of products and dissemination of key benefits.

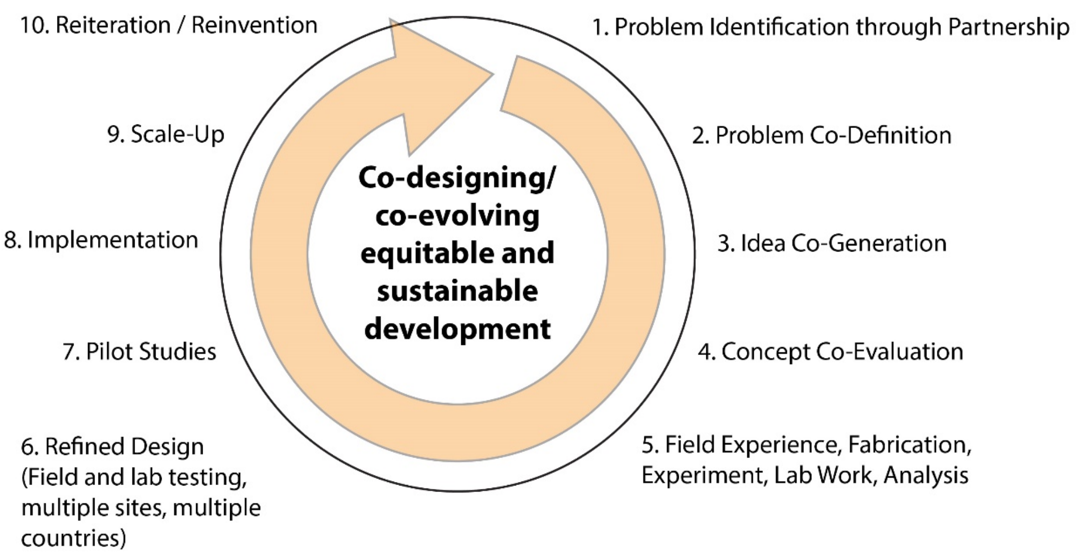


Figure 4 - Co-Design and Implementation Process (Murcott, 2007)

The Appropriate Technology Design Methodology (Sianipar et al., 2013) shares similar values with Murcott (2007) and stresses the importance of resource localisation and onsite development and testing, as opposed to cross-country problem-solving. Both processes champion the idea of designing products with community members and not for them, a theme expanded upon later in this section.

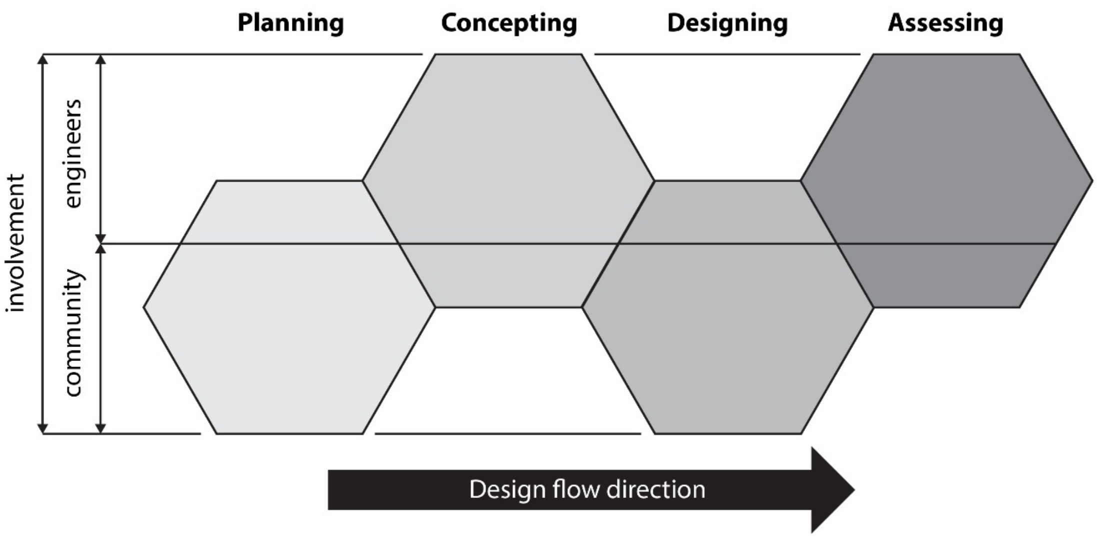


Figure 5 - Appropriate Technology Design Methodology (Sianipar et al., 2013)

The Human Centred Design Toolkit (IDEO, 2015) also states the importance of user-centred projects involving in-community development and testing. The process highlights the benefits of community member involvement as a way of ensuring buy-in and trust in a product. The process uses the more abstract terms *empathize, define, ideate, prototype* and *test* to define the steps the designer should transition through while always verifying decisions with the community. Chandra and Neelankavil (2008), who examined a range of HTD projects, further this point, stating that a company will be successful by either utilizing technology-driven product development or a "*thorough understanding of the customer needs*" (Chandra & Neelankavil, 2008, p. 1023).

Another study of HTD projects in India (Viswanathan & Sridharan, 2012) supports a focus on understanding the community. The authors state a number of key factors for success including meeting critical basic needs, aspirational needs, customization of product offering and the leveraging of existing infrastructure. These factors all centre on identifying the community member's needs, whether functional or psychological, and the importance of empathy in the design process. This study states "*the environment for market-based products in subsistence marketplaces is significantly shaped by constraints imposed by physical/social infrastructure in communities and economic/psychological factors at the household level*" (Viswanathan & Sridharan, 2012, p. 53). This differs from Western product markets, as described by Burgess and Steenkamp (2006), and again shows the need for processes specific to developing contexts.

When discussing the various design processes, it is helpful to categorize them in terms the collaborative relationship between the designer and the community. Many researchers have discussed this collaborative relationship in terms of three different formats; *design for*, *design with* and *design by* (Kaulio, 1998; Wang & Oygur, 2010; Smith, 2017). While most of the processes explored in this section utilize a *design for* collaboration, there are other, more participatory approaches, which align with *design with* and *design by* collaboration. These will be discussed in the following section. Table 1 provides an overview of the three approaches and examples of design processes that align with each approach.

Table 1 - Design paradigm summary

Collaborative Relationship	Characteristics	Example Processes
Design for	A process led by professional designers who research user requirements, design solutions and verify their designs with community members	– Stage-Gate process – Human Centred Design
Design with	A collaborative process in which professional designers and representative community members work together to design, prototype and testing potential solutions.	– Co-design and Implementation Process – Appropriate Technology Design Methodology – Participatory Design (Initial stages)
Design by	The process in which representative community members are empowered to design solutions for their own problems and utilize professional designers as supporting actors for technical development.	– Participatory Design (Final stages)

2.2 Participatory Development

Participation in international development activities can take many forms. While the present research focuses on participation during the design of technology, other areas of participation include participatory rural appraisal (Chambers, 1994), participatory technology assessment (Schot, 2001) and community-based participatory research (Wallerstein & Duran, 2006). These participatory development approaches have been used in Western and developing contexts and provide some of the foundational, and competing, principles of PD.

2.2.1 Participatory Techniques for International Development

Participatory rural appraisal (PRA) is an approach used for collaboratively understanding the rural, agricultural environment present in a particular context and using this understanding to generate positive change, or sustainable management practices. The approach evolved from rapid rural appraisal (RRA) during the 1980's and 1990's (Chambers, 1994) and aimed to take the focused, qualitative fundamentals of RRA and combine them with the proven participatory focus of other development methods. The result was a methodology, complete with a range of tools to focus on appraisal, planning, implementation, monitoring and evaluation, topic investigation and training (Chambers, 1994).

Next, technology assessment (TA) was developed as a way of combating the *technocratic* vision of governments in Western contexts; the vision that introducing new technologies would have a guaranteed positive effect on social welfare (Hennen, 1999). TA can be viewed as an approach to ensure a wide range of factors (social, environmental, ethical, economic and scientific) are included in any technology appraisal or implementation. TA is focused at a governance level and aims to provide structured methods for analysing the effects of technology, and technological policy on the wider population. Participatory technology assessment (PTA) follows very similar guiding principles but looks to improve the meaningful understanding of social effects through "*bringing public values and opinions into the assessment of technologies*" (Schot, 2001, p. 39). This high-level method for ensuring appropriate, sustainable technology implementation is important as it has influence on policy and large-scale technology implementation. However, it does not allow community members to have an influence on the design of the technology itself. This means that the assessed technology is already developed and therefore less adaptive to the needs of the community. Schot (2001) adapted the PTA process to focus on the technology design process itself, and, in turn, enabled community members to have an influence on the solution while it was being created. Schot stated, "*This will counteract the prevalent tendency to organize technology development in a basically linear fashion (from development, to market introduction, to regulation) and will allow for more continuous evaluation and modification of new technologies in the making*" (p. 41).

It is generally agreed that participatory approaches to development yield positive results. However, the approaches mentioned in this section do not meaningfully aim to include participants in the design of new technologies. PRA aims to collaboratively learn about rural activities and influence planning, monitoring and evaluation procedures. PTA aims to involve community members in the assessment of existing technologies to gauge their appropriateness in a given setting and Schot (2001) adapts PTA processes with explicit mention of involvement in technology assessment in the design process.

The next section introduces the main area of research for this PhD study, participatory design. This is a participatory method with explicit focus on collaborating with community members to create technologies.

2.3 Participatory Design

Context-appropriate, collaborative approaches to design have become common practice in recent times, and as such, different design processes inside this paradigm have been explored in literature

(Duschenes et al., 2012; Wilkinson & De Angeli, 2014; Ali & Liem, 2015). PD is one of these approaches and looks to gain meaningful insights about community members and their environment while empowering the involved individuals to have increased ownership over the end result (Holmlid, 2009). It achieves this by involving community members in the process of planning, designing and testing potential technological solutions (Greenbaum, 1993; Schuler & Namioka, 1993; Sanders et al., 2010). Schot (2001) contrasts the difference between PD and traditional product development practices by stating that in the traditional "*method of consumer research, manufacturers design new products and then ask potential consumers to respond to prototypes or product ideas. Users are not offered any space in which to come up with their own ideas*" (p. 43).

2.3.1 Origin

PD was developed in Scandinavia, in the 1970's, as a way of empowering industrial workers during the transition towards computer usage (Schweitzer et al., 2014). The methodology, driven by trade unions, was based on the ideology of democratic decision making and believed that the individuals affected by development should have the ability to shape the solution throughout the design process (Simonsen & Robertson, 2012). The UTOPIA project (Gregory, 2003; Sundblad, 2010) is viewed as one of the seminal projects in participatory design and aimed to support the introduction of computers into the printing industry in Sweden. Since then, the paradigm has developed into a holistic design process applicable in many areas (Dell'Era & Landoni, 2014). While the seminal work in PD was focused on human-computer-interface (HCI) design an increase in popularity in recent years has seen researchers and practitioners look to adapt and apply these practices to areas outside of information technology (Demirbilek & Demirkan, 2004) and outside of the Western contexts originally intended (Byrne & Sahay, 2007). This is due to its potential at overcoming the challenges discussed in the previous sections of this literature review. The new application of PD, HTD-using-PD, is discussed in the next section.

2.3.2 Present Day

Over the past four decades, PD has been used in a variety of applications, and as such has dealt with challenges around terminology, ideology and identity (Wang & Oygur, 2010). It is clear that participation is key to successful project implementation; however, the motives for participation vary from project to project. Of importance to the present research are recent HTD-using-PD projects and the rationale for the use of PD in each project. For example, Kam et al. (2006) aimed to use PD to develop a software platform to "*promote the acquisition of English as a foreign language among children from the rural schools and urban slums of India*" (p. 3). The aim of the project was to design a software platform for wider use. This, in turn, influenced the approach the designers took to planning and decision-making during the project. For example, Kam et al. stated, "*low-tech* *prototyping was highly frustrating because rural student participants found it difficult to come up with initial ideas and to iterate on their initial designs.*" (p. 6). They decided to discontinue this activity, as it was ineffective at generating insights.

Contrastingly, Byrne and Sahay (2007) used PD to develop a community-based health information system in South Africa while stressing that "*participation can improve social development through the inclusion of the voices of the excluded, who are affected by the development programs*" (p. 74). This led to a strong focus on developing the participants' *capacity to participate*. Byrne and Sahay stated, "*Capacity development is required to overcome the constraints identified in the design research process. This goes beyond the skill enhancement issues addressed by Ehn (1993) to issues of responsibility, knowledge, and access to resources*" (p. 89). These two examples illustrate two different foci for HTD-using-PD projects. The first, a technology-focus, aimed at creating a widely usable product; the second, a technology and empowerment focus, aimed at software creation and social empowerment.

The HTD-using-PD research field has generated several theoretical models that aim to explain the complexity of using PD in complex socio-cultural settings.

2.3.3 Theoretical Frameworks

As a starting point for discussion Hussain and Sanders (2012) offer a design hermeneutic approach to user-product interaction (Figure 6), in which a user's interaction with a product is subject to "*the physical product, the user, and the society and culture in which the product is used and interpreted*" (p. 49).

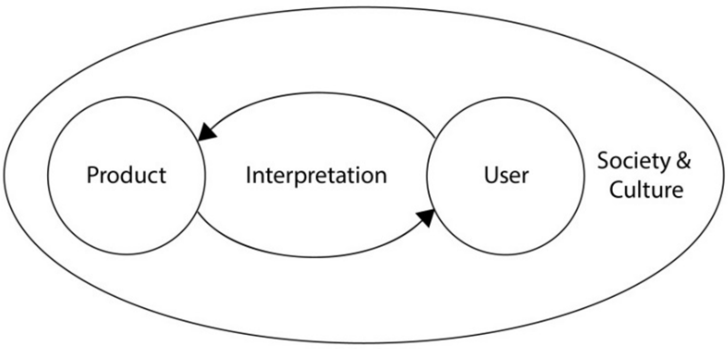


Figure 6 - Hermeneutics-Oriented Design Model (Hussain & Sanders, 2012)

While not directly related to development activities, this model highlights the importance of viewing any interaction an individual has with a technology as a function of not only the user and product but also the societal and cultural values of the environment in which the interaction occurs. This is an important consideration to begin with as it shows that the interaction a community member has with technology is so engrained with cultural value that failure to consider this would result in a large risk of project failure.

Sanders and Stappers (2014) have developed the *Making* Framework, a more operational framework for PD with a focus on the types of tools used and stages in which to use them (Figure 7). It is helpful for understanding the stages undertaken during PD, the designer-community relationship and the iterative nature of PD project. The *Making* Framework shows how a PD project progresses through *pre-design* (learning about the user and context), *generative-design* (co-creating ideas to address an opportunity), *evaluative-design* (prototyping, testing and assessing potential solutions) and *post-design* (implementation and monitoring of solution). It aims to provide a high-level structure, without prescribing specific activities at each stage. This aligns with the PD ideology that projects must be grounded in the corresponding socio-cultural environment and that activities and decisions must be situation-based (Simonsen & Robertson, 2012). These activities vary based on the aim of the project, stage in the project and characteristics of the participant group. Sanders and Stappers (2014) present the terms *making*-style (constructing models, maps, and collages), *enacting*-style (theatrical and testing) and *telling*-style (discussion, stating current practices, and paper-based ideation) as three different categories of activity, each utilizing a different mode of communication.

Importantly, this framework uses the terms *design for* and *design with* to describe times in which the expert designer is leading the process and times in which true collaboration is occurring, respectively. It shows the realistic nature of participation, where at times, the designer will be leading the design process and at other times the community member and designer will both mutually design. The framework is important as it represents realistic project progression, and not the ideal *design by* status in which a community member is empowered to design products without direct leadership from a designer. While *design by* is the goal of any PD project, it can be disheartening for a designer to expect elevation to this level immediately.

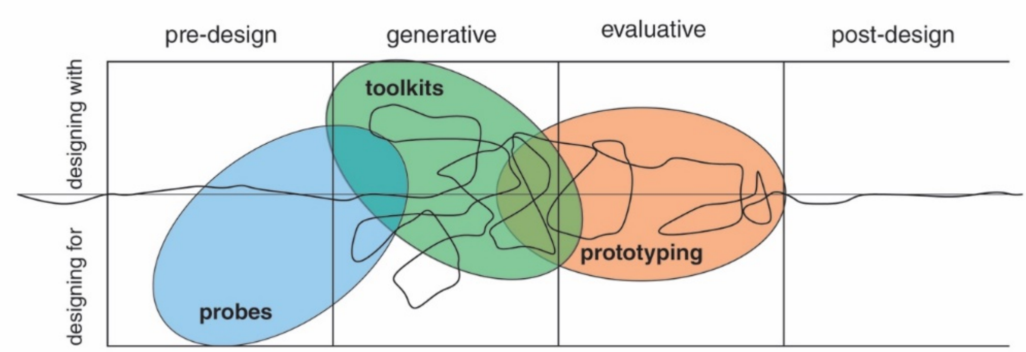


Figure 7 - The *Making* Framework (Sanders & Stappers, 2014)

Next, Simonsen and Robertson (2012, p. 128) present the *Use-Oriented Design* process, as used in the Florence Project at Oslo University, as a way of changing focus from the individual themselves to the actual use of the solution. The study proposes a design cycle (Figure 8) as guidance for practitioners looking to implement a similar strategy. Again, this conceptual model is helpful for understanding the process at an operational level.

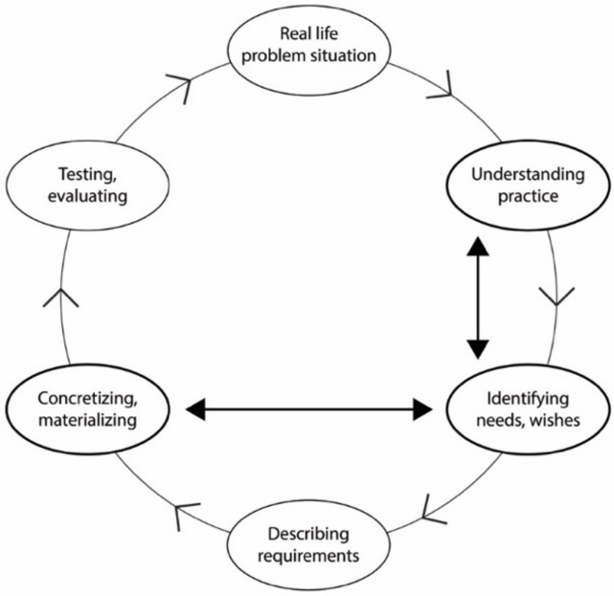


Figure 8 - The Use-Oriented Design Cycle (Simonsen & Robertson, 2012)

2.3.4 Challenges of HTD-using-PD

To date, there have been a limited number of academic studies documenting the use of HTD-using-PD. In general, while showing promise for resolving many of the traditional challenges mentioned previously, these studies have noted their own set of process challenges due to cultural, societal and geographical differences (Burgess & Steenkamp, 2006; Chandra & Neelankavil, 2008; Zeschky et al., 2011; Schafer et al., 2011; Sianipar et al., 2013). This is well summarized by Winschiers-Theophilus et al. (2010) who state, "*The challenges of participation in cross-cultural design contexts are particularly evident in designing and implementing… [technology] …for socio-economic development*" (p. 2). Cultural and societal barriers can include community members having limited exposure to advanced technologies, local power structures, low levels of education, and low-familiarity with design concepts. In the design of English language software for rural school children in India, Kam et al. (2006) found that "*they (children) have very little exposure to high technology which may limit their ability to envision prospective designs*" (p. 1). Furthermore Kam et al. stated that they "*discontinued low-tech prototyping on the last day of Phase II since participants found low-tech prototyping to be frustrating*" (p. 5).

A second example is that of Hussain et al. (2012), working with rural communities in Cambodia. Hussain et al. posed the question "*What happens when PD approaches are transferred to cultures that have much stronger social hierarchal structures than Scandinavian societies and have greater variations in education and income level than in Western countries?*" (p. 92). Their study encountered challenges with participant motivation, power structures between stakeholders (children and parents) and a lack of understanding of the design process. Ultimately Hussain (2011) stated "*it is first now, after completing all the work in the four field studies, that the designer and participants are ready to undertake a PD project together.*" (p. 28). Hussain categorized the challenges they faced into four categorizes; *human*, *social, cultural and religious*, *financial and timeframe* and *organisational* (Hussain et al., 2012).

Thirdly, Winschiers-Theophilus et al. (2010) present an honest account of their experience co-designing an information system for managing indigenous knowledge in Namibia. They stated, "*That planned activities related to the project cannot be imposed but must be accommodated within villagers daily schedules and we must recognise that villagers are busy most of the day*" (p. 5). This lead to "*anxiety within the research team as we learnt to accept that events would not be as planned but were determined by the community*" (p. 5). Findings from this project suggest that a formalized PD process, with planned activities, is difficult to implement and may not produce the intended results.

To generate a more detailed understanding of the challenges faced in HTD-using-PD, a review of HTD-using-PD literature was conducted with eight studies identified as relevant to the current discussion. This relevance was determined as the articles were focused on one or more practical case study using PD and discussed challenges faced. A summary of these challenges is presented in Table 2.

Table 2 - Summary of Challenges in PD Projects

Challenges faced	**Context**	**Reference**
Power structure between school students and teachers restricted creativity	Design of educational software with rural Indian primary school students	(Kam et al., 2006)
Value perceptions of parents became a barrier to long term involvement of students		
Struggle to create and maintain an encouraging environment		
Child facilitators were not mature enough to focus on required tasks		
Low resolution prototyping was slow and ineffective at engaging participants in the design of educational games and software		
Power structure between school students and parents restricted creativity	Design of prosthetic limbs with rural children in Cambodia	(Hussain et al., 2012)
Focus on rote learning in formal education meant participants had poor comprehension of problem solving, design process, activities or expected outputs		

Challenges faced	Context	Reference
Designer needed to meet with participants in their own environment to ensure they felt comfortable		
Lack of experience with the design process and related activities		
Long time period before true co-creation could occur		
Western bias during analysis of findings due to cultural differences	Design of IT systems in Namibia	(Winschiers, 2006)
Lack of computer literacy (technological skills)		
Ineffectiveness of traditional data collection tools (interviews and surveys) due to a listener satisfaction cultural convention		
Lack of user tenacity once design challenges arose		
Difficult to schedule activities with community due to the busyness of rural life	Design of IT systems in Namibia	(Winschiers-Theophilus et al., 2010)
Participants struggled to understand the role, and expected outputs, of some activities		
Difficult for designers to adjust to the oscillation of control between designer and community		
Lack of clear process to evaluate impact of project		
Difficult to align planned activities with local socio-cultural characteristics		
Difficulty running some activities due to community members having a lack of experience with scientific thinking	Interviews with 14 PD practitioners	(Mazzurco, 2016)
Engineers taking too much time away from community members in order to engage with methods		
Lack of access to cameras or knowledge of how to use them effectively		
Challenging environment damaging generative design activity resources		
Poor translation of important information during workshops		
Participants lack education to participate in design meetings, read plans, etc.	Design of agricultural processing equipment in Benin	(Godjo et al., 2015)
Shift from paper-based description to oral description because of cultural and educational influences		
Difficulty of designing software with participants who had no understanding of the technology	Design of information system for community health workers in Lesotho and Sierra Leone	(Molapo & Marsden, 2013)
Difficult for participants with low computer proficiency to engage with the abstraction of low-fidelity paper prototypes		
Difficult to initiate PD in such hierarchical setting (India)	Design of IT health systems in India, Mozambique and South Africa	(Puri et al., 2004)
Difficult to use Western PD activities due to large socio-cultural differences		

As shown in Table 2, the challenges facing HTD-using-PD are diverse. A brief thematic analysis of these case studies yields the themes presented in Table 3. Interestingly, socio-cultural differences and design experience are the most commonly documented challenges.

Table 3 - Thematic analysis of challenges faced in HTD-using-PD projects

Challenges faced	**Reference**
Capacity to participate	
Educational experience	(Hussain et al., 2012; Mazzurco, 2016)
Design experience	(Kam et al., 2006; Winschiers, 2006; Winschiers-Theophilus et al., 2010; Hussain et al., 2012)
Technical knowledge	(Winschiers, 2006; Molapo & Marsden, 2013; Mazzurco, 2016)
Socio-cultural differences	
Appropriateness of activity	(Winschiers, 2006; Winschiers-Theophilus et al., 2010; Godjo et al., 2015)
Power structure	(Puri et al., 2004; Kam et al., 2006; Winschiers-Theophilus et al., 2010; Hussain et al., 2012)
Designer ability	(Winschiers, 2006; Kam et al., 2006)
Design environment	(Kam et al., 2006; Hussain et al., 2012; Mazzurco, 2016)
Perceived value of project by community	(Kam et al., 2006; Mazzurco, 2016)
Long time period	(Winschiers-Theophilus et al., 2010; Hussain et al., 2012)

In an effort to understand the how the *capacity to participate*-themed challenges could be overcome, the next section focuses on the collaboration between designer and community member, as this is most relevant to the present research.

2.3.5 Collaboration in PD

There are several frameworks for assessing collaboration, and participation, with community members in the PD process. These include participation ladders (Druin, 2002; Hussain, 2010), project evaluation criteria (Schot, 2001) and participation evaluation criteria (Kanji & Greenwood, 2001).

Schot (2001) explored the role of participation in technology evaluation. This is the process of working with community members to assess the positive and negative effects of technology implementation on an environment. Schot developed the three criteria of *anticipation*, *reflexivity* and *societal learning processes* as measures of effectiveness of participation in the technology assessment process. Anticipation refers to the process of providing opportunity for community members to provide more open, generative feedback than traditional market research. Reflexivity refers to the process of managing conflicts and trade-offs between community members, designers and wider stakeholders.

Finally, societal learning processes refers to the need for the process to allow for technology and society to evolve together, with equal priority. This is in contrast to traditional approaches that prioritize technology development above all else. Schot states that the process facilitates and utilizes "*the ability of actors to consider technology design and social design as one integrated process and to act upon that premise*" (p. 44).

Druin (2002) presents a tool for categorizing community involvement with the development of four roles a community member can have in the PD process. These are as a *user, tester, informant* and *design partner* with each step representing a higher level of autonomy and meaningful input. A separate study adopts the same terminology in the design of assistive learning solutions for children with special needs (Frauenberger et al., 2011). While these archetypes were designed specifically for projects involving children, they still provide evidence of a hierarchy of community member involvement and capabilities. Similarly, Hussain et al. (2012) utilized Zimmerman's model for psychological empowerment (Zimmerman, 1995) as the foundations of an *extended product development process* which includes considerations of how collaboration actually aids in empowering the involved community members. Of note, are the three levels of empowerment shown in Table 4.

Table 4 - The Design Participation Ladder (Hussain, 2010)

Level of participation	**Characteristics**
Empowered	– Children learn design skills and take part in developing new solutions – Designers put great effort into seeking and understanding children's opinions
Consulted	– Children are asked what they need and want – Designers put effort into finding ways for children to express their views
Included	– Only adults are consulted – Children might be observed while testing products

While once again focused on PD with children, there are aspects of this hierarchical structure that are important to all applications of HTD-using-PD. The ascension from *user* to *design partner*, as Druin (2002) terms it, can be viewed as the designer's ability to facilitate or develop an involved community member's capacity to participate. These roles are achieved through careful selection of specific community members or through facilitation and capacity building during the process. However, difficulties highlighted in accessing community members (Leahy, 2013; Dell'Era & Landoni, 2014), and maintaining long term involvement (Kam et al., 2006) suggest that utilizing selection alone would not be an effective strategy for ensuring highly effective participation and collaboration.

The traditional model of PD collaboration (shown in Figure 9) shows how designers and community members (both users and stakeholders) collaborate. It shows the key actors and their interactions but lacks consideration for how PD methods affect this interaction, as well as the influence of the wider environment.

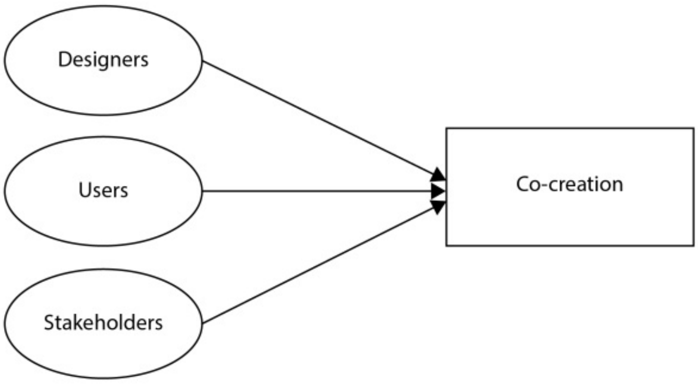


Figure 9 - Traditional Model for Participatory Design (Hussain et al., 2012)

In fact, Hussain et al. even describe the lack of appropriateness of this model for explaining collaboration in HD-using-PD and present an adapted version (Figure 10). This was designed to remove barriers due to power structure and cultural hierarchy in the project's Cambodian context. After project completion Hussain et al. (2012) summarized what they had actually experienced, this is shown in Figure 11.

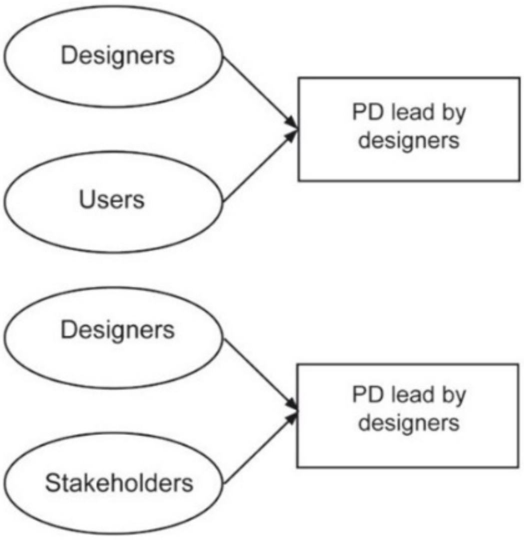


Figure 10 - Adapted Model for Participatory Design (Hussain et al., 2012)

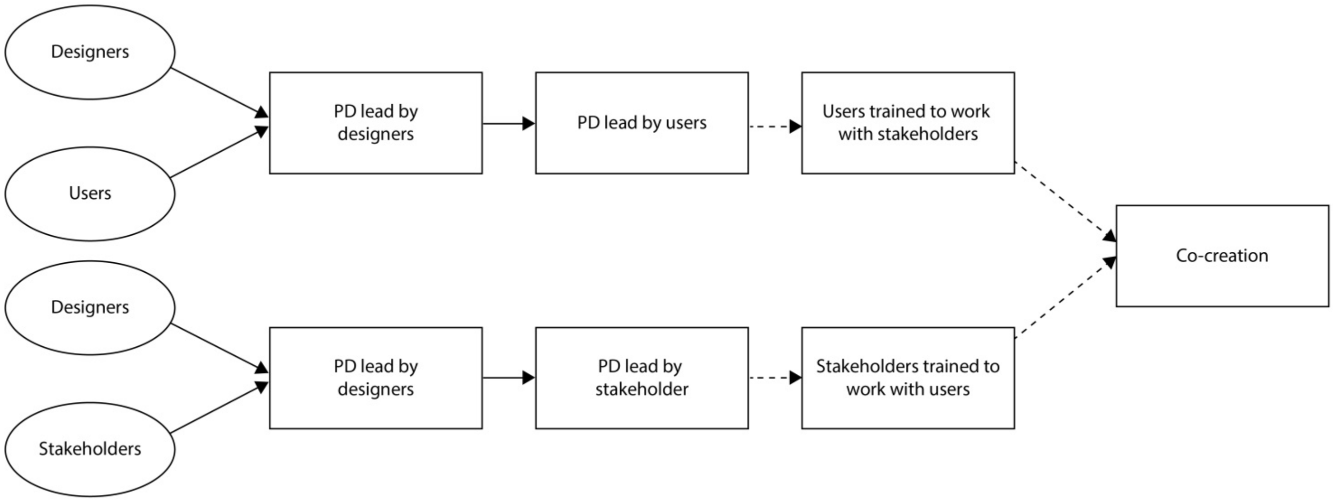


Figure 11 - Evolution of Participatory Design projects for marginalized people (Hussain et al., 2012)

What Hussain et al. (2012) lack in these models, is clear communication of what *co-creation* actually entails. For this detail, a separate study is presented (Christiaans, 1992). Christiaan's PhD research focused on the role of domain knowledge, in this case industrial design engineering, in creativity and design. Through this study, he developed a conceptual model of the knowledge required for completing a design activity effectively. The three knowledge areas are *process knowledge, design knowledge* and *basic knowledge*. Furthermore, they state that *process knowledge* is domain-independent while *design* and *basic knowledge* are domain-specific. These three types of knowledge are defined below:

- *Process knowledge* – understanding of the required design steps, ability to work within ill-defined projects and possessing a mind-set conducive with design work
- *Basic knowledge* – general understanding of a range of topics that provide a wide breadth of knowledge, and the ability to draw from a range of disciplines
- *Design knowledge* – in-depth understanding, specific industrial design and engineering concepts, existing solutions, methods and techniques

These components are shown in Figure 12.

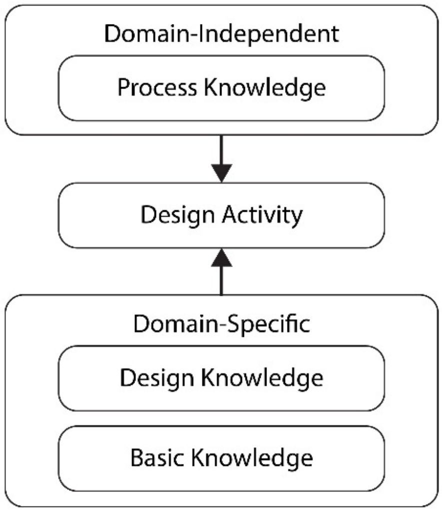


Figure 12 - Knowledge and design activity model (Christiaans, 1992)

This model is important to PD practices as it highlights the need for involved community members to have an understanding of the design process in order for effective design to occur. The present researcher also argues that *basic knowledge* would inherently include an individual's tacit knowledge about their socio-cultural environment, daily activities and specific wants and needs.

Others have also looked to understand the key knowledge and skills needed for effective PD. A number of different terms have been used in literature to describe a community member who possesses these attributes. Terms include *ideal user*, *power user*, *empowered user* or even the commercially focused *lead-user* (Von Hippel, 1986; Fischer & Ostwald, 2002; Hussain & Keitsch, 2010). The general concept (of a community member who is highly equipped to collaborative) is well summed-up by the empowered level of the Design Participation Ladder (presented in Table 4). The concept is also well articulated by Fischer and Ostwald (2002), who state, "*they [*community members*] are no longer passive receivers of knowledge, but need to be active researchers, constructors, and communicators of knowledge*" (p. 3). Similarly, Lettl (2007) identified that three prerequisite characteristics were needed for effective innovation from community members. These were a *motivation caused by a current problem*, *an openness to new technologies* and *imagination capabilities.* Lettl further developed this theory by presenting a three-layer model for user involvement in innovation. This included passive development contribution in the user domain, active development contribution in the user domain and active development contribution in the technological domain. This is similar to the previously mentioned ideal user profiles, however, it contains a stronger focus on technical knowledge (due to its grounding in medical device development).

Collaborative Competencies

In an attempt to synthesize all of these definitions, as well as the insights presented in extant HTD-using-PD literature, a review of relevant literature was conducted. Following this, specific studies of importance were identified (Haggar et al., 2001; Druin, 2002; Demirbilek & Demirkan, 2004; Kam et al., 2006; Winschiers, 2006; Moraveji et al., 2007; Byrne & Sahay, 2007; Frauenberger et al., 2011; Hussain et al., 2012; Le Dantec & DiSalvo, 2013; Molapo & Marsden, 2013; Mazzurco, 2016). Finally, thematic analysis was undertaken, guided by Bryman (2015) and Saldaña (2015), to identify a set of five competencies deemed important for effective collaboration during PD projects. These competencies will be referred to as the *collaborative competencies* from this point forward. These are summarized in Table 5.

Table 5 – Collaborative competencies for effective PD

Collaborative competencies	**References**
Ability to express critical opinion about the project	(Kam et al., 2006; Winschiers, 2006; Hussain et al., 2012; Molapo & Marsden, 2013)
Ability to generate insightful ideas	(Kam et al., 2006; Hussain et al., 2012; Molapo & Marsden, 2013)
Ability to create insightful prototypes	(Kam et al., 2006; Hussain et al., 2012; Molapo & Marsden, 2013)
Understanding of the design process	(Winschiers, 2006; Hussain et al., 2012; Mazzurco, 2016)
Motivation to contribute over an extended period of time	(Kam et al., 2006; Winschiers, 2006; Hussain et al., 2012; Mazzurco, 2016)

These competencies represent the qualities that need to be present in PD activities. They could be present in the involved community member or facilitated by the designer (through active facilitation and appropriate activity design and planning). The competencies will be used to guide design, data collection and analysis of the case studies undertaken for this PhD research. The use of these competencies, for assessment of initial and longitudinal collaboration, aims to receive value from two separate assessment approaches. Firstly, the *trait*-approach, which views creativity as the attainment of a set of traits that can therefore be focused on during assessment. Secondly, the *process*-approach, which focuses on the design process, and associated decisions, as a more meaningful way of assessing creativity (Christiaans, 1992). The present researcher's philosophical views align more closely with the latter approach. However, the need to understand the current state of the research field and to provide structure to data collection and analysis has resulted in the formation of the five competencies. Therefore, both a traits and process-approach are utilized in the present study.

The question remains, how can designers include *ideal* users in PD projects? Furthermore, once included, how can designers facilitate their involvement effectively? This is a question already posed in the area of lead-user theory (Urban & Von Hippel, 1988) in which specific traits are identified and used as recruitment criteria for users who are then involved in collaborative product development. Lettl (2007) furthered the work of Urban and Von Hippel (1988) stating, "*The case study analysis reveals that manufacturing firms that involved capable users in distinct phases of the innovation process benefited significantly from the users' contributions*" (p. 60). However, the implementation of a selection-based method, for involving community members with specific skills, can be limiting as access to desired community members can be difficult. For example, Conradie et al. (2015) state the difficulty of recruiting visually-impaired lead users for a project in Belgium. In the context of HTD-using-PD, Kam et al. (2006) found recruiting children difficult as firstly parents were not in favour of the time taken to contribute and secondly the local school Principal seemed to ignore requests for a representative group and instead provided a group of high achieving students. As the project was to develop learning systems this was viewed as a barrier to gaining insights and evidence of selection-bias affecting the project. The present researcher suggests that selection-based methods are not appropriate for HTD projects and a new approach is needed. Utilizing a capacity building approach may well hold the answers to effective HTD-using-PD.

2.4 A Capacity Building Approach

"*Capacity development is about transformations that empower individuals, leaders, organizations and societies*" (Wignaraja, 2009, p. 5).

One way of reducing the risk associated with a selection-based method is to look for ways of improving the involved community member's capacity to participate. There is a strong argument to be made that PD is at its core a capacity building process, through inclusion, situation-based actions and mutual learning (Kensing & Greenbaum, 2012). However, the present researcher highlights several studies (Kujala, 2003; Kam et al., 2006; Hussain & Sanders, 2012) which stress the long time periods required to truly elevate the participants to the level of *design partner* (Druin, 2002). It is therefore important to investigate what form a proactive capacity building stage could take and how it could fit into the PD process. Furthermore, many of the collaborative competencies, listed in the previous section, align with themes already discussed in capacity building literature. For example one study highlights "*the articulateness of the community in expressing its needs*" (Cottrell Jr, 1964, as quoted in Liberato et al., 2001, p. 6) as well as "*community participation in defining and reaching goals*" (p. 6). Dearden and Rizvi (2008) provide a strong argument for exactly this, in a review article of PD research. They state that "*users need understanding; and learning in order effectively to take part in the process*" (p. 7).

Furthermore, they highlight the work of Ehn and Kyng (1992) which is critical of *design by* and *design for* approaches, as both explicitly remove the focus of mutual learning and collaboration. Instead, they argue that only a *design with* approach will allow for an effective design process. The present researcher agrees with aspects of this logic but also highlights the risk of minimal capacity building and long-term independence if a *design by* process is not viewed as the ideological goal.

One attempt at capacity building implementation in the design process is the *Creative Capacity Building* (CCB) framework, developed at the MIT D-Lab (Smith & Leith, 2014). This looked to develop similar competencies as the present research but focuses on using a structured four-day training to instil creative skills in the community members as opposed to using both capacity building and PD as in the present research. An example of the CCB approach is well documented by Taha (2011) in which the author implements the approach in post-conflict Uganda with some positive results. A detailed teaching plan is also presented in this study and will be used for guidance in the present researcher's research.

A second study of note is that performed by Diehl (2010) at Delft University of Technology. Diehl investigated how product innovation knowledge could be transferred to individuals in developing contexts. This is important as capacity building and knowledge transfer are considered an effective aim for international development programs. Diehl states, "*Within this context, knowledge on product innovation is expected to play an important role in this development since it contributes to economical as well as social development*" (p. 3). The study looked to address documented challenges such as individuals in developing contexts having low absorptive capacity (Al–Ghailani & Moor, 1995) and knowledge transfer programs requiring highly tailored content for each socio-cultural context (Aubert, 2005). It did this by investigating four case studies in Tanzania, India, Central America and Croatia. The research developed a conceptual model for product innovation knowledge transfer in developing contexts (Figure 13).

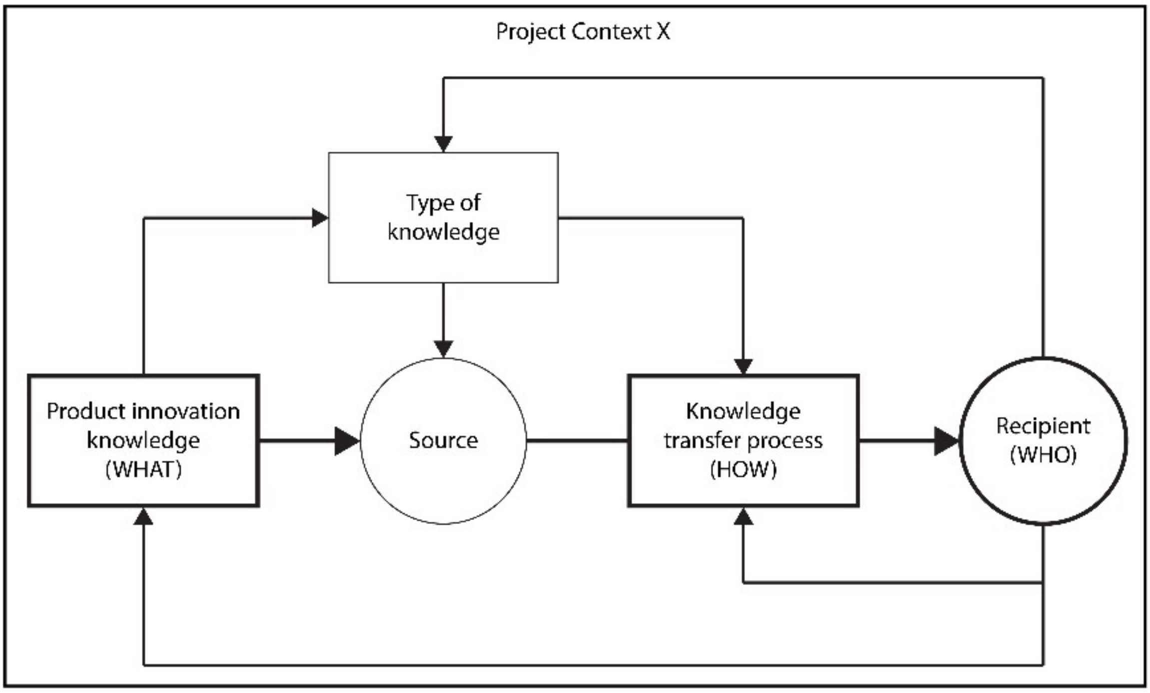


Figure 13 - Knowledge transfer conceptual model (Diehl, 2010)

Of note to the present study is that the above model shows that the *what*, *how* and *who* are of equal importance to the knowledge transfer (previous literature had not stressed the importance of the recipient). Secondly, the model highlights that the project context (socio-cultural environment and characteristics of the involved organisation) is an over-arching theme that influences all aspects of a project. These aspects will be valuable to consider in the present research. While Diehl's study focused on the role of innovation for small businesses in developing contexts, Aubert (2005) suggests that the definition for innovation needs to be widened. They state that by defining innovation as "*something new to a given context; the notion [innovation] then becomes fully relevant to developing countries, even the poorest ones, and applies to all walks of life, from the most basic welfare improvements to the building of vibrant competitive industries*" (p. 34). The present research utilizes this view of innovation and its potential impact on the lives of people with disability in rural Cambodia.

2.4.1 Definition

The meaning of capacity building needs to be discussed, as this varies depending on research field and application. The present research aligns with the United Nations Development Programme definition, which makes a clear distinction between *capacity building* and *capacity development* (Wignaraja, 2009). In this 2009 report, capacity building is defined as "*a process that supports only the initial stages of building or creating capacities and assumes that there are no existing capacities to start from*" (p. 54). In contrast, capacity development is defined as "*the process through which individuals, organizations and societies obtain, strengthen and maintain the capabilities to set and achieve their* *own development objectives over time*" (p. 54). This difference is important to note as the present research looks to use a capacity building stage to build the initial capacities required to effectively collaborate with designers, not become fully autonomous designers themselves, as Taha (2011) proposes. Instead, it will act as a first step to familiarize and build confidence in individuals to engage further with design activities throughout the PD project. This prolonged engagement is deemed by other researchers to act as capacity development in involved individuals through empowering them to design and problem solve on their own (Spinuzzi, 2005; Sanders et al., 2010).

Eade (1997) discusses capacity building in terms of *a means*, *a process* or *an ends*. The view of capacity building as a process aligns well with this research as it looks to foster "*processes of debate, relationship building, conflict resolution and improved ability of society to deal with its differences*" (Eade, 1997, p. 35). This would essentially focus on building each individual's ability to debate and overcome socio-cultural barriers to PD involvement. The sentiment shown in many PD studies, that contextual factors must be considered, is also present in capacity building literature with Eade again stating, "*Capacity building cannot be seen or undertaken in isolation. It is deeply embedded in the social, economic, and political environment*" (Eade, 1997, p. 3). Borg et al. (2012) discusses the terms *capacity* and *realized functioning* in terms of disability and poverty. In basic terms, Borg stated that capacity referred to "*what a person can do or be*" (p. 113) and realized functioning as "*what a person does or is*" (p. 113). In other words, capacity (also referred to as a *capability set*) is an individual's ability to undertake a range of options in an environment while realized functioning (also termed *performance*) is the actual option the individual chooses. This is an interesting description as it highlights the importance of choice in observing disability and poverty. For example, Sen (2001) contrasts an affluent person choosing to fast with a poor person unable to afford food. Although the realized functioning is the same, the capacity of each individual is difference, thus highlighting the inequality more accurately than purely focusing on the individuals actions.

2.4.2 Content Development

There are many existing processes suggested for designing capacity building programs. To begin discussion, Mutoro (2013) developed the four steps of the capacity building cycle for the Rwandan National Capacity Building Secretariat This cycle involves 1. *Setting up*, 2. *Identifying your needs*, 3. *Developing your plan* and 4. *Implement, monitor and evaluate*. This shows that there are a number stages that need to be worked through (steps 1, 2 and 3) before a program is actually implemented. These include setting up partnerships and project funding, developing appropriate content to address needs and developing a project plan for implementation. The importance of developing partnerships is also supported by Jue (2011). Jue analyzed a number of engineering projects at MIT, USA and found that collaborating with a solid community partner was critical to the long-term success of humanitarian engineering projects. Step 2 is important for the present research, as it requires the researcher to identify the needs of the community. It provides three descriptive levels of capacity building to assist in this, *institutional*, *organizational* and *individual*, where individual refers to "*the skills, knowledge, competencies and attitudes of your male and female staff members to perform their role to the expected level of quality*" (Mutoro, 2013, p. 15). While focused on large-scale capacity development programs this framework does provide four attributes deemed important to individual success, as shown in Table 6.

Table 6 - Individual levels of Capacity Building (Mutoro, 2013)

Individual Level	
1	Adequacy of skills, knowledge and qualification of male and female staff members to fully deliver on all their responsibilities
2	Availability of highly specialised skills required
3	Alignment between formal values, mission and vision of the organisation and observed staff behaviour
4	Team-spirit and willingness to work as part of a team reflected by all individuals

The levels of community member involvement in the PD process are also relevant to this planning section as they represent the ideological goals of empowerment in the PD process (Angeles & Gurstein, 2000). Of note is the Design Participation Ladder (see Table 4), designed by Hussain (2010), for work with rural Cambodia amputee children. While focused on PD with children it does provide a number of insights synonymous with all PD with underserved communities as its development centred on the unequal power-structured created through poor, marginalized community's positons in Cambodia's socio-cultural hierarchy.

These characteristics, as well as the collaborative competencies (see Table 5), were used to develop the learning aims and needs for the present research. At an operational level, the present study followed the seven steps outlined in the widely cited Oxfam development handbook (Eade, 1997). The seven steps are summarized in Table 7.

Table 7 - Seven Steps for Planning Capacity Building (Eade, 1997)

Steps	Description
Aims (why)	Clear, explicit and consistent with those of the people or organization seeking training. Include monitoring and evaluation methods.
Learners (who)	Consideration for homogeneity of group, selection methods (self-selection, selection by community or selection by trainers).
Access (where & when)	Consideration for work schedules/seasons, time to practice skills and potential for on-the-job training.
Trainers (who)	Important for facilitators to be experts in managing group dynamics and engaging participants as well as experts in content.
Needs Analysis (what for)	Carefully identify learning needs, including monitoring methods to feedback to trainers.
Content (what)	May include awareness, knowledge, skills or behavioural aspects. Should also include time for introductions and group building.
Methods (how)	Chosen to meet the learners' specific needs. Appropriate education and linguistics levels as well as culturally sensitive. The methods should challenge negative stereotypes.

While this capacity building stage needs to adopt the same flexible, context-sensitive approach as the design of PD methods it has the following additional benefits:

1. Allows participants to focus solely on the understanding of key design concepts, without the added cognitive load of trying to access tacit knowledge related to the project

2. Provides participants with small, simpler project examples or exercises to build confidence and a more holistic view of the design process

3. Allows participants to have more meaningful involvement in the actual PD project once it begins

The capacity building stage also required a number of critical considerations, such as:

1. Facilitating the stage in a way that does not create unequal power structures

2. Ensuring that community members ideas/opinions are not biased by their perceptions of what has been presented

3. Ensuring content and delivery style is at a level that is both appropriate for the participants and valuable to the project

4. Ensuring the time used for this stage provides more value than similar time added to the normal PD process

5. Ensuring that the community members capacity to participate is actually enhanced

The implementation of a CCB stage is supported in several studies with one author stating CCB became an informal aspect of the project (Wilson et al., 1996). Another study concluded it could have been beneficial to "*organize a short session to teach participants about the various stages in a design process*" (Hussain et al., 2012, p. 97). Furthermore, capacity building has already been utilized in the development of technical skills for communities involved in PD. Winschiers (2006) developed community member computer skills and introduced them to appropriate usability principles to aid in the design and testing of prototypes. This was viewed as an important step as community members were co-developing IT solutions without a working knowledge of the limitations of computer systems. To effectively integrate CCB into a PD project, a clear integrated model is needed. The next section presents a new model to allow for this.

2.5 The Adapted Making Framework

In the present research, the researcher has proposes the addition of a capacity building stage at the beginning of the PD process. As discussed, this new stage will be used to address the challenges currently encountered when conducting HTD-using-PD.

After a thorough investigation of extant literature, it was found that no formal integration of capacity building and PD has been developed. Furthermore, there are no conceptual models that guide the implementation of capacity building into a PD project. Winschiers (2006) provides the closest model to what is needed. Winschiers developed the Generic Culture-Driven Design Framework, which included explicit mention of capacity building in the form of ethnographic, computer and cross-cultural training. However, this represents a specific plan, developed for a specific project (requiring computer-use) and is therefore of less value to other projects. Furthermore, the model does not illustrate when in the project each capacity building stage should occur.

A popular structure for viewing the PD process is the *Making* Framework (Figure 7) developed by Sanders and Stappers (2014). This presents a four-stage process, as discussed in Section 2.3.3, that the present researcher will modify to communicate how capacity building should be integrated into the beginning of the PD process. Figure 14 presents the new Adapted Making Framework, which integrates a CCB component into the pre-design stage.

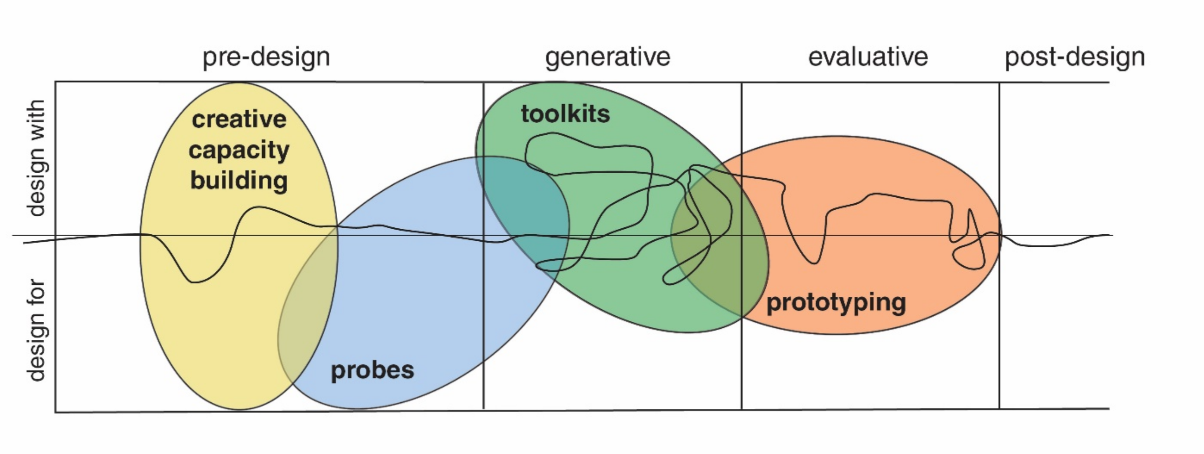


Figure 14 - Adapted *Making* Framework

The present researcher proposes that the Adapted *Making* Framework is the most effective PD process when conducting HTD-using-PD. The framework will be used to structure the planning, data collection, reporting and analysis of the present research. In essence, Research Question 4 (see Section 1.4), aims to validate this framework through the investigation of the usefulness of CCB in enhancing HTD-using-PD.

In the previous section, PD was introduced and a research aim was identified. It is now important to discuss the context in which the present research is situated; PD with people with disability in rural Cambodia. Next, literature on disability will be discussed, followed by a section on the history, and current state of Cambodia.

2.6 People with Disabilities

"*Statistics indicate that about half of all people with disabilities in developing countries live in extreme monetary poverty*" (Borg et al., 2012, p. 112). This statement highlights the importance of addressing issues faced by PwD in developing contexts as it is not only societal implications which restrict their development but also financial constraints.

When discussing disability it is important to understand exactly what the term *disability* describes. While there are many definitions stated in literature (Thomas, 2005), the United Nations Office of the High Commissioner for Human Rights (OHCHR) provides a credible and progressive view of disability. OHCHR (2014) frame their concept of disability as an evolving state that "*results from the interaction between persons with impairments and attitudinal and environmental barriers that hinders their full and effective participation in society on an equal basis with others*" (p. 17). This understanding of disability is important as it highlights the cultural and societal catalysts that create disability. Therefore, disability cannot be viewed as a static medical term, based on the concept of a poorly functioning body, but instead must be seen as a lack of inclusion and acceptance by the direct environment. Utilizing this definition seems appropriate when understanding disability cross-culturally as it allows specific contextual influences to be considered. For example, Cambodia is a predominantly Buddhist country which believes that an individual's present life is a result of actions undertaken in previous lives. This view, that disability is somehow deserved, reduces the acceptance and sympathy for people with disabilities in Cambodia (Connelly, 2009). Viewing disability from a purely impairment-focus would not allow for religious influences to be understood. WHO (2011) describe this shift in mind-set as a transition from *medical model* to s*ocial model* but also highlight the importance of not viewing these models as mutually exclusive. WHO claim a balanced approach is needed as PwD can experience problems related to health conditions as well as problems related to social inclusion. This shift is well articulated by Schulze (2010), on behalf of International Development of the United Kingdom, the European Initiative for Democracy and Human Rights and Handicap International, who explains that "*Persons with disabilities include those who have long-term physical, mental, intellectual or sensory impairments, which in interaction with various barriers may hinder their full and effective participation in society on an equal basis with others.*" (p. 25).

This balanced approach can be facilitated through the use of the International Classification of Functioning, Disability and Heath (WHO, 2002) and in particular the *bio-psychosocial model*. This model (Figure 15) shows how both health conditions and contextual factors contribute to body functions (physiological functions of body systems), activities (execution of tasks) and participation (involvement in real-world situations). Environmental factors are defined as both socio-cultural and atmospheric/geographical while personal factors are defined as an individual's demographic and psychographic characteristics such as age, social background, profession, education, etc.

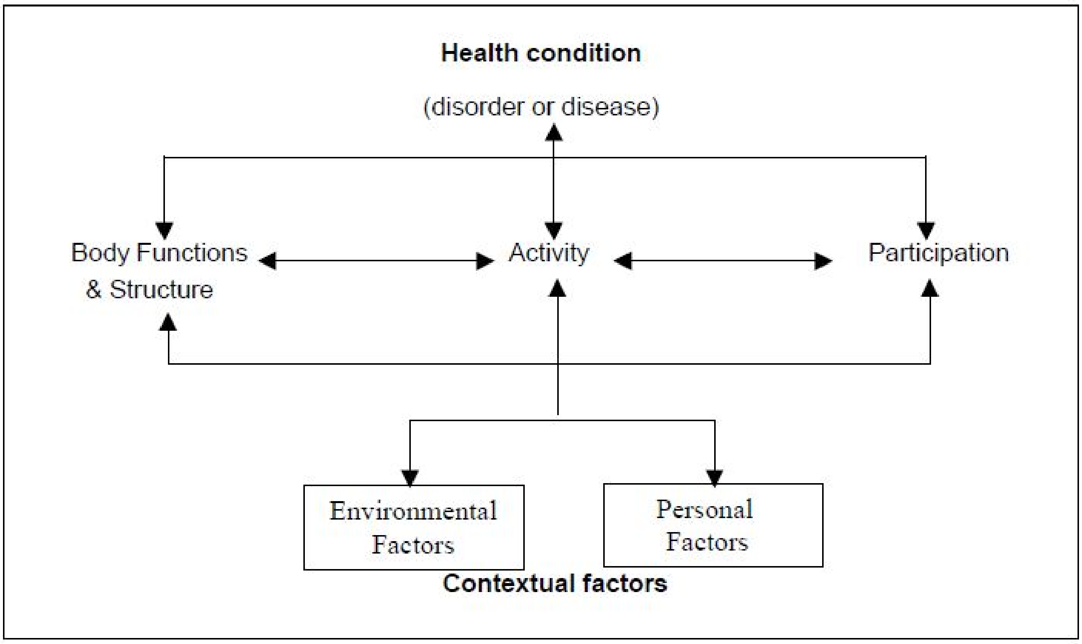


Figure 15 - Bio-psychosocial model (WHO, 2002)

The bio-psychosocial model leads to the categorization of three types of dysfunction used to describe disability:

1. Impairment - Problems with body function or structure
2. Activity limitation - difficulties an individual may have in executing activities
3. Participation restrictions - problems an individual may experience in real-world situations

To provide clarity, WHO (2002, p. 17) present the example shown in Table 8.

Table 8 - Example of bio-psychosocial description

Health Condition	**Impairment**	**Activity Limitation**	**Participation Restriction**
Spinal Injury	Paralysis	Incapable of using public transportation	Lack of accommodations in public transportation leads to no participation in religious activities
Vitiligo	Facial disfigurement	None	No participation in social relations owing to fears of contagion

This descriptive framework is important to the present research as an analytical tool for understanding the current situation for PwD in rural Cambodia and guiding socio-cultural considerations for technological solutions developed.

The Convention on the Rights of Persons with Disabilities (OHCHR, 2014) aligns strongly with the ideology of participatory design and states "*participation goes beyond consultation and includes meaningful involvement in activities and decision-making processes, the possibility to voice opinions, to influence and to complain when participation is denied*" (p. 15).

2.6.1 Assistive Technology

The Assistive Technology Act of 1998 (USA) defines assistive technology (AT) devices as "*any item, piece of equipment, or product system, whether acquired commercially, modified, or customized, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities*" (Alper & Raharinirina, 2006, p. 47). This is a good starting point for AT discussion, as it highlights that AT can be commercially purchased, or created locally, and that the focus is to improve functional capabilities of PwD.

Relating this to the bio-psychosocial model, presented in the previous section, AT relates to improving an individual's ability to perform activities by alleviating impairments in body function and structure. Examples of general AT include mobility devices (such as wheelchairs, canes and prostheses), hearing devices (such as hearing aids) and visibility device (such as glasses). Examples of application-specific devices include agricultural devices such as tractor steering-wheel modifications; single-hand nailing, power-assisted wheelbarrows, reduced-effort shovels and vertical garden structures.

A more novel approach to AT by Ripat and Woodgate (2011) investigated the intersection of culture, disability and AT to more clearly define how culture influences the adoption and retention of AT. The study states it is important to view disability as a construct intersecting gender, socio-economic status, education, sexual identity and social class. As these elements essentially make up the culture of the individual, and their environment, the argument is made that disability and culture must be considered together. Furthermore it is shown that current AT theory "*is based on Western philosophies and ideologies that favour autonomy, independence, and self-determinism*" (Ripat & Woodgate, 2011, p. 91). This highlights that culturally-specific influences are not included in AT theory and in the design of AT devices. This oversight is potentially harmful for PwD in developing contexts where Western ideology is not the norm and where Western infrastructure and utilities are not necessarily present.

A lack of cultural consideration may be one of the reasons why 85-95% of individuals who need assistive technologies do not have access to them (Borg et al., 2012). The present researcher considered this misalignment throughout the research and looked to utilize PD methods as a way of ensuring culture is considered in the design process; as well as the society, environment and individual.

Relevant examples

There are a range of applications for AT in both Western and developing contexts. However, literature tends to focus on the development and assessment of prostheses and wheelchairs. An article focused on western AT devices stated that mobility related devices were the most common type of AT

(Scherer, 2002). Similarly, a study analysing applications for AT, by 33 PwD in Denmark, showed that mobility devices (such as scooters and wheelchairs) were the most common items applied for by individuals. There have also been a number of studies looking at prostheses and wheelchair design for developing contexts, such as the design of prosthetics for children in Cambodia (Hussain & Sanders, 2012), the assessment of prostheses and wheelchairs in India (Pearlman et al., 2008) and the design of wheelchair cushions in Brazil (Guimaraes & Mann, 2003).

The growing number of articles focused on the design and assessment of AT is promising and shows a clear movement in academia towards multi-disciplinary, appropriate engineering projects. This movement has resulted in several open-access internet-based databases for accessing AT designs and connecting with AT device suppliers. Websites such as Appropedia (www.appropedia.org), AgrAbility (www.agrability.org), AbleData (www.abledata.com) and Thingiverse (www.thingiverse.com) have allowed for people around the world to share and access customizable designs for a range of disabilities. For examples of such designs, see Buehler et al. (2015).

The growing availability of AT device designs online is valuable if you are an internet-literature, design-savvy individual. However, it is not a solution for PwD in rural areas of Cambodia who may not have the ability to understand the content or the ability to manufacture the designs themselves. Secondly, designs available through these online sources are only customizable through engineering processes, such as computer-design and workshop machining, and any customization still requires detailed knowledge of the context and individual the AT is intended for. Therefore, the present researcher argues that AT has a lot to gain from the contextualization approach of HTD-using-PD. The next section pivots discussion towards the geographic location of the case study, Cambodia.

2.7 Cambodia

Cambodia is the socio-cultural environment in which this PhD research is located. Elovaara et al. (2006) state that an individual's ideas, values and understanding do not exist in isolation but are instead a product of their socio-cultural environment. Therefore, it is important to state that it is within this setting that our project is located. The following section introduces Cambodia and PwD in Cambodia.

2.7.1 History

While the history of Cambodia is complex and too detailed for the scope of this section, a number of key events need to be discussed including the Angkor Empire, Khmer Rouge and the establishment of a democratic government. The Khmer Empire reigned over large parts of Southeast Asia from around 800AD to 1400AD. Its capital city, Angkor, was located in the northeast Cambodian province of Siem Reap. This civilisation was considered highly advanced constructing irrigation systems, large temples and effective farming practices (Tully, 2006). While the exact reason for the collapse of this empire is not known, a combination of resource scarcity and invasion from the west and east (Siam and Vietnamese Kingdoms respectively) are the most probable cause. In 1863, the French Protectorate was established in Cambodia following a continuation of colonisation in the Southeast Asian region. This was to last for the next 90 years until Cambodia's independence, in 1953, under the rule of King Norodom Sihanouk (Chandler, 1983). Although the period of French occupation did result in political and economic reforms (from socialist to capitalist approaches to ownership and trade), it was largely remembered as a repressive regime which, along with the wars that followed until the mid-1970's, restricted Cambodia's potential to prosper as an independent nation.

Following the end of the Vietnam War and the removal of Western military forces from Cambodia, a period of civil war broke out between the communist Khmer Rouge guerrilla faction and the established Lon Nol government. This was to result in the overthrow of the government in 1975 by the Khmer Rouges, led by Pol Pot. The next four years damaged Cambodia and its people in many horrific ways including the deaths of close to two million people (Ebihara et al., 1994), destruction of any technology or industrial practice deemed to be Western and the complete removal of the formal education system (Tully, 2006). Pol Pot commanded this autocracy with the belief that Western countries had brainwashed urban and educated Khmer people and, that in order for the country to return to its former greatness (during the Angkor Empire), all people and technology affected by the western world should be removed. He then created a plan to reduce every member of the population back to rice farmers, build resources and develop the country again in a way he deemed truly Khmer. This plan resulted in the execution of hundreds of thousands of people and the deaths of well over a million individuals due to malnutrition, dehydration and overwork in the rice paddies around Cambodia.

Even after the Khmer Rouge regime was ended by the Vietnamese, in 1979, the country continued to struggle without adequate agricultural practice, medical supplies or skilled workers. This resulted in hundreds of thousands more Khmer people dying before help was finally received from international organisations and the United Nations. Since this time the country has been governed by one party, the Cambodian People's Party, under Prime Minister Hun Sen. While democratic elections have been undertaken on numerous occasions (1993, 1998, 2003 and 2008) it is widely thought that the oppressive nature of the government, towards opposition parties, has made it impossible for truly democratic politics (Tully, 2006). However, even with such an autocracy Cambodia is slowly improving in almost every measurable way as higher education systems, healthcare and water/sanitation infrastructure continue to improve due to heavy involvement of the international development community.

2.7.2 Religion

There are a range of religious practiced in Cambodia, such as the Sunni Islamic Chams, with Theravada Buddhism being the dominate religion practiced by the Khmer people. A central focus of most villages is the Buddhist temple and robed monks who act as religion leaders. Religion is intertwined with Khmer culture and still features heavily in their daily life. One example of this is the common practice of young Cambodian boys spending a short period as a novice monk at some stage in their childhood. One of the key concepts of Theravada Buddhism is *karma* which essentially views current good and bad aspects of an individual's life as the result of actions in a previous life (Gartrell & Hoban, 2013).

2.7.3 Education

A review of the socio-demographic effects of the Khmer Rouge by De Walque (2006) shows that the Cambodian education system was destroyed during this period and as a result "*individuals of school age at the end of the 1970s, especially men, have a lower level of educational attainment than those in the preceding and subsequent birth cohorts*" (p. 223). This is supported by statistics collated by the EPDC (2012) examining male and female education levels in Cambodia. This study shows that a large amount of the male population does not complete primary school and that the percentage drops dramatically for individuals above 39 years old. For example, for males aged between 35 and 39 years old, 51% have completed primary school. For males aged between 40 and 44 years old, 35% percent have completed primary school. A similar trend is evident in the female population. De Walque (2006) shows the Khmer Rouge's impact on secondary education, for people alive in 1975, in Figure 16. Of note is the dip for individuals aged 14-18 that highlights the inability for students to attend secondary school during the Khmer Rouge period.

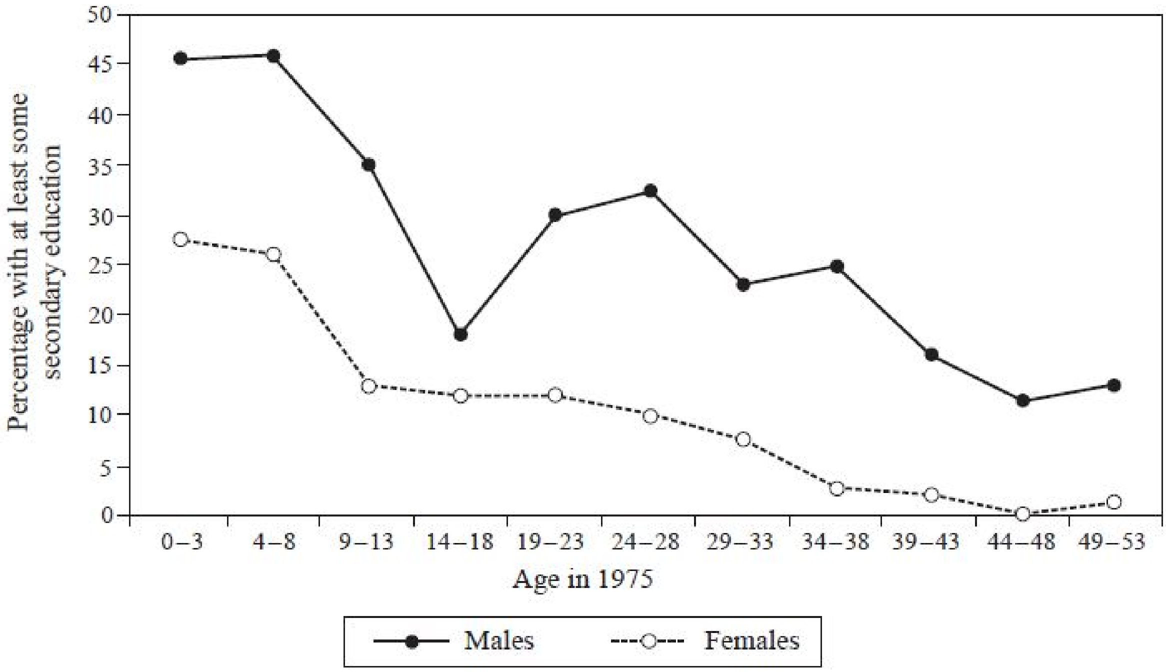


Figure 16 - Secondary school education in Cambodia (De Walque, 2006)

Statistics provided by UNICEF suggest primary school education levels should be expected while secondary school levels will most likely not be present (UNICEF, 2013). Basic Khmer literacy may be present but should not be expected as the total adult literacy rate in Cambodia was around 74% in 2012. A breakdown of Cambodian educational data is shown in Table 9.

Table 9 - Socio-economic data of Cambodia (UNICEF, 2013)

Socio-Economic Measure	**Value**
Total adult literacy rate	73.9%
Primary school participation male, net attendance ratio	85.2%
Secondary school participation male, net attendance ratio	45.9%
Urbanized population	20.1%
Gross national income	880USD, 2360USD using purchasing power parity adjustment (Worldbank, 2016)
Official development assistance	792.3 million USD (2010)

2.7.4 People with Disability in Cambodia

Cambodia has a high number of PwD. Although the exact number is debated, a summary of sources by Thomas (2005) found estimates between 170,000 and 1.4 million, it is widely accepted that Cambodia has one of the highest percentages of people living with disabilities in the world (Connelly, 2009). Gartrell (2010) presents sources estimating between 1.5% and 9.8% of the population may have a disability.

A unique characteristic is that Cambodia has the highest number of amputees per capita in the world (Stover et al., 1994; HALO, 2017); due in large part to the incredible number of land mines laid before, during and directly after the Khmer Rouge regime. Stover et al. (1994) estimated the number of mine amputees to be 36,000 (approximately one in every 236 Cambodians) while Connelly (2009) states it is approximately 40,000 to 50,000. Cameron et al. (2005) state that 46% of the villages in Cambodia are still contaminated by landmines. The need for action has been recognized by the Cambodian Government with the formation of the Disability Action Council (DAC) in 2009 (DAC, 2017). A national disability strategy plan, for 2014-2018, was released by the DAC and highlights the vision that "*persons with disabilities and their families have a high quality of life and participate actively, fully and equally in a society in which their rights and dignity are respected with the inclusion of disability across all sectors*" (Sauth, 2014, p. 3). This is further detailed through a strategic objective which aims to "*reduce poverty of persons with disabilities, through increased work and appropriate employment for persons with disabilities, to ensure their improved livelihood and enhance independence*" (Sauth, 2014, p. 11). This is important as it shows a strong alignment between the present research and the priorities of the country in focus. It also shows the need for development projects that increase accessibility of farming practices for PwD in rural areas and the importance of context-appropriate assistive technologies.

Cambodia is a heavily hierarchical society with stature based on age, gender, wealth, family reputation and political position. However physical capacity overrides this structure and results in less-able individuals being ostracized from the normal social system (Gartrell & Hoban, 2013). This is important to note as it has a direct impact on a person's ability to be involved in community-based farming practices (such as shared equipment and labour, pooling of crops and finances, etc.).

Buddhism and disability in Cambodia

Buddhist values in Cambodia provide challenging cultural influences that limit PwD inclusion in everyday life. Approximately 85% of Cambodians identify as Buddhist (Gartrell & Hoban, 2013) and in turn align with the concept of karma; the idea that an individual receives retribution in the current life for actions performed in a previous life (Gartrell, 2010). This is harmful as it views a person's disability as punishment for wrongful deeds performed in a past life. This view results in PwD not receiving the support, sympathy or inclusion required to live fulfilling lives.

Ripat and Woodgate (2011) wrote an interesting article titled "*The intersection of culture, disability and assistive technology*" in which they analyse a number of existing disability, and assistive technology, studies in order to understand the role that culture plays in the design and implementation of assistive technologies. They found that "*constructions of disability intersect with* *gender, socio-economic status, education, acculturation, sexual identity and social class*" (Ripat & Woodgate, 2011, p. 90). While religion is not explicitly mentioned, the present researcher argues that for a country like Cambodia, with such a deep religious culture, religious influence is implied.

2.8 Important Literature

Through this review of literature, a number of important researchers, and specific research studies were identified. As the present research study sits at the intersection of participatory design, capacity building and a Cambodian context it is important to highlight key works in each of the three areas. Figure 17 is provided for clarity.

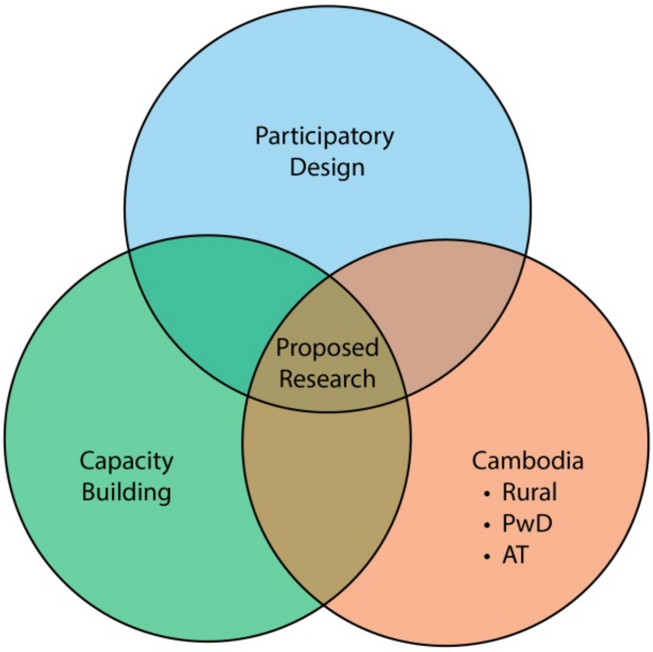


Figure 17 - Contributing areas of research

2.8.1 Participatory Design

Of importance to the present research are the works of Hussain et al. (2012). Sofia Hussain's PhD research, based at the Norwegian University of Science and Technology, looked to investigate the empowerment effects of participatory design processes with amputee children in Cambodia. Working with the International Council of Red Cross, Hussain documented the design and delivery of a HTD-using-PD project over 2 years including a detailed analysis of barriers and limitations. This research provided the present researcher with guidance around the design of qualitative research methods appropriate for a Cambodian context as well as insights into the challenges to expect when conducting PD projects in Cambodia.

Secondly, the multiple works of Elizabeth Sanders (Sanders, 2002; Sanders & Stappers, 2008; Sanders et al., 2010), are important in understanding the second wave of development in participatory design (taking the process from industrial practice to a range of developing and marginalized contexts). Sanders developed the *Making* Framework, now adapted to include a CCB stage.

Finally the International Handbook of Participatory Design (Simonsen & Robertson, 2012) will be used as a detailed guide during the planning and delivery stages of this project. It features chapters from many of the leading authors in this field and was released relatively recently.

2.8.2 Capacity Building

This project will require capacity building knowledge to allow for effective design and delivery of the proposed CCB stage. As such, a development guide produced by Oxfam International (Eade, 1997) will be used to guide the stages of workshop development. This document includes step-by-step support for designing, piloting and delivering capacity building as well as analysis of effectiveness. This will be further supported by the User Research Framework developed at the D-Lab at MIT, USA (Smith & Leith, 2014). This framework provides guidance for conducting qualitative research in underserved communities as well as how to introduce communities to technical concepts throughout the design process. Finally the teaching plan presented by Taha (2011), used for Creative Capacity Building in Uganda, will be used as guidance for the development of the specific capacity building content needed.

2.8.3 Cambodian Context

As all of the fieldwork has taken place in Cambodia (either in the capital city of Phnom Penh or in the rural province of Kampong Chhnang), the cultural and societal characteristics of the country are discussed. In particular, the role of PwD in Cambodia needed to be fully understood. This understanding was crucial to the design of appropriate capacity building content as well as the design of the participatory design project. The work of Gartrell (2010) was used to understand insights about the PwD population of Cambodia.

It was also important to align with a current, international disability framework for planning, conducting and analysing research. Therefore, the International Classification of Functioning, Disability and Health (WHO, 2002) was an important document for this study.

Finally, a participatory design handbook was created by the Melbourne-based company CoDesign Studio to formalize lessons learnt during their project work in Cambodia (Ferguson & Candy, 2014). This will be used, along with cross-referencing with Hussain and Sanders work, as the basis for the tools and overall plan the project will follow.

In summary, the important literature in this research is shown in Table 10.

Table 10 - Summary of important research

Area of Research	Reference	Reason for Importance
Participatory Design	(Hussain, 2010; Hussain & Sanders, 2012; Hussain et al., 2012)	– Description and analysis of a full participatory design project with children in Cambodia – Partnered with an organisation based in Cambodia
	(Sanders, 2002; Sanders et al., 2010; Sanders & Stappers, 2014)	– A number of processes and conceptual models which will be important in the design and analysis of this project
	(Simonsen & Robertson, 2012)	– A handbook with contributions from many important authors – Chapters on the design of methods and on conducting PD with underserved communities
Capacity Building	(Eade, 1997)	– A handbook outlining the history of capacity building, its key ideology and the steps required for design and evaluation of workshops
	(Smith & Leith, 2014)	– A framework for conducting qualitative research in developing contexts and for introducing creative capacity to communities.
	(Taha, 2011)	– A critical account of implementing creative capacity building in Uganda. – A detailed teaching plan including goals, materials needed, presentation notes and reflection
Cambodian Context	(Gartrell, 2010)	– An ethnographic study of the status of PwD in rural Cambodia and how physical infrastructure acts as a barrier to community inclusion
	(Ferguson & Candy, 2014)	– A handbook based on first hand project experience working with rural Cambodian communities on a participatory project
	(WHO, 2002)	– A framework for describing disability using the *bio-psychosocial* model. This categorizes disability as a function of body functions, activity and participation.

2.9 Chapter Summary

This chapter has provided a detailed review of relevant literature in the fields of product development, humanitarian technology development, participatory design, capacity building, disability and Cambodia. It has discussed important findings of previous research and clearly stated the most important studies for the present research. This literature was used to guide the research design, data collection and data analysis process. Additionally, this chapter presented the Adapted Making Framework. This framework represents a new addition to the area of HTD-using-PD and will be investigated through its use in the present research.

CHAPTER THREE

METHODOLOGY

CHAPTER OVERVIEW

This chapter presents the research methodology followed in the present research. It includes a summary of the research scope, questions and objectives. Next, it discusses a range of research methodologies and presents the final methodology chosen for the research. Finally, a detailed research plan is presented, including stages, timeline, data collection and analysis, risks and ethical concerns.

3.1 Research Aim

3.1.1 Scope and Boundaries of the Research

The present research focused on investigating the effect of building creative capacity in community members (termed *participant* from this point forward) before involving them in a PD project. It was therefore limited to a focus on designer-participant collaboration and is not concerned with many other factors identified in literature unless linked to participant involvement in PD.

The research utilized a case study methodology. It focused on the population of technical experts (whether engineers, designers or other professions) conducting HTD projects for, or with underserved communities in developing contexts. This definition is important as "*selection of an appropriate population controls extraneous variation and helps to define the limits for generalizing the findings*" (Eisenhardt, 1989, p. 537).

The study was also limited to one in-depth project (termed Project 1), containing three cases (termed case 1, 2 and 3), investigating the use of CCB and PD activities in a real-world HTD project in Cambodia (detailed description can be found in Chapter 5). This is shown in Figure 18.

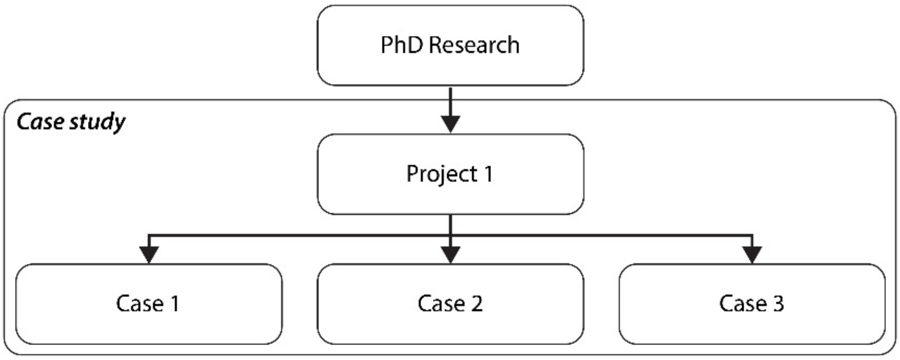


Figure 18 - Overview of research structure

Project 1 worked with three Cambodia-based organisations, Agile Development Group (ADG), Engineers Without Borders Australia (EWB) and Light For The World Cambodia (LFTW) to develop solutions to improve livelihoods of PwD, in rural areas of Cambodia. A description of each organisation can be found in Section 5.2. The research involved designing and delivering CCB content and monitoring the full PD project to investigate the quality of collaboration between professional facilitation staff and a group of rural PwD.

3.1.2 Research Questions and Objectives

This research aimed to identify the competencies desired in a participant to allow for effective collaboration during PD. It aimed to develop context appropriate CCB workshops to proactively develop these competencies as a way of minimizing the limitations and barriers highlighted in literature.

The study aimed to answer the following research questions:

Research Question 1

How are individuals from underserved communities currently involved in HTD-using-PD?

1. What enablers or barriers have been identified for effective collaboration between designer and participant?

Research Question 2

What are the key competencies required to enable individuals from underserved communities to participate effectively in HTD-using-PD?

1. Are these generic for all projects or specific to the project content and context?

Research Question 3

How can CCB be utilized to build the required competencies in participants?

1. Are there context specific delivery methods and learning styles that must be utilized?

2. What are the challenges with implementing this stage in a HTD-using-PD project?

Research Question 4

Does the implementation of CCB enhance the quality of collaboration between designers and participants during HTD-using-PD?

1. How can this improvement be measured?

2. Are certain stages affected by the capacity building activities more than others are?

The research objectives can be stated as follows:

1. Understand the current state of HTD-using-PD, including enablers and barriers to success

2. Investigate whether existing conceptual models are adequate for guiding successful HTD-using-PD

3. Identify the key competencies required for participants from underserved communities to collaborate effectively in HTD-using-PD

4. Develop CCB workshops to build participants ability to collaborate effectively in HTD-using-PD

5. Evaluate whether implementing CCB workshops results in better quality collaboration between designer and participant during HTD-using-PD
6. Provide a detailed account of the process utilized to add to the growing research field of HTD-using-PD with underserved communities

The research questions and objectives were used to develop a research plan.

3.2 Epistemological and Ontological Perspectives

The present researcher's methodology and analysis was inherently biased by their own philosophical views and pre-understanding. It is therefore important to articulate their personal views and the effects that this may have on the interpretation of findings (Bryman & Bell, 2015). These philosophical perspectives also helped to guide the selection of appropriate research tools and techniques. Firstly, an ontological view is stated as this is "*the starting point of all research, after which one's epistemological and methodological positions logically follow*" (Grix, 2002, p. 177).

3.2.1 Ontological Perspectives

In general, ontology is the way in which an individual believes society (any environment involving individuals interacting) operates and interacts with itself and how knowledge about this society exists. There are two contrasting views in this area (Grix, 2002; Bryman, 2015). Firstly, the view that actors (people) in an environment interact with each other and in turn create the culture and networks which exist (known as a *constructivist* view). Secondly, that these social phenomena are independent of the people involved in them and may even influence the way people interact and operate (known as an *objectivist* view).

A constructivist ontological view was taken for the present research that focused on both the design process as well as how people, in this case designers and participants, interacted with the process. This view enabled social constructs to be identified and used to explain how a participant may interact with a designer in the design process.

3.2.2 Epistemological Perspectives

In general, epistemology refers to the way in which knowledge about the social world can actually be learnt (Mertens, 2010). In other words, it is the discussion about the knowledge available in a discipline, its validity and acceptable methods for gaining that knowledge. One of the main questions posed is "*whether the social world can and should be studied according to the same principles, procedures and ethos of the natural sciences*" (Bryman & Bell, 2015). *Positivism*, which affirms the previous statement, refers to a view of social phenomena in which researchers will look to understand phenomena in a similar way to natural sciences (i.e. through quantitative methods).

Conversely, *interpretivism* is the belief that human interaction is fundamental to the understanding of social phenomena and therefore methods founded in natural science would not be suitable for such understanding. It relies on the idea that a person's point of view should be understood to accurately describe a social phenomenon and that a failure to understand an individual's pre-understanding, and biases, would result in incorrect assumptions and conclusions.

This research utilized an interpretivist perspective with emphasis placed on how interactions and relationships with designers and participants affected the quality of collaboration. Some focus was placed on a benchmarking measure of success; however, understanding the key drivers for successful participant involvement was more important than quantitative benchmarking.

3.3 Research Methodology

The following section discusses the various research methodologies that could be used in the present research. It then provides an overview of the chosen methodology including its limitations.

3.3.1 Appraisal of Alternative Research Methodologies

There are two main groups used to categorize research methods; quantitative and qualitative. Although a dichotomy is arguable (Bavelas, 1995), each group defines the role of theory in relation to research, and to some extent the epistemological and ontological perspectives of the research (Bryman & Bell, 2015). The mixed methods approach has also become popular as it looks to combine aspects of both quantitative and qualitative methodologies to provide an arguably more robust approach (Doyle et al., 2009).

Quantitative Methodology

Quantitative methodology utilizes a deductive approach to research where a hypothesis is devised from theory and tested through rigorous, measurable methods. This process naturally fits with a positivist epistemological perspective as it tends to adopt approaches from natural sciences and look to explain correlations between variables (Mertens, 2010). The assumption that a context can be studied without the effect of individual actors and an objectivist ontological perspective are centre to the research tools used in this area. Often, statistical analysis of numerical data is used to create generalizable findings and confirm or disprove a stated hypothesis.

This approach has received criticisms relating to a lack of distinction between people and natural objects and the lack of appropriateness of the measurement process to account for individual's views of reality (Cicourel, 1964). However, the easily measurable nature of this approach can make it very useful for generating broad insights into a population as well as validating qualitative findings. The replicability of a quantitative design is also seen as a benefit as it allows others to retest a hypothesis in a range of contexts to ensure generalizability.

Qualitative Methodology

Qualitative research utilizes an inductive approach by using in-depth research studies to propose theoretical explanation (Bryman & Bell, 2015). This research fits with an interpretivist epistemology and looks to understand the social world through a focus on the individual actors present in the environment (Doyle et al., 2009). It also utilizes constructivist ontology and focuses on the "*interactions between individuals, rather than phenomena 'out there' and separate from those involved in its construction*" (Bryman & Bell, 2015).

When deciding on a methodology to align with it is important to understand the characteristics of the paradigm. Creswell (2013) summarizes the following basic characteristics of qualitative research:

1. Natural Setting - data tends to be collected in the field with participants engaging in everyday activities. This allows the researcher to gather up-close information and explore events through interacting with participants directly.

2. Researcher as key instrument - The researcher plays an important role in data collection and analysis as it is their intuitive understanding of a subject, as well as explicit data sources, that allow for meaningful analysis and conclusion to be drawn.

3. Multiple sources of data - Qualitative research generally utilizes multiple data sources as a way of triangulating and cross-referencing findings.

4. Inductive and deductive data analysis - While research starts with the building of theory through identification of patterns, themes and categories, a researcher should also look back on the data deductively to investigate whether emergent themes can be supported by additional data gathered.

5. Participants' meanings - The research process involves understanding the underlying meaning a participant holds about an event and not only the researchers pre-understanding.

6. Emergent design - As most qualitative research is exploratory in nature it is important to allow for research plans and questions to change as the researcher's understanding grows.

7. Reflexivity - Explicit discussion around the researcher's personal background, culture and experiences is important for both identifying potential bias and for understanding the process of analysis and conclusion.

8. Holistic account - A systems-thinking approach to understanding multiple perspectives and factors in the process of building theory and establishing a holistic view.

Although there is debate around the exact definition of qualitative research, there are a number of traits common to research in this area. Research findings in this area are generated through in-depth studies of a small number of individuals, or groups. These studies utilize tools such as ethnography, interviews, focus groups and thematic analysis and aim to describe a particular social construct in detail and to derive theory from what has been observed. One criticism of this is that the process relies heavily on the personal perspectives of the individual acting as the research tool and so reproducibility and generalizability cannot be assumed. Qualitative approaches will be valuable for the present research as interactions between social actors, as well as perceptions of value in the design process will need to be investigated.

Case Study Research Design

Of note to the present research is the qualitative approach known as case study research design. This is explained by Schwandt (2001) through its contrast with traditional, quantitative variable studies. In a case study, the case is the focus, not explicit variables. As such, this exploratory approach allows theory to be discovered which explains a range of social phenomenon. A case is defined by Schwandt (2001) as being "*typically regarded as a specific and bounded (in time and place) instance of a phenomenon selected for study. The phenomenon of interest may be a person, process, event, group, organisation, and so on*" (p. 22)

Inside of this research design, there are two distinct design approaches: single-case design and multiple-case design. While both options have merit, Yin (2013) highlights five rationales for single-case designs relevant to this research; *critical, unusual, common, revelatory* or *longitudinal*. A critical case refers to a single case that is so insightful that significant theory can be confirmed, challenged or extended. Unusual or extreme cases represent cases well outside the theoretical norms of the research field with the potential to uncover unique insights. Common cases are used to represent everyday situations in which a single case study can capture generalizable insights. Revelatory cases are opportunities to "*observe and analyse phenomenon previously inaccessible to social science inquiry*" (Yin, 2013, p. 52). Finally, and most relevant to the current research, is the longitudinal case in which a single case is observed over a period of time with multiple data collection opportunities.

This type of case is appropriate when the study is interested in changes in conditions, or perceptions over a period of time.

Multiple-case design research is also a common, and arguably more favoured, method. Multiple-case design can be used to allow for literal and theoretical replication (external validity) and the potential to develop more rigorous findings (Palakshappa, 2003). Multiple cases can also allow for cross-case analysis, which in itself can identify theory.

Mixed Methods Methodology

A mixed methods approach refers to the combination of both quantitative and qualitative methods in the same study; either concurrently or sequentially. While this methodology allows, in theory, for the benefits (Doyle et al., 2009) of both approaches to be combined into one rigorous study there is also criticism that the two approaches, with two separate philosophical perspectives cannot exist together without creating contradictions in perspective.

This research methodology was considered, it was decided that the qualitative nature of the research field, as well as the challenges of access to participants made quantitative methods a poor choice and as such removed the possibility of a mixed methods approach. A qualitative methodology is selected and is outlined in the next section.

3.3.2 Chosen Research Methodology

The following section outlines the chosen research methodology, specific research methods used and ethical considerations that were adhered to throughout the project.

Qualitative Methodology

A qualitative methodology was used, as the research undertaken was inductive in nature. The study aimed to identify competencies of an *ideal* participant, ways of enhancing these competencies and investigate the quality of collaboration between participant and designer. It did this through a series of interviews and observations. This aim is well aligned with a case study, qualitative approach as "*in the entire qualitative research process, the research keeps a focus on learning the meaning that the participants hold about the problem or issue*" (Creswell, 2013, p. 186).

The following sections outlines the case study plan and data collection and analysis plans used for completing the research.

Case Study Methodology

A longitudinal multi-case design was undertaken to apply CCB to a real world HTD-using-PD project and qualitatively assess its effectiveness. The present researcher worked with the Cambodia-based organisations ADG, EWB and LFTW, to develop assistive solutions to improve the livelihoods of people with disabilities in rural Cambodia. The present researcher worked with ADG to design the CCB stage and with all three organisations to facilitate Project 1. Project 1 was proposed through a discussion with all organisations and aligned with the aims and objectives of all. Project 1 utilized existing research into participatory activities as inputs for project planning (Reinders et al., 2007; Marschke & Sinclair, 2009; Hussain, 2010; Ferguson & Candy, 2014; Mazzurco, 2016) as well as capacity building literature (Eade, 1997; Taha, 2011) and assistive technology research (Steele, 2006; WHO, 2011).

Project 1 involved 11 designers, 60 participants and 3 design briefs. The three design briefs were used to form three cases inside of Project 1 (termed case 1, 2 and 3). This allowed for more rigorous analysis of the role of the designer and project-focus as well as cross-case analysis.

Table 11 explains how the cases were formed and their unique and similar aspects.

Table 11 - Multi-case research design

	Project 1		
	Case 1	***Case 2***	***Case 3***
Defining characteristic	**Design brief 1**	**Design brief 2**	**Design brief 3**
Unique aspects	1. Focused on rice planting 2. Involved unique participants 3. Involved unique designers	1. Focused on ploughing fields 2. Involved unique participants 3. Involved unique designers	1. Focused on chicken farming 2. Involved unique participants 3. Involved unique designers
Similar aspects	1. Participants are a mix of able and PwD 2. Designers are a mix of expertise, genders and nationalities 3. Participants completed CCB 4. Participants completed PD design stages		

Justification of Case Study Methodology

Yin (2013) states that case study methodology is appropriate if the research focuses on answering *how* or *why* questions and if research questions require an extensive, in-depth investigation. This is supported by Schwandt (2001) who highlights the importance of case study research when "*the inquirer has little control over events being studied, when the object of the study is a contemporary phenomenon and the context are not clear, and when it is desirable to use multiple sources of evidence*" (p. 23). Case study research is therefore focused on understanding phenomenon present in real-world, single settings (Eisenhardt, 1989).

In relation to the present research, there are several points to discuss. Firstly, due to the logistical constraints of undertaking first-hand research in a developing context, thousands of kilometres from the present researcher's country; it would have been difficult to perform case study research on multiple projects. This would have most likely compromised either the richness of data collection or the fundamental ideology of PD. This compromise could have led to poorly planned and executed projects, which did not fully utilize the participatory methodology. Therefore, the decision was made to focus on one project (Project 1) and to utilize the three unique design briefs (case 1, 2 and 3) inside of this project to create a multi-case design. This addressed the above challenge while also minimizing the issues associated with a single case design.

Secondly, to truly understand the PD project the researcher needed to observe and document the entire design process. This level of detail required multiple trips to Cambodia and the collection of longitudinal data from a range of sources. The present researcher believes that alignment with PD ideology is essential to fully understanding the enablers and barriers of PD implementation and in reducing the effects of cultural bias during collection and analysis of data. This also led to the decision to utilize a three-case research design.

This multi-case design was chosen as it allowed for clear structuring of data collection, analysis and reporting and the ability to undertake cross-case analysis. Given all three of the cases were situated within the same socio-cultural context and larger project, the present researcher acknowledges that the generalizability of findings were not strengthen to the same extent as other multi-context case study research. Instead, the three cases represented literal replications, which helped to improve the robustness of findings (within the clearly stated context) through strengthening external validity. As the foci of each of the three cases emerged naturally through the project, it was not possible to view the cases as theoretically different during planning. However, differences that emerged during the project were identified and discussed during analysis.

Limitations of Single-case Methodology

"*Single-case designs are vulnerable if only because you will have put all your eggs in one basket*" (Yin, 2013, p. 64). The present researcher acknowledges the limitations of a single-case design including an increased amount of risk, lack of generalizability of findings and inability to verify results through cross-case analysis. These limitations may well be a reason for the lack of published research in the PD field, and the lack of developed theory to support HTD-using-PD. Eisenhardt (1989) supports this sentiment highlighting the risk that "*building theory from cases may result in narrow and idiosyncratic theory*" (p. 547). Eisenhardt suggests that enfolding case study findings with extant literature to discuss similarities and conflicting results in similar and widely different contexts can help to build confidence in internal validity and generalizability. These limitations were also taken into account when deciding to utilize a three-case research design.

Next, a detailed description of how the multi-case research design was implemented is presented. This includes the presentation of the research plan, data collection methods and associated ethical and risk concerns.

3.4 Research Plan

The present research was conducted in four stages. These are summarized in Figure 19.

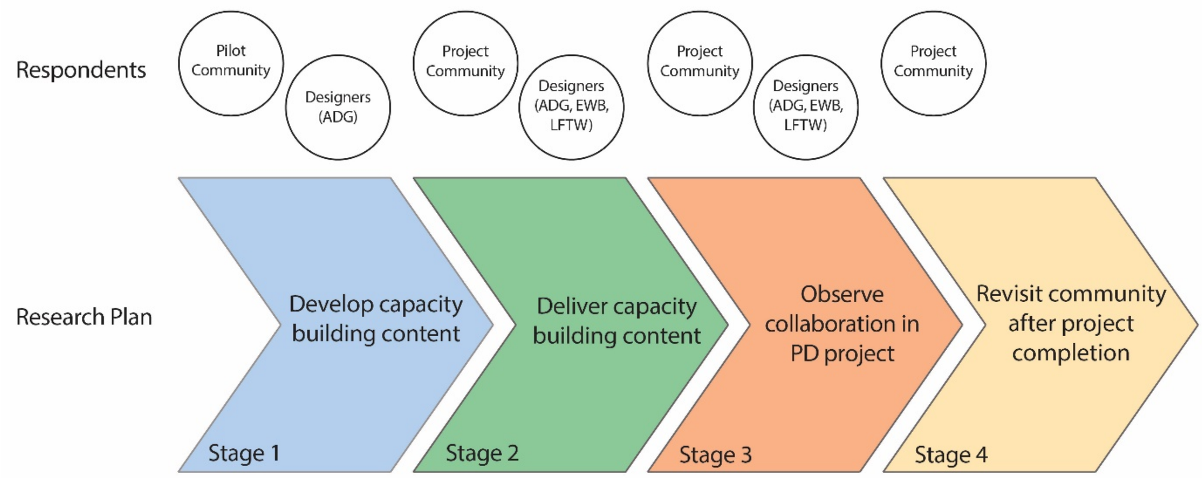


Figure 19 - Summary of research stages

3.4.1 Stage 1

The aim of this stage was to design creative capacity building content for use in Project 1. This content was based on extant literature and was also developed through workshops with ADG in Cambodia. A first iteration of material was developed in New Zealand, from literature and internal expertise, before travelling to Cambodia to work with ADG to refine and pilot the content. This was important as cultural and societal practices specific to Cambodia were considered as they affect the delivery mechanisms and the pedagogical approach taken. The CCB content development process is shown in Chapter 4.

3.4.2 Stage 2

This stage involved the delivery of CCB content, developed in Stage 1, as well as interviews with designers and participants to understand its effectiveness. Cambodian designers delivered the content in the local dialect (Khmer). Live translation, audio recording and independent translation/transcription was used during data collection and processing to ensure the present researcher understood important conversations and responses to interviews and field diaries.

3.4.3 Stage 3

This stage involved engaging in, and monitoring, the actual PD project, involving a large amount of designer-participant interaction. The Adapted *Making* Framework guided this stage (Sanders &

Stappers, 2014). The aim of the present research was to understand whether the delivery of CCB (Stage 2) had any effect on the quality of collaboration between participants and PD designers in the PD Project.

3.4.4 Stage 4

Stage 4 was used to investigate the mid-term effects of the CCB and PD project. This involved independent interviewers visiting the community and interviewing a select number of participants. The aim of this stage was to understand if creative capacity had been developed and to understand what impact the PD project had had on the community.

3.4.5 Timeline

In order for each stage to be completed, a number of field visits were needed. These are outlined in Table 12 along with their aims and activities.

Table 12 - Overview of Field Trips

Field Study	Actions	Aims
I: January 2017 (Stage 1)	• Interviews with local designers • Workshops to develop CCB content • Pilot sessions to test CCB content	• Get an initial understanding of the local designer knowledge, experience and motivation • Develop final CCB content for use in PD project
II: June 2017 (Stage 2 and start of Stage 3)	• Workshop with community to present CCB content • Workshop with community for pre-design stage • Interviews with designers and participants	• Expose community to creative capacity building • Understand direction/aim of PD project • Gain initial understanding of contextual requirements / constraints • Gain an understanding of participants ability to be creative
III: July 2017 (Stage 3)	• Workshop with community for generative design stage • Interviews with designers and participants	• Generate initial ideas of solutions • Gain an understanding of participants ability to be creative
IV: September 2017 (Stage 3)	• Workshop with community to revisit generative design stage • Workshop with community for evaluative design stage • Interviews with designers and participants	• Investigate whether more ideas have been developed between visits • Generate more ideas of solutions • Create prototypes to test ideas • Gain an understanding of participants ability to be creative
V: November 2017 (Stage 3 & Stage 4)	• Workshop with community for evaluative design stage • Workshop with community for post design stage • Interviews with designers and participants	• Create prototypes to test ideas • Develop an implementation plan to ensure technology has impact • Gain an understanding of participants ability to be creative

A more detailed timeline, showing all stages of the present research is shown in Figure 20.

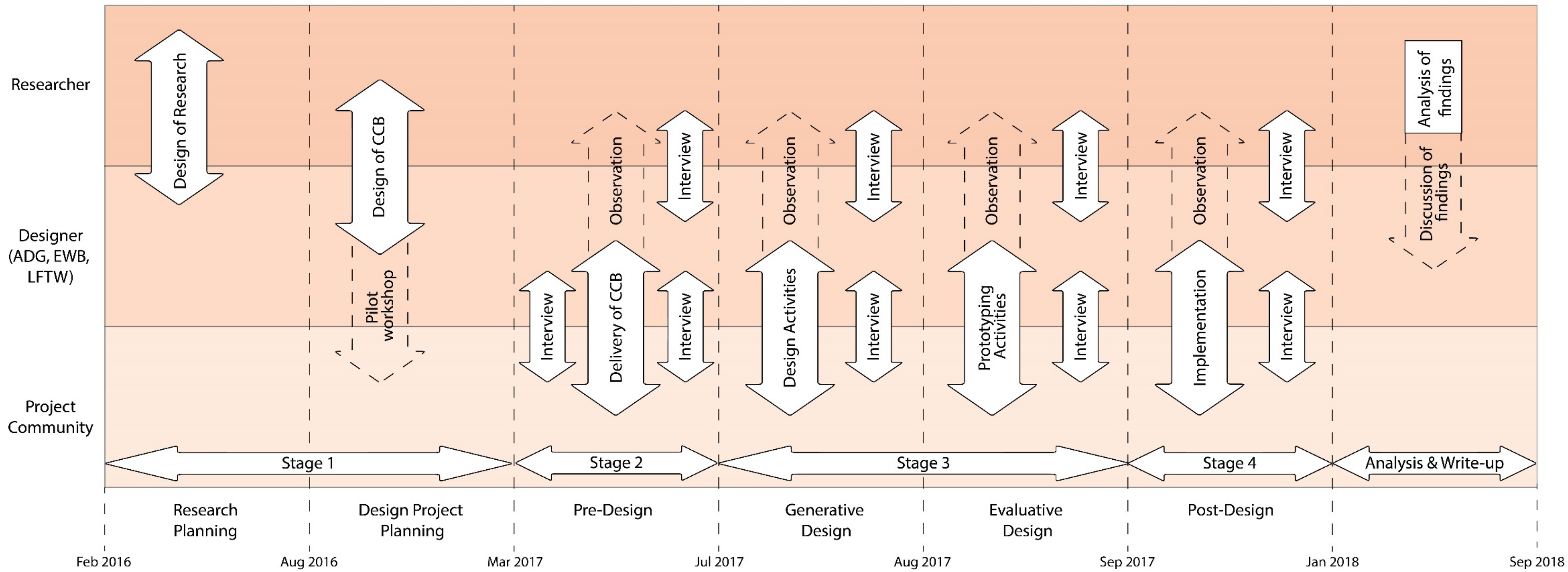


Figure 20 - Summary of research plan

When will the research study end?

A common challenge in qualitative research, and in particular ethnographical studies, is deciding when to finish data collection. This is because in many studies there is no obvious end-point (for example, if a researcher was living in a community researching social behaviour with no obvious entry and exit point). Brink (1993) suggests that data collection and analysis should persist until no new information is being collected; known as saturation or redundancy.

In the present research, a project was followed from start to completion. This defined a set time and a set number of interactions with designers and participants and allowed clear entry and exit points to be identified.

3.5 Data Collection Procedures

Yin (2013) states the importance of using multiple data sources and states there are six key sources of evidence. These are presented in Table 13.

Table 13 - Sources of Evidence (Yin, 2013)

Source of Evidence	Example
Documentation	Letters, memoranda, e-mails, diaries, calendars, notes, agendas, administrative documents (such as proposals, progress reports and internal records), formal evaluations and news clippings
Archival records	'Public use files' (such as census and statistical data), service records, organizational records (such as budgets), maps or charts and survey data produced by others
Interviews	Structured or qualitative (participation, recordings or transcriptions)
Direct observation	Observation, field notes, photographs, recordings all recorded as an uninvolved observer
Participant observation	Observation, field notes, photographs, recordings all recorded as an observer involved in the activities and environment being observed
Physical artefacts	Technological device, tool or instrument, work of art, or other physical evidence

This particular research study utilized documents, interviews, direct and participant observations and physical artefacts.

3.5.1 Documents

Documents were collected to gain insights into designer perceptions during each workshop. Designers were asked to record their thoughts in a field diary, which provided a template to guide their reflection in a way that allowed for longitudinal comparison. This personal reflection occurred during stage 2 and 3 and allowed flexibility in terms of the number of entries and the time at which an entry was completed. This ensured each designer had the ability to document all events deemed important. Stage 1 also utilized written teaching plan documents for the capacity building stage.

This is summarized in Table 14. An example of the field diary template is shown in Appendix A.

Table 14 - Overview of documents

Source	**Objective**			
	Stage 1	**Stage 2**	**Stage 3**	**Stage 4**
Documents	To record teaching plans and gain insights into the changes proposed to each iteration of teaching plan	To gain feedback from local designers of the capacity building sessions about the content and delivery style and its perceived effectiveness	To gain insights into the local designers perceptions of how effective participants were in participatory design activities in the PD process	Not Applicable

3.5.2 Interview

Interviews were used in all four stages of this research. There are two main types of interview research, highlighted by Bryman and Bell (2015); *structured* and *qualitative*. Structured interviews focus on ensuring reliability and validity of measurement by conducting interviews in a rigid, predetermined way and repeating this exact way in each interview conducted. This method generally utilizes closed questions and is closely linked to survey research.

Conversely, qualitative interviews, which can be unstructured or semi-structured, involve the interviewer having a list of topics that they would like to cover. However, the interview has the freedom to ask new questions, to delve into emerging topics during the interview. Unstructured interviews are exploratory in nature and can lead to a conversation-style interaction (Bryman, 2015). Semi-structured interviews combine some structured questions/topics but the flexibility to engage in news lines of questioning and conversation with the interviewee. Turner III (2010) stated that they were "*able to ask follow-up or probing questions based on their responses to pre-constructed questions*" (p. 755) and that they found this quite useful in their interviews because they "*could ask questions or change questions based on participant responses to previous questions*" (p. 755).

Semi-structured interviews were used in all four stages of the proposed research as a way of gaining detailed insights into the perceptions of the designers and the participants. They were also used as tool for tracking participant competency levels. Semi-structured interviews allowed for a consistent structure and focus to be kept through each interview over a series of months while still allowing emerging themes to be explored. The present researcher conducted the interviews with designers in English with all interviews being transcribed for later analysis. Interviews with participants were conducted by a Cambodian interviewer, in Khmer, and were kept short and simple to remain as nonintrusive as possible. These interviews were either recorded, translated and transcribed or not recorded and a summary of answers written by the interviewer.

A summary of planned interview techniques is shown in Table 15. Examples of the interview scripts used are shown in Appendix A.

Table 15 - Overview of interviews

Source	**Objective**			
	Stage 1	**Stage 2**	**Stage 3**	**Stage 4**
Semi-structured interview	To understand each designer's experience and gain insights and feedback about the CCB content, developed from literature, and the proposed delivery methods	To gauge initial participant experience and to gain feedback from designers and participants about the CCB content, delivery style and its perceived effectiveness	To gain insights from designers and participants the quality of collaboration throughout the PD project and gauge participant collaborative competency levels	To gain insights from participants about the mid-term impact of the CCB and PD project

3.5.3 Observation

Observation was utilized during stages 2 and 3 of the research. This involved observing the CCB content delivery during piloting (stage 1) and during the actual delivery (stage 2). Observation was also undertaken throughout the PD project (stage 3) including planning activities beforehand and debriefing afterwards. Similar to interviewing, observation has a range of techniques available ranging from structured observation through to less-structured ethnographic approaches.

Structured observations refer to the process of observing an environment and recording behaviour in terms of predetermined categories developed before the start of data collection. The use of field stimulations is also described in conjunction with structured observations as a way of influencing the observed environment (Bryman & Bell, 2015). This technique has some relevance to the present research as it essentially asked designers to use a novel process of participant involvement, in a real world PD project, and monitor the effect of such use. However, the use of new development tools is common in the highly evolving area of PD and as such practitioners are well practiced in learning about and implementing new tools (Red et al., 2013).

Ethnography is the extended involvement of the researcher in the day-to-day lives of those who they study (Bryman & Bell, 2015). It is essentially a researcher spending a long period as a *fly-on-the-wall* in the participant's environment, taking notes and observing activities and interactions in an open, exploratory way. The term *micro-ethnography* (Wolcott, 1990) is also used to describe a smaller, more focused observational study in which particular aspects of participant's activities can be studied in detail over a shorter period of time than a full ethnographic study.

Bryman (2015) highlights the work of Bell (1969) who presents four forms of ethnography; overt/covert and open setting/closed setting. Combinations of these terms are presented in Table 16.

Table 16 - Forms of ethnography

	Open setting	**Closed Setting**
Overt role	Type 1	Type 2
Covert role	Type 3	Type 4

The labels overt/covert refer to whether the participants being observed are aware of your role as a researcher; while the labels open/closed refer to the environment in which the observation is occurring. For example, an open setting could involve observing a person's interactions in the wider community while a closed setting could be observing the interactions between customers and a particular sales member at a particular company. Another key characteristic of ethnography to define is the level of researcher involvement in the environment being observed. Gold (1958) classifies four participant observer roles ranging from complete observer, in which the observer does not interact with the participants at all, through to complete participant, in which the observer also acts as a fully functioning member of the social setting, while not conveying their role as an observer. This spectrum is presented in Table 17.

Table 17 - Observer involvement in ethnography (Gold, 1958)

Involvement ⟵			⟶ **Detachment**
Complete participant	Participant-as-observer	Observer-as-participant	Complete observer

Participant-as-observer roles are similar to complete participant roles but the participants are aware of the researcher's motives. Observer-as-participant is similar to the complete observer role, but allows for interviews and interactions with participants while still ensuring little observer participation in the social setting.

The present research utilized participant observation, in stages 1, 2 and 3, in which an overt, observer-as-participant role was held by the researcher. A summary is shown in Table 18.

Table 18 - Overview of observations

Source	Objective			
	Stage 1	**Stage 2**	**Stage 3**	**Stage 4**
Overt, closed setting participant observation	To pilot the capacity building content with representative participants	To gain insights into the interactions between the designers and participants during the capacity building session	To gain insights into the interactions between the designers and participants during each stage of the PD process	Not Applicable

Observations were recorded through brief field notes at the time of each particular event as well as a full write up of events at the end of a day of observation. Observations included appearances, verbal behaviour and interactions, physical behaviour and gestures, personal space, people who stand out and any other information deemed relevant. Key themes relating to the effectiveness of CCB and designer-participant collaboration will be identified and used to discuss the overall effectiveness of the PD project.

3.5.4 Physical Artefacts

Physical artefacts are not always relevant to case study research. However, given the focus on design and the creation of assistive technologies it would have been irresponsible to not discuss the physical outputs to this project. These included pre-design outputs (completed templates and collages), generative design outputs (sketches, mind maps and models) and evaluative design outputs (prototypes). Relating back to the design hermeneutic model (Hussain & Sanders, 2012), presented in Section 2.3.3, it was important to view a participant's interaction with a product as a function of the participant, product and the society and culture in which the interaction occurs. Similarly this research project looked to understand the products (physical artefacts) created during the process and discuss these in terms of the environment (both the design environment and the socio-cultural environment) in which they were created. To ensure the community was not negatively impacted by the research, artefacts were only removed if permission was granted by the community and no negative impact was caused. In some cases photographs and videos were used to record the artefacts for further analysis.

Stage 1 and 2 also resulted in the design of small prototypes during CCB activities. These were documented through photographs and included in discussion during analysis. This is summarized in Table 19.

Table 19 - Overview of physical artefacts

Source	Objective			
	Stage 1	**Stage 2**	**Stage 3**	**Stage 4**
Design artefacts	To document the physical examples that were utilized during the pilot workshops	To document the physical prototypes that were presented and created during CCB workshops	To document the physical outputs (collages, models and prototypes) that were created during the PD project	Not Applicable

3.5.5 Summary of Data Sources

The present research used documents, interviews and observations as the main sources for detailed analysis. The strategy behind was as follows:

1. Documents (designer field diaries) were used to gather structured feedback from designers related to the participant competencies and effectiveness of each design activity
2. Interviews with designers were used to explore a wider range of topics around designer-participant collaboration as well as probe for more detailed answers to questions answered in the field diaries.
3. Interviews with participants were used to learn about their perceptions of the collaboration and gauge collaborative competency levels
4. Observations were used as a tertiary source for verifying data collected through documents and interviews as well as identifying interesting interactions to discuss during interviews.

As the present research utilized a number of data sources, as is expected in case study research (Schwandt, 2001; Yin, 2013), it is important to clearly understand the sources which were collected and used for data analysis. Table 20 provides an overview of all the data sources, the reason for its collection and the specific data that will be collected.

Table 20 - Summary of Data Sources

Source	Objective			
	Stage 1	**Stage 2**	**Stage 3**	**Stage 4**
Documents	To record teaching plans and gain insights into the changes proposed to each iteration of teaching plan	To gain feedback from local designers of the capacity building sessions about the content and delivery style and its perceived effectiveness	To gain insights into the local designers perceptions of how effective participants were in participatory design activities in the PD process	Not Applicable
Interviews	To understand each designer's experience and gain insights and feedback about the CCB content, developed from literature, and the proposed delivery methods	To gauge initial participant experience and to gain feedback from designers and participants about the CCB content, delivery style and its perceived effectiveness	To gain insights from designers and participants of the quality of collaboration throughout the PD project and gauge participant collaborative competency levels	To gain insights from participants about the mid-term impact of the CCB and PD project
Observations	To pilot the capacity building content with representative participants	To gain insights into the interactions between the designers and participants during the capacity building session	To gain insights into the interactions between the designers and participants during each stage of the PD process	Not Applicable
Physical Artefacts	To document the physical examples that were utilized during the pilot workshops	To document the physical prototypes that were presented and created during CCB workshops	To document the physical outputs (collages, models and prototypes) that were created during the PD project	Not Applicable
Data Produced	• Teaching plans • Interview recordings and transcripts • Field notes and photographs from workshops • Photos of prototype and sketch examples used in workshops	• Field diary entries from designers • Interview recordings and transcripts • Field notes and photographs from workshops • Photos of prototype and sketch examples used and created in workshops	• Field diary entries from designers • Interview recordings and transcripts • Field notes and photographs from workshops • Photos of collages, models, prototype and sketch created in workshops	• Interview recordings and transcripts

3.6 Data Analysis

The next section draws from the work of Bryman (2015), Eisenhardt (1989) and Yin (2013) as well as previous PhD case study analysis such as Hussain et al. (2012), Palakshappa (2003) and Troy (2008). As mentioned previously, the present research utilized documents, interviews, observations and physical artefacts collected across four stages of the project spanning approximately 12 months. The following section provides an overview of the data analysis plan used. The analysis itself is described in Chapter 6.

3.6.1 Preparation for Analysis

To ensure all data was properly archived for future use a naming system was developed. This utilizes four codes pertaining to the stage of research, the specific workshop (if applicable), the focus of the data (i.e. an interviewee or wider group) and the type of data source. The abbreviations are shown in Table 21.

Table 21 - Data Source Abbreviations

Abbreviation	Description
S(n)	Stage n
W(n)	Workshop n
D(n)	Designer n
P(n)	Participant n
INT(n)	Interview Transcript or Recording
FD(n)	Field Diary
OBS(n)	Observation Notes
PHO(n)	Photograph

For example, the file name "*S3 W1 D1 INT1*" represents interview 1 during stage 3, workshop 1 from designer 1. "*S1 W1 OBS1*" represents the present researcher's observational notes from workshop 1 of stage 1 (pilot workshop). "*S2 W1 D3 FD1*" represents a field diary completed by designer 3 during workshop 1 of stage 2 (CCB workshop). All data collected was named using this coding system with a master reference sheet maintained to aid in accessing each file. All data was then imported into the qualitative data analysis software Nvivo for storage, processing, coding and analysis. Nvivo allows for two separate types of data tagging to occur; *classification* and *coding*. Firstly, classification is used to assign data to a particular class of interest (for example, a case, a designer, a workshop, etc.). This is useful for organising the data without actually coding themes inside of the data. Secondly, coding is used to tag sections of text and link them to a particular theme (such as the collaborative competencies, enjoyment, inclusion, etc.). Both of these data tagging processes were utilized in the present research.

Multi-Case Categorization

Each data source needed to be categorized into its corresponding case to ensure data were not missed during the analysis process. Some data was solely connected to one case (such as a designer field diary about a particular design brief), while other data was connected to multiple-cases (such as the present researcher's observational notes from a workshop). To ensure that data was correctly categorized, a range of classifications were created in Nvivo and used to categorize all data. This allowed for all data for a classification (such as case, designer and workshop) to be isolated and analysed.

3.6.2 Analytical Strategy

The analysis stage of the present research aligned with both the *ground-up* and *descriptive framework* approaches (Yin, 2013, p. 139). Using both of these approaches allowed for emergent themes to be identified through exploration and comparison of data while the design of a descriptive framework aided in categorizing data from a range of sources into predefined descriptive categories. The present research used the collaborative competencies as the descriptive framework to aid data analysis.

A ground-up approach to reviewing the data was undertaken in an effort to understand the narrative of the project and to identify themes and relationships within the data. This stage remained flexible and reactive to newly identified areas of interest while remaining focused on designer-participant collaboration. The basic analytical steps followed are shown in Table 22.

Table 22 - Data Analysis process

Analytical Step	Rationale
1. Import all data into Nvivo, sort files into appropriate source folders	Importing all data into Nvivo allowed for easy storage, processing, coding and analysis
2. Review all data sources chronologically (i.e. all data for stage 1)	Remind researcher of the narrative of the project and all data collected. Formative themes and links may be identified
3. Classify all appropriate data into appropriate classifications. These were both pre-defined and emergent from the analysis	This ensured that all data was easy to query and was aligned to the appropriate individuals and events
4. Code all appropriate data to thematic codes. These were both pre-defined and emergent from the analysis	This ensured that all data was reviewed multiple times and emergent, and pre-defined themes were developed
5. Once coding was complete, perform a second sweep of all data	This ensured the data was fully saturated with codes and classifications
6. Once fully saturated, use matrix coding tables to investigate the link between different codes and cases (for example, the participants collaborative competencies during each of the workshops)	This allowed for patterns and links to be identified as well as key phenomenon to be investigated

Analytical Step	Rationale
7. Perform cross-case analysis identifying and analysing similar, difference and conflicting findings from each case.	Identify case specific findings and look to consolidate more general findings
8. Compare/contrast each designers perceptions of each stage (interviews and diaries)	Look to understand strong points of agreement and disagreement
9. Perform text searches, utilizing codes and classifications, to identify example text units for each key finding	Provide clear illustrative examples for each finding

3.7 Limitations of Methodology

This section provides a critical review of the proposed research plan by assessing the potential reliability and validity of any findings generated.

3.7.1 Reliability

The term reliability refers to the *repeatability* and *reproducibility* of the data collection and analysis in a study. Repeatability is an individual's ability to measure the same subjects using the same methods on multiple occasions and end up with the same findings. Similarly, reproducibility is the ability of a study (i.e. same subjects and same methods) to be performed by a separate researcher and end up with the same findings.

Both repeatability and reproducibility are important to the present study as they provide trustworthiness of results and credibility that the study has been performed and documented in a rigorous manner. This pertains to both the data collection and data analysis stages. Brink (1993) highlights the following methods for ensuring reliability in a qualitative study:

1. Multiple repetitions of measurement using the same methods over a period of time. This will allow the research to check for repeatability and whether results are the same or understandably different (i.e. due to changes in participants over time)

2. Detailed description of data collection and data analysis procedures to allow for clear reproduction by other researchers.

3. The use of a second researcher during data collection to compare observational notes and review initial findings. This would allow for reproducibility to be instantly validated and also ensure information is not missed that could affect findings (i.e. improving internal validity).

4. Comparison of analysis of the same data from other researchers familiar to the topic area. This could involve having a transcript independently coded, using a set procedure, by multiple researchers and comparing thematic findings.

3.7.2 Validity

The term validity refers to how well the research represents the true reality of the situation and not other, unknown variables. It can be discussed in terms of internal and external validity. Both terms have similar underlying meaning (i.e. how accurate and truthful the findings are) but focus on different aspects of the research.

Internal validity is essentially a measure of how well the data collection and analysis methods actually measure the intended phenomenon. This could be in terms of the type of method, construction of data collection tool (such as an interview script) or the analytical strategy employed. Brink (1993) highlights the following measures for ensuring internal validity:

1. Ensure the researcher has spent a period of time in the situation before beginning data collection. This is to allow the researcher to acclimatize to the socio-cultural environment and for the researcher to begin building trust relationships with the community.

2. Make sure respondents are aware of the nature and focus of the research study to ensure they are clear of how and why they are being studied.

3. Using multiple data sources to triangulate findings. This will allow for the validity of each source to be cross-referenced through comparing and contrasting results.

4. Ensure that all data collection tools have been piloted before utilizing them in the main data collection stage.

5. Search for disconfirming evidence to check the strength of findings. This will provide a rigorous check of whether initial findings were developed through the unconscious ignorance of conflicting data.

External validity relates to how generalizable the findings of a study are and looks to define what exact settings, populations, activities, etc. could utilize the findings in a valid way. External validity is difficult to ensure for qualitative studies (especially single-case studies). However, there are a number of ways to improve a studies external validity, such as:

1. Cross-case analysis to understand effect of known variables.

2. Relate research to external theories that support, or conflict, with findings. This can be used to improve the credibility of the findings by cross-referencing them against existing, validated theory.

3. Compare research findings to existing similar case studies and discuss similarities, differences and the potential for theoretical validation of findings.

4. Clearly state the details of the research study (environment, participants, methods, researcher background etc.) and any contextually specific elements that may influence the findings. This will allow for external researchers to independently review the generalizability of the study.

5. Clearly state the level of generalizability of the research findings. This will ensure clarity and avoid misuse of findings.

A discussion about the reliability and validity of the present research is provided in Section 8.5 and 8.6.

3.7.3 Comparison to Literature

The present researcher acknowledges the potential lack of generalizability of findings. However, this is a common criticism of most qualitative, case-study research. Due to the importance of creating PD methods that are customized to the culture and society of the project, it is common for PD research to be limited in generalizability. Furthermore, a single case design qualitative approach is the most common approach to participatory design research in recent years (Kam et al., 2006; Winschiers, 2006; Hussain & Sanders, 2012) and further highlights the level of depth required to effectively analyse and report on PD activities. There has also been recent PD research that provides discussion on multiple cases (Puri et al., 2004). However, this research tends to involve relatively shallow amounts of detail about each case, as the researcher is not usually involved in the entirety of each case. The present research improves on previous PD research design by structuring the project into multiple cases, and immersing the present researcher in the entire PD process for each case.

3.8 Ethical Considerations

Low Risk Ethics Approval from the Massey University Human Ethics Committee has been obtained (Ethics Notification Number: 4000017196).

Due to the social nature of this research, there are a number of ethical considerations that needed to be considered. These centred on the involvement of private organisations and the involvement of individuals from an underserved community. As this research was conducted through Massey University, it was guided by the Code of Ethics defined by the Massey University Human Ethics Committee (University, 2015). A summary of considerations are shown below.

3.8.1 Respect for Persons

This highlights the importance of recognizing "personal dignity, beliefs (including cultural and religious beliefs), privacy and autonomy of individuals" (University, 2015). Given this research focused on underserved communities from foreign, culturally diverse backgrounds, it was important to ensure participants cultural beliefs were not offended during Stage 1, 2 or 3. Care was taken during Stage 1 to ensure capacity building content was of an appropriate level to ensure participants do not feel any stress, embarrassment or frustration during the process.

3.8.2 Minimisation of Harm

This principle outlines the importance of minimizing physical and mental risk to participants and researchers as well as minimizing damage to relationships, and reputation of institutions and groups. While there was no obvious stage in this research which would potentially harm participants, there were potential risks to the researcher, due to the foreign, remote environments potentially involved. As research was conducted in Cambodia, both in the developed city of Phnom Penh, and remote villages, care was taken to ensure the present researcher was not exposed to disease, physical harm or mental harm. Risk mitigation methods such as vaccinations, first aid training and contextual training through EWB preliminary field trips were implemented. As this study aligned with a real world project care was taken to ensure existing relationships between organisations and communities were not harmed.

3.8.3 Social and Cultural Sensitivity

This principle highlights the importance of being sensitive, and responsive to cultural aspects of the environment in which research is conducted. This included planning workshops and interviews in a way that did not disrupt religious practices, social gatherings or national holidays. Therefore, priority was given to local practices over workshop activities. This resulted in times when participants left the workshop to attend funerals and to pray in the nearby pagoda.

3.9 Chapter Summary

This chapter has presented a discussion of alternative research methodologies as well as the chosen methodology and research plan. It outlined the specific research stages, data collection tools, and analytical processes as well as logistical aspects of the project such as timeline, risks and budget. The discussed research plan was implemented in the completion of the present research. Data collection and analysis will be discussed in detail in later chapters.

CHAPTER FOUR

CREATIVE CAPACITY BUILDING CONTENT DEVELOPMENT

CHAPTER OVERVIEW

The following chapter provides an overview of stage 1 of the present research. This involved the design and refinement of the CCB content used in Project 1. The chapter presents the content development process, piloting with a community and finalization of content.

4.1 Content Development Process

The content development process followed three stages that involved designing the initial teaching plan, refining it with the staff at ADG and piloting the content with an independent community in Cambodia. This process has been published as a journal article (Drain, Shekar, & Grigg, 2017).

The final teaching plan is presented in Appendix B. The refinement process is shown in Figure 21.

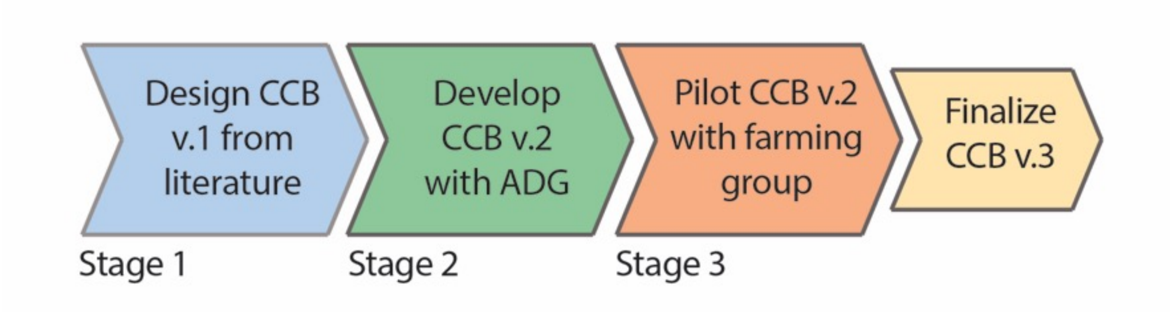


Figure 21 - Overview of CCB content development

The design of the CCB content followed the process outlined by Eade (1997). This ensured that the community and socio-cultural environment were effectively considered. As much of the required information was included in Chapter 2, only new information is presented in the following chapter. The steps used are shown in Section 2.4.2, Table 7.

4.1.1 Aims

CCB workshops aimed to enhance the participants' capacity to participate in PD activities. This was guided by the collaborative competencies as well as insights from the partner organisation ADG.

4.1.2 Learners

The learners in the Project 1 (stage 2 and 3) were from a single community in Kampong Tralach District, Kampong Chhnang Province, Cambodia. The participants were a mixture of PwD and able community member (carers and community representatives). A full description of Cambodia is provided in Section 2.7. A full description of the participant group is provided in Section 6.2. The participants in the pilot study of CCB were from a single community in Takeo Province, Cambodia.

Gender

The participants were both male and female and as such efforts to ensure gender equality through pedagogy and informal interacts was prioritized. One of these efforts was the use of male and female designers in the project to ensure both genders are represented in the facilitation and participant groups. The participants in the pilot study were all male.

History

Provided in Section 2.7.1.

Religion

Provided in Section 2.7.2.

Occupation

As the PD project aimed to involve PwD in the design of assistive agricultural technology, the occupation of the involved participants was farming (specifically, rice and chickens). Most participants maintained a subsistence lifestyle, meaning the majority of their crops were consumed by their families with some trade at a local market. Some participants also occupied other small jobs in the community such as maintenance of shared assets (such as water supply) and roles in the village council.

Education

Provided in Section 2.7.3.

Field Research

The present researcher undertook two field trips to rural communities in Cambodia, with EWB, before the CCB content was developed. The researcher travelled to several Mekong Islands in the Kratie Province and worked with several western engineers, and a local NGO. This work involved working with the community to scope new engineering projects that could be supported by the local NGO.

4.1.3 Access

Access to the community was in the form of multi-day workshops conducted in a central meeting place, usually the religious pagoda. Workshops were scheduled to be no longer than three days and at least two weeks apart. This was to ensure participants were still able to tend to their farms and look after their families. Given the subsistence nature of rural Cambodian communities, it was not ethical to demand more time from them. Furthermore, the schedule needed to remain flexible and considerate to the demanding work schedules of the community.

4.1.4 Trainers

The trainers chosen to facilitate the CCB were two female Cambodian designers (D1 and D2) working for ADG, based in Phnom Penh, Cambodia. They were supported by several other designers, both male and female. See Section 5.3 for more detail about the designers.

To understand the two female designers' background, pre-understanding and experience, semi-structured interviews were undertaken with each of them. Both designers spoke the local dialect

(Khmer), and English, and had previous experience working with communities on both capacity building programmes and design projects. Both were from the same rural province in Cambodia and had university-level degrees from Phnom Penh universities. The projects they had previously worked on included a 6-month financial literacy programme for farmers in Angkor Chey, Kampot Province, the facilitation of a project to design playground equipment, an agricultural "*net house*" project and assistive technologies to improve access to sanitation services for PwD. Given the relatively young tertiary education sector in Cambodia and lack of tertiary graduates (WBG, 2008), the designers were deemed to have high levels of experience in this area and, as such, were considered experts in community development. The present researcher also gave support during the planning stages and a *train-the-trainer* approach was used for areas requiring development. The researcher was present for all formal contact with the community. However, relied on the Khmer trainers for most facilitation due to language and cultural barriers.

4.1.5 Needs Analysis

The needs that were addressed were identified through analysis of previously conducted PD projects. In summary, the following competencies were identified as being important:

1. Ability to express opinion about a project
2. Ability to generate insightful ideas
3. Ability to create insightful prototypes
4. Understanding of the design process/activity
5. Motivation to contribute

These were viewed as the learning outcomes that should be developed through the CCB workshops, and throughout the PD project.

4.1.6 Lessons from Previous CCB

It is important to learn from previous project work, as such, the next section reviews the practical challenges faced by Taha (2011) in Uganda.

To begin, Taha utilized the CCB methodology, developed at MIT's D-Lab, to introduce the design process to a community of refugees in Uganda. This project utilized four days of workshops slowly introducing each stage of the design process with accompanying activities. It was deemed successful; however, a number of difficulties were faced. Key learnings from the project are summarized below:

1. A charcoal brisket press was used as an example to illustrate the design process. While the example was effective at highlighting the relevance of design to the rural community the technology may have been too distracting to community members, as they had not seen a

charcoal press before. Therefore, the attention of the participants was on the new technology and not the design process. To avoid this issue, an example which was both relevant and novel, while not being so innovative that the community would be distracted by the effectiveness of the technology, had to be considered.

2. During a prototyping activity, participants were asked to design a prototype out of paper that could lift maize 10cm off the ground. To improve instruction clarity, the designers showed an example of a possible solution. Unintentionally, this resulted in all participants copying the exact example.
3. This project found that relocation, due to rain, resulted in a long delay. This suggests that having a clear contingency plan in the event of rain or extreme weather would be helpful.
4. It is important to practice all demonstrations before each workshop to ensure they will work effectively. One demonstration in this project did not work when required resulting in a lack of engagement and potentially a negative effect on the perceived importance of the design process.
5. 60% of participants were not literate; this meant that evaluation of the programme was difficult as verbal feedback yielded mostly polite answers through translation. To address this, two feedback tools were implemented. The first used a multi-choice format in which participants would select a certain nut (which corresponded to predetermined answers ranging from *terrible* to *excellent*) and place it in a bowl. The second used open-ended questions and placed the participants into small groups with one scribe in each group, to record the answers. Questions focused on the effectiveness and fun of each activity.
6. The programme worked with 55-65 participants; however, the research stated that it would have been more effective with 20-25 participants.

The present researcher utilized the content and reflection from Taha (2011) as a starting point for CCB version 1. This is presented in the next section.

4.2 CCB Content Development – Version 1

This section discusses the design and refinement of the CCB content used in Project 1. The section presents an overview of the teaching content and discusses feedback received through the piloting process. The teaching plan used for Project 1 (CCB version 3) is shown in Appendix B; a final CCB teaching plan can also be found in the practitioner handbook (Drain & McCreery, 2018). This utilized the feedback from Project 1 to create a refined version for future use.

4.2.1 Overview

Version 1 of the CCB content was based on the work of Taha (2011) with guidance from Eade (1997) and Ferguson and Candy (2014). Given the challenges with recruiting community members for a large amount of time (Kam et al., 2006; Hussain, 2010) it was decided that a two-day schedule would be developed. This utilized the initial stages of Taha (2011) but transition into the pre-design stage of the PD process during the fourth session. The CCB sessions were included in Workshop 1 along with initial pre-design activities. An overview of the CCB version 1 teaching plan is shown in Table 23

Table 23 - Overview of CCB content version 1

Session	1	2	3	4
Overview	Greeting, introductions, "What is design" discussion	Example of a full design process (rice de-husker)	Small scale design exercise (pre-design, generative and evaluative design)	Transition from CCB to pre-design probes (identify actual community opportunities)
Content	Presentation and discussion thanking community, introducing ourselves and the project, reviewing the schedule and engaging group in a discussion around design	Presentation of the design cycle, discussion around examples and presentation of example of full process (rice de-husker)	Activity facilitating community members designing a small solution (e.g. *Maize Raise*). This will include idea generation, prototyping and selection	Use design process as a backdrop for talking about community opportunities for projects. Open discussion with identification of project and requirements

4.2.2 Critique of Version 1

Before Agile Development Group and the pilot community provided external feedback, the present researcher reflected critically on the CCB content. This was structured around the five collaborative competencies.

Ability to Express Opinion about a Project

Session 2 of the CCB involved presenting and discussing a full design process for a relatable product (i.e. rice de-husker). This product was presented as a way of highlighting the importance of using a design process to refine and improve ideas and also to generate discussion about what is good and bad about a range of de-husker designs. As these designs were not created by anyone present in the workshop it was hoped that there would not be any bias or barriers due to the creator being present. The designers were to support the participants to express opinion about the different ideas in a safe and open way to show that critical opinion is okay and should be encouraged during the design process.

Ability to Generate Insightful Ideas

This learning outcome was to be facilitated during Sessions 2 and 3. Session 2 was to show an example design process with a number of idea generation activities. This would provide more clarity to the participants while not intentionally leading them towards particular ideas in their own project. Session 3 would allow participants to trial idea generation techniques in the design of the *Maize Raise* activity. This simple task would provide an understandable project brief to focus on while learning how to generate ideas. The only criticism of this was that the Maize Raise exercise may be too simple to fully expose participants to the complexities of generative design. However, given the CCB was only one stage of the PD process, and not the whole project as with Taha (2011), it was not deemed an issue.

Ability to Create Insightful Prototypes

Once again, this learning outcome was to be facilitated during Sessions 2 and 3. Session 2 would provide similar examples of what and how to prototype while Session 3 would allow for hands on prototyping and testing using paper. This was a small activity, which would show the importance of making basic prototypes and testing before choosing the final idea. The activity may have been too basic to effectively prepare participants for detailed prototyping in the project but the combination of detailed example and basic practice would have allowed for better understanding and less discouragement while building capacity.

Understanding of the Role of the Design Process/Activity

This learning outcome was to be addressed in all four of the sessions. Session 1 introduced the design process and each stage in a basic sense before Session 2 showed a detailed example. This detailed example allowed for a basic understanding of the role of each stage to be gained before actually trying to use the process, a common barrier in PD projects to date. The design process was trialled during the Maize Raise activity in Session 3. Finally, the newly introduced stages were framed in terms of a community project to be undertaken over a long term period, in Session 4. This transition from example and activity to application needed to be well facilitated with constant reinforcing of the design process and its role.

Motivation to Contribute

It was difficult to review this learning outcome at this stage, as no external feedback had been received. As such, the present researcher decided to wait before reviewing this learning outcome.

4.2.3 Version 1 Development Workshop

Next, the CCB workshop content was refined through dialogic reflection with a group of ADG staff. The version 1 content, and development process was presented to ADG staff and dialogic reflection on the content was undertaken, guided by Hatton and Smith (1995), including discussions about previous training and design projects ADG had undertaken. The next section outlines the changes that were suggested from this discussion, to make the content more contextually appropriate.

Recommended Changes

Overall

1. Try to limit each of the four sessions to one hour as ADG have found participants will lose concentration and may need to attend to other matters around the community if the trainings are too long.
2. Each of the four sessions should be flexible enough to run at times which suit the community. This may mean each session will run on different days over a week or that all sessions will run on the same day. To ensure this is possible a clear introduction, summary of previous session and wrap up will need to be included into every session.
3. Literacy levels are expected to be low in many of the middle-aged to older community members. ADG suggested that members above age 45 might not know how to read or write. This is supported by EPDC (2012) that shows there is a substantial drop in primary school completion in people currently aged 40 – 44 compared to 35-39 (65% compared to 49% respectively). Younger community members will most likely be literate. Therefore, to ensure inclusivity, little written content should be used or required of participants. ADG highlighted the use of pictures and numbers in their previous financial literacy training programme.
4. Motivation of older participants (in ADGs example they were male participants) has also been an issue in the past. This was partly because participants were getting money for petrol costs. This was addressed by splitting the less co-operative participants into different groups.
5. No participants will be given money, however, food can be provided. Any local project coordinators should be paid for their time.
6. Lunch in Khmer communities is at 11am, followed by a short nap. This is important as morning sessions may be difficult as agricultural routines will take place early in the morning with food preparation beginning at around 10am. To address this it was suggested that the sessions aim to run between 2pm and 3pm, with flexibility to move to a more suitable time at short notice.

Session 1: Greeting, introduction and 'what is design'

1. Allow the *what is design?* activity (Session 1) to generate open discussion by developing a list of guiding questions. It would also be helpful to have an example ready to use in case participants are not sure of the direction the discussion should go.
2. Ask the group if they have heard of design before as they may have been exposed to concepts by other NGOs.

3. Some type of interactive activity might be useful in setting the interactive tone of the project. Perhaps this could link with the icebreaker activity.
4. Give a brief overview of the programme including CCB and project. Ensure the local coordinator understands the content of the CCB so they may assist the community while ADG are not there.
5. Open discussion is possible if we take the time before the CCB to interact with the community and be very polite and aware of local customs.
6. At the end of the session add a few questions reflecting on what was learnt and what was not presented very clearly. This is helpful for both the participants and the designers.

Session 2: Full design process example

1. The design process was thought to be good as it is simple and descriptive. It will need to be translated into Khmer and have each of the meanings piloted to ensure they are clear and match the intended English meaning.
2. The example was changed from a rice de-husker to a mango picker (a tool for picking mangoes out of tall trees) as it was thought to be more relatable, less technical and easier to show physical prototypes during the workshop. This product will need to be researched to ensure it can be used to illustrate a strong enough design process without captivating the participants at a product-level (i.e. the product should highlight the process not become the focus itself).
3. Draw several ideas on individual pieces of card so they can be presented and passed around individually.
4. If participants come up with ideas while you are discussing the mango cutter then make sure they are included in the process if possible.
5. Write a simple description for each stage that can be screened and modified by the Khmer designers to ensure clear translation.
6. Ask local coordinator to source any prototyping materials ahead of time.
7. Give the group homework to come up with one more idea for cutting mango from the tree.
8. At the end of the session add a few questions reflecting on what was learnt and what was not presented very clearly.

Session 3: Small scale design exercise

1. The activity was thought to be interesting and engaging. It was suggested that more pieces of paper could be used to make the process more exciting (as more maize could be held). This will depend on the size and thickness of the paper used.
2. Only allow a single iteration to ensure participants do not become bored of the simple activity. If the group would like to make more prototypes, this can be added at the time.

3. The activity could involve discussing different materials available around the village. “What could you make this out of so it lasts for a long time?”
4. At the end of the session, add a few questions reflecting on what was learnt and what was not presented very clearly.

Session 4: Transition to Pre-design

1. Remove formal community mapping activity and replace with an informal visit to several homes. This will help to keep the natural flow of the training and allow for knowledge exchange as participants show their homes and community practices.
2. After first discussing that we now need to identify problems to solve start a large sheet and write all the problems mentioned on the sheet. This will be used to collate and present all the problems the community believe they have, which will become opportunities for design projects.
3. Keep the session dialogic with no formal templates or activities at this stage. They can be developed and used in the formal pre-design stage if required.
4. After house tours are finished facilitate a group discussion to vote on final 3 (or similar) problems to address during the project. Maybe allocate teams to work on each problem if it seems there are individuals gravitating towards specific design opportunities.
5. At the end of the session add a few questions reflecting on what was learnt and what was not presented very clearly.

4.3 Version 2

4.3.1 Overview

The recommended changes were implemented into CCB content version 2. An overview of the teaching plan is shown in Table 24. Sessions 1, 2 and 3 were all piloted either in full or in part. Session 1 and 2 were piloted with a farming community in Takeo Province, south of Phnom Penh, and Session 3 was piloted internally with six ADG staff members.

Table 24 - Overview of CCB content version 2

Session	1	2	3	4
Overview	Greeting, introductions, "What is design" discussion	Example of a full design process (Mango Picker)	Small scale design exercise (pre-design, generative and evaluative design)	Transition from CCB to pre-design probes (identify actual community opportunities)
Content	Presentation and discussion, thanking community, introducing ourselves and the project, reviewing the schedule and engaging group in a discussion around design	Presentation of the design cycle, discussion around examples and presentation of example of full process (Mango Picker)	Exercise facilitating community members designing a small solution (Maize raise exercise). This will include idea generation, prototyping and selection	Use design process as a backdrop for talking about community opportunities for projects. Open discussion with identification of project and requirements and include a tour around community homes

4.3.2 Session 1 and 2

The participant group consisted of approximately 20 Cambodian male farmers, see Figure 22. This lack of gender diversity was worrying and could be attributed to the self-selecting nature of participant recruitment and the traditional gender-roles in this community. As this was a pilot study, the present researcher was not involved in participant selection. In future projects the researcher will be actively involved in participant selection to mitigate the risk that "*participation can concentrate power and benefits in the hands of men and of local elites*" (Mazzurco, 2016, p. 36).

The pilot workshop was facilitated by two ADG female Cambodian facilitators. This allowed for free-flowing dialogue and open discussion without constant translation. The researcher was present for this and had a live translator to understand the Cambodian dialogue. They interacted with the wider group on several occasions through the translator. The pilot session covered content from CCB

Sessions 1 and 2 but did adjust some of the activities since a long-term project was not going to be undertaken with this community.

Figure 22 - Takeo training session with farming group

Of initial note was the seating arrangement of community members, with the five group leaders at the front, trailing off to a large group sitting on chairs behind the table. This arrangement also seemed to reflect the people who responded to initial questions made by the facilitators. Whether this was due to inherent power structures in the group, confidence in interacting with facilitators or practical limitations of the learning environment is not known. Rambaldi et al. (2006) suggest involving local elite, in this case the farming group leaders, could result in them dominating the session and influencing the outcomes.

Regardless, this did seem to result in few of the back group speaking to the facilitators or engaging in open discussion. This lack of interaction may well have had an influence on the learning of all participants, as adult learning theory suggests (Merriam, 2008). However, exactly how to remove this imbalance while not ostracizing or upsetting participants is a challenge. Perhaps the use of small groups to encourage discussion, as used by Ferguson and Candy (2014), would address this.

The beginning of Session 1 moved much faster than expected with participants exhibiting a basic understanding of problem solving which was in many ways synonymous with design thinking. This level of knowledge meant that initial discussions that aimed to introduce *design* through aligning the concept with existing practices in the community was not needed and participants pushed towards more complex content. Again, this was driven by group leaders, which made gauging the understanding of the entire group difficult. The design process was presented (Figure 23) with each stage explained in detail.

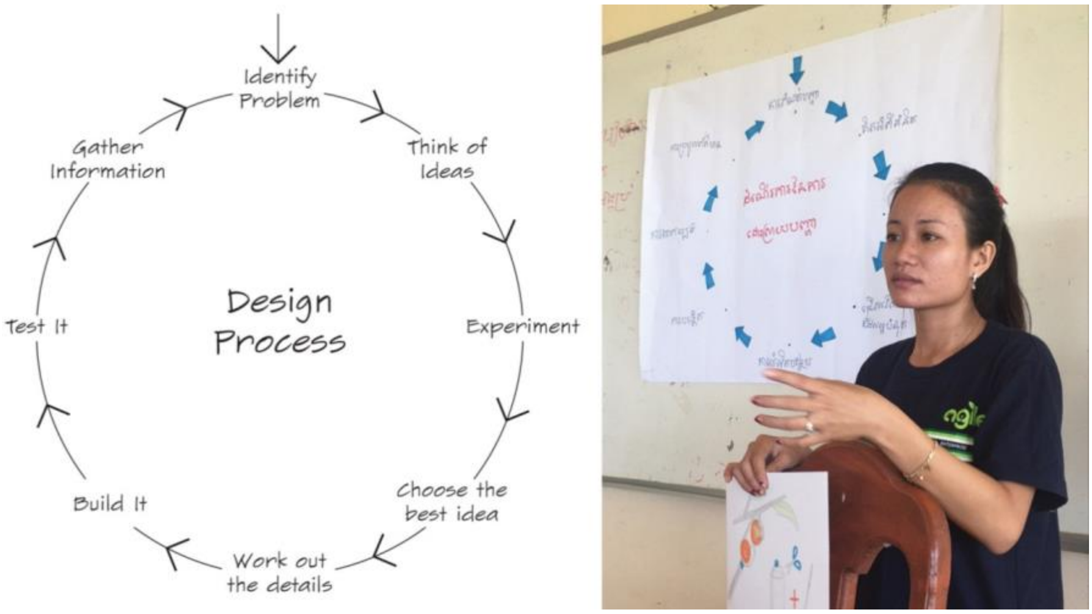


Figure 23 - Cambodian facilitator presenting the design process (Taha, 2011)

While each stage title and description had been translated to Khmer through a number of iterations, to ensure clear understanding, there was still difficulty in conveying the meaning of some stages. The description of the unclear stage *work out the details* follows:

> *"Now you have the final idea chosen you will need to decide on all the details. How big does it need to be? What should it be made from? Who will make it? How heavy should it be? How fast should it work? Does it need to be maintained? How expensive can it be? You should think carefully and make any changes needed. You can try and make some more prototypes or drawings if needed"*

From discussion with facilitators before and after the pilot session, the confusion seemed to be in the title of the stage itself. While this *miscommunication* did generate discussion with the group, it may also have added an extra level of cognitive loading onto less experienced participants.

Next, in Session 2, the example problem of '*how to get mangos out of trees'* was introduced and discussed. This problem was used to communicate examples at each stage of the design process. The problem itself generated a large amount of discussion with many participants highlighting their existing methods including "*climbing the tree*" and "*shaking the tree a lot*". Some individuals had experience with customized bamboo poles that could be purchased at the local markets. The relatability of this example was a strength while its simplicity avoided the issues faced by Taha (2011).

Taha stated that during the introduction of a charcoal press example participants were so impressed by the product that they did not focus on the design process being presented. This link to previous experience is also a well-established principle in adult learning theory as it facilitates the new sensory inputs to be linked with established connections and information (Merriam, 2008).

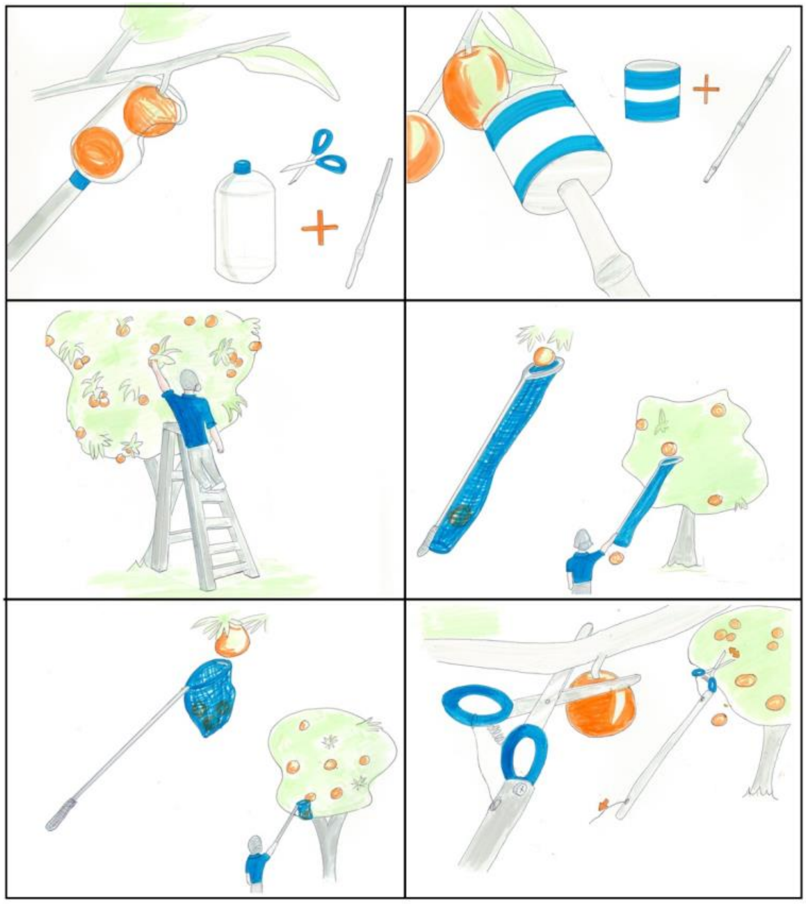


Figure 24 - Examples of idea generation sketches from CCB session

Multiple sketches were circulated to show examples of ideas (Figure 24) and stimulate discussion about potential solutions. Initial discussions centred on the incorrect colour of the mangos depicted in each sketch and that mangos were "*yellow or green, not orange*". This discussion was helpful for enabling open discussion as well as providing the participants with the opportunity to teach the facilitators about local produce, a technique to enable mutual learning (Simonsen & Robertson, 2012). The importance of this discussion is reiterated by Winschiers-Theophilus et al. (2010) who found that "*user driven activities create equal grounds for participation. This starts to tackle the often referred to power gap, leading to users' feelings of intimidation and performance anxiety*" (p. 6).

Open dialogue was used to select which ideas to experiment with (in this case, that meant creating small-scale prototypes to trial). There was a lot of discussion at this point with many of the individuals at the back of the room contributing as well as the usual input from group leaders. The *bottle-design* and *can-design* were chosen to take forward with comments about reusing local waste and how to connect the materials together. There was little-to-no consideration of function until physical prototypes were created (see Figure 25). The initial bottle-design prototype was constructed by the facilitator using bamboo, a water bottle and adhesive tape, for attaching the components. This was tested by participants who quickly identified the design would not be strong enough to dislodge mangos and would most likely break. One participant suggested removing the cap of the bottle, and pressing the bottle onto the end of the bamboo. This was attempted and resulted in a strong, rigid fit. Again, this collaborative process during the example design process helped to keep participants engaged but also aimed to create a sense of empowerment through mutual learning (in this case, about joining techniques). These multiple stages of reflection (i.e. identification and communication of design issues and the suggestion of a remedy from previous experience) show that some participants engage well with a reflection-in-action process (Hatton & Smith, 1995).

Figure 25 - Bottle-design prototype

The facilitator asked whether this was the best idea, resulting in one participant stating, "*that is not a perfect idea but is a good idea*". At this stage, the session was interrupted by the arrival of development practitioners from a local NGO with a long-term project with the farming group. This interruption was unexpected and did result in a 10-minute break from the pilot session. Interestingly, the theme of *flexibility* which arose during interviews was tested during this period. To begin the session again, the previous few points, covered before interruption, were reiterated before continuing with the design process. Participants, especially towards the back of the room, appeared distracted and less engaged with content from this point on. This disengagement seemed to stem from a lack of interaction with any visitors while the group leaders were talking to the NGO practitioners. Re-engaging all participants was challenging and better techniques for restarting sessions will need to be developed to ensure effective *flexibility* is designed into the programme.

Evaluation

A semi-structured reflection was undertaken with the farming group leader, facilitators and other staff involved from ADG. This used the teaching plan as a structure for discussion and aimed to gain insights into the clarity of the content and its effectiveness for building creative capacity. Of note was the group leader's interest in exactly how to identify which problem to address first, this was explained by one of the facilitator's comments.

> "*The biggest learning was that they need to be critical about which exact problem they look to address. They should not just focus on solving whichever problem comes to mind or try to solve a large number at once*"

Secondly, the realisation that the design process is iterative was helpful as the group leader stated that traditionally "*if they create it and it does not work they throw it away*". This wasteful approach could now be shifted towards the continuous cycle of testing and refining. This statement shows evidence of potential reflective discourse resulting in behavioural changes (Mezirow, 2000). Of course, this instance is anecdotal but it does show the importance of clearly communicating the iterative nature of the design process. A related issue mentioned by the group leader was identifying exactly when to stop iterating and move onto the next opportunity, as this was a confusing aspect of the process. This was further compounded by the fact that design process diagram used did not show any exit point, as explained in the next section. Again, this highlights the importance of clear *communication* of the design process.

The presentation of the design process and example solution seemed to engage the participants and create a central reference around which a future project could work. This will help to address documented challenges such as poor understanding of the role of each design activity/stage, long time periods before community members became design partners and poor ability to collaborate during each activity. It will also help to facilitate traditional PD principles such as situation-based actions and mutual learning.

Recommended Changes

The following recommendations addressed both iterative changes to the CCB content and wider recommendations to further support others looking to introduce design concepts in developing contexts.

The Design Process

Both the visual form and Cambodian translations of the design process needed to be adapted to more clearly highlight how to enter, iterate and exit the process. The adapted design process is shown in both English and Khmer in Figure 26. The new process shows clear entry and exit points while highlighting the *test it* step as the critical measure of whether to implement or iterate.

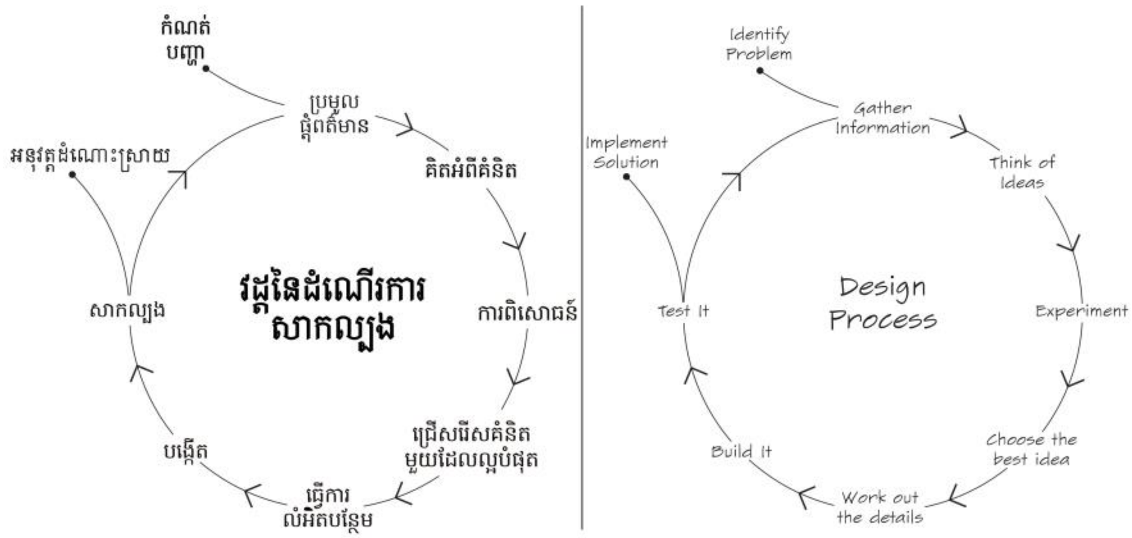


Figure 26 - The adapted design process

Important Questions

The pilot study shows that a number of underlying themes are critical to delivering effective creative capacity building in developing contexts. These themes are especially important during planning, as it is during the formation of the training sessions that *flexibility, relevance* and clear *communication* can be designed into the content. To do this effectively the participants pre-understanding (Gadamer, 1975) must be understood as well as possible. This includes exploring the participant group's *experience, learning capacity* and *socio-cultural* background. The importance of this understanding is reiterated in recent adult learning publications (Merriam, 2008) and in PD literature (Spinuzzi, 2005; Lee, 2008; Hussain & Sanders, 2012). During future capacity building design, the present researcher recommends answering the following questions during planning:

Understanding the participant

1. Learning capacity
    a. What previous formal education has the participant undertaken?
    b. What style of pedagogy will be inclusive and effective?
    c. How confident are they to engage in open discussion?

2. Previous experience
    a. What previous development projects has the participant been a part of?
    b. Has the participant been exposed to similar concepts before?
    c. Has the participant implemented similar concepts before?
3. Socio-cultural background
    a. Is there a clear power-hierarchy present in the participant group?
    b. What is the history of education in the socio-cultural environment (local and national)
    c. What are the priorities of the participant group? (daily and long-term)

Ensuring appropriate content

1. Clear communication
    a. Does the content leverage the strengths of the participant group?
    b. Is all content clearly described? (post translation)
2. Contextual relevance
    a. Are concepts and examples relatable?
    b. Are learning outcomes aligned with participant priorities?
3. Flexibility
    a. Can the content be delivered in sections if required?
    b. Is there a plan for re-engaging participants after disruptions?

These questions aim to direct the focus of the content developer towards the principle, shared in both PD and capacity building, that there is no single best practice for engaging with community members (Winschiers, 2006; Winschiers-Theophilus et al., 2010). Explicit consideration for socio-cultural aspects of the context as well as a participants pre-understanding must be included in the CCB content development process. Creating content that is relatable and clear will allow for more time to focus on mutual learning, trust building and solidifying concepts and less on clarifying and keeping participants engaged.

Next, the pilot workshop for Session 3 is discussed.

4.3.3 Session 3

The *Maize Raise* session was piloted with staff at ADG as a way of testing whether the materials and time provided would be appropriate for the CCB session. This was deemed appropriate as little detail was found regarding the size and thickness of paper used in previous versions of this activity. The session was not piloted with the Takeo farming group due to a lack of available time to work with them and the feedback from ADG that sessions over 1 hour face issues such as lack of concentration and participant attrition due to farming commitments. This session was therefore piloted to understanding whether the activity itself was practical.

Overview

The basic premise of the *Maize Raise* activity (Session 3) was that the local community flooded occasionally and, because of this fresh produce needed to be lifted above the level of the water. To design a solution, participants needed to make a small model of a design out of paper. The design needed to lift the produce 10cm above the ground. The activity originally involved the participants using a piece of paper to hold as many pieces of corn as possible off the ground. However, it was modified to use one piece of corn and as many bananas as possible as we did not have access to enough corn. The materials are shown in Figure 27. The pilot session consisted of two teams with three people in each. The first team had two Khmer staff (one male and one female) and one Australian female. The second team had one Khmer female, one French male and one Spanish male.

Figure 27 - Materials used to pilot Session 3

The 10 minutes scheduled for making prototypes was not enough. It took around 10 minutes per design, about 30 minutes in total for the activity. A lot of this was due to the participants not having many ideas to prototype. Both teams made a cylinder-based design as their most successful design. This was partly because the thin paper resulted in only a cylinder having enough strength to hold the weight required. It was also mentioned that a discussion around how the community currently elevate produce during flooding would be good to have before idea generation as it may help them come up with a range of ideas that seem relevant to the community. The use of both corn and bananas was deemed to be a good thing as it created a fixed requirement (one corn) and a more flexible requirement (as many bananas as possible). This seems to keep the teams interested in improving their designs once the initial requirement had been achieved. Figure 28 shows an example prototype created.

Figure 28 - Successful testing of idea

Overall the session was engaging and fitted well with the goals or team work, practicing the design process and highlighting the value of prototyping.

Recommended Changes

To assist the participants in generating a number of ideas a discussion will be facilitated around existing ways in which this is done in the community (for example putting vegetables in a raised house, up a tree or carrying them on shoulder or head). Next, each team will be asked to spend 10 minutes drawing ideas on paper before they start to prototype. Participants will choose their best 3 ideas and have 10 minutes to make them. This timing will be kept flexible to the abilities of the participants. Thicker paper will be used as this will allow for a wider range of ideas to be tested. This is because thicker paper will provide the ability to generate a range of unique shapes and structures which can hold the weight required. The dimensions of the paper (A1-sized) will not be changed.

4.3.4 Session 4

This session was not piloted as it is closely linked to the actual PD project itself and would not be practical to pilot with a community unless long-term interaction was expected. This is because it may create unrealistic expectations of continued project support.

4.4 Version 3

4.4.1 Overview

The recommended changes were used to develop version 3 of the CCB workshops. The full teaching plan is shown in Appendix B. This version was implemented into the project handbook and used for Project 1.

An overview of the teaching plan is shown in Table 25.

Table 25 - Overview of CCB program version 3 (final version)

Session	**1**	**2**	**3**	**4**
Overview	Greeting, introductions, "What is design" discussion	Present the full design process and run an example project (Mango Cutter)	Small scale design exercise (generative and evaluative design)	Transition from CCB to pre-design stage. Begin the PD project
Content	Presentation and discussion, thanking community, introducing ourselves and the project, reviewing the schedule and engaging group in a discussion around design	Presentation of the design cycle, discussion around examples and undertake a small project to design a mango picker	Undertake an activity where community members design a small solution using basic materials (banana boost). This will include idea generation, prototyping and idea selection and testing	Use design process as a back drop for talking about community opportunities for projects. Facilitate a large group discussion about the challenges faced by the community, and by PwD

Based on the effectiveness of Project 1 some changes were made and a new handbook version produced. This ensured that learning from the present research could be captured and disseminated for future projects.

4.5 Chapter Summary

This chapter has presented the CCB content development process utilized in the present research. This involved designing the initial CCB from literature, and knowledge from field trips and then refining it with development experts at ADG. Finally, the content was piloted with a community in Takeo, Cambodia and required changes were made before implementation into Project 1. The following chapters focus on stage 2,3 and 4 of the research design. Chapter 5 presents an overview of the PD projects undertaken in each case, Chapter 6 presents an analysis of emergent themes and a cross case analysis of case 1, 2 and 3.

CHAPTER FIVE

CASE SUMMARY

CHAPTER OVERVIEW

This chapter provides an overview of Project 1 including its context and each of the stages conducted. It presents the overall project, including partners, location and methodology, and describes each of the three cases that were focused on during the project.

5.1 Aims

The primary aim of Project 1 was to work with a community of people with disabilities to design technology that enables better access to agricultural livelihoods. This could involve the design of technology that assists in any phase of farming work such as field preparation, sowing, weeding, harvest, processing, transportation or storage. The secondary aim was to build capacity in the involved community to allow them to solve future problems independently.

5.2 Partner Organizations

Project 1 was conducted in partnership with three partner organisations, along with Massey University.

Agile Development Group (ADG)

ADG are a social enterprise based in Phnom Penh, Cambodia. They specialize in agricultural development, community development and engagement, engineering design and assistive technologies. ADG were the lead organisation during Project 1 and provided two Cambodian designers for the duration of the project. ADG also provided three staff for most parts of the project. ADG have experience in designing and delivering capacity building workshops, facilitating design and working with marginalized communities in Cambodia. ADG have conducted projects with a number of international organisations including World Vision and the Cambodian Ministry of Agriculture.

Engineers Without Borders Australia (EWB)

EWB are an international NGO based in Melbourne, Australia. EWB facilitate multiple international placements for engineers in countries such as Vanuatu, Cambodia, India, Nepal and East Timor. EWB provided one Australian engineer for the duration of the project. EWB also provided three other engineers for parts of the project.

Light For The World Cambodia (LFTW)

LFTW are an international disabled persons' organisation (DPO) with their headquarters in the Vienna, Austria. LFTW have a branch located in Phnom Penh, Cambodia and an extensive network of PwD and local-DPOs across Cambodia. LFTW provided one disability consultant for the duration of this project.

Massey University (MU)

MU are the university in which the present researcher is conducting his doctoral studies. MU provided funding assistance, expert guidance and workshop facilities for the duration of the project.

5.3 Designers

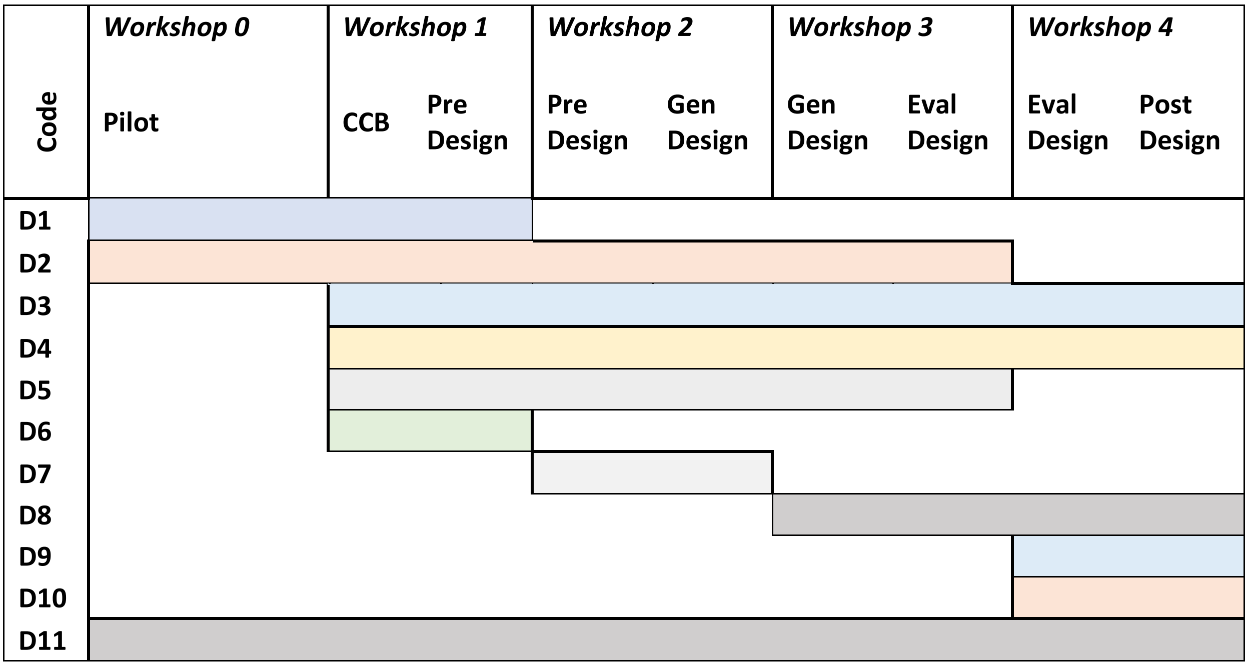
Regardless of each individual's specific profession, all involved members of the above organisations will be referred to as *designers* during discussion and analysis. Table 26 provides detail about each of these professionals and their background. The order is based on when the designer first contributed to the project. The present researcher was acting in an observer-as-participant role and as such has been included on the list of designers (D11). There were 11 designers who contributed across Project 1. However, many of these only contributed at particular stages of the project. This was due to availability issues caused by designers leaving Cambodia (D5 and D9) and leaving their respective organisation (D1, D2 and D10). An overview of the designers present at each workshop is shown in Table 27. Designers worked in pairs, usually with one Cambodian designer (lead designer) and one Western designer (support designer).

Table 26 - Table of involved professionals in Project 1

<table>
<tr><th>Designer Code (anonymized)</th><th>Role in Project 1</th><th>Profession</th><th>Gender</th><th>Country</th><th>Organisation</th></tr>
<tr><td>D1</td><td rowspan="3">Lead designer</td><td>Community development practitioner</td><td rowspan="2">Female</td><td rowspan="3">Cambodia</td><td rowspan="3">Agile Development Group</td></tr>
<tr><td>D2</td><td>Agricultural advisor</td></tr>
<tr><td>D3</td><td>Architect, engineer</td><td>Male</td></tr>
<tr><td>D4</td><td>Support designer</td><td>Mechanical engineer</td><td>Female</td><td>Australia</td><td>Engineers without Borders Australia</td></tr>
<tr><td>D5</td><td>Lead designer</td><td>Disability consultant</td><td>Male</td><td>Cambodia</td><td>Light For The World Cambodia</td></tr>
<tr><td>D6</td><td rowspan="2">Support designer</td><td>Engineering masters student (intern)</td><td>Female</td><td>Poland</td><td>Agile Development Group</td></tr>
<tr><td>D7</td><td>Product design engineer</td><td rowspan="2">Male</td><td>Australia</td><td rowspan="2">Engineers without Borders Australia</td></tr>
<tr><td>D8</td><td>Lead designer</td><td>Community development practitioner</td><td rowspan="2">Cambodia</td></tr>
<tr><td>D9</td><td>Support designer</td><td>Community development practitioner</td><td>Female</td><td>Agile Development Group</td></tr>
</table>

Designer Code (anonymized)	Role in Project 1	Profession	Gender	Country	Organisation
D10	Support designer	Mechanical engineer	Female	New Zealand	Engineers without Borders Australia
D11		Product design engineer & researcher	Male		Massey University

Table 27 - Table of designers and workshop attendance



5.4 Community

Project 1 was undertaken in collaboration with a local DPO in Kampong Tralach District, Kampong Chhnang Province, Cambodia. This is a small community approximately 2 hours' drive from Phnom Penh (see Figure 29 and Figure 30). The community's education-levels, occupations and socio-cultural characteristics align closely with those discussed in the Chapter 2 and 4. The main livelihoods in the district are rice farming, fishing, raising animals and factory work. Buddhist religion plays a large role in the community's daily life with three notably large temples in the centre of the community.

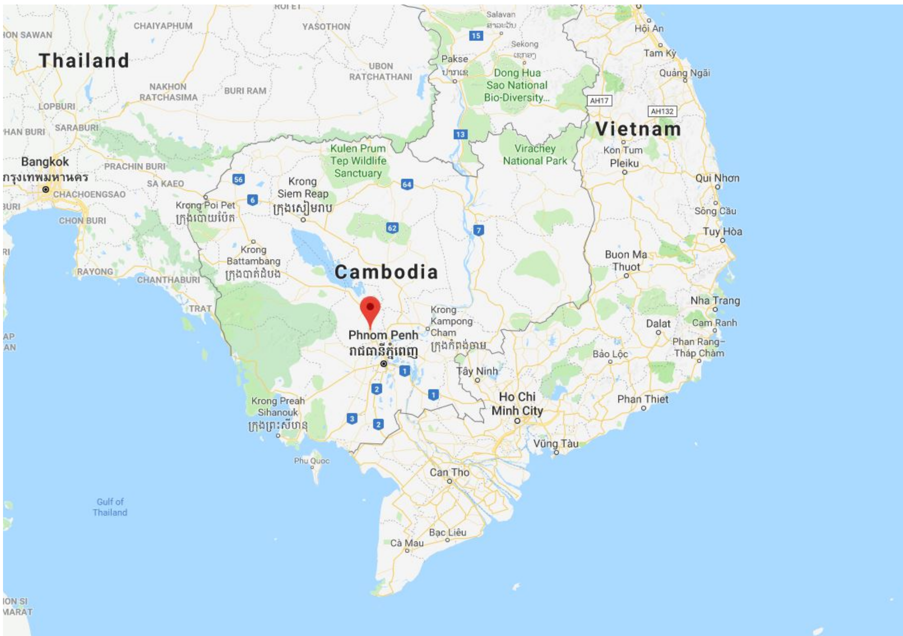


Figure 29 - Image of Cambodia showing Kampong Tralach District (Google, n.d.-b)

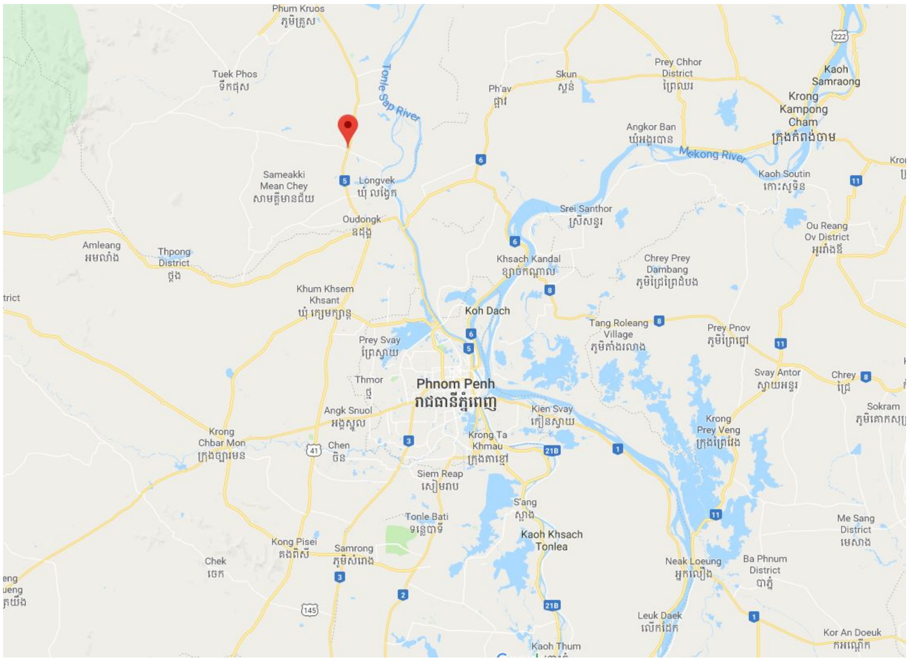


Figure 30 - Image of Kampong Chnnang Province (Google, n.d.-a)

The participants of the Project 1 were selected by the local DPO based on the following criteria:

1. Existing relationship with local DPO
2. Self-identify as having a disability OR a carer of someone with a disability OR high-level community representative
3. Interested in collaborating to create new technology
4. Located within the Kampong Tralach district

Based on these criteria the following participant numbers were present at each workshop:

- Workshop 1 – 46 participants
- Workshop 2 – 44 Participants
- Workshop 3 – 45 participants
- Workshop 4 – 39 participants

Participants self-identified as having a range of disabilities such as mobility (six participants), hearing (four participants), vision (seven participants), cognitive (four participants). The rest of the participants were either carers or community representatives. Not all of the participants in Workshop 1 attended all of the workshops. In many instances, a different member of the same household attended one or more of the workshops on behalf of the original participant. A breakdown of attendance is shown below:

- 60 participants attended at least one of the four workshops
- 40 participants attended at least three of the workshops
- 23 participants attended all four workshops
- 30 participants who attended the first and last workshop

5.5 Workshop Venue

The four workshops were all conducted in the same general area; the central pagoda of the district.

Workshops 1, 2 and 4 were held in a large, open plan pagoda; however, due to the religious ceremony Pchum Ben using the pagoda, Workshop 3 was conducted in the local primary school. This change in venue did result in participants having to sit at school desks, as opposed to on the floor.

The pagoda was arranged in two different ways. Firstly, plastic chairs were arranged in a presentation style layout (Figure 31) for introductions and some content delivery. Secondly, the chairs were removed and participants sat in small teams on the floor to complete activities (Figure 32). The latter was considered more comfortable for participants. In the school, participants sat at desks for introductions (Figure 33) and then spread across multiple classrooms for activities (Figure 34).

Figure 31 - Participants sitting on chairs in the pagoda

Figure 32 - Participants sitting on the floor in the pagoda

Figure 33 - Participants sitting at desks in a school classroom

Figure 34 - Participants sitting on the floor in a school classroom

5.6 Timeline

Planning, and piloting, for Project 1 began in January 2017 with the first workshop being conducted in June of 2017. The final workshop was conducted in late November of 2017 followed by exit interviews in January of 2018. Each workshop cycle consisted of one or two days planning, two or three days of workshops and one day of debrief. An example is shown in Table 28.

Table 28 - Example of a workshop cycle

Day 1	Day 2	Day 3	Day 4	Day 5
Planning day with design team	Planning day with design team. Travel to community in afternoon	Workshop day	Workshop day. Travel back to office in afternoon	Debrief day with design team

The full workshop timeline is shown in Table 29.

Table 29 - Timeline of Project 1 workshops

Workshop	Date	Designers present
Planning and piloting	January 2017	D1, D2, D11
1	20/21 June 2017	D1, D2, D3, D4, D5, D6, D11
2	11/12 July 2017	D2, D3, D4, D5, D7, D11
3	11/12 September 2017	D2, D3, D4, D5, D8, D11
4	28/29/30 November 2017	D3, D4, D8, D9, D10, D11
Exit interview	26 January 2018	D9, independent interviewer

Following these formal stages, the local project partners will continue to support the community as they refine and implement the final solutions.

5.6.1 Design Process

As discussed in Section 3.4, an adapted version of Sanders and Stappers (2014) *Making* framework was used to structure each of the projects. This four-stage design process will be used to categorize the activities completed during Project 1. An overview of all formal activities completed is shown in Table 30. A full description of each activity is presented in an open-access handbook created by the present researcher (Drain & McCreery, 2018).

Table 30 - Project 1 activity summary

	Day	Stage	Activity
Workshop 1	Day 1	Intro	Introductions and welcome
			Game: What is this?
		Creative capacity building	Session 1: What is design?
			Session 2: The design process
			Session 3: Small design project
			Macaroni feedback (an anonymous feedback process using macaroni pieces and jars representing very-sad to very-happy)
	Day 2		Game: What is this?
			Session 4: Transition to community project
		Pre-design	Role play
			Daily activity and yearly calendars
			Identification of challenges
			Macaroni feedback
Work	Day 3		Game: Follow the leader
			Design process discussion

	Day	Stage	Activity
			Revisit challenges
			Game: Hoops
			Team formation
		Generative design	Local precedents
			Macaroni feedback
	Day 4		Game: Marco Polo
			Materials
			Brainstorming
			Game: Pass the ball
			Model-making/ Rapid-prototyping
			Macaroni feedback
Workshop 3	Day 5		Game: What is this?
			Design process discussion
			Existing solutions
			Construction techniques
			Brainstorming (revisited)
			Game: Pass the ball
		Evaluative design	Ranking and selection of ideas
			Macaroni feedback
	Day 6		Prototyping and testing
			Macaroni feedback
Workshop 4	Day 7		Game: Pass the ball
			Design process discussion
			Design Review
			Planning (process mapping, assigning roles, materials and skills)
			Macaroni feedback
	Day 8		Construction
			Testing
		Post design	Implementation planning
			Macaroni feedback
	Day 9		Construction

5.7 Data Collection

Project 1 resulted in the following data being collected:

- 19 designer interviews
- 32 participant short interviews
- 9 participant long interviews
- 59 designer field diary entries
- 100 pages of observational notes from workshops and planning sessions
- 380 photos from workshops
- Workshop documents (models, prototypes, posters, templates)

- 3 technology evaluations
- 4 workshop reflection documents

5.8 Project 1 Cases

During Project 1, three clear project briefs emerged. These were unique as they focused on different community challenges and had different designers and participants working on them. These project-specific teams were formed during Workshop 2 (pre-design) and were kept consistent for the remainder of the project. To assist in discussion and analysis, these three project briefs will be used to structure three separate cases. The cases were formed during the pre-design stage of the project. For clarity see Figure 35. Each case analysis will draw from the same project planning, creative capacity and pre-design stages and unique generative design, evaluative design and post design stages.

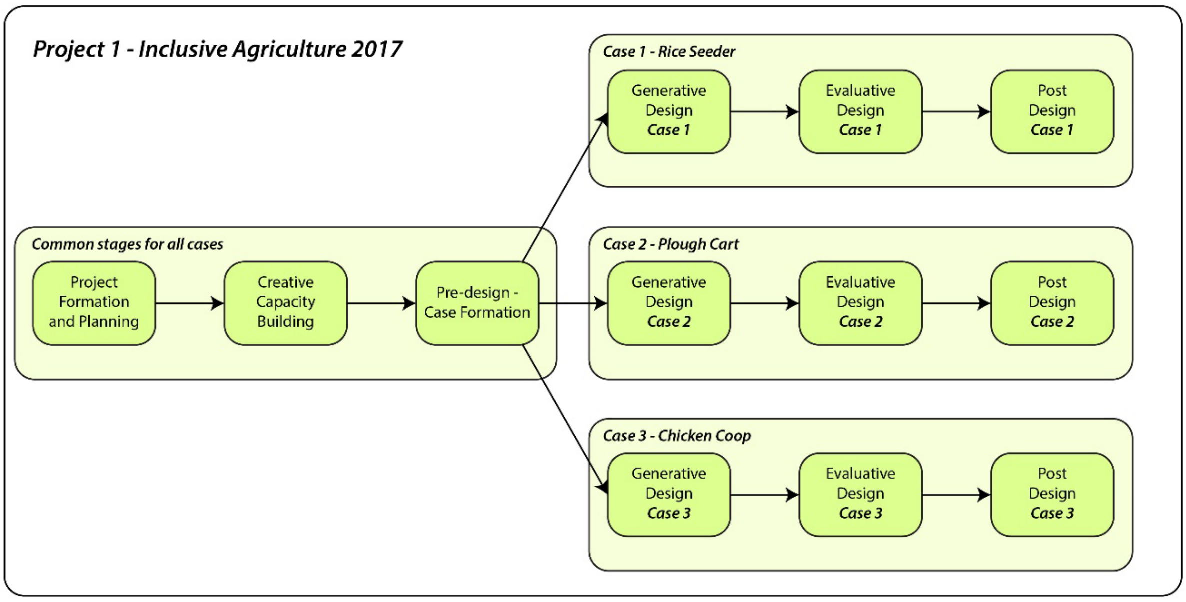


Figure 35 - Overview of Project 1 and cases 1, 2 and 3

5.8.1 Group Formation

While the formal case teams were formed during the pre-design stage, there were other arbitrarily formed teams created during CCB and pre-design. Table 31 provides an overview of the group formation in each workshop.

Table 31 - Group formation table for Project 1

Workshop	Group formation
1	Large group discussions and some work in arbitrarily defined smaller teams
2	Large group discussions, some work in arbitrarily defined smaller teams and some work in purposefully defined case teams. Participants could self-select the project brief they wanted to work on at the end of the pre-design stage
3	All work in purposefully defined case teams (as defined in pre-design stage)
4	All work in purposefully defined case teams (as defined in pre-design stage).

The following section provides an overview of the CCB sessions, each of the design stages and how they were facilitated. It is intended to provide the reader with an understanding of the general flow of the project, key decisions as well as communicate some of the learnings and challenges faced by the design team. A full analysis and discussion will be provided in Chapter 6.

This section will follow the general flow shown in Figure 35 and discuss the CCB sessions and pre-design holistically before structuring the generative, evaluative and post design stages around the specific cases.

5.9 Creative Capacity Building

Each day started with a short welcome to the community and an overview of what they would be undertaking that day. Following this, the designers and participants started the creative capacity building workshops. The full teaching plan can be found in Appendix B.

This involved four structured sessions, each introducing and practicing a different aspect of the design process. Session 1 aimed to discuss the term *design* and make connections between existing problem solving practices in the community and activities planned during the collaboration. Session 2 involved the introduction of the *design process* (Figure 36 and Figure 37) as well as a hands-on exercise creating low-tech mango pickers (Figure 38 and Figure 39). Session 3 aimed to reinforce the hands-on creative problem solving through a cardboard-based activity called the *banana boost*. Finally, session 4 aimed to pivot thinking from controlled, theoretical activities towards contextually relevant projects.

Session 1

This session involved D1 and D3 trying to facilitate the whole group of participants in a discussion about design, problem solving and whether they had done this in their own lives. This discussion was slow and challenging as participants were new to the project and the designers. Furthermore, some had not met the rest of the participant group before. Some of the more confident individuals did speak during this discussion and highlighted existing activities such as the design of wooden traps to catch lizards, fishing rods made from bamboo, woven baskets and wooden ox-drawn carts. Most of these comments came from elderly individuals in the group.

Session 2

This session flowed immediately on from Workshop 1 and presented the specific design process that we were to use in the PD project. D1 described each step, why they are important and how the steps build upon each other to solve problems (Figure 36).

Figure 36 - Presentation of the design process

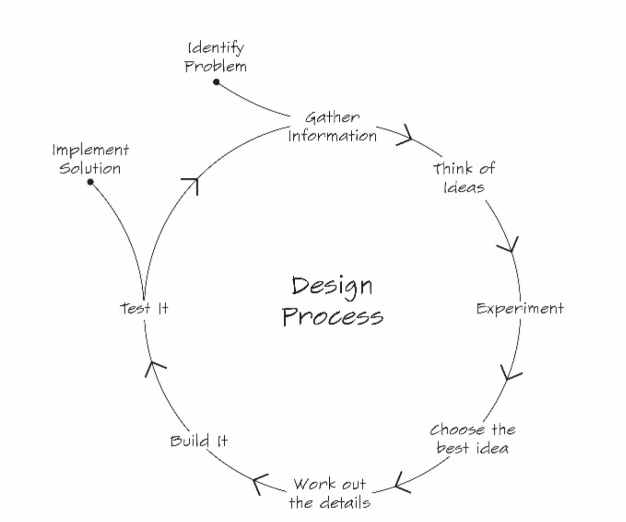


Figure 37 - English translation of the design process

Next, D3 presented a basic example of using organic fertilizer in the community. This example was not planned but did work well by linking to a well-known problem in the community. Next, D1 presented the mango picker example. While this was initially meant to be a group discussion, D1 and D3 decided to run the example as a small team-based design activity. Participants were grouped into three small teams. Selection was mainly random, while we ensured that highly impaired individuals had their carer with them. D3 presented the problem of 'getting mangos out of the tree' and asked the teams to try to come up with lots of ideas. Two of the teams worked well together and developed multiple concepts for pulling mangoes out of trees. D11 had also prepared a range of sketches that could be used to assist each team. Two teams created prototypes and tested them with a range of group members (Figure 38 and Figure 39).

Figure 38 - Participant testing mango picker prototype

Figure 39 - Participant testing mango picker prototype

From testing, one team identified that the clear plastic bottle could not be seen by vision-impaired users. This resulted in a redesign of the product so that a bright red can was used instead of a clear bottle (Figure 40). The third team struggled to work together and did not generate ideas by themselves. D1 found it difficult to facilitate discussion around the problem and idea generation. The team was mainly made up of elderly participants. D1 stated that "*they think, 'oh they're already old, they're not going to think, they cannot come up with all this type of thing*". They were shown the example ideas and eventually chose a design and began to prototype and test. The participants became more energetic and engaged during prototyping and testing.

Figure 40 - Modified mango picker prototype

Finally, D3 facilitated a group discussion about what they learnt and what could be improved to make the prototypes better. Participants were engaged and provided feedback about necessary improvements. Improvements focused on getting lighter, longer bamboo, changing the colour of the product and using better techniques for connecting the parts together.

Session 3

Session 3 aimed to provide the participants with another small design project called the *banana boost*. This allowed them to think about a problem, and use a more abstract prototyping process, paper models instead of bamboo and bottles, to create ideas. The *banana boost* activity required each small team to think of ways of using one piece of paper to raise a bunch of bananas 10cm (the high of a ballpoint pen) off the floor. The teams needed to think of ideas, experiment and choose the best idea (Figure 41). Afterwards, the best idea from each team was used in a competition to see who could hold the most bananas.

D1 introduced the activity and the instructions. There was a lot of clarification required as the participants did not understand what was required. After clarification from D3, the participants seemed to understand the instructions and were very engaged in the activity. One challenge that arose was the lack of ability, or willingness, to sketch ideas. D1 commented that during "*the banana session, because our proposal was difficult, we want them to draw for us. But most of them, they could not draw so they just start to do the prototype*". This made it difficult to focus the teams on the 'think of ideas' stage, as they would tend to explore new ideas through physical experimentation. The design team viewed this as a limitation but also allowed this to happen as participants were engaged. The purpose of the activity was to create different structures out of paper and test whether they were effective at holding bananas (Figure 41).

Figure 41 - Participants experimenting during the banana boost activity

Most participants created a cylindrical or square structure, with few exploring any other formations. D4 stated "*even within one group, where everyone was trying to think of different ideas and everyone ended up making the same thing*". To finish the activity each team were required to select their best idea and trial it in front of the group. This became a competition to see who could hold the most bananas. This aspect of the activity was fun and enjoyable with lots of laughter. In the end, all groups presented similar ideas and the difference between each team during testing was due to the skill of the person stacking bananas. Once testing was complete, D1 and D3 led a discussion about what was learnt and how these ideas could be scaled up and built out of locally available resources.

Session 4

Session 4 aimed to transition the participants' focus from small, well-defined projects to their own community challenges. This workshop became the first activity in the pre-design stage of the PD project as participants discussed community challenges as a large group. The discussion was lively; however, it did not engage all participants and the challenges that were identified seemed like general community challenges, and not specific to PwD. This seemed to be the fault of the designers as the introduction to the discussion did not focus on PwD. There was also evidence that some participants were too shy to speak in a large group. D1 stated:

> "*I think they're not really there to talk with the group, with the big group, because when we ask them into the big group, some of them they feel very shy and they said they're not there to talk in front of the whole group*".

To address this challenge, smaller teams were formed and the majority of the pre-design stage was conducted in these teams.

5.10 Pre-design

This stage focused on the identification of challenges that limited PwD inclusion in local farming practices. The aim of the stage was to understand the challenges, local priorities and to define a number of projects to progress into generative design. To do this, the designers and participants completed the following activities:

1. Small team discussion
2. Role play
3. Daily activity and yearly calendars
4. Identification of challenges
5. Revisit challenges
6. Team formation

Four teams were formed to continue discussing PwD-specific challenges that occur in their community. The teams were arbitrarily defined with some effort to ensure an even distribution of gender and impairment. There was a discussion among the design team about the best way to define teams at this stage with two options emerging. Firstly, the distribution described above, secondly, grouping individuals with common impairments. While the latter would potentially allow for more focused discussion, it was decided that segregating participants based on impairment did not align with the aim to include and empower PwD. The small team discussion, daily activities and calendars activities generated multiple insights about the lives of PwD (see Appendix C).

At this stage, staff member from LFTW, not formally involved in the project, suggested we run a role-play activity to get participants up and energetic. The design team agreed and decided to allocate each team with a particular impairment, and ask them to choose one challenge for someone with that impairment and act it out in a role-play. The activity had mixed results as some of the elderly participants seemed reluctant to act in front of a crowd. The four scenes acted out were:

1. Difficult for mobility-impaired individuals to pump and carry water each morning
2. Difficult for deaf student in school to hear instructions and interact with other students
3. Difficult for blind person to attend social gatherings, such as weddings, as they need help travelling to the event and help during the event
4. Difficult for elderly people to get fruit from trees, such and coconut and mango, as the traditional way of getting the fruit is to climb the tree

Workshop 1 culminated with each team creating a list of challenges for PwD in their community. This list was used as a starting point for screening by the design team between Workshop 1 and Workshop

2. This screening was undertaken to ensure alignment with the original project objectives, design team capacity and organizational objectives. The following screening criteria were used:

1. Challenge is faced by people with disability in the community
2. Challenge relates to an individual's ability to engage in agriculture
3. Challenge allows for physical, mechanical solutions to be developed

The remaining challenges were presented back to the community in Workshop 2 and became the basis of choosing the final challenge that each team would focus on. The participants continued this discussion at the beginning of Workshop 2, with three project briefs being developed. These were:

1. The design of a solution to assist the elderly in direct seeding rice seed onto a field
2. The design of a solution to assist mobility impaired individuals to prepare their fields before sowing
3. The design of a solution to allow wheelchair users, and the visually impaired, to engage in small-scale chicken farming

Participants were given the opportunity to reform teams based on the project brief they were most interested in. This gave individuals who weren't interested in their current team's brief a chance to join a different team. This marked the end of the pre-design stage.

As mentioned previously, Project 1 resulted in three clearly defined projects being undertaken. These came from collaborative scoping during the pre-design stage and will be used as separate cases for description and analysis. Each case contained its own unique designers, project brief and participants. For clarity, Table 32 shows a description of each case.

Table 32 - Overview of all cases inside Project 1

Case	Project brief
1	The design of a solution to assist the elderly in direct seeding rice seed onto a field
2	The design of a solution to assist mobility impaired individuals to prepare their fields before sowing
3	The design of a solution to allow wheelchair users, and the visually impaired, to engage in small-scale chicken farming

The generative design stage involved the following activities:

1. Local precedents
2. Materials
3. Brainstorming
4. Model-making/ Rapid-prototyping
5. Design process discussion

6. Existing solutions
7. Construction techniques
8. Brainstorming (revisited)

The stage aimed to generate discussion around existing farming practices, whether they are inclusive, locally available resources and finally generate potential solutions to each of the project briefs. The output, to this stage were detailed-designs, models and prototypes of a range of potential solutions. The stage spanned both Workshop 2 and Workshop 3.

The following sections are structured around each of the three cases and their corresponding design stages.

5.11 Case 1 – Rice Seeding

Table 33 - Case 1 overview

Case	Project brief	Designers	Result
1	The design of a solution to assist the elderly in direct seeding rice seed onto a field	*Workshop 1*: D5, D6 *Workshop* 2: D5, D7 *Workshop 3:* D5, D8 *Workshop 4:* D8, D9, D10, D11	Project completed successfully

5.11.1 Generative Design

This stage began with D5 facilitating the local precedents activity. This activity involves learning about the current methods used in the community for doing a particular activity and the differences experienced between individuals performing the same activity. This ran smoothly with some interesting learning about how rice seeding is currently performed in the community. The community currently uses a technique called *broadcasting*. This is a direct-seeding technique where a farmer will prepare the field and walk around it throwing large handfuls of rice seed. The aim is to completely cover the field. Next, as the rice saplings grow, the majority are pulled out of the ground and placed into a hessian sack, leaving only plants that sit in a 250mm by 250mm grid. This is the optimal spacing for rice plants. Finally, the removed saplings are transplanted into other, empty fields, at the same 250mm spacing. This labor-intensive process involves bending over or squatting for long periods. This process is shown in Figure 42.

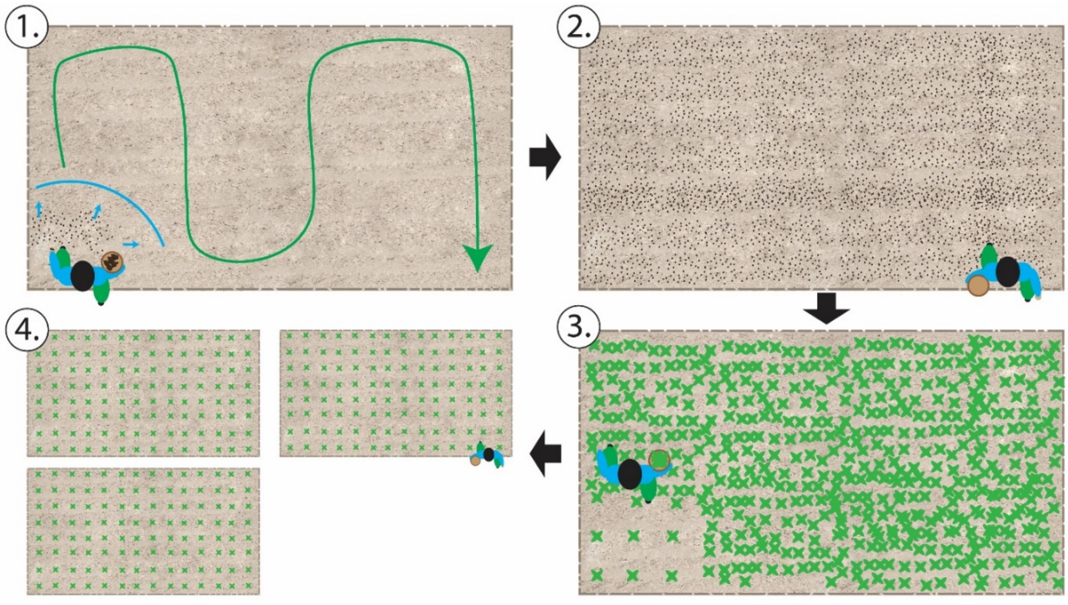


Figure 42 - Traditional broadcasting rice seeding process

The materials activity was engaging and seemed enjoyable for the participants. D5 did face some challenges stating:

> *"The big challenge for me is the communication between the deaf people and me because I don't understand the body language and particularly the language the parents use in this area, so this is the challenge by far"*

Next, the team attempted their first brainstorm, with the aim being to design something that addressed the project brief. The breadth of ideas was limited but there were several different solutions identified that would improve the seeding process. Ideas included adding something (rope, wire, lights, etc.) to create guidelines for throwing rice seed, crutches and a machine to drop rice seed. The latter idea was chosen by the team and was developed into a drum rice seeder concept. This is a rolling unit that is pulled along by ox or human and drops rice seed at standardized spacing. This process drastically reduces the labour requirements and physical effort of the farmer. The process is shown in Figure 43.

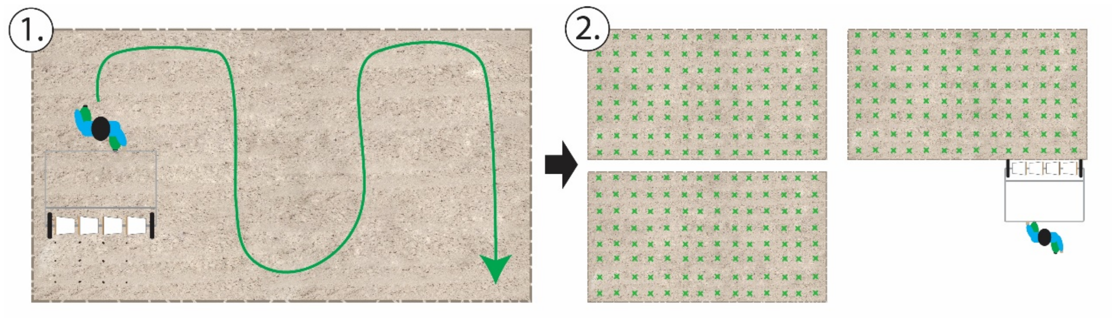


Figure 43 - Rice seeding process using a drum seeder

This was not a new idea, as drum seeders are common in many countries. However, it was unique to this area of rural Cambodia. None of the participants had seen drum seeders for sale, nor did they have any access to importing them. Desk research also showed that existing units sold for upwards of $50USD, well outside of the price range of this community. These factors meant that the design of a low cost, locally available drum seeder would be novel and valuable. D5 was also very interested in this idea as he had experience working with drum seeders and large tractor seeding machines in other provinces.

Next, the team began creating small models of potential solutions out of basic materials such as cardboard, straws, string and plastic bottles. This process helped to uncover differing views, local construction processes and important functional requirements. The making process and final model are shown in Figure 44 and Figure 45.

Figure 44 - Model making process for rice seeder in case 1

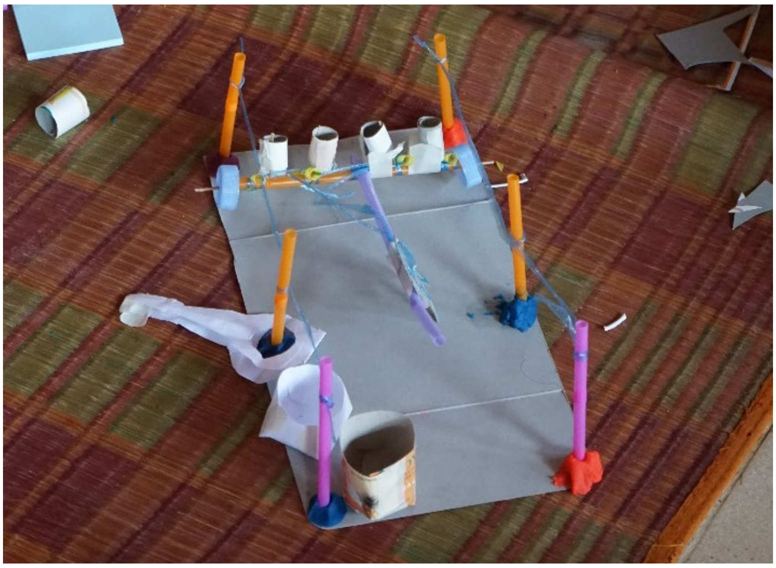


Figure 45 - Rice seeding model made in case 1

The rice seeder design, created during the model-making activity, utilized locally available materials such as old bicycle wheels, bamboo, rope and wire. Team 1 identified that the dosing mechanism (the thing that controlled how many seeds fell out and how often) was critical to the design. Therefore, it was agreed that the designers would develop this aspect of the product independently, and present it back to the community during Workshop 3. This marked the end of Workshop 2. After Workshop 2, the design team (lead by D11) reviewed the activities undertaken and synthesised a set of functional requirements. This information was captured by creating a design-requirements board (Figure 46). The requirements were driven by community needs as well as the universal design principles (Story, 1998). This requirements board was used to guide design work in Workshop 3. D11 also produced a range of ideas that could be used to assist the team during brainstorming in Workshop 3. These are shown in Appendix D.

The final dosing mechanism allows for a metered dose of rice seed to be dropped eight times per revolution; or every 45 degrees of rotation (Figure 47). It works by collecting rice in the dosing hole at the bottom of the rotation and releasing it once the plate has rotated 180 degrees to the top of the rotation (Figure 48). The plate, along with a standard size bicycle wheel (600mm) would result in seeds dropping with an approximately 240mm spacing. This was a requirement identified during generative design.

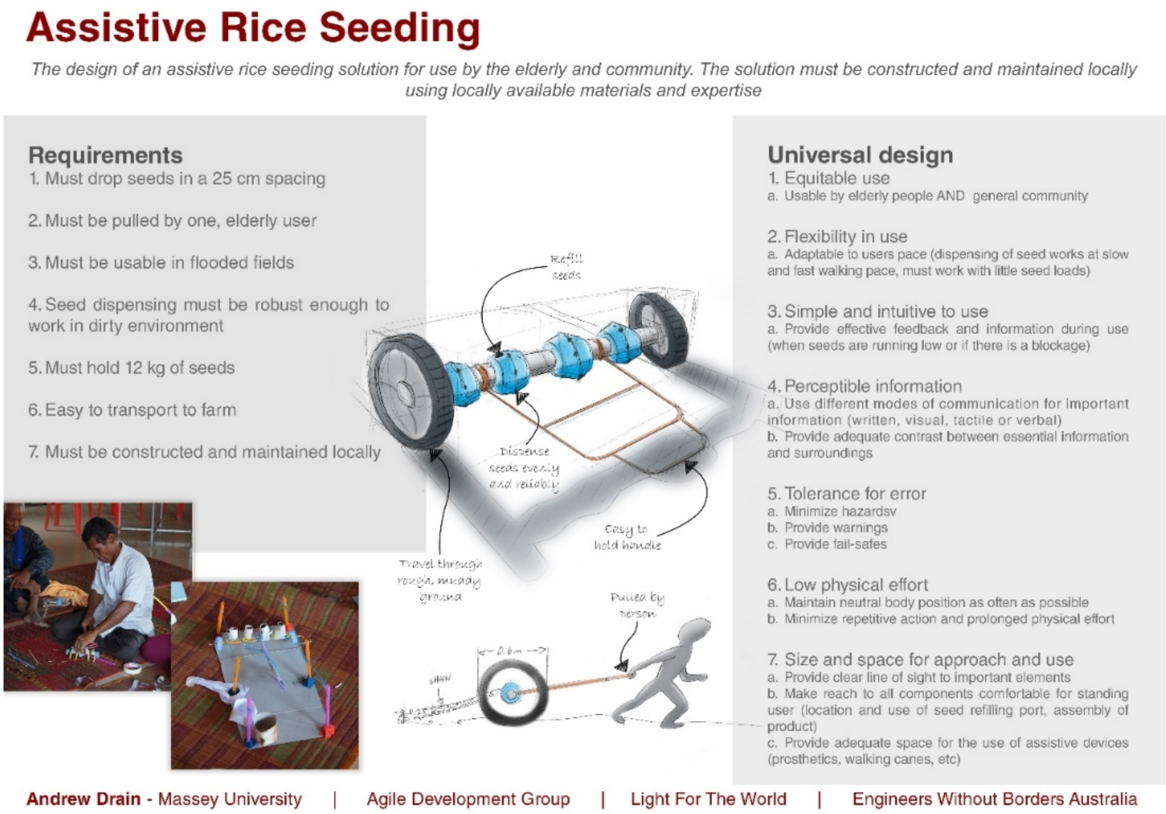


Figure 46 - Design requirements board for case 1

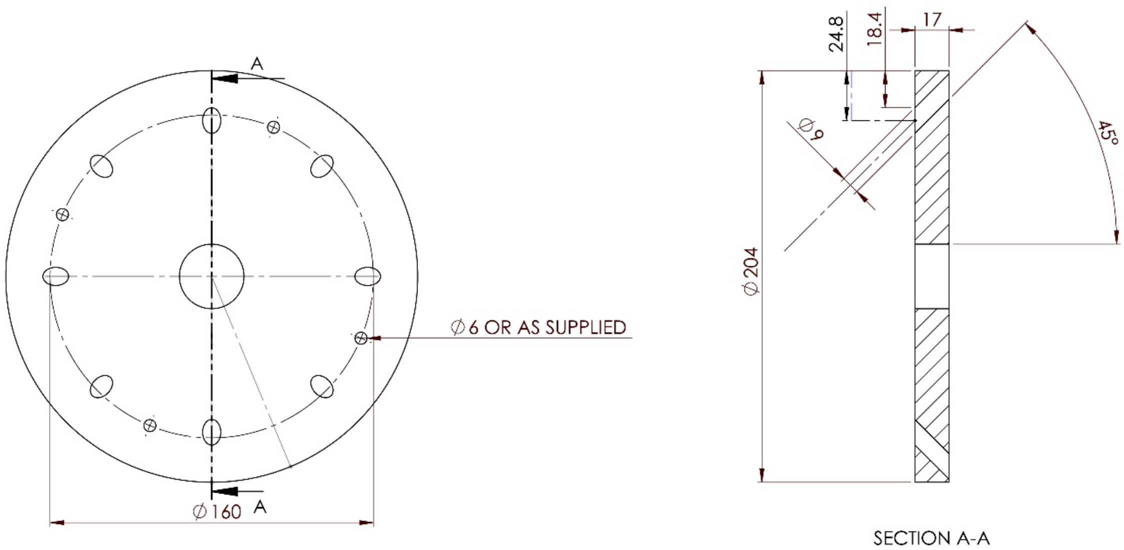


Figure 47 - CAD drawing of doser-plate

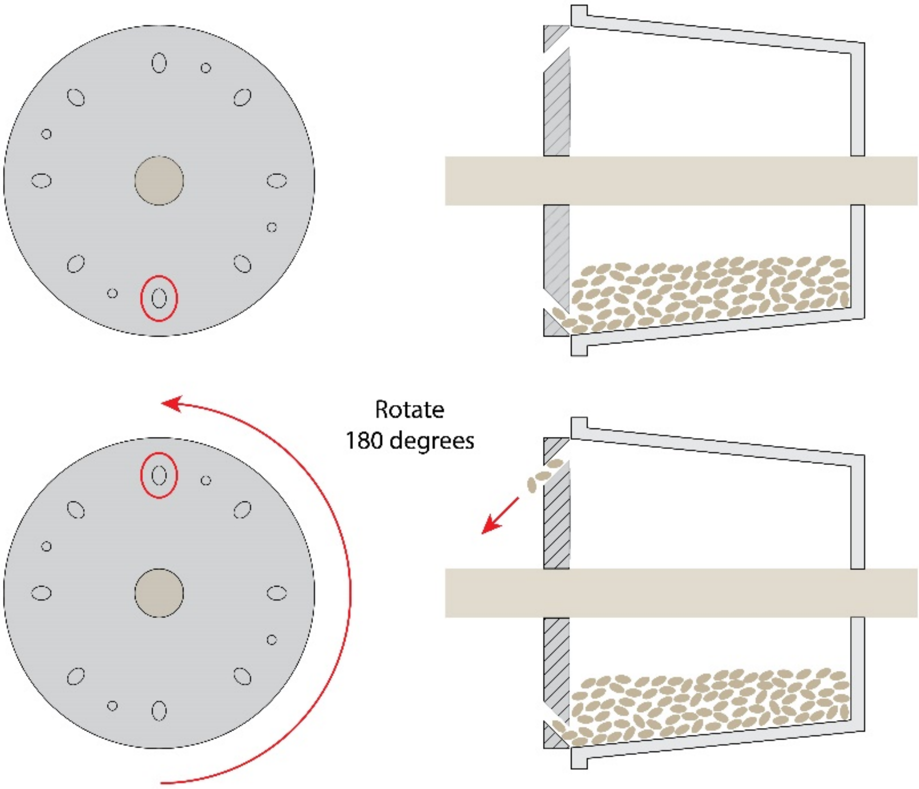


Figure 48 - Illustration of seed dosing system

This dosing mechanism was refined by D11 before Workshop 3 to ensure it met the functional requirements (Figure 49). This involved trialling a range of dosing hole angles and sizes and running tests to ensure reliable output.

Figure 49 - Lab testing of dosing-plate for Team 1

During Workshop 3, the team revisited their original design, reviewed a range of existing solutions (compiled by the design team) and refined their design. It was originally planned for D5 to lead the team through a pros and cons assessment of each of the existing drum seeder designs. However, in practice the activity involved group discussion about the designs and selection of which one they thought was best. From there the team skipped the second brainstorming activity and the ranking ideas activity and began to plan their functional prototype. This was due in part to the motivation of the participants to create a working prototype as well as a lack of understanding of the design process by D5. This change from the plan led to some disagreement between D5 and support designer D8. However, it was decided that the team could continue, as they wanted, given the high levels of engagement. This marked the end of generative design.

5.11.2 Evaluative Design

The team planned and constructed a simple drum seeder (Figure 50 and Figure 51), utilizing bamboo, PVC pipe, bicycle wheels and the dosing plate designed by D11. The participants led the design and build process and utilized local techniques such as cutting strips of bamboo, notching the bamboo, rope knots and heating and stretching the pipe. D5, D8 and D11 all assisted with some of the more technical elements of the build, such as attaching the wheel to the axle. Once constructed, the prototype was tested with a range of participants to ensure it was universally usable (Figure 52). A limitation of the testing was that it was done on hard dry ground, not the tilled, wet ground that would most likely be present during use. However, the testing did highlight the need for a more rigid connection between the main axle and the dosing unit as it was bending under the weight of the seeds. This was improved, and a second prototype was constructed. The prototyping activity was good at engaging all participants in either construction or testing.

Figure 50 - Team 1 building a drum seeder prototype

Figure 51 - Participants discussing improvements for rice seeding prototype version 1

Figure 52 - Participant testing the rice seeding prototype version 2

The testing of this prototype marked the end of Workshop 3. Based on lessons learnt from Workshop 3, D11 designed another iteration of the rice seeding prototype. This incorporated the dimensions and components developed by the community but aimed to improve engineering feasibility of the frame, and wheel hubs (Figure 53).

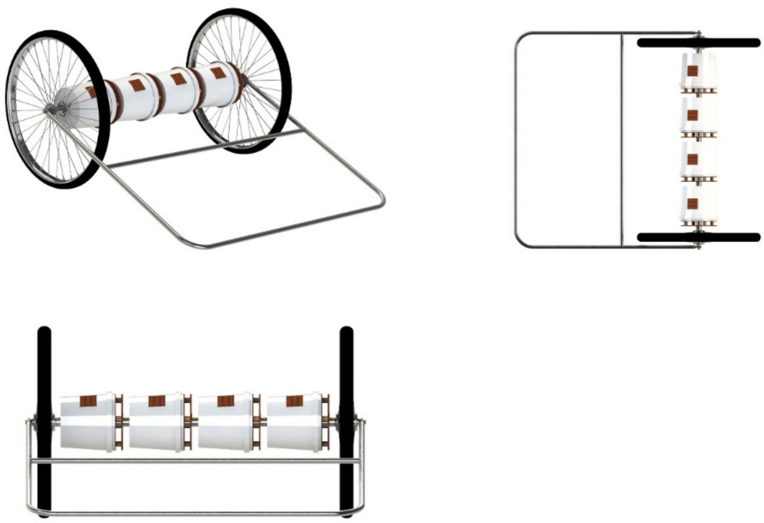


Figure 53 - Engineering design of rice seeder for case 1

The doser plate was also modified based on feedback during Workshop 3 that the seeds were falling out and bouncing off the main axle. This created a less accurate position once the seeds hit the ground. To mitigate this issue the holes were drilled on a 30 degree angle. This improvement is illustrated in Figure 54.

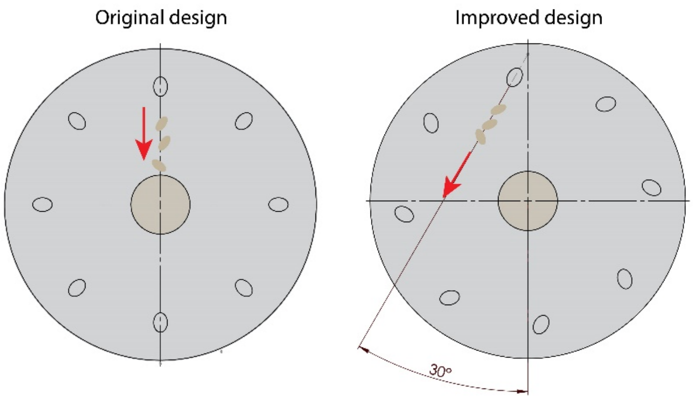


Figure 54 - Original and improved doser plate design

The change in doser plate design increased the complexity of the fabrication process as holes now needed to be drilled in a difficult direction. The design change also meant that rice seeder needed to be pulled in a certain direction, as the opposite direction would result in the seeds not being picked up correctly by the dosing hole. It was decided that these added complexities were required as the accuracy of the seed dropping was critical to the function of the product. To assist with this, a small metal jig was created to allow the community to drill the angle dosing holes accurately and safely. To communicate the design to the community effectively during Workshop 4, multiple instructional images were created. These aimed to show step-by-step assembly instructions for the new design

(Figure 55). This could be used to communicate the intended design and allow for the community to provide feedback and modify it as required.

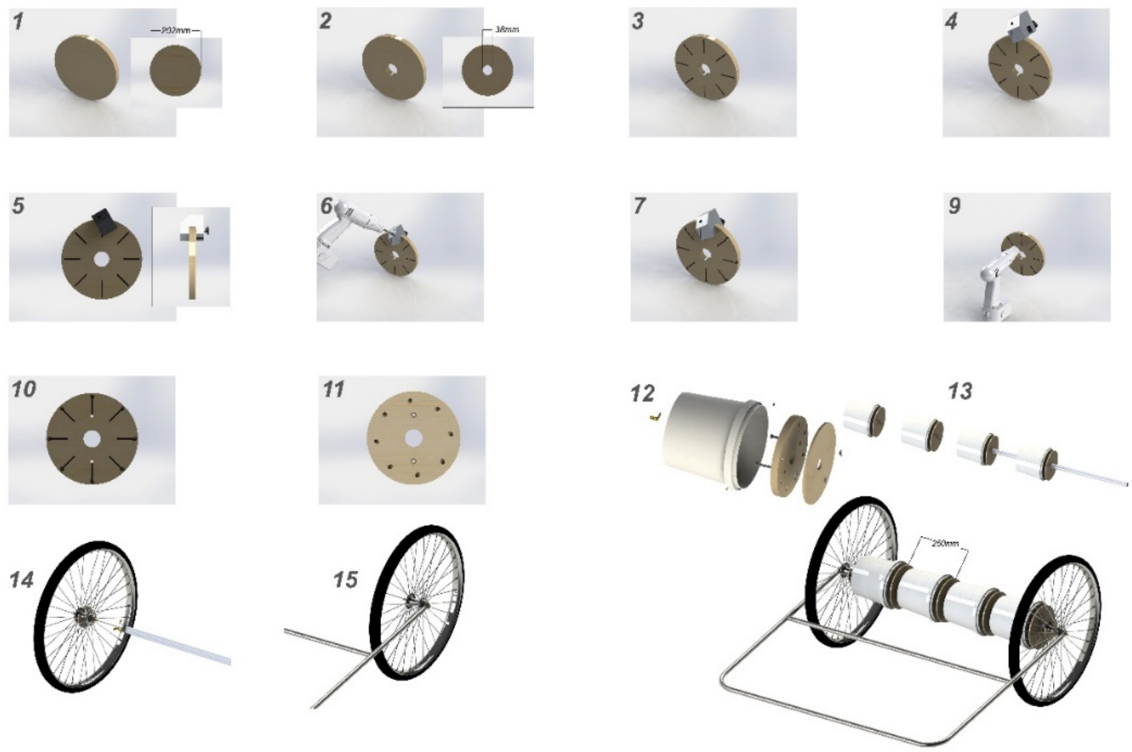


Figure 55 - Step-by-step assembly instructions for Team 1

When the participants and design team reconvened for Workshop 4, one of the participants arrived with a homemade version of the rice seeder (Figure 56). This design was stronger than the prototype made in Workshop 2 and had four wooden stakes placed in front of the seeding units to plough a small groove in the dirt for the seed to drop into.

Figure 56 - Rice seeder made independently by case 1 participant

This independent creation was surprising, but very helpful, as it allowed the team to focus on a physical prototype and discuss ways that it could be refined and improved. The design made by D11 was also presented to the team. It was democratically decided that both designs should be continued with and that half the team could work on each design. From there, all team members worked for rest of Workshop 4 planning, building and testing the two designs. The community design (Figure 57 and Figure 58) utilized a heavy wooden frame and a simple dosing mechanism involving an old paint bucket with holes drilled in it. The frame was strong and created a rigid, durable product. However, the dosing mechanism did not work effectively as it relied on the user pulling the product at a particular speed to achieve correct dosing. The addition of 4 metal spikes to plough the ground in front of the dosing unit was considered novel and effective, but also added complexity to the design as they needed to be adjusted to a particular height depending on the user. During an exit interview, one participant stated "*we should measure width between each rake's teeth. We shouldn't use metal rake because it's too small. We should use wood the size of a toe*". The same participant also stated:

> *"We haven't finished it yet. This is an experience. Technical experience. But, it is not properly made. First, we missed the back. Second, the rake's teeth aren't correctly placed. They are too small. So, we haven't practiced it. Also, it is the wrong season. It's dry season"*

Figure 57 - Construction of community designed rice seeder

Figure 58 - Testing of community designed rice seeder

The construction of the D11 designed rice seeder went well with all participants working together to construct the unit. However, there were multiple changes to the intended design due to material limitations and community decisions. These are presented in Table 34.

Table 34 - Table of design changes for rice seeder

Original design decision	**Change to design decision**	**Rationale**	**Associated design issues**
Dosing plate to be 202mm in diameter	Dosing plate end up being 180mm in diameter	Limited sizes of buckets available. This meant the design needed to work with a smaller bucket	Dosing plates needed to be hand cut smaller, this resulted in a less accurate fit with bucket
4 dosing units spaced 250mm apart on the main shaft. Overall width of unit 1200mm	5 dosing units spaced 250mm apart on the main shaft. Overall width of unit 1500mm	The participants wanted more dosing units to allow for more efficient rice seeding	A wider overall unit meant it was more difficult to manoeuvre
Handle of frame length 1060mm	Handle length increased to 1600mm	Allows user to stand more upright than previous design	A longer handle meant it was more difficult to manoeuvre and more loading was placed on the frame during turning
Tubing for frame 22.2mm x 1.2mm mild steel	Tubing for frame 22.2mm x 1.2mm aluminium	Decided by partner organisation as it was cheaper and easier to source	Frame much weaker than originally intended

Figure 59 - Construction of D11 designed rice seeder

Figure 60 - Testing of D11 designed rice seeder

Unfortunately, it was difficult to test these prototypes in their actual use environment (muddy, ploughed fields) as field preparation and sowing does not occur until May (Workshop 4 was conducted in November). Some basic testing was conducted using local rice seed. This worked to some extent but seed dosing was not as reliable as it was during lab testing by D11. This was partly due to the less accurate construction and partly due to the rice seed that was used being slightly wet and sticky (in reality it would be hard and dry).

5.11.3 Post Design

After testing had been attempted, D3 facilitated a discussion about who would keep the prototype, and what would be done to ensure the identified issues were addressed. The participant who created the rice seeder independently between Workshop 3 and Workshop 4 took ownership of the improved version of his design. A different older man took ownership of the prototype designed by D11.

During exit interviews, the participants were asked about any next steps they have planned. One participant responded that he has "*a plan with four people. I was the one who initiated the idea to make a tool. Then, we mentioned to the group that we wanted a rice seeding tool*".

5.11.4 Technology Evaluation

The design team undertook a technology evaluation after exit interviews were complete. See Appendix E for the technology evaluation of the community designed and design team designed rice seeders.

5.12 Case 2 – Plough Cart

Table 35 - Case 2 overview

Case	Project brief	Designers	Result
2	The design of a solution to assist mobility impaired individuals to prepare their fields before sowing	*Workshop 1:* D3, D4 *Workshop 2:* D3, D4 *Workshop 3:* D3, D4 *Workshop 4:* D3, D4	Project completed successfully

5.12.1 Generative Design

The generative design stage began with the completion of the local precedents and materials activities. The local precedents activity worked well for identifying a range of differences between able-people and PwD, as well as PwD-specific challenges. These included:

1. Walking long distances makes PwD sick
2. General community don't like PwD
3. PwD can work but not as fast as able people
4. PwD cannot see very well so difficult to walk around
5. PwD cannot make money easily

Interestingly, most of the differences and challenges identified were not focused on the project brief, but more general to community-life. Therefore, the new insights generated helped to build an understanding of the general environment but not the specific issues associated with preparing fields.

Similar to case 1, the materials activity worked very well in case 2. It was inclusive and engaging for all participants. After this was completed, the team progressed into brainstorming. The case 2 team originally had a wide range of ideas including new foot-designs for prosthetic limbs, tools for planting rice saplings and new eyewear for the elderly. One of the brainstorming pages is shown in Figure 61.

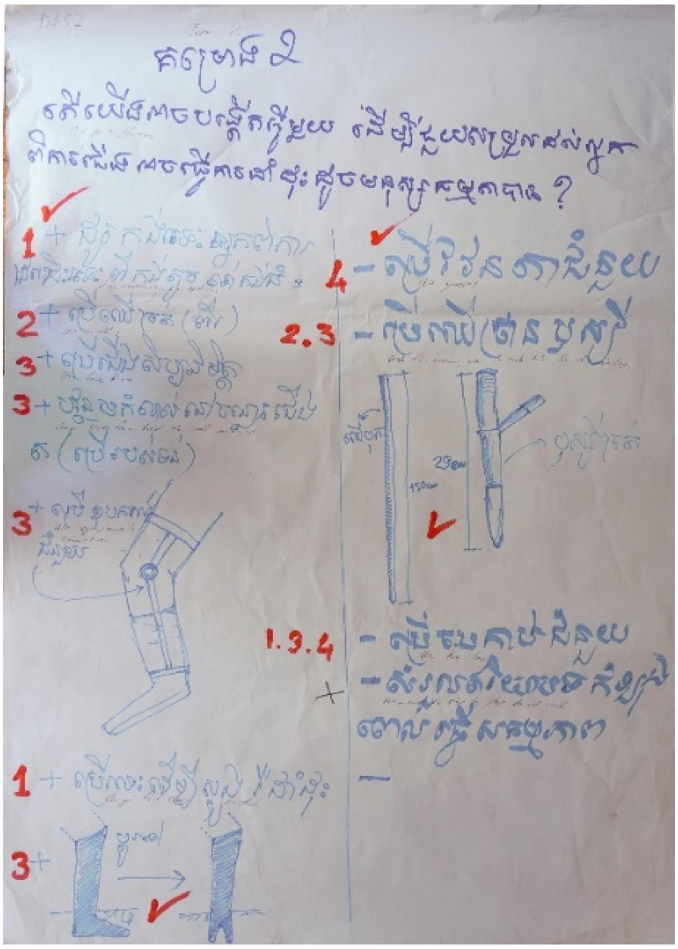


Figure 61 - Brainstorming page from case 2

The lack of focus during brainstorming seemed to be linked to one of two elements. Firstly, the project brief was broad, as improving how a field was prepared could be interpreted in many ways. This, coupled with the range of impairments present, resulted in quite divergent solutions. Secondly, there were several dominant male participants present, each with different ideas. For example, there was a man with a prosthetic leg who was very active during each activity. D3 stated:

> *"I look to that man, and feel like he's very like, want to join us, join the workshop. Every session that we run he always share his idea or share his knowledge. Especially, generate idea to show the problem. He have many idea, but the way to design the leg that using in the rice fields, that is from his idea too"*

Several ideas were chosen to make models of during Workshop 2. For example, a new prosthetic food design for walking in mud (Figure 62). This marked the end of Workshop 2.

Figure 62 - Model of prosthetic attachment made during model-making in case 2

When the team regrouped at the beginning of Workshop 3, the man with a prosthetic leg was not present. The design team were told he could not come, as he had to work on the farm that day. The team completed the existing solutions and construction techniques activities as planned and then revisited brainstorming. The absence of the man with a prosthetic leg seemed to help the rest of the team as they relatively quickly decided to pivot the project direction away from prosthetics, towards plough attachments. This highlighted the value of having a team that is focused on one particular challenge. Once brainstorming was complete, a more systematic screening process was used to choose the final idea for prototyping. This involved using a pre-defined set of criteria to rank each idea and select the idea to continue with into prototyping. The criteria were developed by the design team based on the first two workshops. The screening table is shown in Figure 63.

Criteria	Mobility Project 1: ☹, 2: 😐, 3: ☺ Description	1	2	3	4	5	6	7	8	9	10
Design requirements											
Critical component availability	*Are there particular components which are important? Can you get them?*										
Easy to build	*Can it be made locally? Are any special skills required?*										
Easy to use	*Can it be used by most people? Can it operate at different speeds? Is it comfortable to use?*										
Easy to understand	*Can people understand how to use and maintain it?*										
Price to make	*How much money will it cost to build? 3 - $10 or less, 2 - $100 or less, 1 - $1000 or less*										
Does it solve the problem?	*Does it help people with disability move around the rice field?*										
Impairment suitability											
Vision	*Can it be used by the vision-impaired?*										
Hearing	*Can it be used by the hearing-impaired?*										
Mental	*Can it be used by the mentality-impaired?*										
Mobility	*Can it be used by the mobility-impaired?*										
Dexterity	*Can it be used by the dexterity-impaired?*										
TOTAL											

Figure 63 - Idea screening matrix for plough cart project

The plough cart was chosen due to its universality and inclusiveness. It could be used by able and impaired individuals. The project aimed to create a small cart that could attach to the back of an ox-drawn plough to provide individuals with a way of resting during ploughing. This marked the end of generative design.

5.12.2 Evaluative Design

The initial prototype created in Workshop 3 used bicycle wheels and locally available wood to create a wheelchair-like structure. The prototype highlighted the woodworking skills of the participants and showed some helpful ways of constructing the final product (Figure 64). However, participants identified issues that needed improving such as larger wheels, a more robust connection to the plough, more control over the plough depth and a stronger frame (Figure 65). The designers also identified issues such as the safety of the person sitting on the cart, the ability to climb on and off the cart when in use and the strength of the connection between cart and plough. This marked the end of Workshop 3.

Figure 64 - Participants constructing a prototype in case 2

Figure 65 - Participants and designers discussing improvements to their Workshop 3 prototype

Between Workshop 3 and Workshop 4, D11 refined the case 2 design and developed a new design to use as a starting point for Workshop 4. The new design aimed to integrate the community design, woodworking skills and ideas with a safe, feasible frame. The new design also allowed for the community to have more control over the plough depth by moving forward or back on the cart. The ability to control the plough depth is related to the force the person applies to the plough. Without the cart, this force is generated by leaning on the plough. With the cart, this force can be generated by standing on the cart structure between the plough and the wheel of the cart. An analysis of the original design is shown in Figure 66. This shows that the maximum downward force that could be applied to the plough was 232N (24kg) and that this is only possible if the user stands up and leans forward.

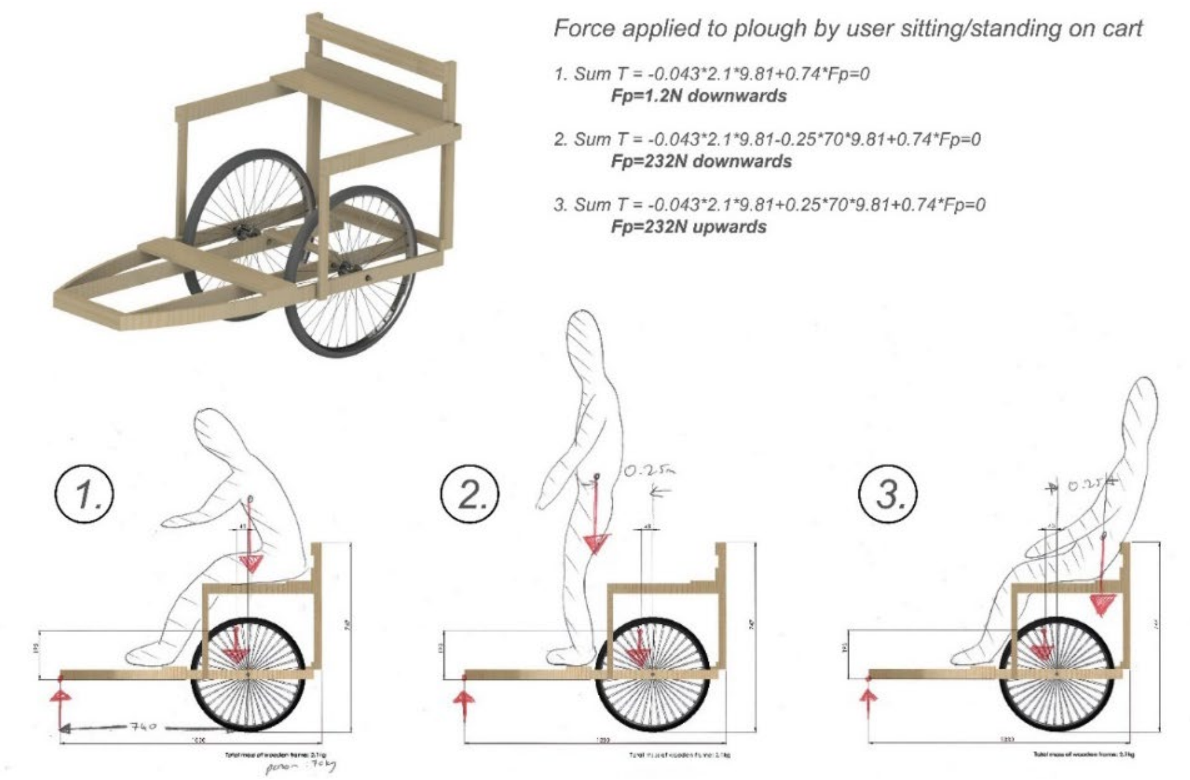


Figure 66 - Force analysis of Team 2 original plough cart design

To increase the ability to control this downward force, and the maximum force possible the cart was re-designed with the wheel further back, creating a longer lever arm. To improve safety and usability the seat was removed and a larger wooden platform was created at the same level as the wheel hub. This new platform could be knelt on, sat on or stood on, and could be easily mounted and dismounted in use. Finally, a handrail was added for stability and a metal sub frame was added to ensure the cart was strong enough to carry the weight of a large person. This design was built in an engineering lab at Massey University, New Zealand and tested (Figure 67). Following this, the new design was reviewed with D3 and D10 with some changes made based on the availability of materials.

Figure 67 - Prototype built in engineering lab for testing

The design is shown in Figure 68 and Figure 69. This engineering design phase was conducted without community involvement; however, it was crucial for ensuring the final design was safe and effective.

Figure 68 - New plough cart design

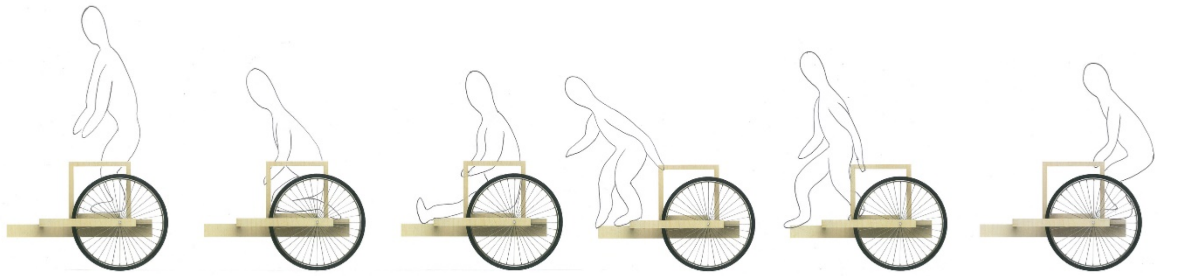


Figure 69 - User positions on cart

The new design was presented to the team using a step-by-step instructions poster (Figure 70) and discussion was facilitated about the good and bad aspects of the design. Once a consensus was reached about the final design, several planning activities were completed to ensure all team members would be involved in the construction of the prototype. This worked well; however, there was no one in the participant team who could weld. This meant the design either needed to be changed, or a welder from outside of the team needed to be found (there were many available at the nearby markets). It was decided that D3 would perform all of the welding tasks, while the team cut and prepared all of the steel box-section. The team would construct all of the wooden parts and complete the final assembly (Figure 71). Interestingly, the man with the prosthetic leg did attend Workshop 4 and again took a leading role in construction. He was energetic and enthusiastic about the design, even though it was not what he had originally championed.

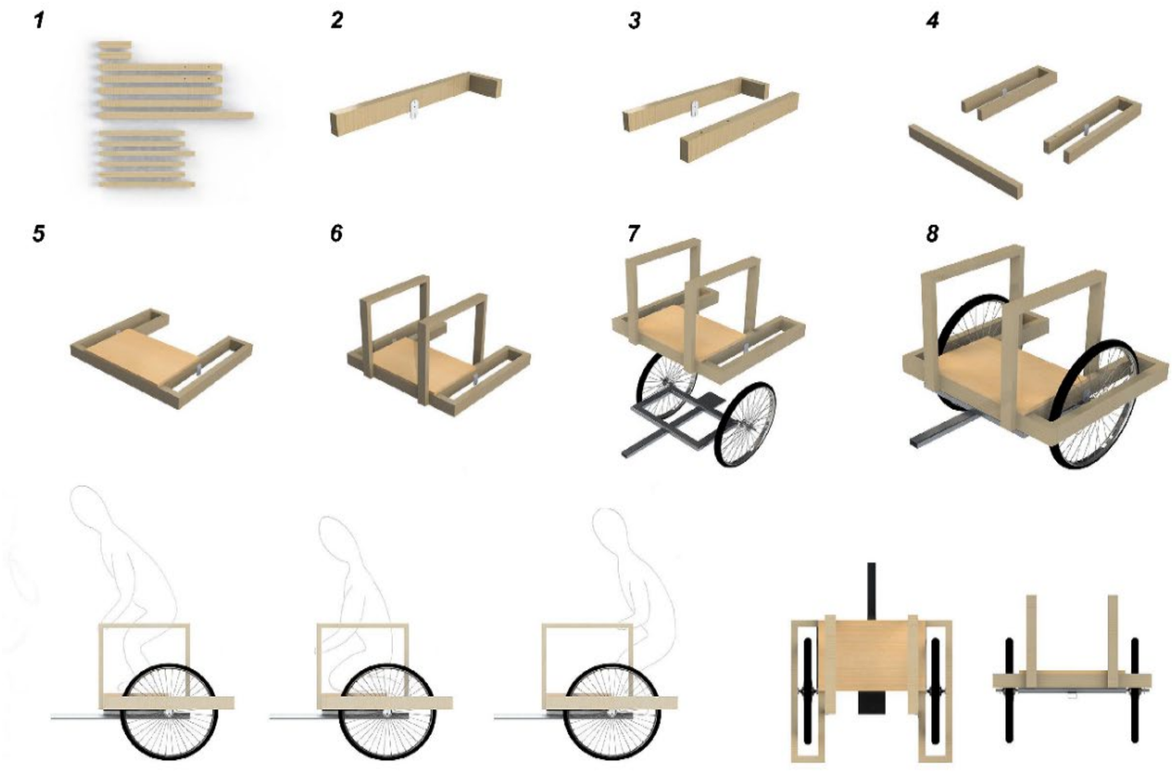


Figure 70 - Step-by-step assembly instructions for plough cart

Figure 71 - Case 2 members building the plough cart wooden frame

Figure 72 - Case 2 final prototype of the plough cart

The final prototype (Figure 72) contained much of the design work of D11 with some local changes due to local construction techniques, available materials and community preferences. The majority of participants were engaged in the construction process with D4 working solely with the women of the group to ensure they were comfortable and encouraged to contribute. They built the bamboo seating and plough-cart connection. The team ran out of time to complete the prototype within the two days planned for Workshop 4 so the design team invited any participants that were interested to attend a third day. The design team planned to complete construction of the prototype and perform field-testing; however, meaningful field-testing was not possible due to unforeseen circumstances (participant's oxen were at the vet and his neighbour's oxen became agitated due to the unfamiliar master and crowd of people watching). This is shown in Figure 73.

Figure 73 - Participant attempting to test plough cart

The participant performed testing privately and sent a video of the product in use to the design team. The prototype was tested on hard, dry ground. This would not be the case in actual use, however, given testing was performed in dry season, it was difficult to find a wet field. From testing the following improvements were identified:

1. Longer connection between cart and plough needed to allow for the plough tiller (control lever) to be located in a more usable position
2. More comfortable seating position needed
3. Adjust wheel position to account for a more forward seat position

5.12.3 Post Design

During the exit interviews, it was found that participants already had a plan developed to regroup and refine the prototype. It was also evident that they did not think the prototype was finished and that they would like more support refining the design and sourcing materials. During an exit interview, the participant who tested the prototype stated, "*We should design at the time we plough so we know the seating and holding position. It was a bit wrong from what we have done there*". He explained, "*If we plough on dry land, we can sit and relax our legs. When we make the cows walk, we don't have to walk and hurt our legs*".

5.12.4 Technology Evaluation

The design team undertook a technology evaluation after exit interviews were complete. See Appendix E for the technology evaluation of the plough cart.

5.13 Case 3 – Chicken Coop

Table 36 - Case 3 overview

Case	Project brief	Designers	Result
3	The design of a solution to allow wheelchair users, and the visually impaired, to engage in small-scale chicken farming	*Workshop 1:* D2, D11 *Workshop 2:* D2, D11 *Workshop 3:* D2, D11 *Workshop 4:* NA	Project stopped after Workshop 3

5.13.1 Generative Design

The generative design stage started with the team completing the local precedents activity. Conversely, to case 2, the activity yielded insights into the specific challenges of PwD raising chickens in the community, such as:

1. They have the ability to raise chicken but not the money or skill to make chicken coop
2. Difficult to know if all chickens are there
3. Difficult to know if all chickens are healthy
4. Difficult to give medicine if chickens are sick

5. Difficult to travel to the coop to feed the chickens
6. Difficult to weight the chickens to see if they are ready to sell

It also highlighted the wealth of knowledge and skill about chicken farming in the general community. While the original brief was to focus on both vison-impaired individuals and wheelchair users, the team seemed to focus on vision-impairment and most of the insights came from the one young male participant (a young male landmine victim who was blind and missing an arm), as well as other partially blind individuals. The project aimed to create a solution that would allow individuals with visual impairment to engage in chicken farming. This was driven by the young male participant and his aspiration to help his family look after their large number of chickens. The project became focused on either designing a new chicken coop or designing ways of modifying existing structures to be more accessible. All participants were engaged in the project, but also realised the final solution would not be as relevant to them as the other teams projects were (given the vision-impairment focus). The team completed the materials activity as planned (Figure 74) and began brainstorming.

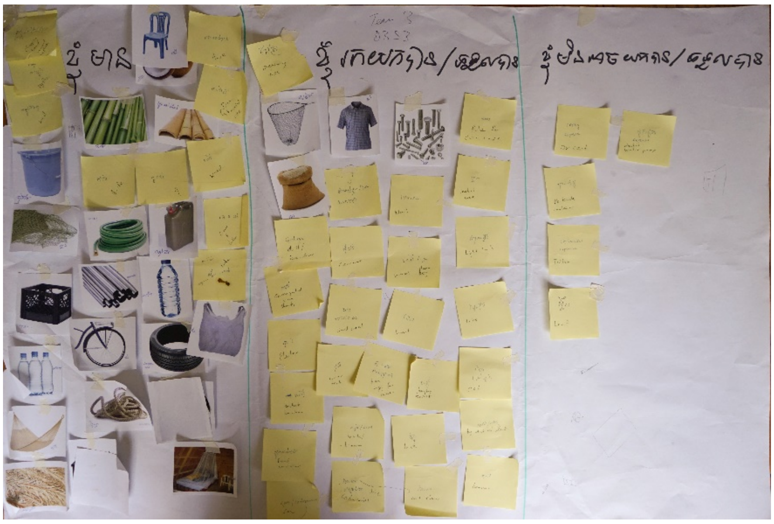


Figure 74 - Completed materials activity with case 3 participants

The ideas generated all focused on modifications or design requirements for a full sized chicken coop. These included modifications such as adding handrails, an electric water pump and bamboo pipes (to allow water to be supplied from outside the coop). They also included specific design requirements such as building food containers out of concrete, making the door at least 1.5m tall and having two areas in the coop (for chicklets and large chickens). The ideas were not very broad, nor did they extend past the design of the chicken coop structure. However, participants seemed enthusiastic and chose a combination of these ideas to make as a model at the end of Workshop 2 (Figure 75).

Figure 75 - Model of chicken coop made during model-making in case 3

After Workshop 2, the design team (lead by D11) reviewed the activities undertaken and synthesised a set of functional requirements. This information was captured by creating a design-requirements board (Figure 76). The requirements were driven by community needs as well as the universal design principles (Story, 1998). This requirements board was used to guide design work in Workshop 3.

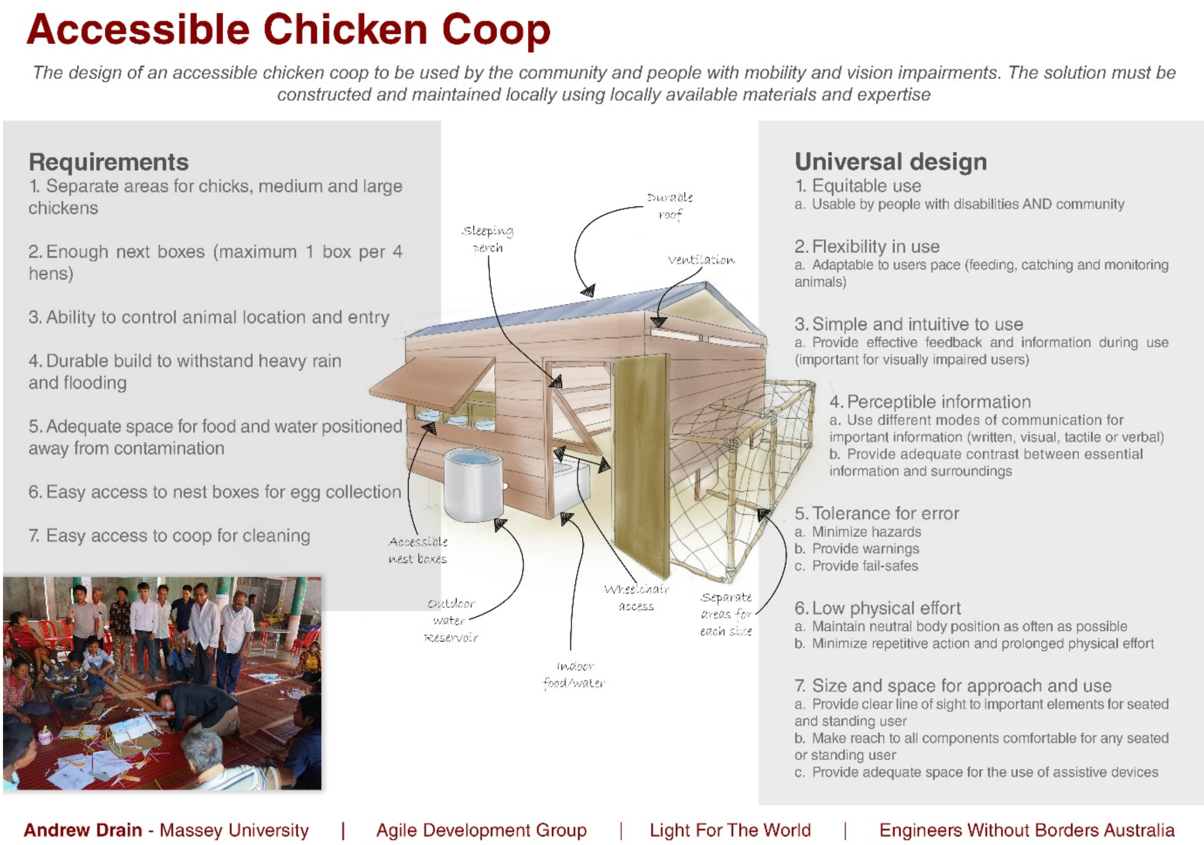


Figure 76 - Design requirements board for case 3

Similar to case 1, D11 generated a range of new ideas for novel chicken coops that would allow PwD to engage in chicken farming. These were meant to help participants think more divergently in Workshop 3. These are presented in Appendix D.

Workshop 3 begun with the team reviewing a range of existing chicken coops and discussing the pros and cons of each design. The activity engaged most participants; however, given its visual nature, the vision-impaired participants were not well included, relying on verbal descriptions from others. The team completed the construction techniques activity and revisited brainstorming. This yielded some new ideas and participants were very engaged. However, during the screening activity the team struggled to decide on a meaningful way of addressing the project brief. At the end of the first day, they decided to build some small woven cages to hold chickens. When the design team probed, as to why this was the chosen idea the participants replied that it was "*easy to make in one day*". It was clear that the participants did not grasp the impact that this project could have on the vision-impaired boy's life and that they still viewed the project as a structured activity with the design team. Furthermore, on investigation that evening we found that the boy's household already had the exact woven cages that were proposed. This poorly aligned solution may have been due to the participants not truly engaging in the process, as the solution was not for them, or due to the fact that idea generation was occurring away from the actual user environment (at the community pagoda).

In an effort to address the latter, the case 3 team spent the next morning generating new ideas at the young male participant's house. This yielded much more focused ideas and lead to the final idea that his family's current chicken coop could be made more accessible by modifying it in the following ways:

1. Raising the door frame height
2. Moving the chicken perch away from the entrance
3. Adding hand rails to improve navigation between the house and chicken coop

This marked the end of generative design

5.13.2 Evaluative Design

The participants were eager to start the modifications; however, care needed to be taken to ensure the young male participant's family were in agreement with the proposed changes (as they were not present in the workshop) and to ensure the construction process was safe. Therefore, for the remainder of Workshop 3, the team developed a plan for raising the doorframe (Figure 77) as well as prototyped several new door designs that could be used in the final installation (Figure 78). This marked the end of Workshop 3.

Figure 77 - Case 3 team planning the process of raising the chicken coop doorframe

Figure 78 - Case 3 team testing chicken coop door designs

Between Workshop 3 and Workshop 4, the design team reviewed the planned modifications and performed a risk assessment. This was to ensure the plan was safe for the team members and would result in a safe, usable structure. This review resulted in a finalized step-by-step plan which was to be presented back to team 3 for feedback (Figure 79).

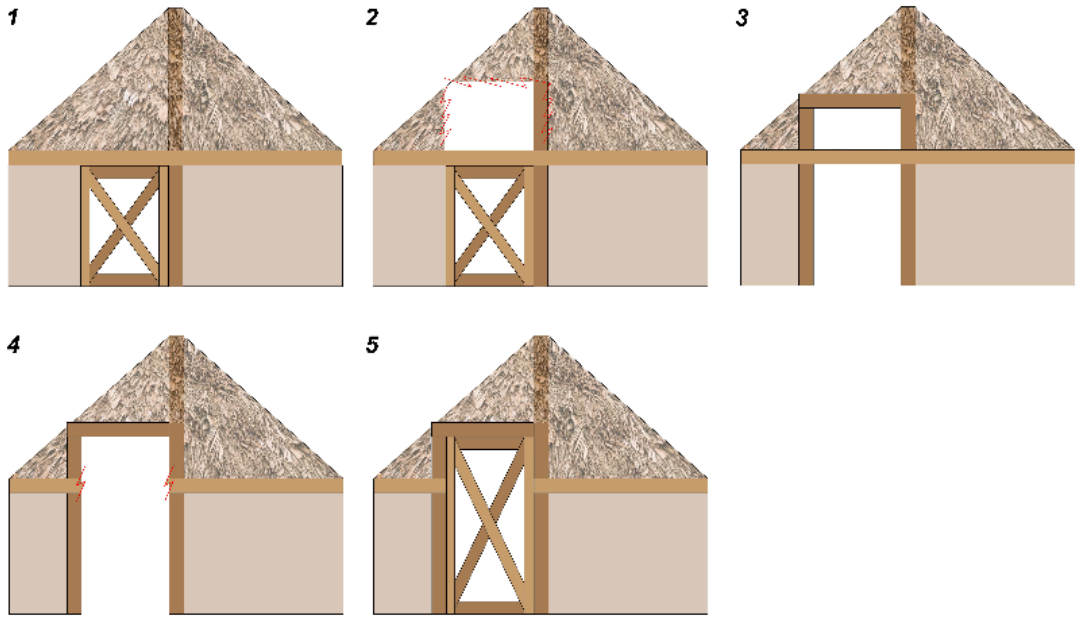


Figure 79 - Step-by-step instructions for chicken coop modifications

A day before the beginning of Workshop 4, the design team visited the young male participant and his family to discuss the planned modifications to the chicken coop. The design team explained the steps they planned to undertake, the risks at each step and the risk control measures already considered to lower the risk of an issue arising. The participant's mother seemed worried that the structure may end up broken and non-functional. This would have big consequences as part of her income was generated from raising and selling chickens at the local market. After a long conversation between the mother and D9, she agreed for the project to continue and consented to the small risks associated with the modifications. However, when the boy arrived at Workshop 4 the next morning, he explained that his estranged father had heard about the planned modifications and was not happy about it. This dis-pleasure seemed to stem from three main reasons:

1. Risk associated with the modifications. Probability of issue was very low but the severity of impact, if the chicken coop was not functional, was high
2. Lack of involvement of father in consultation and design process. This was due to the design team not being aware of his existence or role as a key decision maker
3. Lack of understanding of the importance of disability inclusion and the aspirations of the boy. This aligned with previous research about disability in Cambodia (Gartrell & Hoban, 2013)

The design team discussed this issue and decided it was best to stop this project. While there was support in the design team and in the community to continue with the modifications, there was potential that the process could result in the young male participant being punished by his family. Furthermore, without buy-in from the whole family, any issue that did arise would have been viewed as much more serious than before. This project was therefore terminated, and the project and factors resulting in its failure were communicated to the local DPO and LFTW. The remaining team members were told their project would not continue. They were given two choices:

1. Leave workshop straight away and continue with their normal days activities
2. Join one of the other two teams and contribute to their projects for Workshop 4

All participants chose to stay in the workshop and spread themselves across the two remaining teams. The universality of the projects of case 1 and case 2 meant participants were very engaged as all participants could benefit from the final outputs.

5.13.3 Technology Evaluation

The design team undertook a technology evaluation after exit interviews were complete. See Appendix E for the technology evaluation of the chicken coop modification conceptual design. Note, the evaluation for case 3 is based on the conceptual design that was intended to be implemented, hence many of the requirements are evaluated as achieved. However, as no technology was actually implemented the adoption of the technology is evaluated as unsuccessful.

5.14 Effectiveness of Collaborative Competencies

During the planning stage of this research a set of five collaborative competencies were developed from literature. These aimed to describe the skills required to collaborate effectively during a PD project. The skills could be explicitly present in the individual community member, developed through CCB training or carefully facilitated by the design team. These competencies are:

1. An ability to express opinions
2. An ability to generate insightful ideas
3. An ability to create insightful prototypes
4. An understanding of the design process/activity
5. A motivation to contribute

The competencies were originally defined based on a 5-point Likert scale; this is shown in Table 37.

Table 37 - Description of collaborative competencies

Ability to express opinions about project				
Very poor No evidence that the participant is able to express brief opinion about solutions	*Poor* Little evidence that the participant is able to express brief opinion about solutions	*Fair* Participant is able to express brief opinion about solutions when guided by designer	*Good* Participant is able to express detailed opinion about solutions when guided by designer	*Very* good Participant is able to express detailed opinion about solutions without the need for designer guidance
Ability to generate insightful ideas				
Very poor No evidence that the participant is able to expand on ideas presented by designer or generate ideas independently	*Poor* Little evidence that the participant is able to expand on ideas presented by designer or generate ideas	*Fair* Participant is able to expand on ideas presented by designer when closely guided	*Good* Participant is able to expand on ideas presented by designer and generate own ideas when closely guided	*Very good* Participant is able to expand on ideas presented by designer and generate own ideas independently
Ability to create insightful prototypes				
Very poor No evidence that the participant is able to build basic or detailed prototypes	*Poor* Little evidence that the participant is able to build basic or detailed prototypes	*Fair* Participant is able to build basic prototype when assisted and directed by designer	*Good* Participant is able to build basic prototype when directed by designer	*Very good* Participant is able to build basic prototype independently and detailed prototype when directed
Understanding of the design process / activity				
Very poor No evidence that the participant is able to identify the current stage of the process or explain the rationale behind the use of design activities	*Poor* Little evidence that the participant is able to identify the current stage of the process or explain the rationale behind the use of design activities	*Fair* Participant is able to identify the current stage of the process when prompted by designer	*Good* Participant is able to describe the current stage of the process when prompted by designer. Participant is aware of the rationale behind the use of each design activity	*Very good* Participant is able to describe the current stage of the process independently. Participant is aware of the rationale behind the use of each design activity
Motivation to contribute				
Very poor No evidence that the participant is engaged in the process or that they are likely to continue involvement throughout the project	*Poor* Little evidence that the participant is engaged in the process or that they are likely to continue involvement throughout the project	*Fair* Participant requires designer effort to stay engaged in the process but seems likely to continue involvement throughout the project	*Good* Participant seems engaged in the process and is likely to continue involvement throughout the project	*Very good* Participant seems highly engaged in the process and is likely to continue involvement throughout the project

The original intention of these competencies was to provide a clear set of criteria with which to reflect on the design stages, the effectiveness of CCB and the quality of collaboration throughout the PD project. However, it is important to reflect on the criteria themselves to ensure they do provide effective structure for discussion.

5.14.1 An Ability to Express Opinions

Throughout Project 1, there was clear evidence that *an ability to express opinion* was a key competency required to contribute to a project. However, when evaluating an activity with this competency, it was found that there were two sub-themes that more actually described the collaboration occurring. Furthermore, the two sub-themes were often present in different ways and so reflection on the higher-level competency did not accurately describe the situation. The two sub-themes are *an ability to express contextual insights* and *an ability to express design critique*. These are discussed explicitly in Chapter 6.

An Ability to Express Contextual Insights

This sub-theme describes the ability of an individual to share knowledge about their socio-cultural, geographical environment as well as knowledge about their own personal circumstances. This knowledge could be related to general community information or focused on a particular challenge that they face. The important characteristic of this theme is that it relates to the sharing of exploratory information.

An Ability to Express Design Critique

This sub-theme describes the ability to provide feedback about a specific design concept. This concept could be in the form of a spoken idea, drawing, model, prototype, or any other form that communicates an idea. The important characteristic of this theme is that the opinion given is centred on a particular design concept, and is therefore very guided and focused.

5.14.2 An Ability to Generate Insightful Ideas

There was evidence to support the inclusion of this competency. This competency was discussed throughout Project 1 with sub-themes such as *communication of ideas, divergent thinking* and *creativity* emerging. However, these sub-themes do not provide contrasting views of the competency, and instead act as descriptors to highlight the exact ways in which the individuals collaborate. Therefore, the competency will not be modified for Project 1 analysis.

5.14.3 An Ability to Create Insightful Prototypes

Similarly, there was evidence to support the inclusion of this competency also. Sub-themes such as technical skills, local knowledge and disability-inclusion emerged; however, these do not provide contrasting views and instead act as descriptors. Therefore, the competency will not be modified for Project 1 analysis.

5.14.4 An Understanding of the Design Process/Activity

This competency was complex as it referred to both conceptual understanding (of the design process and associated concepts) and operational understanding (of specific activity instructions). This wide focus made the use of this competency challenging as an individual may demonstrate a good understanding of a particular activity, while having little understanding of the conceptual design process being used. It was decided that the important aspect of this competency was the understanding of the design process itself. Therefore, the competency will be refined to *an understanding of the design process*. *An understanding of design activities* will be reflected upon during analysis and this will focus on the clarity of the activities chosen by the design team as opposed to the competence of the participants.

5.14.5 Motivation to Contribute

This competency encompasses several important sub-themes of PD projects. These relate to motivation, attendance, engagement, opportunity, enjoyment and buy-in. While sub-themes such as attendance are relatively easy to investigate (attendance rates, attrition, commitment outside of workshop hours), sub-themes such as engagement are more complex. This is because the opportunity provided directly impacts how engaged an individual appears. For example, if an activity is not inclusive for individuals with visual impairment, they may seem dis-engaged. However, this is the result of a poorly designed activity and not the intent of the individual.

Given the complex nature of this competency, care will be taken during discussion to articulate the inter-connections between sub-themes. However, no new sub-themes will be explicitly stated, as there are several of equal importance that should not be prioritized above one another.

5.15 Chapter Summary

This chapter outlines the key stages of the design process for three cases inside of Project 1. Overall, each of the case summaries provides useful learning into the varying aspects of engineering design, collaboration and community engagement. The research-related implications of these are discussed below.

5.15.1 Research Issues

Capturing Multiple Perceptions

It was clear from case 1 that a single designer's perceptions would not provide a reliable view of the project. This was evident through comparing the comments of lead designer D5 and support designer

D8. D5 was very happy with the progress made during the generative design state stating "*the workshop is great, that we can have all person with diverse disability attend and share their idea and prototype what they need"*. In contrast, D8 was more critical of the workshop and in particular the fact that D5 did not follow the planning schedule. D8 stated "*the designers should have more like when they have a briefing like D5 should have a very clear understanding of what we gonna do, that like some of the who wanted to do or not, I mean like the miscommunications*". This statement focuses on the difficulty of D5 not clearly understanding the schedule and therefore not performing each activity as planned. This led to miscommunication and challenges for D8.

Furthermore, it was important to document the views of the participants, as there were times when the information and opinions provided by the designers was different to that provided by participants. For example, during the evaluative design stage for case 1, the rice seeder prototypes were being tested with local rice seed. The dosing process did not work reliably and D9 communicated this was due to the dosing holes being too small for the seed. It was not until an interview with a participant that we found out the seeds used were slightly wet and sticky, and would normally be dry and smooth by the time sowing occurred in 5 months' time. This insight was important for technology development and evaluation.

The Role of Culture

An interesting cultural dynamic was also present between Western and Cambodian designers. Western designers were much more critical of the overall design process than their Cambodian counterparts were. For example, when describing the participants' ability to generate insightful ideas, Cambodian designers stated:

D5, Case 1, Generative design - "*Their ability to generate idea, yes that's good, all of them come up with their own idea*"

D3, Case 2, Generative design – "*Yeah, from what I see that people, they have a lot of good ideas to come up with and also they share they discuss with each other to do more things*"

D2, Case 3, Generative design – "*Yeah, it's like, some of the people, they change. On the first day in my program, they keep silent, but for the second day, they come up with many ideas*"

Contrastingly, the western designers stated:

D7, Case 1, Generative design - "*ideation seems to be the hardest part of co-creation, we train students so much on how to ideate but you can't do that with a community*"

D4, Case 2 Generative design – "*Generating ideas, was something that was a bit more challenging. Um I don't think it's something they're used to doing*"

These contrasting opinions only seemed to be present when discussing idea generation and creativity. Perhaps this was due to the Cambodian designers being privy to more information (as they spoke Khmer) or perhaps it was due to a differing view of what the term *insightful ideas* actually meant. Either way, this highlights the value of collecting the data from both Cambodian and Western designers.

CHAPTER SIX

CROSS-CASE ANALYSIS

CHAPTER OVERVIEW

Chapter 6 discusses key themes emerging from the cross-case analysis of case 1, 2 and 3. The aim of this research is to identify whether CCB can be used to enhance PD projects with communities in developing countries. As such, this analysis aims to identify the ways in which CCB has affected collaboration and the ways it has affected the impact of the project on a whole. It begins by discussing baseline data to describe the community's initial collaborative competencies and presents the changes observed longitudinally throughout the project. A discussion about other factors that may influence the quality of collaboration follows, and it finishes with a discussion about the impact of the project and key findings.

6.1 Analytical Process

This process has been guided by the procedures outlined in Chapter 3 with data from Project 1 analysed both holistically, and in relation to each of the cases. The cross-case analysis utilized an inductive approach and aimed to uncover new themes that help to describe the PD process. It also aimed to evaluate the effect that CCB has had on the project. This was achieved through structured discussion about each of the collaborative competencies and other emergent themes that had an impact on collaboration.

All data collected was coded using the qualitative data analysis software Nvivo 11. This coding resulted in 188 unique themes/categories and approximately 5600 coding instances overall. A full coding table is provided in Appendix F. Similar to Chapter 5, discussions around the CCB and pre-design stages will be kept holistic, while discussions about generative design, evaluative design and post design will focus on each individual case. Furthermore, discussions will be structured around baseline competencies and longitudinal changes (across the PD project); see Figure 80 for clarity.

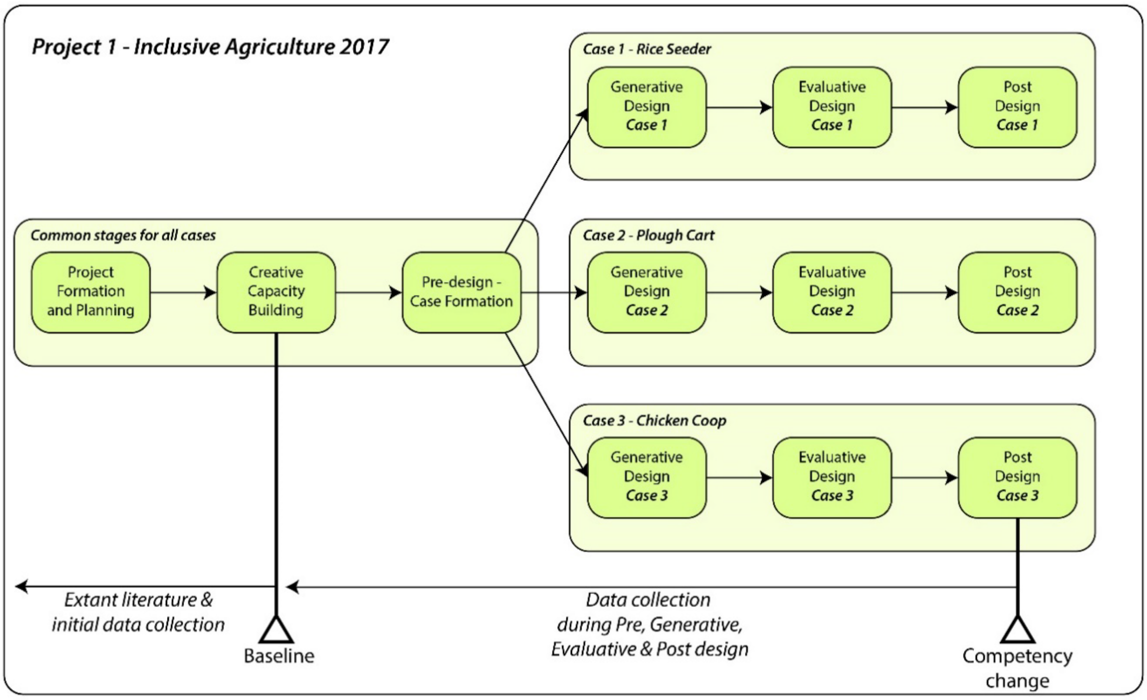


Figure 80 - Overview of Project 1 and cases 1, 2 and 3

The use of the baseline and longitudinal change structure allows CCB impact to be discussed in terms of immediate improvements as well as improvements that may occur through collaboration in the PD process. While the intention is to provide a detailed discussion about each competency, Figure 81 provides an example of how a visualization can be used to summarize the changes in each competency. This example shows two competencies improving and one remaining unchanged.

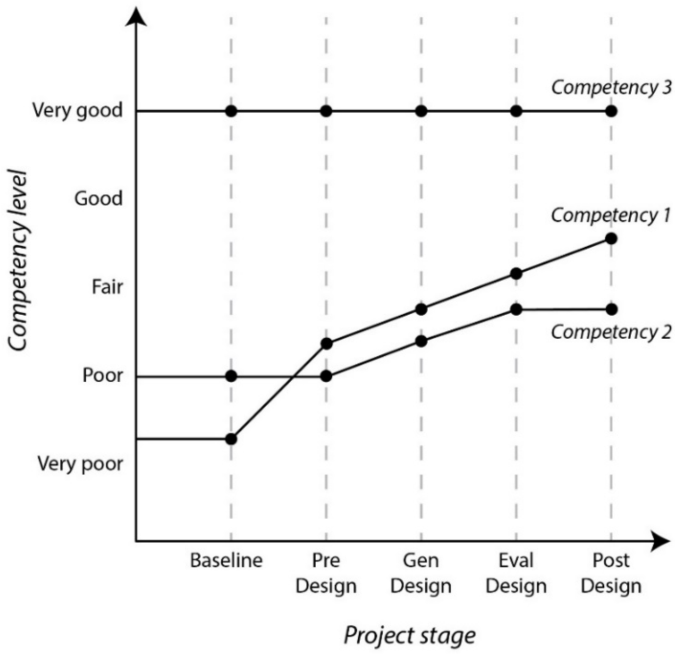


Figure 81 - Visualization of changes in competencies over time

At each pre-determined stage, the researcher will also presents a spider diagram (Whitehead et al., 2016) to visualize the perceptions of the participant groups competence. Again, this is intended to aid discussion and summarize perceptions and not to quantify aspects of collaboration. See Figure 82 for an example of this.

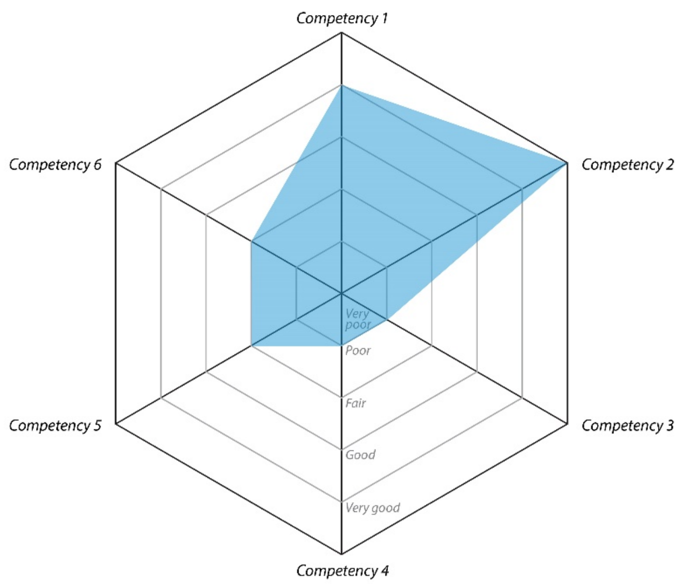


Figure 82 - Example of a competency spider diagram

6.2 Baseline

Evaluating the effect that CCB has had on the participants, the collaboration and the project in general is challenging. Firstly, the researcher did not run a control study, parallel to Project 1, in which CCB was not implemented. While such a study was possible, it would add no value to this investigation. There are too many uncontrollable variables at play, given the real world nature of the project, which meant trying to run a control study and a study with CCB would have yielded irrelevant results. For example, the make-up of the participant group would have a direct effect on the perceived quality of collaboration, regardless of CCB. What is important in the pursuit of answering the research questions is whether for a particular participant group CCB has enhanced their ability to collaborate during a specific project. Of course, this process is open to criticism that it is not generalizable or that it cannot rigorously investigate the role of CCB. However, these criticisms are common to the methodology and research field (Yin, 2013) and are a product of the complex, real world situation in which the project is grounded.

As such, this section aims to describe the characteristics the participants had when entering the project. To do this, a discussion about the socio-cultural characteristics of the Cambodian population, PwD and data collected during Project 1 is presented.

There are many occasions in this analysis where interviews with participants are discussed. To ensure clarity, Table 38 shows all of the participants discussed in this chapter, along with their age, gender and impairment.

Table 38 - Summary of participants interviewed in Project 1

Participant code	Age	Gender	Impairment
P1	56 year old	Female	No impairment
P2	53 year old	Female	No impairment
P3	53 year old	Male	No impairment
P4	72 year old	Male	Intellectual impairment
P5	55 year old	Male	Mobility impairment
P6	20 year old	Female	No impairment
P7	56 year old	Female	Mobility impairment
P8	23 year old	Male	Vision and amputated arm
P9	80 years old	Male	Deaf impairment
P10	59 years old	Male	No impairment
P11	45 years old	Male	No impairment
P12	76 years old	Male	Elderly impairments (slight vision and mobility)
P13	47 years old	Male	No impairment
P14	59 years old	Male	Hearing impairment
P15	37 years old	Male	Lower leg amputation
P16	25 years old	Male	Wheelchair user with cognitive impairment

6.2.1 Participant Overview

Project 1 involved participants with a range of ages and impairments. An overview is provided in Table 39.

Table 39 - Overview of participant age and disability

	Frequency				%
Age	**Male**	**Female**	**Total**	**With disability**	**With disability**
15-19	1	1	2	2	50
20-24	1	2	3	1	33
25-29	4	2	6	3	50
30-34	2	1	3	2	67
35-39	2	1	3	2	33
40-44	2	1	3	1	33
45-49	5	1	6	1	17
50-54	6	6	12	1	8
55-59	6	5	11	6	55
60-64	1	1	2	0	0
65-69	1	1	2	1	0
70-74	1	2	3	2	67
75+	2	1	3	2	67
Unsure	1	0	1	1	100
Total	**35**	**25**	**60**	**25**	**42**

Figure 83 shows the distribution of participant ages. Of note is the large number of participants aged between 45 and 60 (28 participants) as well as the cluster of participants aged above 70 (6 participants) and between 25 and 35 (9 participants). Half of the 50 to 60 year olds identified as having a disability while the other half did not, the able participants were present as either carers of PwD or community representatives. All but one of the participants aged above 70 identified as having a disability, with the majority being age-related. Finally, 5 out of 7 of the participants aged 25 to 35 identified as having a disability.

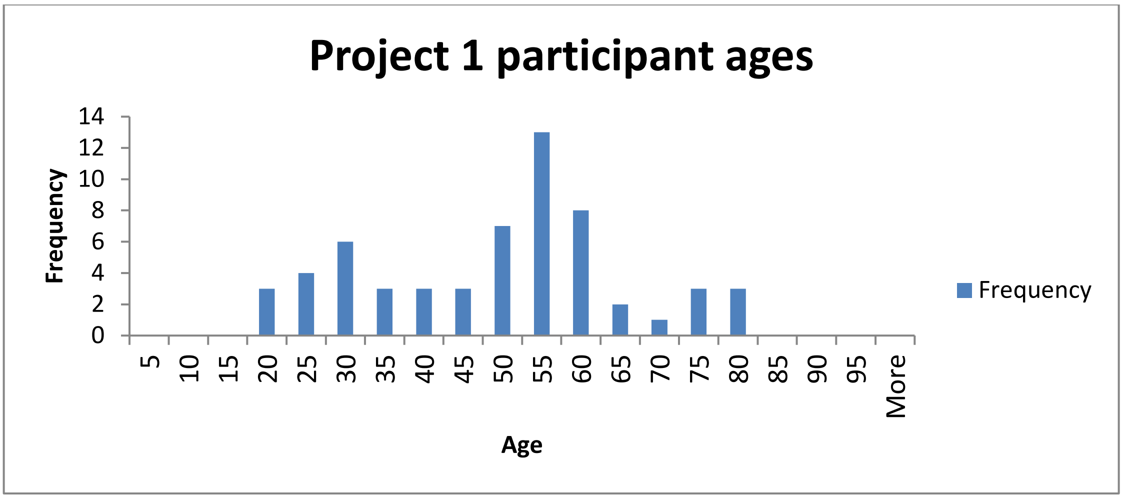


Figure 83 - Range of participant ages for Project 1

As discussed in Chapter 2, there are three criteria, which are influential to collaboration in the present research: participant education levels, disability and experience. These are discussed in the following section.

Education

Firstly, a formal education shows that the participant has experience engaging in formal activities and that they have basic literacy and numeracy skills. Data from EPDC (2012) suggests that individuals aged over 39 years old have a drastically lower rate of primary and secondary school completion. This is even more pronounced in woman. For example, nationally 22% of woman aged 35-39 have attended or completed secondary school, while only 7% of woman aged 40-44 have. Literacy levels also decrease with age with 85% of women aged 15-19 being literate compared to 62% of woman aged 45-49. This focus on education shows that a large number of participants may not have formal education experience, nor possess literacy skills. This was verified through interviews during, and after, Workshop 1. Firstly, D1 stated "*most of them [participants], they cannot read, most of them they cannot read or write. So I think we have to use very, very simple words and some we have to point and I think it's very good for use to design the design process with colour*". This comment was based on interactions during CCB session 2. There were a couple of exceptions, with a 20 year old university student (termed P6 in Table 40) attending to support a family member and a well-educated elderly man who was attending as a community representative.

Disability

Secondly, disability is an important aspect of the participants' characteristics. WHO (2002) describe disability in terms of environmental (socio-geo-cultural), personal (confidence) and functional (physiological functions and anatomical parts of the body) factors.

As discussed in Section 2.7, Cambodia is a heavily hierarchical society with stature based on age, gender, wealth, family reputation and political position. However physical capacity overrides this structure and results in less-able individuals being ostracized from the normal social system (Gartrell & Hoban, 2013). There is potentially an amplifying effect as Borg et al. (2012) states, "*statistics indicate that about half of all people with disabilities in developing countries live in extreme monetary poverty*" (p. 112). This means that poverty, as well as disability, can affect a PwD's standing in society. Furthermore, Buddhist culture adds another barrier for PwD in Cambodia. Overall, this environment leads to the expectation that PwD will be shy and lack confidence to speak their mind. This was verified during Workshop 1 as participants found it difficult to engage in large group discussion. There was evidence this was due to participants being shy, such as:

D11, CCB - "*A discussion was then generated... …This was done with the entire group and focused on any challenge that the community faces. The discussion was very slow and only a couple of individuals spoke about challenges*"

D1, CCB – "*I think they're not really there to talk with the group, with the big group, because when we ask them into the big group, some of them they feel very shy and they said they're not there to talk in front of the whole group*"

It should be noted that the observed shyness was most present during activities that involved the entire participant group (approximately 45 people). When smaller groups were formed, of around 10 to 15 people, most participants were more comfortable. However, a level of shyness was still observed in PwD as stated in D11's observational notes.

D11, CCB - "*The teams then continued this discussion for another 20 minutes. The discussion was much more open with many different participants speaking and writing down challenges. The PwD in each group were also given a chance to share their challenges although they didn't provide many insights initially*"

Another aspect associated with disability is the body functionality factor and the barriers it creates to engage in a project. For example, several participants had hearing impairments. This created a communication barrier for designers to work with. When asked if there were any differences between participants during initial discussions in CCB, D2 stated, "*Yes, the deaf, and they cannot get the point and have to take time to say it loudly and to the older people. But for the people, the 35 – 50 it is easy to understand because they have more experience*". Similar challenges were present during activities with vision-impaired participants. This aspect of disability was unlikely to be changed during the project; however, it is important to mention, as it forms the baseline collaborative competency of the participant group. Table 39 shows the number of PwDs present across the entire project. Overall, 42% of the participants identified as having a disability. Interestingly, of the original participants in workshop 1, 49% identified as having a disability. After Workshop 1, 13 new participants joined the project, only one of whom had a disability. This increase in able-participants may have been due to participants spreading news of the programme around the community, and several curious able participants wanting to be involved. The design team found it challenging to control who attended each workshop as it was controlled by the local DPO. Furthermore, the design team found out at the end of the project that even more community members would have liked to join.

It should be noted that the number of participants with disabilities shown above is an estimate. While participants were asked to state if they had a disability, several individuals with mobility impairments (amputated arm and leg) were not recorded as having a disability. The researcher adjusted the records as accurately as possible to represent the actual participants present.

Experience

Experience related to a participant's previous experience with problem solving, designing solutions and engaging with external organisations. Firstly, Cambodia has no formal education institution offering design education (Hussain et al., 2012), but does have two engineering schools based in Phnom Penh. These schools teach traditional engineering content and to the researcher's knowledge do not promote participatory techniques or community engagement.

The role of *design* is not well understood in Cambodia. For one thing, the term *design* directly translates to the Khmer word for *decoration*. This is linked to cultural dynamics of Cambodia such as an emphasis on rote learning and highly centralized decision making (Hallinger, 1998). It also may be due to the lack of engineering and design industries in Cambodia. These dynamics directly affect an individual's ability to autonomously create, critique or explore local solutions. It was assumed that this would be participants first time engaging in design with an organisation. However, given the large number of NGOs active in Cambodia, 3500 as of 2013 (Domashneva, 2013), it was highly likely that participants had engaged with an NGO in some capacity (all participants had some connection to the local DPO).

To verify this, short interviews were conducted with a random selection of eight participants each morning to learn about their previous experience, perceptions of the workshops and understand content retention. Responses are shown in Table 40.

Table 40 - Participant responses from interview before CCB

Code	What do you think the term 'design' means?	Have you ever made something in your life?	Have you ever been involved in a design project with an NGO before?	If you were going to solve a problem, what steps would you go through?
P1	*Never heard*	*Yes*	*No*	*Go to find other job*
P2	*Never heard*	*Yes*	*No*	*Go to do another thing*
P3	*Used to hear*	*Yes*	*many times*	*Used to use the design process*
P4	*Make something new*	*Yes*	*no*	*Ask someone who can help*
P5	*Make something new*	*Yes*	*no*	*Not much difficult*
P6	*To create something new and make the tool or equipment easy to use*	*Yes, I have. I designed garden at school, design some tool for use at school*	*Yes, I have. Just involved with university project but*	*Think about the problem and ask someone for help like teacher or friends*

Code	What do you think the term 'design' means?	Have you ever made something in your life?	Have you ever been involved in a design project with an NGO before?	If you were going to solve a problem, what steps would you go through?
		like village machine and so on	*for NGO I never involved*	
P7	*To create something new make by ourselves*	*Yes, I have. Like a hat*	*Yes, ADD International*	*Do not know. Maybe ask someone for help*
P8	*Never heard*	*No*	*Yes, ADD International*	*No*

Half of the participants interviewed had worked with an NGO before and almost all had made something before in their lives. Only the vision-impaired male participant had not. Interestingly, half had heard of the term *design*; however, only P6 could provide detail about what it meant or the problem solving process. P6 was a 20 year old university student attending the workshop to support a family member.

Variety of Participants

The researcher acknowledges that the participant group cannot be viewed as homogenous as it contains individuals of different ages, gender, education levels, experience and abilities. For example, Hussain et al. (2012) states that "*age is important for social status and Cambodians are taught that they should respect the ones who are older than themselves*" (p. 96). This could result in younger participants not speaking their mind around older participants. In their study, Hussain also commented that while children were challenging to work with "*adults on the contrary, were not afraid of sharing ideas and opinions. However, they were very careful about criticising each other and not to give negative feedback on prototypes. This can be linked with the concept of face in Khmer culture*" (p. 99). This suggests able adults have a good ability to express opinion and share ideas, but may be influenced by the well-documented *saving-face* characteristic of Khmer culture. During Workshop 1 D3 stated, "*They [participants] have different ability. From what I see, some people look like they have experience; some of them have no experience, and some of them they have like knowledge, educated and some of them uneducated people*". Similarly, the following was noted in D11's observational notes.

> D11, CCB - "*The 'what is design?' discussion showed that there were some individuals who had experience with 'design' in the community, however, of the PwD present only [P7] spoke to the group about her design work. The others may have been shy, or more likely had not engaged in design activities before*"

Therefore, the following discussion about each of the collaborative competencies is meant to provide insights into the group's capabilities while also recognizing the variety of participants present.

6.2.2 Collaborative Competencies

The six collaborative competencies represent the researcher's attempt to describe the important characteristics required for meaningful collaboration between the designer and the community. They will be referred to in shorthand during the following discussion but for clarity, see Table 41.

Table 41 - Summary of shorthand terms

Collaborative Competency	**Shorthand**
An ability to express contextual insights	*Contextual insights*
An ability to express design critique	*Design critique*
An ability to generate insightful ideas	*Ideas*
An ability to create insightful prototypes	*Prototypes*
An understanding of the design process	*Design process*
A motivation to contribute	*Motivation*

All cases will be discussed as one in the baseline discussion, as teams, and therefore cases, were not yet formed.

All Cases

Table 42 shows a frequency-coding matrix of themes coded before and during the CCB sessions. This is one way of investigating the baseline characteristics of the community. As this is the first time that a frequency-coding matrix is presented in the project, the present researcher would like to explicitly acknowledge the limitations of such a tool:

1. The frequency of coding will vary from table to table based on the amount and type of data. Therefore, it is the relative distribution that is of value in the table, not the nominal frequencies.
2. Only formally collected data was coded, and therefore able to be included in the frequency-coding matrix. Given the ethnography elements of the research, there will also be findings that the researcher has inherently developed. These will be discussed throughout the section, but will not be evident in any frequency-coding matrix.

Table 42 - Competency vs description coding from CCB sessions

	Very poor	Poor	Fair	Good	Very Good
1: Opinion	0	9	4	11	1
2: Ideas	0	11	2	10	0
3: Prototypes	0	4	2	19	0
4: Design process	1	15	15	15	1
5: Motivation	1	13	11	17	2

It is clear that there is a wide range of competence described, with most of the occurrences being coded as either *poor, fair* or *good.*

An ability to express opinion about a project

Table 42 shows that this competency was coded as *good* more often than any other description. However, when this theme was split into the appropriate sub-themes of *contextual insights* and *design critique*, as described in Section 5.14.1, *contextual insights* was seen as a theme with evidence of both *poor* and *good* occurrences and *design critique* was seen as being an overwhelming strength inherent in the participant group. This is provided in Table 43.

Table 43 - *Opinion* sub-themes vs description coding from CCB sessions

	Very poor	Poor	Fair	Good	Very Good
1a : Contextual insight	0	3	1	2	0
1b : Design critique	0	1	1	8	0
2: Ideas	0	11	2	10	0
3: Prototypes	0	4	2	19	0
4: Design process	1	15	15	15	1
5: Motivation	1	13	11	17	2

An inability to communicate *contextual insights* was evident during initial discussions about community challenges. The majority of participants did not contribute anything, and those that did, tended to reiterate superficial and generic community challenges such as "*limited water in April, May and June*" and "*lack of agricultural tools*". This improved through designer probing and encouragement. Contrastingly, an ability to provide *design critique* was a strength evident from CCB session 2 onwards. For example, during CCB session 2, all groups gave design critiques about the appropriateness of materials and prototype usability. These included "*the bamboo is too heavy, the bamboo is too short*" and a vision-impaired girl stated that she cannot see the clear bottle used at the end of the design. This insight resulted in the design changing to use a bright red can.

An ability to generate insightful ideas

Table 42 shows a consistent spread of descriptions with *poor* and *good* still having the most occurrences. While there were instances where the participants exhibited the ability to generate ideas, the researcher observed many more instances when the participants found it challenging. These challenging moments required patience, encouragement and creativity of the designers in order for participants to contribute meaningfully.

During CCB session 3 (*banana boost*), participants were asked to generate ideas to lift a bunch of bananas off the ground. Participants found imagining new ideas difficult and most resorted to a basic cylindrical shape. D1 stated, "*They just follow each other in the team. Just like one person do the circle then all the person do the circle. So they have to like, follow each other*". This lack of originality could be linked to several factors. Firstly, a *saving-face* mentality may result in individuals not wanting to create new ideas, for fear of being embarrassed. Secondly, as Cambodia is viewed as a highly collectivistic society (Berkvens, 2017), individuals may not have the willingness to do something that is independent of the group, such as generate ideas. Thirdly, participants' lack of exposure to written forms of communication (written text and sketching) may have created a barrier to communicating their ideas effectively. This is supported by D3 who stated, "*We can ask them to do some drawings before they do the exercise. But actually, most of the group they don't know how to draw. They don't know how to sketch their idea on paper*". Finally, participants may have actually not had any ideas to contribute. It is likely a combination of these factors lead to a lack of demonstrable ability to generate ideas.

An ability to create insightful prototypes

This competency was a strength from the beginning of the project. Participants felt extremely comfortable with making prototypes and were most engaged when doing this, compared to other activity types. This was due to the amount of experience the participants had with hands-on activities in their normal lives. During CCB session 1, D1 asked the participants if they had ever made something before. While only a few participants answered, answers included making hats, lizard traps, bamboo fishing rods and wooden carts. Even one of the heavily impaired female participants wove small baskets during the day (this was communicated by her carer). This skillset was expected as all participants engage in labour intensive agrarian lifestyles, meaning that they were experienced with creating basic mechanical solutions and using hand tools.

An understanding of the design process

There was minimal understanding of the formal design process before CCB sessions began. During the design of the CCB content, the design team decided the important concepts were *the design process steps*, *importance of testing lots of ideas* and *the importance of iteration during a design process*. It was clear that participants were not aware of the design process steps, or anything similar, and instead viewed design as the two-step process of *identifying a problem* and *finding a solution*. Similarly, there was no evidence of a comprehension of the importance of testing and iteration. During the pilot session (discussed in Section 4.3) the group leader stated that traditionally "*if they [community member] create it and it does not work they throw it away*". The researcher observed a similar process in the Project 1 community; however, participants stated that they would try to solve a problem and adapt and deal with whatever the result was, instead of refining and improving it. This process is shown in Figure 84.

Figure 84 - Baseline participant design process

Table 40 shows responses to the question "i*f you were going to solve a problem, what steps would you go through?" A*nswers included "*go find another job*", "*ask someone who can help*", and "*go to do another thing*". Contrastingly, D1 stated that the participants had performed activities similar to the design process before but did not understand the connection between existing practices and the formal design process.

> D1, CCB - "*most of them, they already do [conduct design]. They already did that design, but just like, they not follow the design process that we had. But most of them, when we talk and tell them about a word in the design process, they don't understand. But when we talk and we come up with an example, they more understand. Because like, that is all the work that they already done before*"

Therefore, the researcher argues that the participant group had experience with aspects of problem solving, best defined as a two-step process of *identify a problem* and *find a solution.* However, they did not know about all of the steps of an effective process, or about important concepts such as testing or iteration.

A motivation to contribute

This competency is complex as it encompasses the intrinsic and extrinsic motivation of the individual (Ryan & Deci, 2000) as well as the participant's opportunity to participate. The latter element is in turn a product of the functional ability of the participant and the design team's ability to include the individual in a specific activity. Drawing from the concepts presented in the International Classification for Functioning, Disability and Health (WHO, 2002), a cognitive map of *motivation* is presented in Figure 85.

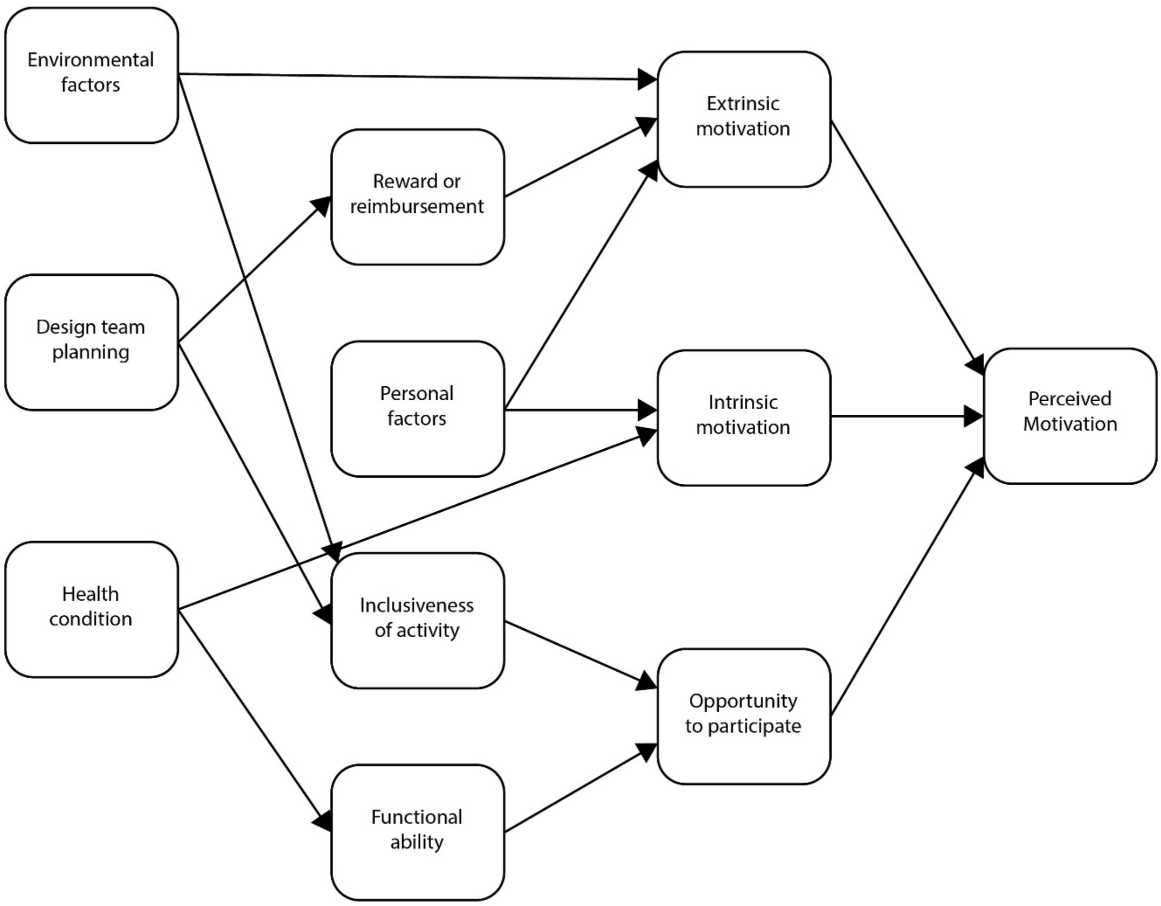


Figure 85 - Cognitive map of the *motivation* competency

This cognitive map uses key factors identified in the International Classification for Functioning, Disability and Health (WHO, 2002), along with fundamental motivation research (Ryan & Deci, 2000; Reiss, 2012). Reiss (2012) provides a simple, operational definition of both intrinsic and extrinsic motivation.

> "*Intrinsic motivation is most commonly defined as 'doing something for its own sake', as when a child plays baseball for no reason other than because that is what he wants to do. Extrinsic motivation, in contrast, refers to the pursuit of an instrumental goal, as when a child plays baseball in order to please a parent or win a championship*" (p. 152)

Firstly, the design team found the participants energetic, personable and eager to be involved in the project. This was most likely due to the novelty of the project, the potential for positive impact and the fact that PwD had little to do during the day, while carers were at work. The latter point was made evident when a vision-impaired participant (P8 in Table 40) stated that he did nothing during the day apart from sit quietly at his grandmother's house until his mother came to get him. Engagement was much more dynamic throughout the early stages of CCB. Most participants seemed unengaged, or at least unwilling to speak, during discussions in session 1 and session 2. Whereas all participants were highly engaged during the making-style activities of session 2 and session 3. This suggests that participant engagement is closely linked to the style of activity, with making-style activities being most engaging. Therefore, engagement is linked to the design team providing appropriate activities for participants to engage. Interestingly, this contrasts with Brandt et al. (2012) who state that a mixture of making-style, telling-style and enacting-style activities is the best approach for collaboration.

It is clear that perceived participant motivation is a combination of intrinsic and extrinsic motivation, and being provided with an appropriate opportunity. Participants seemed intrinsically motivated to be involved in the project. The main evidence of disengagement stemmed from characteristics of the activity itself, such as the style, group size and complexity. As such, the researcher believes motivation was of a *fair* level; however, demonstrable engagement was *poor* during telling-style activities and *very good* during making-style activities.

Visualization

Figure 86 represents the overall perceived collaborative competencies of the participant group before and during CCB sessions.

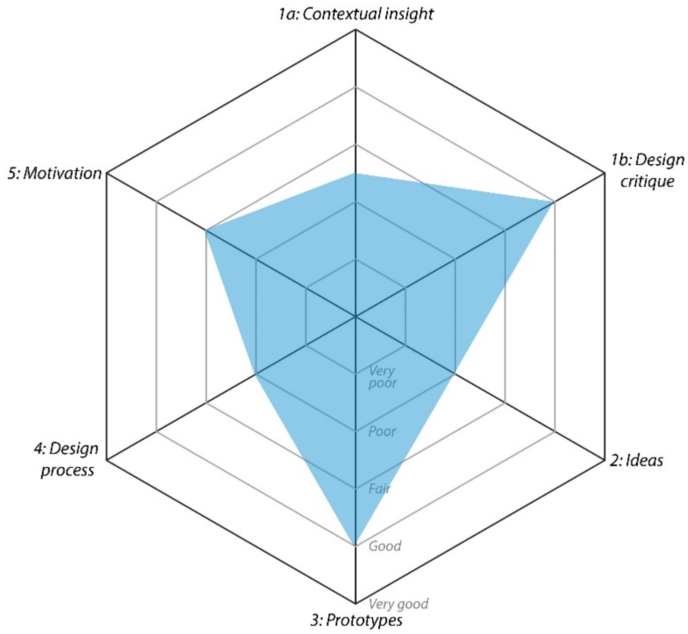


Figure 86 - Visualization of baseline collaborative competencies

6.3 Collaboration across the PD Project

This section discusses the perceived changes in collaborative competency throughout the project. It uses the collaborative competencies to structure discussion before highlighting emergent themes and providing an overview of the collaboration present at each stage.

All cases will be discussed together in the pre-design stage, as teams, and therefore cases, were not yet formed.

6.3.1 Pre-design

All Cases

To begin discussion, Table 44 is presented. This shows the frequency-coding matrix of competencies from all data collected during the pre-design phase. Note that pre-design occurred across both Workshop 1 and Workshop 2.

Table 44 - Competency vs description coding from pre-design

	Very poor	Poor	Fair	Good	Very Good
1a: Contextual insight	0	8	9	12	3
1b: Design critique	0	0	0	1	0
2: Ideas	1	2	1	5	0
3: Prototypes	0	0	0	0	0
4: Design process	0	11	4	10	1
5: Motivation	0	5	4	12	2

Of note in Table 44 is the lack of *design critique* and *prototyping* occurrences and the wide range *of contextual insight* and *design process* occurrences. The lack of occurrences is clearly due to the lack of opportunity to demonstrate these competencies, given the stage of the project. Similarly, there were few opportunities to demonstrate an *ability to generate insightful ideas*. Most of the occurrences of this competency were due to pre-design activities, which focused on challenges, resulting in participants communicating an idea they had for addressing the challenge.

An ability to express opinion about a project

The pre-design stage focused on collaboratively identifying challenges for PwD in the community and selecting the particular challenges that would be the focus of the project. As such, participants were expected to contribute through providing *contextual insights* about the community and the lives of PwD. The design team found this aspect of the project challenging, as they had to find a balance between relying on participants to provide meaningful insights, without guidance, and directing the participant towards areas of interest that the design team had. Ideologically, PD aims to generate *situation-based actions* (Kensing & Greenbaum, 2012), meaning the design team did not want to bias the participants responses by directing them towards challenges they knew existed elsewhere. This exploratory approach put more responsibility on the participants than traditional data collection methods.

One participant stated, "*If I talk out they going to think I want something*", communicating that they did not want to seem dependent or selfish. Again, this is evidence of the collectivist culture and saving face mentality contradicting the purpose of the design project. D3 supported this finding stating "*50% are bad [at expressing opinion], because ah, 50% that they feel like confident to talk to us, to talk, to yeah, with me or the other facilitator, and some of them they feel not confident*".

Contrastingly, a strong ability was observed in small group activities such as daily activities and resource flow. These activities aligned more closely with traditional data collection methods and provided participants with clear questions to answer about their community. These activities were less valuable to the design team, as they didn't capture the desires and priorities of the participants; however, they were effective at engaging the participants.

Overall, the perceived ability to express opinion was better than before/during the CCB sessions. However, this did not seem to be due to the participants' ability to express opinion, but instead, the design teams' selection of exploratory and traditional activities as well as a lot of patience to allow participants to build confidence and express themselves. Furthermore, there was an increase in difficulty between commenting on small-scale activities during CCB (such as the *banana boost*) and engaging in exploratory discussions about their own community. This leads the researcher to believe that this competency is complex and requires high levels of memory and critical thinking by the participants to contribute meaningful insights. D3 stated that they received "*some opinions and some idea from them, but they still feel like they don't know their own problem clearly*". This was the case early in the project; however, through a combination of tenacity and patience, all teams did identify a large number of challenges. This in itself is promising evidence that the participants were engaging in reflective discourse and showing an ability to provide *contextual insights*.

An ability to generate insightful ideas

There was little evidence of this competency during the pre-design stage with most activities focused on identifying challenges and learning about the environment. As mentioned earlier, there were some occurrences of the *ideas* competency during coding, with a wide spread of descriptions. The occurrences mainly referenced unsolicited ideas of solutions to the challenges being described during a pre-design activity. For example, during the small group discussions about challenges, several able-participants were coming up with ideas to solve general community challenges. This was evidence of the *ideas* competency, but did not align with the goal of helping PwD. The role-play activity was introduced in an attempt to focus discussion on disability. D5 explained the rationale for the role-play activity:

> D5, Pre-design "*They [participants] have more ideas, but because here we want to focus more on disability and agriculture, so we ask people that do not have severe disability to play their role as a deaf, or to play their role as a mental disability. So that when they think or when they put their idea inside they put the idea of a deaf of a mental disability rather than themselves*"

Overall, it was difficult to assess this competency at this stage. There was evidence that the more able participants were already generating ideas; however, the focus of these ideas was not necessarily appropriate. Furthermore, there was no evidence of participants with disabilities generating ideas yet, perhaps because they were less confident to communicate their ideas when not explicitly asked to do so.

An ability to create insightful prototypes

As expected, there was no opportunity to engage in prototyping in this stage of the project. Therefore, no occurrences of this competency were coded.

An understanding of the design process

To begin discussion, Table 45 is presented. This shows a summary of interview responses collected the morning after CCB, before the beginning of pre-design.

Table 45 - Participant responses from interview after CCB

Code	What do you think the term 'design' means?	Have you ever made something in your life?	If you were going to solve a problem, what steps would you go through?
P1	*Understand about the design*	*Yes*	*Discuss with family*
P2	*Understand*	*Yes*	*Discuss with family*
P3	*Used to heard*	*Yes*	*Always use design process*
P6	*To create something new and make the tool or equipment easy to use*	*Yes, I have. I designed garden at school, design some tool for use at school like village machine*	*Identify the problem, gather information, think of idea, experiment, choose the best idea, work out the details, build it, test it, implement solution and if it not working, build it again and test it again until we get the result*
P7	*To create something new by ourselves*	*Yes, I have. Like a hat*	*Identify the problem, gather information, think of idea, choose the best idea and solve the problem. If it is good use it*
P8	*Make something that easy to use*	*No*	*Identify the problem*
P9	*Find the problem*	*Yes*	*Find the problem, gather information and solve it. If is not working try to do it again*

Of note, are the slightly different responses of P1 and P2. Their responses to the problem solving questions have changed from "*go find another job*" to "*discuss with family*". Similarly, P7's response changed from "*Do not know. Maybe ask someone for help*" to "*Identify the problem, gather information, think of idea, choose the best idea and solve the problem. If it is good use it*". The responses of P1, P2 and P8 do not suggest an understanding of design, but do show a slight change in thinking. Responses from P6 and P7 show strong evidence of an improvement in understanding.

During pre-design, the frequency-coding matrix shows a similar spread of descriptions for the *understanding* competency to the CCB coding frequency table. This highlights that there is still a wide range of understanding in the participant group, and particular activities that participants struggle to understand. As mentioned in Section 5.14.4, there were two clear sub-themes needed to describe this competency: *understanding of the design process* and *understanding of each activity*. Alternatively, these themes could be viewed as a conceptual understanding (of the holistic process and rationale for each stage) and an operational understanding (of each specific activities instructions and expected outputs). This breakdown is shown in Table 46.

Table 46 - *Design process* competency and sub-themes vs description coding from pre-design

	Very poor	Poor	Fair	Good	Very Good
4: Design process	0	11	4	10	1
4a: Conceptual	0	2	1	2	1
4b: Operational	0	8	1	4	0

Firstly, there was an improvement in *conceptual understanding* noticed by each of the designers. Interview responses from D1 and D3 illustrate this point.

> D1, Pre-design – "*Yes, I think that most of them understand, but not all. I mean, not all steps of the process, but they understand how they make through the example that we go through with them"*

> *D3,* Pre-design – *"From what I think, it look like they are more improved from the day that we've just done [CCB sessions]. Because the day that we've just done, the workshop, when we present the design process, totally they don't know it, they don't know what is design process, they don't know what step of design process is, they don't know. Today, working together, they understand that. But also, they not 100%, like 70% or 80%"*

One major challenge seemed to be remembering the specific order of the process steps. Remembering the steps was not required, as the design process poster was always visible on the pagoda wall. However, it was important to understand the basic order of steps as this made understanding the rationale of each activity clearer. It was clear from observations and interviews that participants had an improved, but still limited *operational understanding of the design process*. They did engage well with the majority of activities and understood the required outputs. D3 stated that participants found it challenging to follow the process step-by-step, but could easily complete an activity when instructed to do so.

> D3, Pre-design - "*I think the answer is still like the day before, because like, they understand about the process, about how to solve it like that, but it's not follow the cycle. It's just like, from 'here to here,' from 'here to here. All over the place, but I mean we still try and ask them to come back and follow the process and everything. But they said that it's hard for them to remember all these things but if we ask them to do the prototype or any activity, they can do it*"

Secondly, an *operational understanding of each activity* relied on the participants understanding, designers understanding and clear instructions for the activity. The exploratory nature of pre-design made it challenging for participants to understand all activities. These challenges are reflected in the *poor* rating shown in Table 46.

Table 46. For example, in the discussion-based activity to identify community challenges, participants did not focus on the intended discussion topic of *challenges for people with disability*. This lack of focus seemed to originate from the design team not clearly communicating that the activity was about disability and not the general community. Initial group discussion started very broad with challenges identified such as "*lack of seeds for rice*", "*limited water in April, May and June*" and "*lack of agricultural tools*". While these community challenges are important, they were outside the scope of Project 1. Designers tried to focus discussions on disability-specific challenges. This led to comments such as "*discrimination from other people*", "*difficult for deaf student to learn from teacher*" and "*I sit on the floor for five hours each day, and do nothing until my mother comes to get me*". Finally, discussion was focused on challenges related to PwD and agriculture. This resulted in some insightful challenges such as "*difficult to travel through field when flooded*", "*difficult to raise chickens when blind*" and "*hard to get water and carry it back to house*". In order for more PwD-focus to occur, it was decided to end discussion and begin the role-play activity. D11 stated the following in observational notes:

> "*LFTW manager explained this [role-play instructions] to the facilitation group. Khmer facilitators not sure but start to understand, hard to understand. Khmer facilitators have concerns with role-play as older people may not want to do it… …Facilitator explaining role play to groups. Teams say they can do it. Very slow to get the activity going*"

The use of the role-play activity was not planned in advance meaning designers needed to be briefed during the morning tea break. There was some confusion from the Cambodian designers about the exact rationale for the activity, which in turn resulted in the participants being slow to understand.

Overall, there is evidence of limited improvement in the conceptual understanding of the design process and evidence that understanding the activity is reliant on not only the participant but also the clarity of instructions, and the type of activity.

A motivation to contribute

Once again, this competency is complex to analyse. To assist in this discussion the two sub-themes of *intrinsic motivation* and *opportunity to engage* will be used.

Firstly, participants did show *good* levels of *intrinsic motivation* during pre-design. Most participants were excited to begin a project focused on their own challenges and it was clear from interviews that no participants had engaged in a design project with an organisation before. This motivation seemed to enhance the participants' tenacity to continue with challenging activities, such as the identification of challenges activity. This tenacity was different from previously documented PD projects, which state a lack of tenacity once project difficulties arose (Winschiers, 2006). One explanation for this difference is that the time spent understanding the holistic design process, during CCB, allowed participants to better understand the role of each specific activity, and have more desire to complete it and produce the required outputs. Contrastingly, it may have been the tenacity of the designers that overcame the initial difficulties during activities. Regardless, this collaboration seemed to work through difficulties and identity insightful disability-focused challenges.

Secondly, *opportunity to engage* includes the type of activity, schedule and designer facilitation. Initially, participants were happy and energetic early in the day, as evident during the morning icebreaker activities. This energy fluctuated relative to the time of day, type of activity and focus of activity. Each of the two days of pre-design had the same drop in participant energy directly before and after lunch. This was also an issue for the design team as the heat and humidity was challenging. The design team stated in their reflection "*the venue was very hot in the afternoon and may have made people more tired*". Unfortunately, this is the reality of community development projects, as best practice dictates meeting the community in their own location as opposed to an air-conditioned training centre in a major city. The type of activity (enacting, making or telling) also seemed to influence the level of engagement of most participants. In previous sessions, making-style activities were more engaging than telling-style activities (such as group discussions). However, given the early stage of the project several telling-style activities were required. The activity style, along with the socio-cultural characteristics of the participants, may have resulted in a perceived lack of engagement. The role of the activity will be discussed in Chapter 7.

Overall, participants demonstrated a *good* level of motivation, with the caveat that the activity-style and time of day also had an effect.

Visualization

Figure 87 represents the overall perceived collaborative competencies during the pre-design stage. Note that the *design critique* and *prototype* competencies are not included.

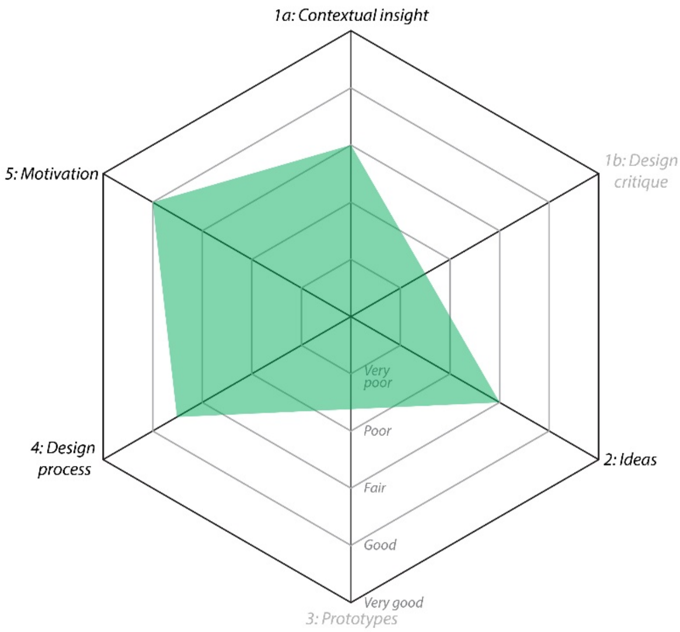


Figure 87 - Visualization of pre-design collaborative competencies

6.3.2 Generative Design

To begin discussion, Table 47 is presented. This shows the frequency-coding matrix from all data collected during the generative design phase. Note that generative design occurred across both Workshop 2 and Workshop 3.

Table 47 - Competency vs description coding from generative design

	Very poor	Poor	Fair	Good	Very Good
1a: Contextual insight	0	0	2	2	1
1b: Design critique	0	0	1	6	2
2: Ideas	0	12	10	13	1
3: Prototypes	0	2	3	13	4
4: Design process	1	4	9	13	2
5: Motivation	0	3	3	20	9

Of note in Table 47 is the relative lack of *contextual insights* and *design critique* occurrences, the wide range of descriptions for occurrences of *ideas* and the good and very good descriptions of occurrences of *prototyping*, *design process* and *motivation.* The lack of occurrences is clearly due to the lack of opportunity to demonstrate these competencies, given the stage of the project. Few activities in generative design focused on facilitating *contextual insight* meaning that occurrences were mainly due to participants contributing insights during the local precedents activity. Similarly, there were few *design critique* occurrences as activities that focused on this competency tended to occur during the evaluative design stage.

As described in Figure 80, the following sections will discuss each case individually, as they contain unique characteristics influenced by the participant group, designers and project focus. For clarity, the three cases are reintroduced in Table 48.

Table 48 - Overview of all cases inside of Project 1

Case	Project brief
1	The design of a solution to assist the elderly in direct seeding rice seed onto a field
2	The design of a solution to assist mobility impaired individuals to prepare their fields before sowing
3	The design of a solution to allow wheelchair users, and the visually impaired, to engage in small-scale chicken farming

Case 1 – Rice Seeding

Overall, generative design was completed efficiently with a single idea clearly decided on by the team. However, based on interviews with case 1 designers it was clear that the intended activities, and design process were not followed as closely as planned. For example, during the brainstorming activity, the team decided on a particular drum seeder design. The intention was for the teams to continue to think divergently and look to generate as many ideas as possible; however, D5 and the participants ended brainstorming and began discussing the detailed design of the drum seeder. This meant that the specific idea was well developed but that the divergent stage of the design process was not meaningfully undertaken. This was again evident during workshop 3 with D8 stating in their field diary "*participants only stick to same idea*". It seems this misalignment with the design process was due to the understanding of D5; this will be discussed later in the section.

An ability to express opinion about a project

The case 1 team demonstrated a *fair* ability to express *contextual insights* during this stage of the project. This was unexpected, due to the intended generative nature of the activities, but the team was given the opportunity to provide *contextual insights* during the local precedents activity and detailed design of drum seeder. Insights were mostly technical in nature and focused on current practices and required seed dosing, spacing and usability of new design. D5 rated this competency as *good* during generative design and stated, "*As this is the third meeting, majority of them know what the project expectation is*". This may have been due to knowledge obtained in CCB or a clear introduction of the PD project. Either way, participants seemed able to contribute to discussions.

An ability to generate insightful ideas

Coded occurrences for case 1 ranged from *poor* to *good,* with most of the data collected indicating that wide-ranging, divergent idea generation did not occur in this team. Instead, a specific idea was generated and the rest of the team worked together to develop this in more detail. Other ideas generated seemed to be related to the original idea (such as portable guide ropes to ensure the rice rows are straight) and not new ways of addressing the defined challenge. Workshop documents produced by case 1 team support this finding as they show only four ideas generated, two of which are not specific to the challenge, and a large amount of detailed design (Figure 88). The focus on detailed design was much earlier than the other cases and resulted in both positive outcomes (product requirements were defined early in the project and team was clear about project direction) and negative outcomes (lack of divergent thinking meant that only a couple of ideas were generated and discussed).

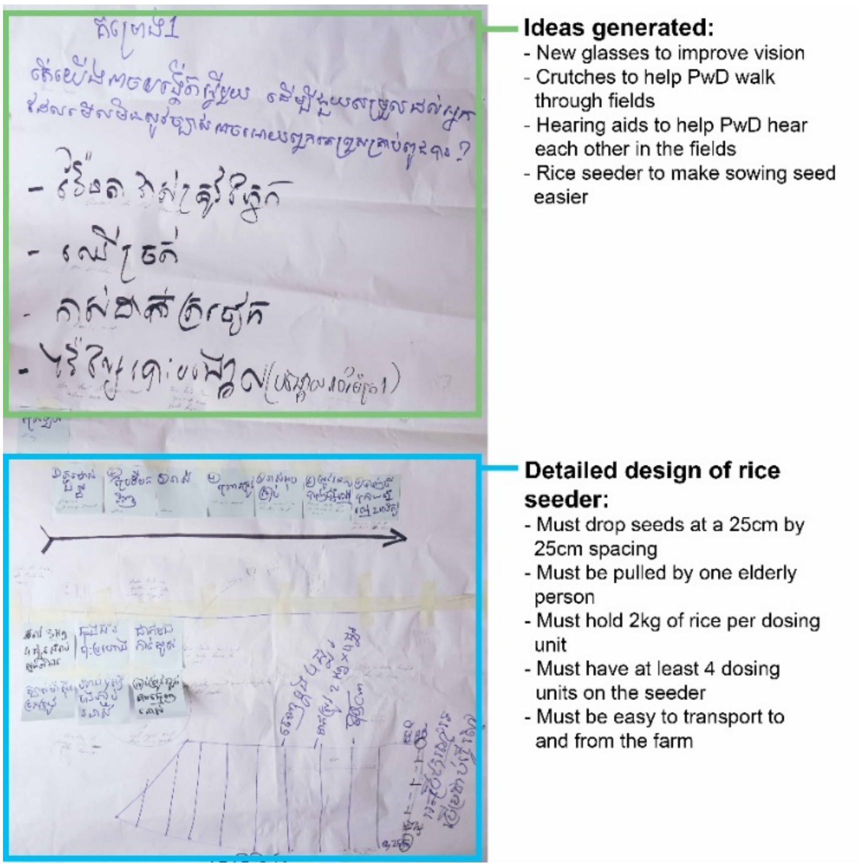


Figure 88 - Case 1 brainstorming workshop document

An ability to create insightful prototypes

Prototyping in the generative design stage referred to the creation of small, basic models that visually represented ideas; the main model from case 1 is shown in Figure 89.

Figure 89 - Model of rice seeder made by the case 1 team

This competency was a strength of the team, as the majority of participants engaged well with the model making activity and gave input to the design that was modelled. Of note, was the fact that the case 1 team did not have any heavily-impaired individuals whose impairments would functionally restrict their engagement in model making. This made engaging all participants in prototyping less challenging than in other cases. Several middle-aged men in the group completed the main assembly of the model and it seemed that both male and female participants were involved throughout the activity with no obvious sign of gender-roles.

An understanding of the design process

Two main observations were made about this competency during generative design. Firstly, the lack of divergent thinking during generative design suggests that participants, and potentially D5, did not understand the importance of generating a range of ideas, discussing and improving these ideas or using a systematic screening process. The process actually undertaken by the team seemed more in line with their original conceptual understanding of *identifying a problem* and then *finding a solution*. This may have been driven by a lack of conceptual understanding, unclear facilitation from the designer or a lack of ability to generate ideas.

Secondly, once a single design was chosen, participants demonstrated a *good* ability to improve the design through modelling, adding detail and iterating through multiple configurations. This was evident during model making as the model contained a guide rope system that was later removed, as it would be time consuming to set up. Based on these observations it seems that participants struggled with following the intention of the generative design stage of PD (steps *think of ideas, experiment* and *choose the best idea* in the design process). However, once the more ambiguous activities were complete, participants showed a *good* ability to develop the idea through the *workout the details* step.

Investigating the participant interviews undertaken at the end of pre-design and midway through generative design (see Table 49) show that the understanding of the design process actually improved throughout the generative design stage. This can be seen comparing answers to the question "*If you were going to solve a problem, what steps would you go through?"* P7 and P9 both started with a simple conceptual understanding and added detail in the second interview.

Table 49 - Participant responses from interview during generative design for case 1

Code	What do you think the term 'design' means?	Have you ever made something in your life?	If you were going to solve a problem, what steps would you go through?
Morning of Workshop 2 Day 1 (end of pre-design)			
P7	*Make something easy to use*	*Yes*	*Identify the problem and find the solution*
P9	*Make something easy to use more than before*	*Yes (make a boat, bed)*	*Identify the problem and find the solution*
Morning of Workshop 3 Day 1 (midway through generative design)			
P7	*Make something better to use than before by yourself. If it not working, do it again and test it*	*Yes*	*Identify the problem, gather information, think of idea, which one is good, and after that take it to use*
P9	*Design is making something useful and people can use*	*Yes (have designed a cow cart)*	*I have solved a problem when I was stuck during making a cart. I just go and see the workshop again get some points that he did not recognised, and sometime just rethinking about what I did and make changes*

Interestingly, the answers P7 and P9 gave at the end of pre-design were less detailed than that given after the CCB workshop, and more in line with the baseline conceptual understanding of design. This could suggest that content was forgotten over the three week break between workshops.

A motivation to contribute

Most occurrences of this competency were coded as being *good* or *very good.* The generative design stage was engaging for all participants and there was little evidence of disengagement or exclusion. D5 stated in their field diary "*Most of participants actively support each other to the design*". They did highlight that it was challenging to get input from the hearing-impaired team members, as communication was either visual or through their carer. Motivation seemed to increase as the stage transitioned to model making in Workshop 3. The team's lack of time spent on generative activities may have also strengthened the perceptions of motivation, as participants were not challenged to stay in the more ambiguous activities such as brainstorming. Finally, given the functional ability levels of the participants in case 1 and the lack of heavily-impaired individuals, there did not seem to be many functional barriers to participation.

Visualization

Figure 90 represents the overall perceived collaborative competencies during the generative design stage for case 3.

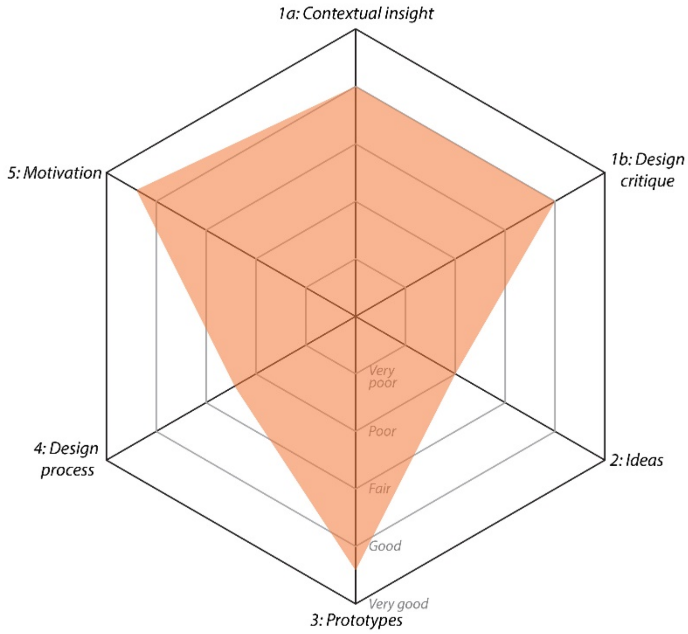


Figure 90 - Visualization of generative design collaborative competencies in case 1

Case 2 – Plough cart

Overall, generative design resulted in a clear focus, good engagement and agreement within the team. The final design seemed relevant for all participants in the team and aligned well with a community need. The process followed was challenging, as different participants seemed to focus on different ideas, and different challenges, making agreement difficult. One reason for this was the attendance of a dominant participant (P15, 37-year-old male with lower leg amputation) who constantly directed the focus towards lower leg prosthetics. This focus was important for the participant, but difficult for other participants to engage with as no one else in the group had the same impairment. He was present for Workshop 2 but not present in Workshop 3. In hindsight, this absence may have helped the team agree on the plough cart idea. The remaining team worked cohesively with each other and the designers to screen ideas and select a final design in Workshop 3

An ability to express opinion about a project

The case 2 team demonstrated a *good* level of competence to provide *design critique* about generated ideas and existing solutions. D4 wrote "*Opinions of what is good and bad was easy to express from this group".* The majority of the group seemed confident to contribute to discussions and there were no obvious signs of exclusion. During the case 2 presentation of models (made during the model-making activity in Workshop 2), there were three separate ideas presented, two created by small groups of only males, and one created by a small group of only females. This suggests that participants still felt more comfortable working in gender-based teams when able to.

Evidence of *contextual insights* was mainly from the materials and construction techniques activities. These used images to focus discussion on whether the particular item was available locally. Participants were asked to build a collage with three groupings; *I have, I can get, I cannot get*. The activities provided the participants with simple questions to discuss before allowing them to add additional items that they thought may be important (Figure 91). With such a clear activity, participants showed a strong ability in this competency.

Figure 91 - Materials collage created by case 2 team

An ability to generate insightful ideas

Occurrences of this competency in case 2 were varied. There was evidence that once participants were focused and engaged, they did have the ability to generate insightful ideas. For example, the man with the lower leg amputation developed several new foot attachments aimed at stopping his prosthesis from becoming stuck in the mud (Figure 92).

Figure 92 - Participant presenting a new prosthetic foot design

These ideas were novel, and did align with the project brief; however, the rest of the group failed to engage with the ideas, most likely due to the lack of perceived relevance. There was also evidence that the team's idea generation was heavily driven by D3. After reflecting on this with the designers, after Workshop 3, it seemed that guidance was needed to both generate new ideas and stay focused on addressing the project brief. The final idea (plough cart) was developed collaboratively through discussions about how the project brief could be met in a way that all participants could use the solution.

Overall, there were two main observations from case 2. Firstly, that the man with the amputated leg (P15) was a dominant participant and seemed to have the ability to generate ideas independently. Unfortunately, the specific focus of his ideas made them difficult for the rest of the team to engage with. This created a barrier to project progress during Workshop 2, which was not present in his absence in Workshop 3. The noticeable divergence of ideas in Workshop 2 may have been due to the project brief statement "*The design of a solution to assist mobility impaired individuals to prepare their fields before sowing*" being too wide in scope. Secondly, the rest of the group were more aligned with each other, but struggled to generate meaningful ideas. They relied heavily on the facilitation of D3 and did not demonstrate the ability to ideate independently.

An ability to create insightful prototypes

Once again, hands-on model making was a strength of the group with all participants engaging well with the activity. The group contained a range of impairments but none that would severely limit an individual's ability to participate in model making. The models created were very basic, but did aid in the communication of each idea during presentations.

An understanding of the design process

Evidence shows there was a wide range of participant understanding about the design process. From observation, participants seemed to understand the place in the design process, the need for divergent thinking and the role of screening, for selecting a final agreed upon design. However, the two involved designers (D3 and D4) stated that constant reiteration of the design process was required to ensure participants knew where in the process they were and the rationale for the activity being undertaken. This is shown in the designer comments below:

> D3 - "*I try to remind them that ok, so right now, this activity is this step of the design cycle. Because I always talk to them and always explain to them about the way we want to solve the problem… …After we explain them, we talk to them a lot about this they feel like they understand design thinking*"

> D4 - "*Some evidence that people understood reasoning behind activity but not a lot. The group understood activity clearly but found it hard. They understood that*"

Interestingly, in their field diaries, both designers scored this competency as *good* for all activities in generative design. This suggests that the activities in generative design were well understood but that the conceptual understanding of the design process is still not present in all participants. This range of participant understanding is evident when contrasting two different participants responses to the interview question, "*If you were going to solve a problem, what steps would you go through?*" during generative design. P6 responded *"Identify the problem, gather information, think of idea, which one is good, and after that take it to use"* while P10 stated they were "*Unsure".*

A motivation to contribute

The designers assessed motivation as either *fair*, *good* or *very good*. D4 stated that during brainstorming "*Contributions from the group were common in the form of opinions mainly about what would and wouldn't work*", this aligns with the finding that *design critique* is also a strong competency.

Energy and engagement seemed low during telling-style activities (such as brainstorming) and much higher during making-style activities (such as materials and model-making). For example, during brainstorming in Workshop 3, participants needed to be continually engaged to ensure they were focused. D4 suggested this may have also been due to the classroom venue being hot and requiring participants to sit on chairs and not the ground, as they preferred. As mentioned previously, during making-style activities all participants were the most engaged.

Visualization

Figure 93 represents the overall perceived collaborative competencies during the generative design stage for case 2.

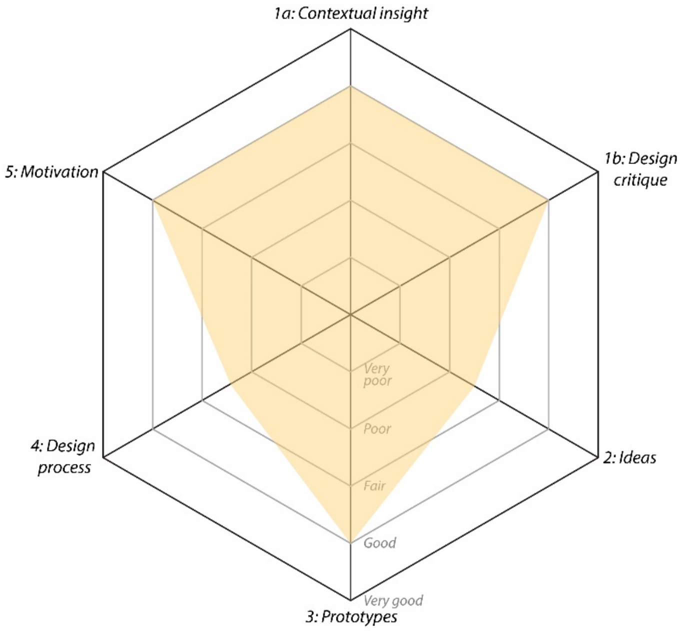


Figure 93 - Visualization of generative design collaborative competencies in case 2

Case 3 – Chicken Coop

Overall, generative design was a challenging stage for case 3. While the project brief was well defined, participants seemed to struggle to think of a wide range of ideas. There were three unique aspects of case 3. Firstly, the project brief was focused on helping one particular participant (P8, blind participant with one arm). This meant that the rest of the team were encouraged to empathize with P8 and work towards a solution that may not affect their own lives. This focus made it more difficult for designer D2 to engage all of the participants. Secondly, the project focused on a large, single structure (chicken coop at P8's home). The scale of the project made it more difficult to prototype and test; this is discussed later in this chapter. Thirdly, the team contained two heavily-impaired individuals, P8 and P16 (25 year old male wheelchair user with physical and cognitive impairment). There were stages in the process when these two individuals could not fully engage.

An ability to express opinion about a project

It was initially challenging to facilitate *contextual insights* about the specific environment for this project. This was due to the environment being so specific (P8's home) and the fact that the more able participants tended to lead discussion. This lead to several occasions when the designers had to encourage P8 to contribute information to the discussion or clarify if an assumption was wrong. There was a power structure present, which resulted in P8 shying away from group discussion. The designers tried to build empathy levels in the group and empower P8 with fun, energizer-style games. An example of this was the use of the game *Marco-Polo*. In this game, two participants are blindfolded and call out to two other participants who call back. The blindfolded participants must navigate the room to find the others (Figure 94). The purpose of the game is to demonstrate the challenges of vision-impairment and to display how skilled our vision-impaired participants were at navigation.

Figure 94 - Participants playing Marco-Polo to build awareness of blind mobility challenges

When discussing this competency there are two participant groups to focus on. Firstly, general team members were comfortable to express their opinions and provide *design critique*. This was helpful for gathering general information about the community, as well as learning about what the community views as best practice for chicken farming. Inside of this dynamic, there was also a power structure present, due to the involvement of the village chief. D2 stated that while everyone in the team provided opinions in some instances it was "*just only him [village chief] and one other guy. He give feedback saying 'you cannot do like this, you cannot do like that'*". The main way of addressing this power dynamic was through active facilitation and the use of activities, which required each participant to have input (such as the local precedents activity). There were also moments when there was a misalignment between what a general team member communicated, and what actually the case at P8's home was.

Secondly, the heavily impaired individuals (P8 and P16) did not demonstrate the same ability to express opinion. Understanding why this was the case is complex, as both had severe impairments that created functional barriers to participation. This meant the perceived shyness might have been due to functional limitations, cultural dynamics or creative capacity limitations. Findings from this study suggest that all three factors were present. Facilitation was also difficult as many of the activities used photos and sketches, which were verbally described to P8.

An ability to generate insightful ideas

Occurrences of this competency in case 3 were mixed and ranged from *poor* through to *good*. To begin discussion, D11 stated in their field diary "*Designer [D2] drove ideation. Some ideas from participants but nothing overly new and insightful*". D2 corroborated this during an interview explaining, "*They have their own idea, but they don't want to talk it out. And after that, I explain and come up with my idea and come up with an example and then they give me their answer*". This suggests that the perceived lack of ability was due to shyness, which was overcome through active facilitation by D2.

Similar to case 1, in Workshop 2 the team aligned with one idea (building a new chicken coop) and spent their time discussing details about the idea, as opposed to brainstorming a range of other options. This resulted in a well-defined concept at the end of the workshop but did not generate any truly novel ideas. To assist the team to be more creative, D11 generated a range of ideation sketches that were used to structure discussion during brainstorming in Workshop 3. These helped to engage the participants but was less engaging than the photographs shown during the existing solutions activity.

Overall, there was a *poor*-to-*fair* ability demonstrated in case 3, as even with extensive guidance and examples the final ideas generated were not well aligned to the project brief, or novel. As discussed in Section 5.13.1, the idea chosen by the team during idea screening (small woven cages to hold chickens) did not address the project brief in a meaningful way. When the design team probed as to why this was the chosen idea the participants replied that it was "*easy to make in one day*". It seemed that the participants did not understand that the final solution did not need to be implemented in one day, but that we had one day left in the workshop to experiment and make prototypes. To address this, the case 3 team spent the next morning at the home of P8 continuing to brainstorm and experiment. This lead to several more meaningful ideas such as modifying the existing coop by raising the door frame height, moving the chicken perch away from the entrance and adding hand rails to improve navigation between the house and chicken coop.

An ability to create insightful prototypes

Once again, hands-on model making seemed to be a strength of the majority of the participants in case 3. Of note to generative design, was the making of a model chicken coop. The chicken coop model was based on discussions during the brainstorming activity and represented a new, large chicken coop that the participants wanted constructed. From observation, it did not seem to be explicitly focused on P8 but did include universal design considerations such as large entranceways, easy to find locations for food and water and small walls for separating chickens. Most of the group were included well in the activity, with the main exceptions being P8 and P16. These two individuals found it challenging to engage in the physical aspects of the activity, however, P8 was included by the group asking him to create small model chickens out of play-dough for use in the presentation. While not part of the core model making process, P8 did seem to enjoy this work and being included in the activity.

Overall, the team showed a *good* ability to prototype, with the exception of P16 who could not participate due to functional limitations.

An understanding of the design process

There were several occurrences in case 3 generative design, which suggest that this competency was not well developed or facilitated. Firstly, the ideas that were generated during brainstorming, and selected during screening, did not fit the original project brief. This meant that the project needed to be re-directed by the design team on several occasions. Whether this lack of appropriateness was due to a lack of understanding of the design process or due to the lack of relevance of the project to some participants (given it was focused on helping P8), is not known. Evidence suggests that the team did not understand that the final idea selected in Workshop 3 did not have to be completed in one day, and could be worked on after the workshop. This miscommunication may have been the reason for selecting an inappropriate final idea. Furthermore, the fact that the solution was not going to have direct impact to many of the participants' daily lives may have also attributed to this, as participants did not want to work outside of the workshop on the project.

D2 stated that the participants' understanding of the design process improved across Workshop 2 and Workshop 3 as ideas were discussed, testing and improved upon. D2 stated:

> "*The second workshop they try understand about the process and they okay, before they build the prototype, they come up with the 'identify the problem' and then we generate the idea and choose the idea which one is good which one is bad and testing. Like our result is not good and we can do it again. Test it again and again they understand about that. This, the second*

day [Workshop 3 day 2], I can they can see they build the prototype for the chicken coop and then testing; ok it is not strong, so we can build it again"

This would suggest that the participants' understanding of design concepts such as testing and iteration, and continuous improvement were improved at the end of the generative design stage. Using this logic, it may be that the inappropriate design ideas were not due to a lack of understanding of the design process, but a lack of understanding and empathy of P8's life and environment. Therefore, if the participants tried to independently design for themselves in the future, they would be more successful.

Overall, the team showed a *poor*-to-*fair* understanding, with concepts such as testing and iteration understood, and concepts such as empathy, focusing on the design brief and understanding the purpose of the project being less clear.

A motivation to contribute

Finally, motivation ranged from *poor* to *very good* depending on the type of activity. As discussed previously, *motivation* encompasses intrinsic motivation, as well as the designer's ability to engage participants, and the participant's functional ability to be engaged. The majority of the case 3 team seemed to have a *poor*-to-*fair* level of intrinsic motivation, limited by the project focus and relevance to them personally. Occurrences when the competency was perceived as being *very good* aligned with when making-style activities were used. There seemed to be the same relationship between motivation and type of activity present in other cases (making-style activities being more engaging than telling-style). For example, D11 stated in their field diary that during brainstorming that it was a "*Quiet activity compared to other activities*" and that the model making activity was "*great for energy*" and a "*visual activity that was very engaging*".

It was clear that P8 and P16 were not meaningfully included in all activities. Their specific functional limitations meant that telling-style activities were most appropriate; however, these were least engaging for the majority of the group.

This lead to a trade-off, which centres on the effectiveness of making-style activities in engaging more able-participants, and the potential for exclusion of heavily impaired individuals during prototyping activities. It should also be noted that both the heavily impaired individuals communicated that they still really enjoyed participating in the project. For example, D2 interviewed P8 and stated:

"*I asked him [P8] are you happy to come here [Workshop 2], are you enjoying to come here and he said, 'yes'. Because he can hear many people, every voice and many noises so he can* *imagine that it's really fun. So he can hear, he can talk and he can play game, and he never played game before*"

Enjoyment is an interesting aspect of social inclusion and will be discussed separately later in this chapter. Overall, the *poor*-to-*fair* level of intrinsic motivation of the general group, and lack of meaningful involvement of the two heavily-impaired individuals means that this competency was viewed as *poor*-to-*fair.*

Visualization

Figure 95 represents the overall perceived collaborative competencies during the generative-design stage of case 3. Note that different levels are shown for general participants and heavily-impaired participants.

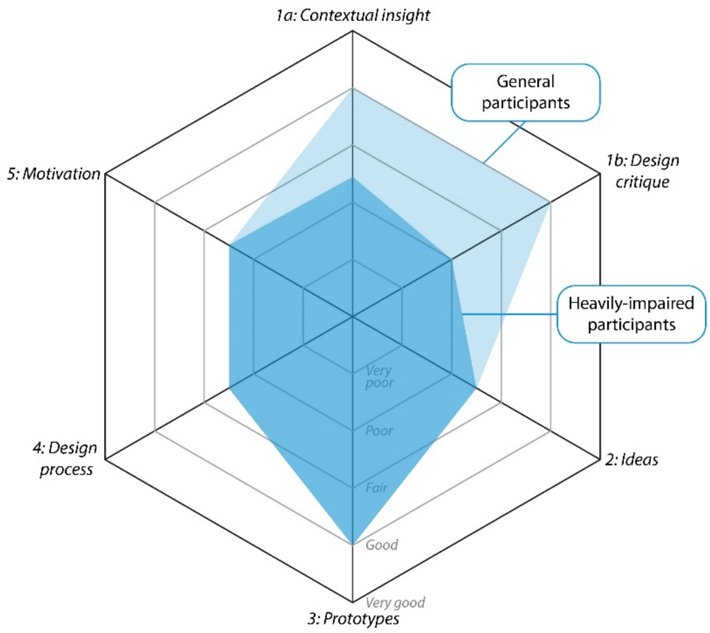


Figure 95 - Visualization of generative design collaborative competencies in case 3

Cross-Case Comparison

To begin discussion, Figure 96 shows the visualizations for cases 1, 2 and 3 super-imposed onto each other. This shows that the competencies *contextual insights, design critique, prototypes, ideas* and *design process* were in close alignment across cases*.* It also shows that the competency *motivation* differed significantly across cases.

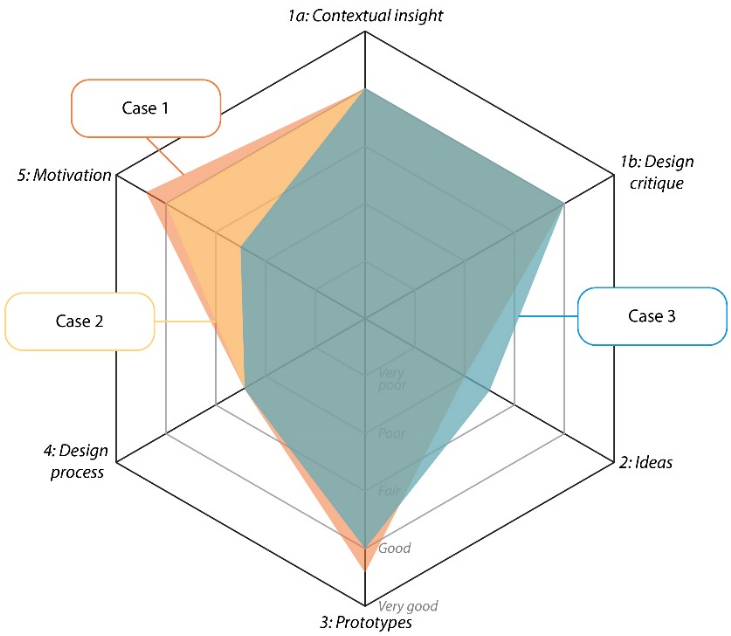


Figure 96 - Visualization of generative design collaborative competencies in cases 1, 2 and 3

This difference seemed to be linked to the relevance of the project to the participants in the team. In cases 1 and 2, the focus of the project was to design a product that was potentially valuable to all participants. The scale of the products also meant that participants could reproduce the design relatively easily. Contrastingly, case 3 focused on the customization of P8's chicken coop to be more usable for the vision-impaired. The project was not deemed relevant to many other participants and so motivation to contribute was driven by some empathy for P8 as well as the directions of the designers to produce an output.

6.3.3 Evaluative Design

To begin discussion, Table 50 is presented. This shows the frequency-coding matrix from all data collected during the evaluative design phase. Note that evaluative design occurred across both Workshop 3 and Workshop 4.

Table 50 - Competency vs description coding from evaluative design

	Very poor	Poor	Fair	Good	Very Good
1a: Contextual insight	0	0	0	0	0
1b: Design critique	0	0	0	4	2
2: Ideas	0	1	0	4	1
3: Prototypes	0	0	0	9	6
4: Design process	0	0	1	6	1
5: Motivation	0	1	0	12	5

Of note in Table 50 is the *good* and *very good* coding occurrences of most of the competencies, with *prototypes* and *motivation* showing to be the strongest competencies. Also, there are no occurrences of the *contextual insights* competency. This was expected, as evaluative design focuses on testing and iterating a design and not learning about the context. As described in Figure 80, the following sections will discuss each case individually, as they contain unique characteristics influenced by the participant group, designers and project focus.

Case 1 – Rice Seeding

Overall, the case 1 team worked effectively throughout the evaluative design stage. They worked closely with the facilitators and seemed very engaged in the process, and outputted product. The main events of note were the change of lead facilitator between Workshop 3 (D5) and Workshop 4 (D8) and independently designed and constructed prototype, by the community, between Workshop 3 and Workshop 4.

An ability to express opinion about a project

There was little opportunity to provide *contextual insights* during this stage of the process. Any occurrences were due to participants sharing local construction techniques (such as notching wood and using rope to join materials).

There were many occurrences of the *design critiques* sub-theme, with all being coded as either *good* or *very good*. One example of this is a comment made by D8 during an interview post-Workshop 3.

> "*in the prototyping, like when they [participants] do something and they feel like it's not going well, [they say] 'this is what I think it should be like' and 'this is what I think it should be', things we could change and make it possible. Yeah I think during the making session, the prototyping session, they really good at expressing their opinion but, um, the other workshop, I'm not sure but with building thing, because, I think they feel comfortable to talk when doing things*"

This statement highlights the effectiveness of making-style activities in facilitating participants' *design critique* competency. The same point is reiterated by D8 after Workshop 4 stating, "*They're [participants] not good at expressing their opinion during the planning and something, but when building they just come up with new ideas and like their thought, they'd immediately say it to the rest of the group*". Interestingly, there were several references to male participants dominating the making-style activities and female participants engaging less, and providing less evidence for this competency. D11 wrote in their field diary that construction in Workshop 4 was "*very good for engaging men but heavy PwD and females did not provide opinions or insights*". D9 supported this view stating, "*They [male participants] just have their own idea. Yeah it's quite good. Especially for the man*". It was clear that male participants felt more comfortable using tools and led the construction activities. The designers actively tried to involve female participants in the process, but noted that they felt more comfortable watching and providing feedback during testing and iteration. The female participants were still engaged in the activities, helping complete non-tool based tasks, such as assembly and testing. In Workshop 3, the team was very inclusive and ensured that several female PwD tested the product and provided feedback (Figure 97).

Figure 97 - Case 1 team constructing a rice seeder prototype

Given the majority of activities in the evaluative design stage were hands-on, either making-style (prototyping) or enacting-style (testing), it seems logical that the participants demonstrated a *good*-to-*very good* ability.

An ability to generate insightful ideas

Given the stage in the design process, there were few formal opportunities to demonstrate this competency. Most of the occurrences were based on feedback from testing and suggestions on how to improve the design. For example, adding pieces of bamboo to strengthen the rice seeder design in Workshop 3 or changing the positioning of the harrows to improve usability of the rice seeder design in Workshop 4. However, it seemed that only a few participants were actually generating ideas in this stage. These were the participants who were most engaged in the construction process, and who most likely had the most experience with construction in the group. D9 stated, "*Some people have a good idea but some people they don't have an idea, they just sit and watch and when the other person do, they just like speak, speak follow or speak behind them".*

The most interesting occurrence of this competency was when a male participant arrived at Workshop 4 with an independently designed rice seeder prototype. This featured most of the design decisions made during Workshop 3 but also added new features such as harrows, a rigid wooden frame and four, used paint-buckets for seed hoppers. The design was not fully functional, nor did it show an understanding of seed spacing (based on the wheel size and location of dosing hole). However, the design did show a strong amount of creativity, and motivation, and led to the design team gaining new insights (such as the use of harrows and techniques for building the frame).

Overall, this competency was *fair* as some of the group demonstrated strong ability, while others did not. It seemed that individuals engaged in the construction process were more likely to contribute new ideas also.

An ability to create insightful prototypes

As has been discussed throughout this chapter, the participant group once again showed a *good*-to-*very good* ability in this competency. Evidence of this included designers rating the team as either *good* or *very good* in their field diaries and interviews and in the researcher's observational notes. This is summarized by Table 51.

Table 51 - Prototypes competency vs description coding for evaluative design case 1

	Very poor	Poor	Fair	Good	Very Good
3: Prototypes	0	0	0	8	2

Two separate findings may contradict the rating described above. Firstly, as with *ideas*, *prototyping* seemed to have a gender-bias towards male participants. Male participants seemed most comfortable with using tools and had experience making basic structures in their everyday lives. Conversely, most of the female participants seemed unwilling to use most tools and opted to watch the construction process, verbally communicate ideas and engage in product testing. While not ideal, the design team decided to work within this socio-cultural structure as it ensured the best health and safety considerations as no one was pressured into attempting an activity they were not comfortable with.

Secondly, it was observed in Workshop 4 that the ability to create a prototype does not necessarily link to the ability to design an effective engineering solution. D8 stated,

> "*I think they have the ability to build it themselves, I can say like 70-80 % that works, I think they need extra building skill, but they can, try and build it themselves. Like I was impressed with the rice things [rice seeder] they built, but they need skill and also proper tool, sometimes they need some more skill and some proper tool*"

This statement referred to both the participants' ability to use more complex tools (such as an angle grinder or power drill) as well as their ability to design a solution that is fully functional. In the design team reflection session, after Workshop 4, the team noted the following improvement for future workshops: "*Training on tools next time - may result in increased participation, learning together and from each other, should include use of safety equipment and behaviour*".

For describing the participants' ability in this competency, the engineering design ability is not considered, as this falls outside of the scope of hands-on construction ability. Therefore, the *prototyping* competency was given a *good* rating for this stage.

An understanding of the design process

Evaluative design focused on the less ambiguous, more logical steps of the design process (*work out the details, build it* and *test it*). The case 1 team seemed comfortable with these steps and understood the role of each activity clearly. Furthermore, the structure of the evaluative stage in Workshop 3 and Workshop 4 was similar (plan, build, test and give feedback) meaning participants were very clear of the rationale for each activity in Workshop 4. D5 stated, "*As this is the third meeting [Workshop 3], the majority of them know what the project expectation is*". This suggests that either the participants are gaining a conceptual understanding of the design process, which helped to understand the rationale of each step, or the logical steps are just clearer, and align with existing practices. While the former may have some effect, it seems the latter is the reason for an improved understanding of each activity.

Similar to previous stages, the participants' conceptual understanding of the design process varied with multiple occurrences of *poor* and *fair* understanding. Firstly, D5 and D9 highlighted a lack of engagement with design theory but a *good* understanding of practical application of the process. Their comments are should below:

> D5, Evaluative design - "*Because it is linked to more technical terminology, like the word 'design', it is not friendly with them, but if we simplify the language, 'do you understand the procedure of doing the simple plan?', they understand well, like making it, testing it, revision it, and they test it, yeah they understand well*"

> D9, Evaluative design - "*I think they don't focus much on the theory, like the cycle of design thinking, because I saw when you recap the theory cycle of design process, it seemed like they didn't focus much. The real practice they do it. But they don't know it clearly which step they are in*"

An interview with a participant (P11), shown in Table 52, highlights the limited understanding of some participants.

Table 52 - Participant response from interview during evaluative design for case 1

Code	What do you think the term 'design' means?	Have you ever made something in your life?	If you were going to solve a problem, what steps would you go through?
P11	*To do something in order to make an improvement*	*Yes, in the farm*	*Don't know*

Overall, the participants demonstrated a *poor*-to-*fair* conceptual understanding and a *good* practical understanding of each specific activity, resulting in an overall *fair* description.

A motivation to contribute

Finally, *motivation* was an interesting competency to observe during evaluative design, as there were clear gender roles evident. These roles, of males working on prototype construction and females watching and providing verbal comments, made assessing motivation challenging. All involved designers stated they observed *good* or *very good* levels of motivation. For example, D5 stated "*all have strong motivation to participate in the production of the prototype, because everybody is busy, they share the idea, they share discussion… …I'd give them 95% of the score for the participation*".

During making-style activities, female participants were not usually using the tools and constructing the prototypes. However, they did show strong interest and an ability to give their opinions during construction and testing. Figure 98 shows a typical formation of participants during a making-style activity. Note, the male participants working on the prototype while multiple females watch on.

Figure 98 - Case 1 prototyping; several female participants watch as male participants use tools

This evidence suggests that both male and female participants had *good*-to-*very good* levels of motivation to contribute. However, the method of contribution was different with males contributing hands-on skills and females contributing opinions and ideas verbally.

Visualization

Figure 99 represents the overall perceived collaborative competencies during the evaluative-design stage of case 1. Note that the *contextual insights* competency is not shown as there was little evidence during this stage.

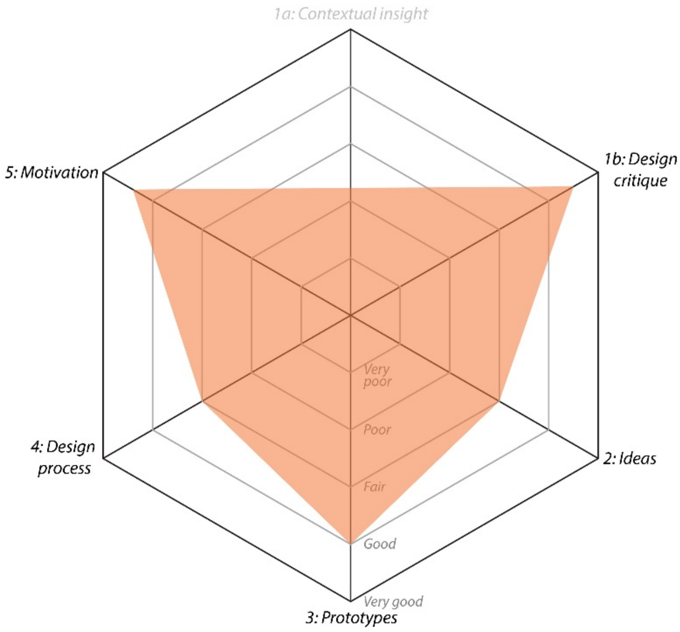


Figure 99 - Visualization of evaluative design collaborative competencies in case 1

Case 2 – Plough Cart

Overall, the case 2 team worked effectively during evaluative design and produced a semi-functional prototype at the end of Workshop 3 and a functional prototype at the end of Workshop 4. There was evidence that both male and female participants were well included in stage, and that this inclusion was the result of high levels of facilitation by D4.

An ability to express opinion about a project

Similar to case 1, there was little opportunity to provide *contextual insights*; however, D3 did state that participants were *good* at "*sharing their knowledge, or share their experience, their own experience with this and also they try to cooperate with us*". This referred to the sharing of knowledge during the planning and construction activities, such as particular participants showing others how to notch wood, use angle grinders and drop saws. These particularly skilled participants were beneficial to the stage as they could lead the planning and construction activities, instead of designers leading them. However, D4 stated that this variety of abilities actually created a divide in the group, similar to that seen in case 1. D4 wrote in their field diary:

"*During construction the team slowly became more divided due to a variety of reasons. There seemed to be clear leaders and people who had worked with tools before and people who had never used the materials or tools before. As a result, some people were able to express opinions about how things could be done but not majority of the group. The participants expressed opinions about the process and about safety during construction*"

D3 and D4 agreed that in future workshops a technical training day would help to address the skill differences in the team. In terms of *design critique,* there were multiple instances where participants reviewed the intended design and suggested changes. For example, the wooden frame of the plough cart was originally to be made from 80mm by 40mm timber; however, this was not available in the community meaning a smaller profile was used. The participants suggested that metal L-shaped brackets should be added to the design to strengthen the wooden joints. This is shown in Figure 100.

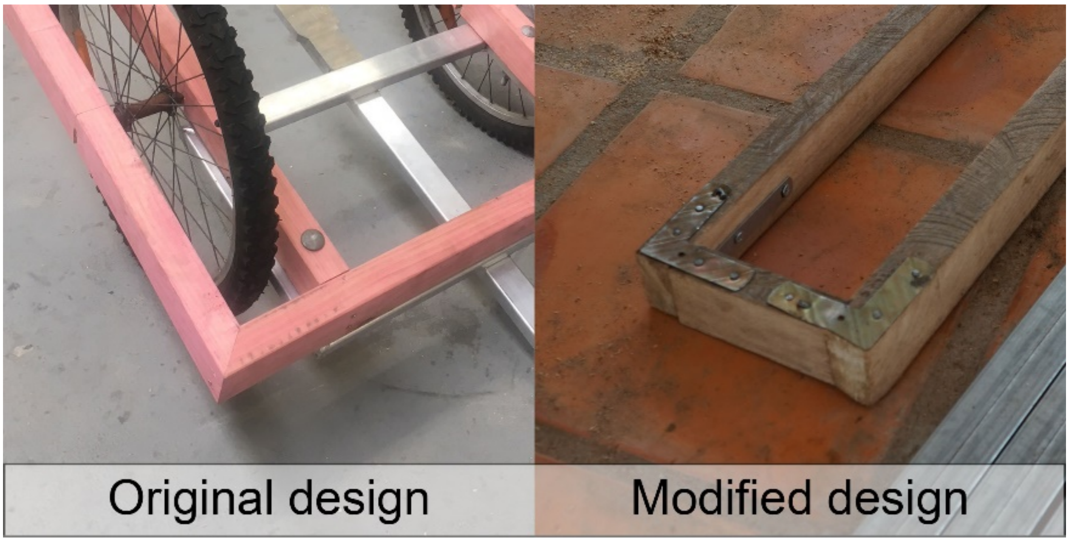


Figure 100 - Original and modified design for plough cart frame joints

To clearly describe this competency, two different participant groups inside of case 2 are needed. Firstly, the skilled participant group showed *good*-to-*very good* ability in this competency while the relatively less-skilled participant group showed *poor* ability.

An ability to generate insightful ideas

Occurrences of the *ideas* competency were closely linked to the *design critiques* sub-theme discussed above, and occurred mainly through the generation of improvements to the current plough cart design. There seemed to be a *good* ability in the participant group to come up with improvement ideas, but also a continued reliance on D3 to lead discussion. This aligns with the *design with* PD approach and is illustrated by a comment from D4:

"The first exercise [design review] we were looking at the improvements we could make to the cart, from my initial thoughts, there was quite a few people that were engaged in that conversation and a lot of people talking, but also a lot of [D3] talking during that session as well"

There was a similar split in the participant group when analysing this competency, though, while the split in the previous section focused on skilled vs non-skill, evidence for the *ideas* competency suggest that the split was gender-based. For example, interview, field diary and observational notes suggested that during construction, male participants took the lead and were able to generate new ideas, about construction techniques and design changes. Conversely, female participants were more reserved and did not naturally engage with this stage of the process. D4 actively tried to involve the female participants by assigning them a challenging technical task of designing and prototyping the plough-cart coupling. D4 explains this below:

"*My interaction with a group of women on the second day [Workshop 4] where we were trying to figure out how we can connect the cart to the plough. We had the plough and we knew the cart would have a steel beam from the front to connect to the plough. I had a lot of different bits and pieces that we could use to connect the two and I was trying to interact with this group of women to generate ideas on how we could do that. It seemed like a lot of the things [prototyping materials] that the people hadn't really seen before. Um that was pretty challenging*"

This comment suggests that a lack of experience with mechanical design and assembly may have been the underlying challenge in this situation, as opposed to socio-cultural characteristics. Overall, this competency ranged from *poor* to *good* with male participants demonstrating *good* ability and female participants demonstrating a *poor*-to-*fair* ability.

An ability to create insightful prototypes

The discussion for this competency follows the same narrative as the previous two competencies. The male participants were very strong at constructing the prototypes in Workshop 3 and Workshop 4 while the female participants were less engaged and did not show as much technical ability. Interestingly, there was a relatively balanced workload, between male and female, during prototyping in Workshop 3, with female participants contributing to cutting and notching wood, as well as assembly (Figure 101).

Figure 101 - Female participants notching wood for plough cart prototype in Workshop 3

This balance shifted in Workshop 4 with less female participants contributing to the construction activity. This seemed to be due to the increased motivation of the male participants as well as the introduction of power tools (drop saw, angle grinder and power drill). These tools were essential to completing the plough cart design, but were not familiar to many of the participants. This created a power structure where only a couple of participants could perform some of the tasks (such as cutting and drilling metal). In hindsight, this was an error in planning by the design team that could have been mitigated by either changing the cart design or introducing a technical training workshop to upskill participants.

This finding is supported by the fact that the female participants were still very good at working with bamboo, hammer and nails to create the seating for the cart in Workshop 4. This suggests that the perceived lack of engagement with prototyping in Workshop 4 was due to the introduction of power tools, and the reliance on using these power tools for much of the construction process.

Overall, the case 2 team demonstrated a *good* ability in this competency with all required skills being available across the team. However, engagement with power tools was varied with male participants demonstrating more experience, and willingness, to use these tools.

An understanding of the design process

There was evidence that the case 2 team had an improved understanding of the concepts of *the importance of testing lots of ideas* and *the importance of iteration during a design process*. This was demonstrated by the team's engagement with creating a semi-functional prototype in Workshop 3 and a functional prototype in Workshop 4, as well as their ability to analyse the design and generate design improvements. D4 stated, "*they understood that the making a small cheap quick product can* *teach you a lot about the product even if you can't use it in the end*" and "*the list of improvements and the list of changes showed that, they had a better understanding of the design process than before*".

Observational notes support the finding that this team had an improved understanding of the design process. However, as with case 1, it may be that the logical nature of the evaluative design stage has given the perception of an improved understanding, as opposed to an increase in competency by the participant group. Regardless, the conceptual understanding of the team seems to have improved from the baseline model to the model shown in Figure 102.

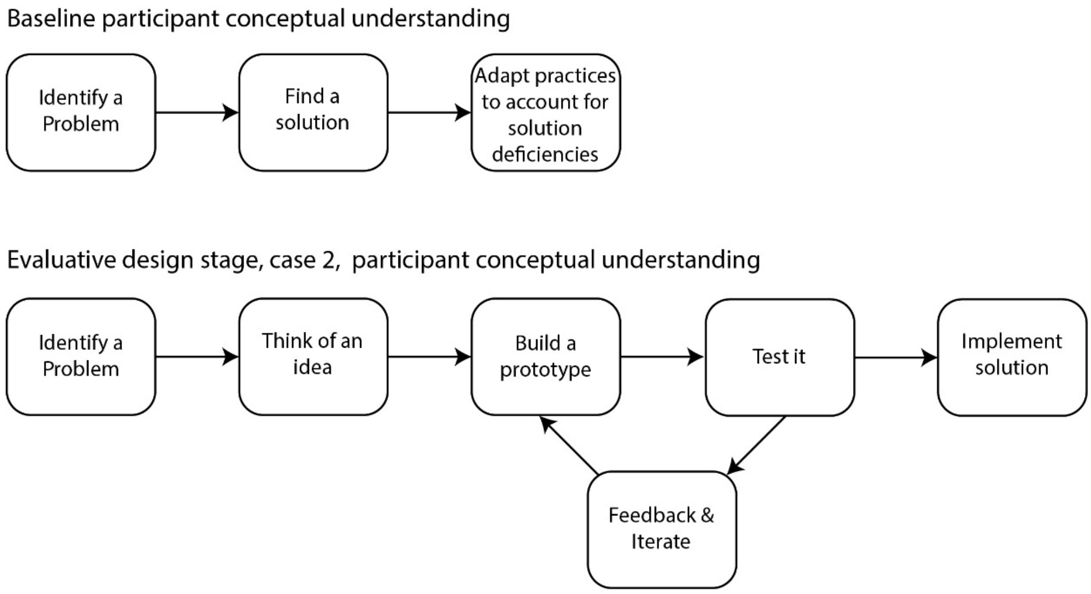


Figure 102 - Change in conceptual understanding of case 2 team

A motivation to contribute

Finally, *motivation* was perceived as a *fair*-to-*good* competency during the case 2 evaluative design stage. Interestingly, there were mixed opinions from designers about how engaged each participant was. This followed the same narrative as the previously discussed competencies with D4 rating *motivation* during the construction activity (Workshop 4) as *poor,* highlighting the lack of perceived engagement by some of the female participants. D4 stated, "*Women were less inclined to contribute*" and hypothesized that:

> "*This may have been related to their lack of interest in learning these techniques, the lack of knowledge and fear of something that is potentially dangerous (electric tools), or it could have been culturally inappropriate to take on tasks that men would normally be responsible for*"

Contrastingly, D3 rated *motivation* during the construction activity (Workshop 4) as *very good*, stating, "*Everyone works from their best capabilities. The activities run as planned. The participants seem to* *be interested in building activities*”. This disagreement can be explained by discussing which participants each designer engaged with during the activity. The male designer (D3) engaged primarily with male participants and assisted them in the construction process. The female designer (D4) engaged primarily with female participants and struggled to engage them meaningfully in the activity.

It seemed that while the intrinsic motivation of most participants was strong during evaluative design, the activities were not inclusive of all participants, resulting in a perceived lack of *motivation* by D4. Furthermore, the strength of participant intrinsic motivation was demonstrated when the prototype was not finished after the planned two days of activities, during Workshop 4. To ensure the prototype was completed, the design team told the participants that they could return the next day to work on the prototype collaboratively; however, no travel reimbursement would be provided. Fourteen members of the case 2 team attended the third day showing the buy-in and motivation to complete the prototype.

Overall, the case 2 team demonstrated a *good* level of *motivation*. This was decided after balancing the male and female evidence, activity inclusiveness and intrinsic motivation.

Visualization

Figure 103 represents the overall perceived collaborative competencies during the evaluative-design stage of case 2. Note that different levels are shown for *skilled* participants and *less-skilled* participants. These terms refer to the participants’ ability to use the tools required for prototype construction.

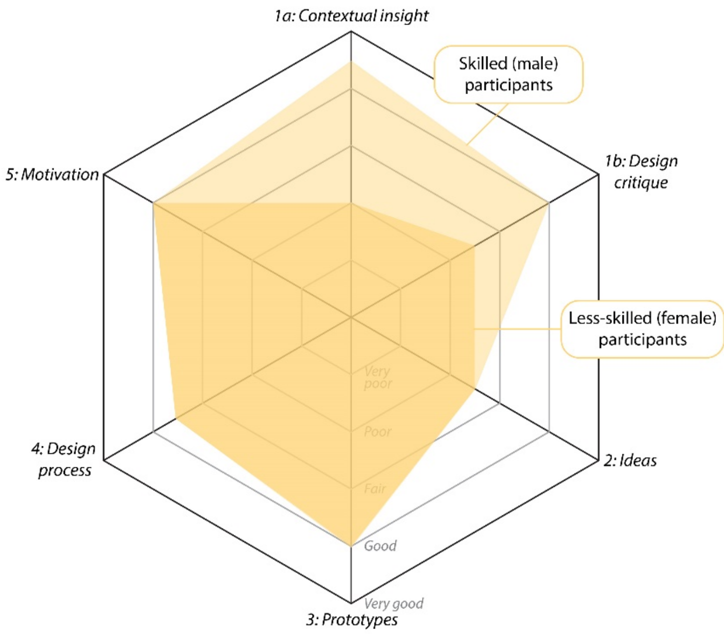


Figure 103 - Visualization of evaluative design collaborative competencies in case 2

Case 3 – Chicken Coop

As discussed in Section 5.13.2, the case 3 team did not successfully complete the evaluative design stage of the project as the parents of P8 (vision-impaired participant) communicated their lack of support for chicken coop modifications. Therefore, the project was not continued in Workshop 4. All discussions for this case will focus on the evaluative design stage that occurred on day 2 of Workshop 3.

An ability to express opinion about a project

Occurrences of this competency mainly focused on *design critique* of the doorframe modification plans and the bamboo door prototypes. General members of the team engaged well with discussing the plan for doorframe modification and engaged in a *good* critical discussion about the positives and negatives of each of the two door designs. This conversation included comments about the design, material selection and usability of the doors and culminated with a democratic voting process to select the final door design. P8 was also given opportunities to provide opinion about the project through testing the door designs, and commenting on the doorframe modification. P8 still seemed shy but did give his input into which door design he found easiest to use but did not engage very well with discussions about the doorframe. This was most likely due to the challenging task of visualizing the modification process, as well as a lack of experience with construction tools. To account for this, D2 tried to focus discussion with P8 around the usability of the final solution. The same dynamic as *opinions* for case 3 generative design was present, with general participants showing a *good* ability and heavily-impaired participants showing a *poor*-to-*fair* ability.

An ability to generate insightful ideas

There were very few occurrences of this competency as evaluative design only involved one day of prototyping and planning. There were moments during the construction of the door prototypes that yielded small ideas but nothing clearly documented in any of the data collected. Therefore, this competency will not be assessed.

An ability to create insightful prototypes

The *prototyping* competency was a strength of the general participant group for case 3 and participants found it very easy to create the door prototypes. This was most likely due to the design being an already constructed product that each participant had made before (for doors around their homes and farms). This is in contrast to cases 1 and 2 where the designs were brand new to the community and involved unfamiliar tools such as power drills and angle grinders. Again, P8 was not involved in the construction process due to his impairment. He did sit with the team during the activity. This was documented in observational notes stating, "*All participants working well to make door prototype. Blind user [P8] sitting and listening*".

An understanding of the design process

Similar to case 2, the case 3 team did demonstrate an improved *understanding* of the *importance of testing lots of ideas* and *the importance of iteration during a design process*. Again, the logical steps in the evaluative design stage seemed to help this understanding. A statement from an interview with D2 supports this finding, they stated:

> "*This, the second day [Workshop 3], I can they can see they build the prototype more for the chicken coop and they testing, 'okay it is not strong', so we can build it again and we can find another way for the make the door is stronger*"

Similar to the findings in case 1 evaluative design, interviews with participants showed a varying range of understanding of the design process steps, with P8 demonstrating no improved knowledge of the design process. This may well highlight the lack of appropriateness of the CCB sessions, and many of the PD activities, for meaningfully engaging an individual with vision-impairment. The majority of the participants engaged best with visual activities (making-style and enacting-style) where as P8 relied on telling-style activities, given his functional limitations. Overall, the general case 3 team demonstrated a *fair understanding of the design process* competency.

A motivation to contribute

Finally, *motivation* was perceived as a *fair*-to-*good* competency during the evaluative design stage. This was evident through the engagement with the prototyping activity (*good motivation)* and the doorframe modification planning (*fair motivation*). D2 stated, "*We can say seventy to eighty percent of the group they are really enjoying, for the motivation, and come up with the idea*". Observational notes during these activities support this statement. The remaining 20-30% of participants seemed to struggle with the telling-style activity format need for doorframe modification planning, the school desk setting, in the classroom further hindered this (Figure 104). D2 stressed the motivation of the team to work on the making-style activity stating, "*They love doing more than learning in the class*".

Figure 104 - The case 3 team discussing the doorframe modification process

The underlying reason for *fair*-to-*good motivation* is challenging to identify but seemed to be less linked to the intrinsic motivation of the participants, as was the case with case 1 and 2, and more linked to the expectations of the workshop. This meant that participants were happy enough to engage with the activities, and produce the required outputs, but did not meaningful commit to the project in the evaluative design stage. As with generative design, the lack of relevance to the project brief, and lack of empathetic connection with P8 meant the general participants did not see the value of the project.

This reasoning was supported by the fact that general participants happily relocated into case 1 and case 2, for Workshop 4, after case 3 was ended.

Visualization

Figure 105 represents the overall perceived collaborative competencies during the evaluative-design stage of case 3. Note that different levels are shown for general participants and heavily-impaired participants and that *ideas* is not shown on the diagram for either group, and *prototypes* is not shown for the heavily-impaired participants.

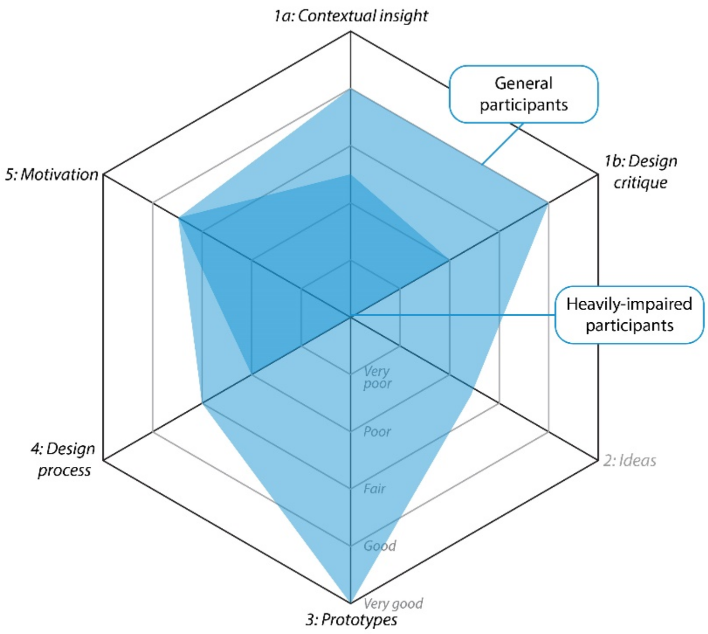


Figure 105 - Visualization of evaluative design collaborative competencies in case 3

Cross-Case Comparison

To begin discussion, Figure 106 shows the visualizations for cases 1, 2 and 3 super-imposed onto each other. This shows that the competencies *design critique, ideas, design process* and *motivation* were in alignment across cases. It also shows that the *prototypes* competency slightly differed between case 3 and the other two cases. This was most likely due to the demonstrated skills of the participants when building the door prototypes, and the lack of use of unfamiliar power tools. However, given the qualitative nature of this analysis, the difference between *good* and *very good* should not be stressed.

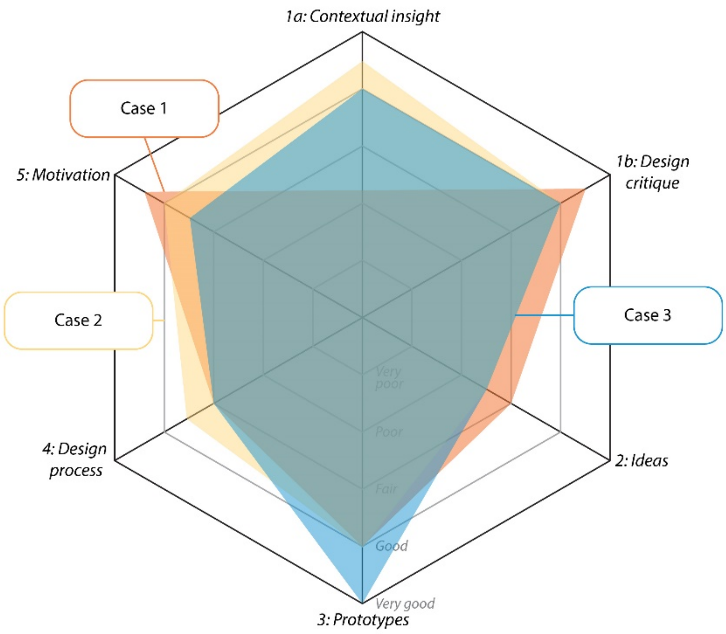


Figure 106 - Visualization of evaluative design collaborative competencies in cases 1, 2 and 3

6.3.4 Post Design

For this analysis, post design included activities that occurred after the construction of the final product in Workshop 4. This included the final implementation activity, but mostly the exit interviews with participants and future plans to continue the PD projects outside of the formally documented workshops discussed in this thesis. There is no discussion about case 3 as this project had been cancelled before post design. Table 53 shows the frequency-coding matrix for the post design stage.

Table 53 - Competency vs description coding from post design

	Very poor	Poor	Fair	Good	Very Good
1a: Contextual insight	0	0	0	0	0
1b: Design critique	0	0	0	5	5
2: Ideas	0	2	0	5	2
3: Prototypes	0	1	2	5	1
4: Design process	0	0	0	9	4
5: Motivation	0	1	0	23	18

Of note in Table 53 are the *good* and *very good* descriptions for *design critique, design process* and *motivation* and the relatively wide spread of descriptions for *ideas* and *prototypes.* As with evaluative design, there were few to no opportunities for the *contextual* insights to be demonstrated.

Case 1 – Rice Seeding

Overall, the case 1 team continued to stay engaged with the project during post design. It should also be noted that while the PhD researcher's involvement in the project ended after the participant exit interviews, and technology evaluation, the partner organizations planned to continue to support the community through technology refinement and implementation. Those future activities are not discussed in this thesis due to time and resource constraints.

An ability to express opinion about a project

Firstly, the implementation activity during Workshop 4 was challenging for D3 to facilitate. The aim of this activity was to develop a plan for who would own the prototype, what needed to be improved and who would improve it. The majority of the participants were quiet in the discussion with only the dominant participants having meaningful input. It seemed this was due to the desire of some participants to keep the prototypes (even if it meant arguing with other participants) and the fact that only a few of the participants felt confident enough to be the owner and future developer of the prototype. The community-led prototype returned home with the man who originally designed the rice seeder while the designer-led prototype was handed over to one of the older male participants as he had a plan to involve others in future development activities. These plans were investigated during the exit interview (approximately 6 weeks later) with P12 (76 year old male) stating, "*I have a* *plan with four people. I was the one who initiated the idea to make a tool. Then, we mentioned to the group that we wanted a rice seeding tool*".

Secondly, the *opinions* competency was coded as either *good* or *very good* and focused on the participants providing excellent *design critique* during exit interviews. Participants seemed confident to communicate shortcomings of the design that had not been identified during the evaluative design stage. For example, P13 (47 year old male) stated the following issues with the current rice seeder design: "*The metal we used it thin, so, it's weak. It's alright for hard metal*" and "*We need to make wider holes, so the seeds can drop easily*". This feedback was helpful for the design team as they completed the technology evaluation activity and made a plan for future design work needed in the PD project. Khmer interviewers who were not involved in the project interviewed the participants individually. This may have helped encourage honest feedback that was less likely to occur in a group setting with the designers who had a relationship with the participants. A second example was P12 stating, "*First, I didn't want to create this type of tool. I wanted the one with a tube on top and the seed drops as we pull. When it came out like this, we can still accept it*". This showed that the democratic process of selecting an idea, used during generative design, did not please all participants.

An ability to generate insightful ideas

The *ideas* competency linked closely to the *design critique* competency with interviewed participants providing ideas about how to improve the current rice seeder designs. For example, one participant stated, "*We shouldn't use metal rake because it's too small. We should use wood the size of a toe*". The researcher viewed this statement as evident of both *design critique* and *ideas*.

Interestingly, the post-design phase should theoretically occur after the design is finalized and focus on how the solution will be implemented, maintained, scaled, etc. The fact that much of the discussion in the post design stage focused on design improvements suggests that the project had not yet completed the generative/evaluative design stages. This idea is also supported by the technology evaluation for case 1, which highlights several design requirements that have not been met yet, and suggests future changes to the design to resolve this. In a less-constrained project, the designers would have continued with evaluative design for several more workshops. However, given the resources available it was decided to continue into post design for the sake of completing a full design process with the participants.

The ideas presented by the participants in this stage were the most focused and meaningful of the project. There were clear links to *design critique* and recommendations for future work. Therefore, this competency was viewed as *fair*-to-*good*.

An ability to create insightful prototypes

Firstly, there was no actual constructing of prototypes in this stage of the design process. All evident of the *prototypes* competency was based on discussions and interviews with participants and prototyping that had happened independently, or was planned for the future. There was evidence that a plan was in place for four of the participants to continue to test and improve the design once the sowing season arrived (March/April). They explained that the reason for waiting was due to a lack of time and materials now as well as the desire to test the prototype on the correct ground conditions and with the correct rice seed. This is illustrated by a comment from P9:

> "*After joining the seminars, they haven't yet helped us to make the tool. It's because the season has passed, so, we haven't had anything yet. When the season comes, we'll prepare the materials and try to make it*"

Interestingly, there was also clear recognition from participants interviewed that they required technical assistance for future design and prototyping activities. This suggested that they had realized the complexity involved in designing an effective solution and wanted to align the project as a *design-with* style project, instead of the *design-by* style the design team had looked to achieve for much of the project. P14 (59 year old male) stated, "*I think if I can make the tool, then let it continue. If there is any thing missing, I'd like to have feedback from the staff. My team can contribute ideas to make the rice seeding tool better*".

An understanding of the design process

During exit interviews, there were three notable observations related to *understanding of the design process*. Firstly, there was mixed evidence that participants could continue with the design process independently. P13 was confident they could remember the design process, and rice seeder design and could continue this independently. P7 also stated they had gained knowledge and could now work independently of the designers, however, they also highlighted that the community should work together to design solutions. P7 stated, "*Each of us has a bit knowledge*" and "*If they say I miss something, we can help each other out. It's normal that we forget something. We cannot remember everything*".

Contrastingly, P12 highlighted their lack of technical knowledge being a barrier for independent design, stating, "*I only know how to use the tool but the ideas of making the rice seeding tool are from them, so, they help with technical ideas. I only have force and some materials*". However, P12 also communicated that they had a plan in place to continue the design project. This suggests that while P12 did recognize technical skill as being a barrier, they were motivated to continue to work on the project regardless.

Overall, this competency was demonstrated to a *fair*-to-*good* level, as participants understood the need for the project to be handed over to the community, the need for future development and scaling of the solution. However, it should be noted that the exit interviews focused on a practical understanding of the design process, evident through actions and planning of the PD project, as opposed to a conceptual understanding of the design process.

A motivation to contribute

Finally, *motivation* was viewed as *very good* during the post design stage. While the implementation activity in Workshop 4 did not result in high levels of engagement, all participants interviewed showed strong levels of buy-in, motivation to continue the project and evidence that plans had been created to ensure the project continued. Evidence of *motivation* is shown below.

> P12 - "*I have a plan with four people. I was the one who initiated the idea to make a tool. Then, we mentioned to the group that we wanted a rice seeding tool*"

> P14 – "*But if my early request can be approved and my team likes the sample, we can share some money to buy old parts of kid bikes to make the tool. That's my idea*"

> P7 – "*We have to try using it before rice seeding. Whether it is usable or not, we will adjust until it can be used. It can't be impossible since we already have ideas. Also, we should right the mistakes*"

Finally, P7 communicated that there was a large number of community members, who were not involved in the project, which would have liked to be. They stated, "*There are more people who want to join. That excludes the previous participants*" and "*They keep asking me why you selected only that amount of people. Why didn't you allow them in?*" This was not known to the design team during the project, and highlights the desire of rural communities in Cambodia to engage in development projects that aid them in improving resilience (through either capacity building or assistive technologies).

Visualization

Figure 107 represents the overall perceived collaborative competencies during the evaluative-design stage of case 1. Note that the *contextual insights* competency is not shown as there was little evidence during this stage.

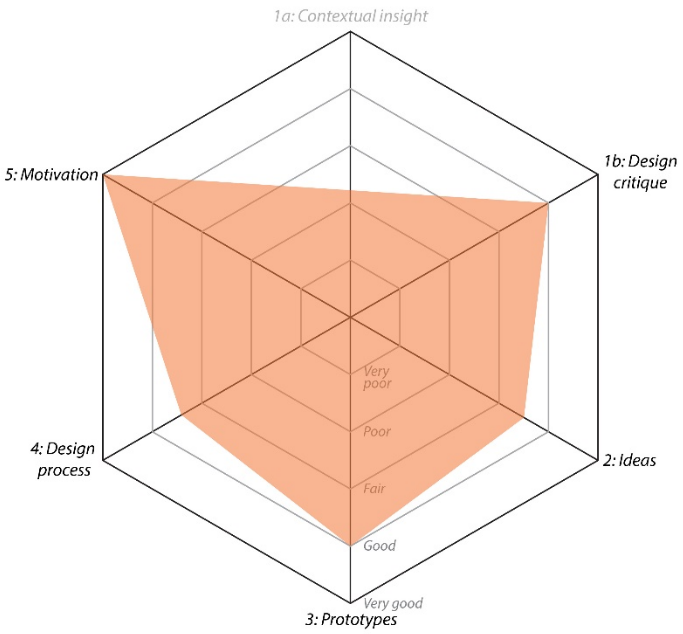


Figure 107 - Visualization of post design collaborative competencies in case 1

Case 2 – Plough Cart

Overall, the case 2 team engaged well with the post design stage and a plan was put in place for future development activities. The post design stage was dominated by one particular individual (P15) who lead the construction activity and wanted to continue the testing and refinement process.

An ability to express opinion about a project

Most of the occurrences of the *opinions* competency were in the form of *design critiques* highlighting areas of improvement needed in the plough cart design. These focused on both usability aspects and technical functionality that needed to be improved for the cart to be an effective solution. For example, in an interview with P15, they stated the following improvements were needed:

> "*Another weakness is the pressure on the plough when we sit on the cart. Also, it cannot be pulled in water*"

> "*We should design at the time we plough so we know the seating and holding position. It was a bit wrong from what we have done there*"

> "*It's not quite good ploughing in water. But if we plough on dry land, it's good*"

It is not possible to comment on the ability of the entire group, as only a select few individuals were interviewed; however, the individuals interviewed showed a *very good* ability to provide *opinion.* They did not seem shy and were honest and critical about the project.

An ability to generate insightful ideas

Similar to case 1, the *ideas* occurrences were linked to the *design critique* occurrences. However, no specific ideas were provided during the interviews, only indication that they had more ideas they would like help developing. P15 stated, "*I can design a similar cart in different ways. Like the one that is easy for us to sit on and is safe. So, I can have another way to design*". This may have been stronger evidence of participant *motivation* than *ideas,* as it was not clear if P15 had a clear idea of what they would like to change or just the desire to continue to work on the project. Therefore, this competency was assessed as *fair*.

An ability to create insightful prototypes

Similar to case 1, there was no actual evidence of prototyping in the post design stage. Furthermore, there was little evidence that a plan had been put in place for future construction. It seemed that the owner of the prototype, P15, did not have a clear direction for the project, and instead was hopeful that the design team would return to continue to work with him. This may have been linked to a lack of participant support (from others in the team), lack of available resource to construct a new prototype design or the complexity of design work required (as it involved re-designing the weight distribution and seated position of the user). Therefore, this competency was not assessed, as no evidence of prototyping was found.

An understanding of the design process

There was clear understanding of the need to test and iterate a design (as explained in the case 2 evaluative stage). P15 highlighted that "*We should design at the time we plough so we know the seating and holding position. It was a bit wrong from what we have done there*". This shows that they understand the importance of testing a product in its real use situation, an important design concept. There was also evidence that the participants did not feel confident to continue the design process independently. P15 stated, "*I don't have any strategies to design the product myself. I only have the design like the sample [prototype made in Workshop 4]*". When asked if they could continue the design project they stated, "*Yes. I can design a similar cart in different ways. Like the one that is easy for us to sit on and is safe. So, I can have another way to design*". These contrasting answers show that the participant is unsure about the conceptual design process, but clear about the specific steps needed to improve the plough cart design. This has been a common difference throughout the project.

A motivation to contribute

Finally, *motivation* in P15 was *very good*, but other participants seemed less engaged in the project after the workshops were completed. This suggests that P15 took full ownership of the final product, and responsibility for testing and refining the design. While case 1 remained collaborative, with a team of participants continuing to work on it, case 2 became more individually driven. P15 was very interested in continuing to work on the project and collaborate with the design team, stating, "*I'd like to have one more strategy about the design. Another design of another type of cart. The cart that we can sit on without having it clamped on our thighs*". Therefore, the post design *motivation* of P15 was assessed as *very good* while evidence of the *motivation* the rest of the team was not available.

Visualization

Figure 108 represents the overall perceived collaborative competencies during the post design stage of case 2. Note that the *contextual insights* and *prototypes* competency is not shown as there was little evidence during this stage. It should also be noted that the only participant meaningfully included in the post design stage was P15. This was due to P15 owning and driving the post design stage independently.

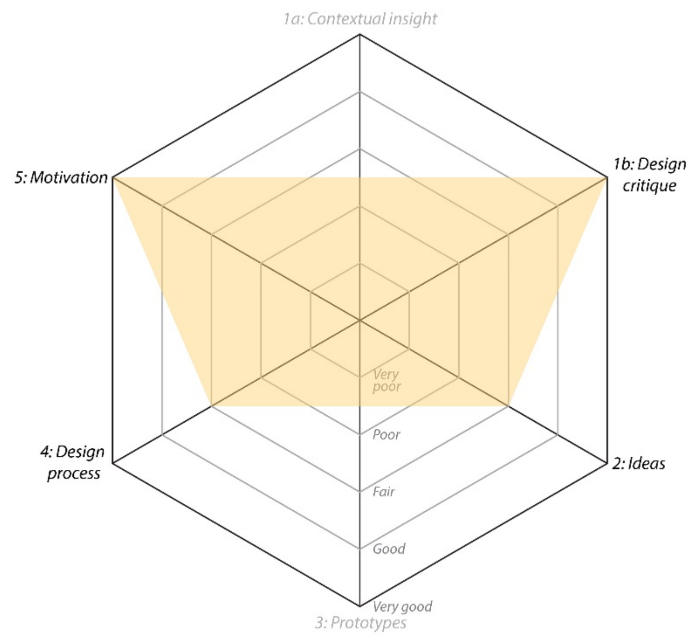


Figure 108 - Visualization of post design collaborative competencies in case 2

Cross-Case Comparison

To begin discussion, Figure 109 shows the visualizations for cases 1 and 2 super-imposed onto each other. This shows that all competencies assessed are similar between each case. While there was evidence of prototyping occurring in case 1 there was no evidence in case 2, hence there is no data point for this competency in case 2.

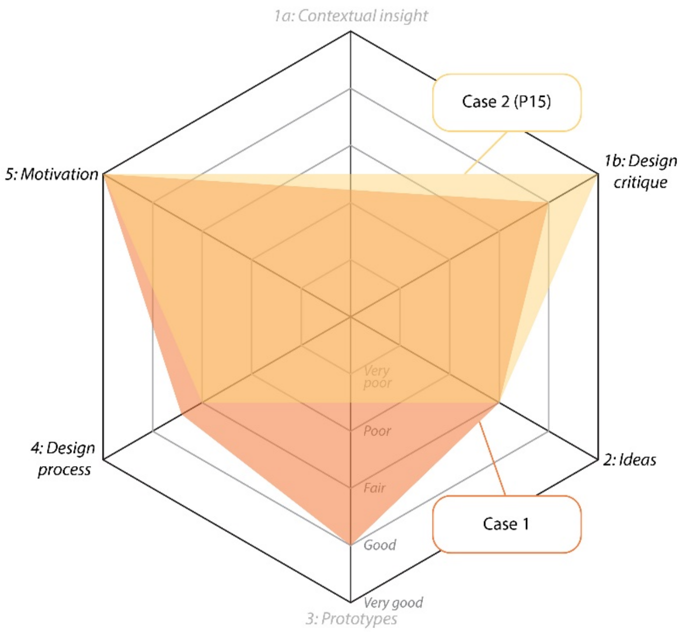


Figure 109 - Visualization of post design collaborative competencies in cases 1 and 2

6.3.5 Project 1 Collaboration Summary

In order to understand how collaboration has been effected by CCB, and developed over time, it is helpful to view the longitudinal characteristics of each competency. For succinctness, the graphs presented in Figure 110 show the combined results of the three cases. Where a drastic difference is present, the separate data points are shown. A summary graph, with all competencies super-imposed is shown in Figure 111. Note, if a data point is not available, a dotted line has been added between the closest data points.

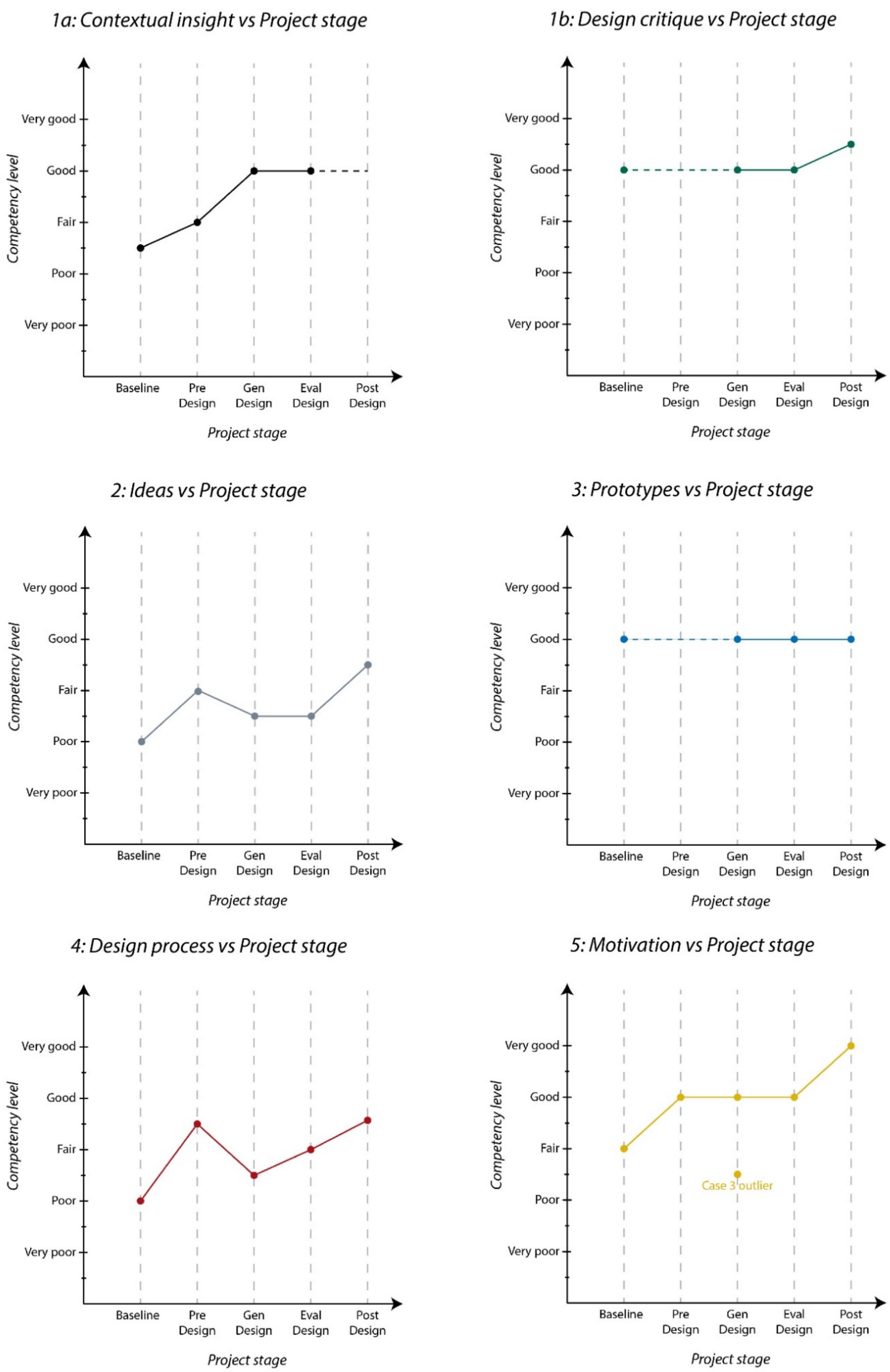


Figure 110 - Ability level vs project stage for each collaborative competency

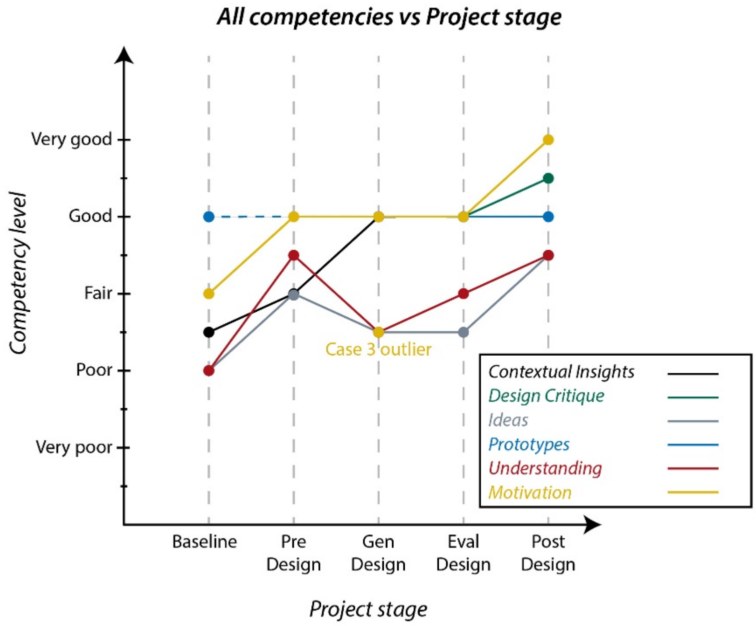


Figure 111 - Summary of all competencies vs project stage

An ability to express opinion about a project

Contextual insights was a challenging competency to facilitate early in the project. There was a slight change in the perceived strength of this competency across CCB; however, the majority of the changes occurred once the project transitioned into generative design.

Design critique was a strong competency throughout the project. Participants were much better at providing feedback on a specific item than topics that were more exploratory. This competency was even stronger at the end of the project, once the prototypes had been left with the community for several weeks.

An ability to generate insightful ideas

This competency was challenging to facilitate throughout the project. Participants, and designers, were tenacious and managed to generate ideas; however, this process was never 'free and easy' as idea generation should be. It was also a struggle to help participants generate meaningful ideas that could be used in the project.

An ability to create insightful prototypes

This competency was a strength of the participant group throughout the project. This was evident at every stage when making-style activities were used. It should be noted that heavily impaired individuals were not well included in these activities due to their functional limitations.

An understanding of the design process

This competency was poor to begin with and improve across the CCB sessions. Interestingly, the perceived ability dropped during the generative design stage, due to the ambiguous, divergent nature of the activities challenging the participants. Once this stage was complete, the competency improved as the project continued through a more logical testing and refinement process.

A motivation to contribute

This competency improved across the CCB sessions and again at the end of the project. The first improvement was linked to participants gaining a better understanding of the project, and design process used, while the latter improvement was linked to the project creating tangible, usable prototypes and a transfer of ownership to the community.

6.4 Discussion

The previous discussions have centred on the link between CCB and collaboration, using the collaborative competencies to structure discussion. However, collaboration was used as a measure for the effectiveness of the design process, and alignment with PD ideology. What is equally important to any development project is the final impact that the project generates. Research linking PD practice to project impact is limited, with Wang and Oygur (2010) highlighting that PD must focus on "*tangible, new outcomes: documentable, replicable and valid*" (p. 366) and aim to address the view that collaborative design processes still lack "*empirically demonstrable benefits in outcomes*" (p. 357). Kujala (2003) further supports this notion stating previous research, such as Wixon and Jones (1995), Ramey et al. (1996) and Dray and Karat (1994) "*state that valuable insights were gained. However, no object measurement of benefits is presented and only a few authors describe the costs incurred on the cases*"(Kujala, 2003, p. 5).

PD is a process which aims to both create technology and empower participants through collaboration during a design project (Holmlid, 2009). Massachusetts Institute of Technology (MIT) researchers describe these two outcomes as the *impact of the product* and *impact of the process* (Budzyna, 2017). The present study will use these two foci to frame the discussion in this section.

6.4.1 Impact of the Product

Firstly, the impact of the product will be discussed as the present project is grounded in the field of engineering (and product development) and aimed to create physical technology that would have a positive impact on the lives of the individuals involved in the project. The intention was to formulate projects collaboratively with the community and then design, build, test, refine and implement technology that addressed a need.

Of the three design projects initiated, two were completed. The third project (case 3 – chicken coop) ended after an important stakeholder (parent of P8) communicated they did not want the project to continue. Both case 1 and 2 resulted in refined, physical outputs, handed over to a selected participant and supported by the local NGO. However, in the period allowed, the products were not developed to a level deemed fully functional. Instead, each product worked but required further refinement to ensure long-term effectiveness. For example, in case 1, the rice seeding final product still required fine-tuning of the holes in the seed-dosing unit to ensure a reliable dispensing of seeds. The participants were aware of this and agreed to continue this development. During exit interviews, participants stated that while they had a plan in place for independent technology development, they still wanted technical support from the design team. When P12 was asked, "*If there are more of these seminars, would you like to join again?*" they responded "*Yes, I'd like to because we haven't learned all yet. We haven't seen that the tool we made is successful. The result isn't clear yet. We will continue. It's not the end yet*".

During interviews with the design team, it was clear that all designers thought the final products met the original community-led briefs. However, the lack of resource to continue to support refinement and testing was stated as a negative aspect of the project. It was agreed that some informal sessions would be set up with the small number of participants who showed continued motivation to help them refine the technical aspects of the design. This challenge is discussed by Wang et al. (2016) as they state that the ideological vision of creating all technologies in community, with local resource, is aspirational but not always practical as "*practical implementations in rural locations are very challenging*" (p. 39). The researcher agrees that if a project is focused on technology outputs, then co-construction can create a logistical barrier and slow the engineering refinement process. Given the fact that technology outputs have not reached a final, refined level, it is helpful to discuss the impact of the product in terms of the current design and the potential once refined.

Impact of the Current Product

Both case 1 and case 2 have resulted in physical, functional products being implemented into the community. Case 1 prototypes (community and D11 designs) both have strengths and weaknesses. As such, neither design individually can be deemed as fully functional. The expert design (D11) had a working dosing system but the frame was deemed too flexible to turn easily in muddy conditions (as this mechanical loading would twist the frame). The technology evaluation in Appendix E shows that many of the technical requirements were met, while some of the contextual requirements were not. Overall, this prototype will provide some helpful impact during field sowing, given it will dose seeds reliably and can be pulled in a straight line. P13 stated in the exit interview, "*Yes, it's easy because there are clear rows. I can also easily remove grass*", highlighting the current helpfulness of the product. Conversely, the community design in case 1 met most of the contextual requirements, but did not have a working seed dosing system, and so was deemed non-functional.

The case 2 prototype shows promise as a solution to mobility-impaired challenges during field preparation. Testing showed that the prototype did provide basic functionality, as a user could sit on the unit, control the ox and plough a field. However, feedback showed that many of the more subtle requirements were not yet addressed (such as the ability to stand on the unit or control the depth of the plough). These aspects could not have been fully understood by the design team until prototype testing was undertaken and so another design iteration would be needed to reach full functionality. Overall, the current design can be used for a variety of tasks, and seems likely to be integrated into the participant's daily life. The cart is essentially a small utility cart that can be attached to ox, motorbikes or pulled manually. It is also likely that the participant will use the cart for some aspects of field preparation, such as, ploughing soft ground or travelling to and from the field.

Potential Impact of a Refined Product

It is clear that with another design iteration both case 1 and case 2 can have strong impact in the lives of the participants. This is evident through the participant desire to continue to refine the designs and feedback from the designers about the importance of ensuring the products are refined. There was evidence that the rice seeder would be valuable for individuals who could not undertake the traditional transplanting process anymore. P12 stated, "*For me, I have to do it because I cannot do transplanting*".

There was also evidence that participants were already thinking of ways the products could help in areas outside of the original project briefs. For example, P14 explained they were interested in trying the rice seeder with other types of seed, stating:

> "*I also want to try with corn seed. But, I think corn seed is bigger. I also want to make bigger holes. I'll try the three types of seed. My team waits to see my sample. If it works, they want to do the same because it's easier than spreading seeds manually. Seeds can be big and small. The tool will keep the balance*"

As stated in Appendix E, both case 1 and case 2 show promise as generalizable solutions that could affect a large number of communities around the world. The design team defined the generalizability as "*Small plot farmers in rural communities in developing countries that use the same farming processes and have similar resources available locally*". Of course, commercial versions of the technology exist; however, the local construction and drastically reduced cost makes the technology in case 1 and 2 potentially very impactful.

6.4.2 Impact of the Process

A focus on the impact of the process increased throughout the project as designers observed the impact the project was having in the community. During project initiation and approval from partner organizations there was a major focus on technology development, and the impact that product could have in the community. However, by the end of the project, a more even balance between impact of product and process was evident, with much of the impact discussion focused on the process itself. It is hard to know exactly why this focus shifted but there are two likely reasons. Firstly, aligning with a PD ideology was always going to result in a project that valued product and process impact. However, given the project was initiated by an engineering-focused NGO, the initial focus naturally aligned with technology. As the project progressed, monitoring and evaluation evidence enlightened the design team, and partner organizations, about the process impact, which was included in evaluation and reporting.

Secondly, as mentioned above the project was initiated with a technology focus but as the project progressed, it became evident that the time and resources allocated to the project were insufficient for creating and refining technology to the point of a fully functional product. Therefore, the decision was made to focus on impact of process as well, as this would allow for wider impact being reported and confidence that technology refinement could be continued after the project had finished.

The former view represents an ideologically driven idea that PD has impact in many ways, regardless of initial project aims and objectives. The latter view represents a more practically driven idea that PD is difficult to use for technology development as it is slower than traditional methods and seems most relevant when impact of the process is a project aim. It seems the reason for the impact of the process becoming such a focus lies in both of these views. The impact of the process was not well articulated in the Project 1 aims and objectives, but in hindsight should have been and the realization that the product was not going to reach the intended level of refinement prompted a more even discussion of product and process during evaluation and reporting to funders.

Regardless of the above discussion, there was clear impact from involvement in this PD process. This can be categorized as either *creative capacity* or *social empowerment*.

Creative Capacity

Creative capacity is a focus of this PhD research. In particular, whether building creative capacity of the participant group (through CCB session) will improve the quality of designer-participant collaboration during a PD project. Therefore, there were two clear opportunities for CCB to occur: during CCB sessions, and during the actual PD project. Conceptually, this can be visualized as the change that occurred between baseline and pre-design (termed *step change*) and the change that occurred between pre-design and post-design (termed *longitudinal change*), respectively. See Figure 112 for an illustration of this.

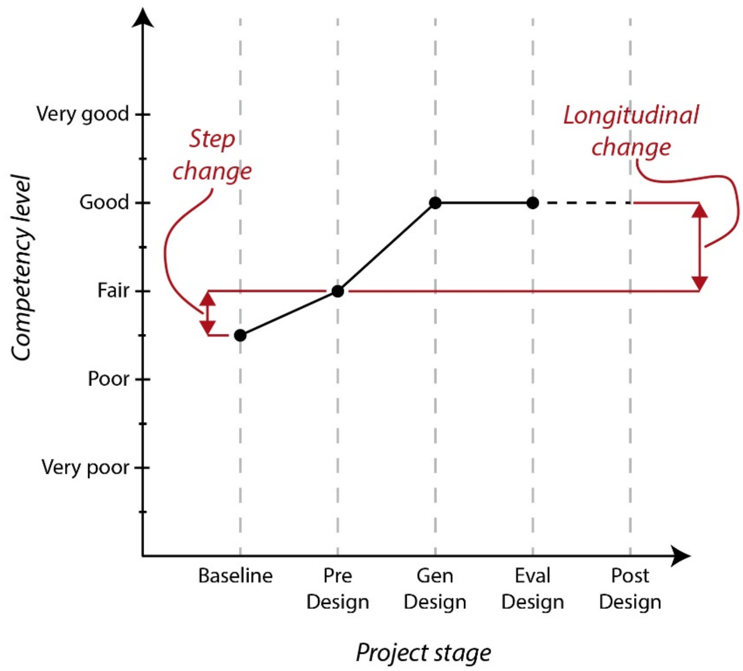


Figure 112 - Illustration of step change and longitudinal change in creative capacity

Step changes

From the analysis undertaken in this chapter, it is clear that there was a step change improvement in *contextual insights*, *ideas*, *design process* and *motivation*. However, when also including the generative design stage in this discussion the competencies *ideas* and *design process* show a decrease in perceived competence. This is most likely due to the perceived competency being enhanced during CCB, due to the simplicity of activities and required outputs. Therefore, once the real-world project was initiated, the complexity and ambiguity of the activities resulted in designers perceiving the competency lower than previously. Considering this, there was still a step change in *contextual insights*, and *motivation* across the CCB sessions.

The improvement of *contextual insights* was due to three different factors. Firstly, the CCB sessions offered an opportunity for team building to occur. This allowed relationships to develop between fellow participants and the design team. As discussed in this chapter, the strength of relationship had a positive impact on a participant's confidence and willingness to provide input. Secondly, the CCB sessions provided several small design projects, which taught the participants what exactly was expected from them during the project, and allowed them to practice this in a low-risk environment. This communication of expectations was important as all participants stated they had never been involved in a design project with an organization before, and few had been involved in any type of project with an organization. This meant that the CCB sessions played a role in ensuring participants realized that they were expected to speak their mind, and provide honest input throughout the project. Given the collectivistic nature of Cambodian society, this should not be taken for granted.

Finally, the CCB sessions may have improved the participants' understanding of the design process, evident by the step change in the *design process* competency. By gaining a better holistic understanding of the design steps and the end goal of the project, participants may have been more able to comprehend exactly what kind of input was valuable to the project. For example, in the calendars activity, participants focused their input around agricultural practices, as they knew that the final output of the project was to be focused on PwD and agriculture. The improvement of the *motivation* competency was also linked to the three points discussed above. Participant *motivation* was likely enhanced during CCB sessions through developing relationships with other participants (and in turn building empathy for others), understanding project expectations (and therefore realizing the leading role they played in the project) and understanding the design process (and in particular the value the process has in the current, and future, projects). The value of CCB is discussed in Chapter 7.

Longitudinal changes

From the analysis undertaken in this chapter, it is clear that there was a longitudinal change improvement in *contextual insights*, *design critique* and *motivation.* The *prototypes* competency did not seem to improve; however, this was already deemed a strength of the group during the baseline assessment. It was predicted that a participant's collaborative competency would improve across the project, as PD research has shown that involvement in PD has an empowering effect. In fact, PD was originally developed for this exact reason (Gregory, 2003; Hussain & Sanders, 2012; Budzyna, 2017). What was surprising was the relatively small improvement in *ideas* and *design process*.

Firstly, *ideas* did improve from *poor* to *fair*-to-*good* across CCB and the PD project. However, it remained the most challenging practical aspect of the project as the design team struggled to facilitate community-led idea generation. In most generative design activities, designers were faced with a trade-off between pushing the participants to ideate themselves (often resulting in slow, less engaging sessions) or suggesting ideas themselves (potentially biasing the direction of the project). This trade-off was managed as well as possible by the design team, but did stem from a lack of perceived creativity. D4 stated during an interview, after Workshop 3:

> "*I noticed even that through the precedent exercise that the existing solutions, the participants had never seen anything like it before. So, in the precedent exercise it seemed to me that the*

ideas were still new ideas to them so it might have been difficult to generate new ideas, because they thought they had new ideas in front of them"

This statement suggests that one barrier to creativity was a lack of knowledge about what already exists, and what was possible. This is a common challenge in radical innovation and has been the subject of much research. For example, Heiskanen et al. (2007) summarize the sentiment of many product developers stating "*The usefulness of involving consumers in product development is often questioned in the context of radical innovation because customers do not know what their requirements are for products that require different behaviour patterns or that open up new applications*" (p. 491). Similarly, Diederiks and Hoonhout (2007) suggest "*The initial steps in this process should be made with an open eye for the needs of the consumer, but it might not be practical or even necessary to actually involve them 'in person' as a co-designer in this stage*" (p. 32). This contrasts the view presented by Hussain and Sanders (2012) who lists one of their guiding principles as "*All people are creative. But they are not often invited to take part in creative activities so they may need some preparation and support*" (p. 53). The present project was not exclusively interested in radical innovation, which may be desired for commercial product development. Instead, the present project was interested in developing the most effective and appropriate solution for this particular community. This intention could have led to either radical, new-to-the-world innovation, or more likely, the modification of an existing technology to fit its new context. This research suggests that any expectation of radical innovation during HTD-using-PD is naïve, and that a project should be structured to help participants through generative design by ensuring they are aware of existing solutions, and leveraging these designs to create the most appropriate incremental improvement. This may also improve the efficiency of the PD process. Secondly, the *design process* competency had mixed results. The participants' practical understanding of the design process seemed to improve throughout the project. Examples of this include the independent design of a rice seeder prototype and planning for independent testing and iteration. However, their conceptual understanding of the design process showed limited improvement. Few participants showed evidence of a holistic understanding of the design process or the ability to remember all of the steps. However, as discussed in the case 2 evaluative design analysis, participant understanding did seem to improve from a basic linear process to one involving aspects of continuous improvement (Figure 113).

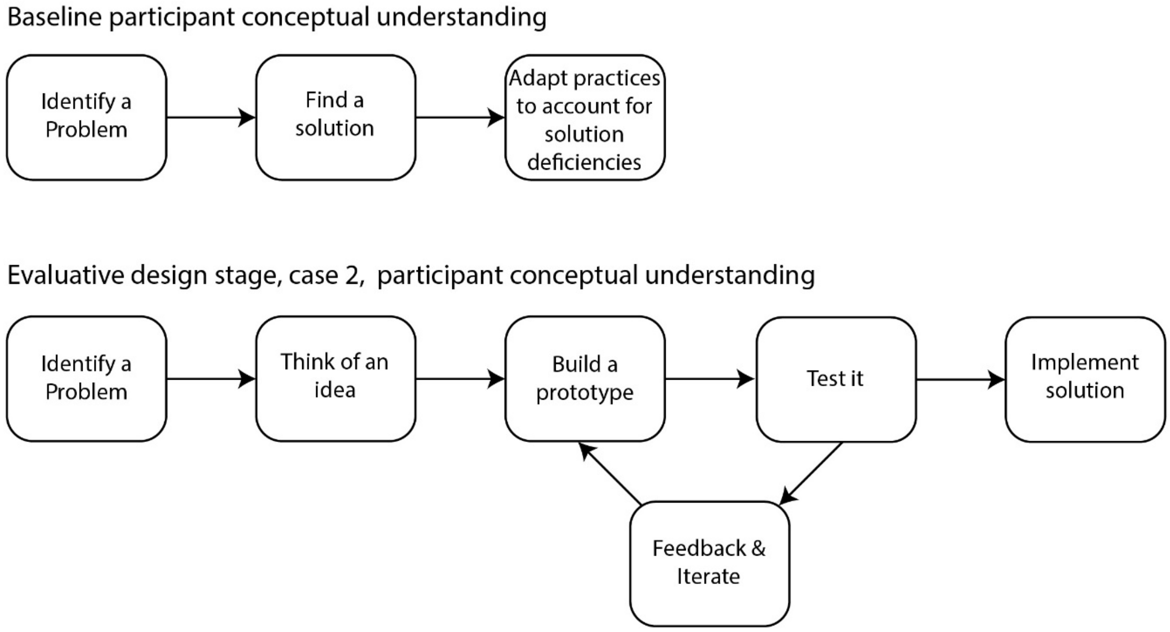


Figure 113 - Change in conceptual understanding across the PD project

Social Empowerment

The second area for process impact was social empowerment. This can be defined in many ways, a good overview is provided by Steiner and Farmer (2017) who state, "*Broadly, empowerment relates to strengthening principles of inclusiveness, transparency and accountability, democracy and development*" (p. 4). The present study views social empowerment as "*a process through which individuals or organised groups increase their power and autonomy to achieve certain outcomes they need and desire*" (Combaz & Mcloughlin, 2014, p. 4). It also views social empowerment in terms of disability inclusion in everyday community life. This means striving to ensure environmental factors (physical, social and attitudinal) and personal factors (gender, age, social background, education, experience, etc.) do not restrict an individual's ability to participate in a chosen activity (WHO, 2002).

There was evidence of social empowerment and improved inclusion of PwD. This came through providing a platform for PwD to voice opinion as well as a focus on building empathy between participants. This was evident through comments from PwD and carers, interviews with designers and researcher observations. An example of this was the impairment-empathy game *Marco-Polo,* presented in Section 6.3.3 Case 3 (Figure 94). The purpose of the game is to demonstrate the challenges of vision-impairment and to display how skilled our vision-impaired participants were at navigation. While not technology-focused, our local partner organisation viewed this outcome as just as valuable as it improved the likelihood of social inclusion for involved PwD. This, in turn, would improve their access to agricultural practices. We argue that the context in which the game was played (during a PD project) was also important as it created a sense of importance and relevance that would not have been presented in a standalone activity. Of course, there were also times when PwD were not well included in activities, or when the general participant ground showed a lack of empathy. For example, generative design and evaluative design in case 3 seemed to stall because the majority of participants did not seem to empathize with the challenges of P8.

Overall, Project 1 had 76 coding occurrences of *PwD inclusion* and 49 occurrences of *PwD exclusion*. This showed that the project did well to include its participants, but the there is clearly more that can be done to ensure inclusion in future projects. It is important to remember the socio-cultural environment in which this project is situated (and the embedded challenges of PwD inclusion). Another aspect of social empowerment is enjoyment, as this directly links to the participants' perceptions of the activities and engagement with others. This is discussed in the following section.

6.5 Research Findings

The analysis in this chapter has led to the identification of many research findings. Some of these are directly related to the focus of this PhD (CCB and collaboration) while others are related to the more general elements of PD. This section introduces all of the minor research findings deemed valuable from Project 1. The key findings are discussed in detail in Chapter 7, with a focus on the research questions posed in Chapter 3.

6.5.1 Minor Findings

PD Involvement is Enjoyable for PwD in Rural Cambodia

Multiple data sources suggest participants had high levels of enjoyment throughout the project. These include participant interviews, during and after the project, designer interviews and anonymous workshop feedback. To begin, Table 54 shows text units from the participant exit interviews. This shows that participants enjoyed the project and were interested in being involved again.

Table 54 - Enjoyment text units from participant exit interviews

Code	Text Unit
P7	Interviewer: *Do you think we have any weaknesses that you want to suggest me should adjust? Regarding the seminars, their teaching, their attentiveness, and materials* P7: *No, I don't think there is any weakness. I am totally satisfied*
P9	*No, I don't. I don't have any things I don't satisfied or like. I completely satisfy*
P12	*I don't have anything I do not like about the seminars* Interviewer: *How did you feel when you joined the seminar? Were you happy or unsatisfied?* P12: *I have said that I am happy and satisfied because making such tool is what I have wanted long ago*
P13	Interviewer: *How did you feel when you participated in the seminars?* P13: *I feel that it's modern and very good*

Next, Table 55 shows designer interview responses that highlight the enjoyment of both participants and designers.

Table 55 - Enjoyment text units from facilitator interviews

Code	Text Unit
D1	*They said that they'd never joined that kind of workshop before and that the first time they see that kind of workshop and they very happy and they really want to be involved in them… …They said, never have the people come and ask them about the things that they do, what kind of thing that they plan or something like that. They said they happy that someone come and ask them and they were like trying to find the problem for them like that*
D2	*Yes, I ask the blind guy [P8]. He cannot see, I ask him, why you come here? He said that DPO called him to come here. I asked him are you happy to come here, are you enjoying to come here and he said, 'yes.' Because he can hear many people, every voice and many noises so he can imagine that it's really fun. So he can hear, he can talk and he can play game, and he never played game before*
D3	Workshop 2 - For *the second day [Workshop 2 Day 2], people feel very happy with the activity especially prototyping before we finish they feel enjoy that, they feel like, after that I ask them, 'how do you feel?' They said, 'feel very good,' they feel very different or they feel very happy with our workshop because they said they never joined that kind of workshop like that* Workshop 3 - *After the workshop, they feel confident, they feel enjoyed with that, they look happy, they try to do the best that they can do*
D8	*Yeah I was feeling great to be part of this and also like to see how excited people are to be like in this thing and also get to learn some building things*

Finally, the anonymous workshop feedback can be examined. This was collected at the end of each workshop day by giving each participant a piece of macaroni and asking them to place it in the jar that corresponded to how they felt about the workshop (Figure 114). The design team left the room to allow for participants to place the macaroni anonymously. The results of this feedback are shown in Table 56.

Figure 114 - Anonymous workshop feedback jars

Table 56 - Anonymous workshop feedback from Project 1

	Workshop 1		**Workshop 2**		**Workshop 3**		**Workshop 4**		
	Day 1	Day 2	Day 1	Day 2	Day 1	Day 2	Day 1	Day 2	**TOTAL**
Very happy	24	22	33	42	37	43	33	35	**269**
Happy	6	20	0	1	2	2	5	2	**38**
Normal	4	0	0	0	0	1	0	2	**7**
Unhappy	1	0	0	0	1	0	1	0	**3**
Very unhappy	1	0	0	0	4	0	0	0	**5**

Overall, the feedback shows participants were either *very happy* or *happy* throughout the project. The high level of participant enjoyment was viewed as a very positive aspect of the project. This was because previous research has been critical of participants being involved, against their choice, for the sake of ideological alignment (Winschiers-Theophilus et al., 2010) and participant enjoyment for PwD is in its own right a good outcome for a disability focused project.

PD Involvement has an Empowering Effect on Involved Participants

If the role of CCB is removed from discussion, there is still evidence that participant involvement in the general PD project (pre-design to post-design) has an empowering effect on the individuals. This is discussed in detail in Section 7.4.4. Of importance were two findings. Firstly, all collaborative competencies either improved (*opinions*, *design critique* and *motivation*) or stayed the same (*ideas*, *prototypes* and *design process*). Therefore, the participant group ended the PD project with a stronger creative capacity than when they began the project.

Secondly, there was some evidence of social empowerment, evident through observations of opportunity (such as engaging in activities and games) and through interviews with participants and designers. There were also moments where PwD were not well included in activities; this showed that the process used by the present researcher did not overcome the functional and socio-cultural limitations expected. Furthermore, there was little focus on collecting social empowerment evidence during data collection. This means conclusions about social empowerment are less detailed than those focused on collaboration, creative capacity or technology. However, participants grew in confidence across the project and enjoyed their involvement in the project.

These findings align with the view of most of the research field, that PD involvement has an empowering effect (Puri et al., 2004). The present researcher also supports the need for a new way of evaluating the social impact of PD project that is "*tangible, new outcomes: documentable, replicable and valid*" (Wang & Oygur, 2010, p. 366) and aims to address the view that collaborative design processes still lack "*empirically demonstrable benefits in outcomes*" (p. 357).

6.6 Chapter Summary

In summary, analysis of Project 1 has resulted in the identification of many PD enablers and barriers and insights into the role of CCB in the PD process. Several key findings have emerged from this work; these are discussed in Chapter 7.

6.6.1 Richness of Case Information

Overall, the cases discussed in Chapter 5 and Chapter 6 contain large amounts of detail. The present researcher's role as an observer and participant (researcher and designer) has added an important layer of understanding to this analysis. Furthermore, unlike the majority of research in the PD field, the present research has sought out the perceptions of all other stakeholders involved in the project (end-users, carers, community representatives and designers). This has provided insight that would not have been available otherwise.

While research findings based on one socio-cultural environment and one project will always be open to criticism, this project has investigated three cases in such a level of detail that socio-cultural nuances, as well as inter-personal, technological and creative influences are well understood.

CHAPTER SEVEN

KEY FINDINGS

CHAPTER OVERVIEW

This chapter presents the findings of Project 1 that relate to the research questions (RQ) of this doctoral research. For clarity, the RQ's being investigated are:

1. How are individuals from underserved communities currently involved in HTD-using-PD?
2. What are the key competencies required to enable individuals from underserved communities to participate effectively in HTD-using-PD?
3. How can CCB be utilized to build the required competencies in participants?
4. Does the implementation of CCB enhance the quality of collaboration between designers and participants during HTD-using-PD?

The chapter is structured around the four RQ's and presents supporting evidence, sub-themes and research outputs (models, frameworks, and guidelines). The findings are discussed in relation to existing literature with agreement and disagreement clearly discussed.

7.1 Research Question 1

How are individuals from underserved communities currently involved in HTD-using-PD?

7.1.1 Key Evidence

Evidence for RQ1 came from the extensive literature review undertaken throughout this project. While the present researcher aimed to align with PD ideology, a review of several collaborative design approaches was undertaken, such as co-design, human-centred design and appropriate technology, as this added practical value to understanding the role of the community member in collaboration (Murcott, 2007; Sianipar et al., 2013; Ferguson & Candy, 2014; IDEO, 2015). Of most importance to this RQ are works of Winschiers-Theophilus et al. (2010), Hussain (2011), Sanders and Stappers (2014) Mazzurco (2016) and Smith (2017). The first two studies report on individual cases where PD has been used in developing countries, while the last three provide a wider focus on a range of projects, tools, techniques and collaborative styles.

To answer RQ1, three findings are presented.

7.1.2 Finding 1: There are Three Types of Collaboration used in HTD-using-PD

To understand how community members are involved in HTD-using-PD, the participation spectrum needs to be understood. Smith (2017) provides the clearest presentation of this, stating there are three different types of collaboration possible, *design for*, *design with* and *design by*. This is also explored in detail by Kaulio (1998). These types of collaboration are described below:

Design for (also known as human-centred design) – Process is led by professional designers who research user requirements, design solutions and verify their designs with community members.

Design with (also known as co-design) - A collaborative process in which professional designers and representative community members work together to design, prototype and testing potential solutions.

Design by (also known as user-generated design) - The process in which representative community members feel empowered and supported enough to design solutions for their own problems and utilize professional designers as supporting actors for technical development.

Smith (2017) states that each collaborative formation has its own benefits and should be selected based on the project type, aims and objectives of the project and resources available. Conversely, Hussain (2010) stated that *design by* should be the ideological goal of HTD-using-PD and presented a three-level participation ladder involving *included*, *consulted* and *empowered* levels. These levels were used to evaluate how well the participant had participated in the collaboration.

The present researcher suggests that the work of both Smith (2017) and Hussain (2010) is valuable to RQ1. Smith presents the three different types of collaboration to choose from while Hussain presents an effective way of evaluating whether the collaboration did indeed reach the desired level.

7.1.3 Finding 2: There are Two Types of Project Undertaken using a HTD-using-PD Approach

There are two different types of PD project present in literature: technology-focused and empowerment-focused. The two foci are explained below.

Technology-Focused

There are projects that focus on using PD to design and implement technology. These projects prioritize the creation of physical outputs that either add immediate value to the community or can be refined and implemented later. Several documented IT projects are technology focused as they work with participants to create cardboard mock-ups of computer program interfaces, which are later developed by software engineers (Kam et al., 2006; Molapo & Marsden, 2013). The community are not involved in the development or implementation of the software and in some stages, the output may not even find its way back to the involved community members.

Empowerment-Focused

There are projects that focus on using PD to empower the involved community members. These projects prioritize inclusion and opportunities for social empowerment and technical learning above technology progress and utilize the PD process as a tool for community development. In this type of project, decision-making is driven by the desire to include community members in every aspect of the project and transfer ownership of the project, and solution, to the community as early as possible.

In practice, these two foci represent a spectrum, not a dichotomy, with projects having varying degrees of importance placed on technology and empowerment objectives. This spectrum is used to investigate the current state of HTD-using-PD projects in the next section.

7.1.4 Finding 3: Recent HTD-using-PD Projects

Utilizing the three collaboration types and two project types, current projects can now be categorized. This is shown in Table 57.

Table 57 - Categorization of HTD-using-PD projects

No.	Reference	Design for	Design with	Design by	Technology - focus	Empowerment - focus
1	(Haggar et al., 2001)	x	x		x	
2	(Puri et al., 2004) - Case 1: South Africa	x	x		x	
3	(Puri et al., 2004) - Case 2: India	x	x		x	
4	(Puri et al., 2004) - Case 3: Mozambique		x		x	x
5	(Kam et al., 2006)		x		x	x
6	(Murcott, 2007)	x	x		x	
7	(Winschiers-Theophilus et al., 2010)		x	x	x	x
8	(Hussain et al., 2012)		x		x	x
9	(Molapo & Marsden, 2013)		x		x	
10	(Godjo et al., 2015)	x	x		x	
11	Present research		x	x	x	x

This table can also be viewed as a cluster diagram showing the type of collaboration on one axis and the type of project on the other. This is shown in Figure 115.

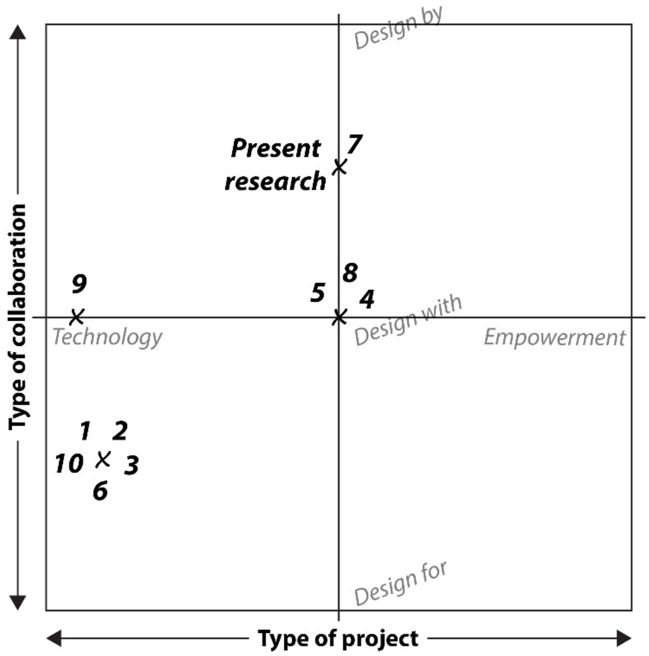


Figure 115 - Cluster diagram of type of collaboration vs type of project

From these figures, two clusters of projects emerge. Firstly, there are projects that focus solely on using a PD approach to generate technology. This focus leads the designers to transition between a more traditional *design for* approach and a more collaborative *design with* approach. Secondly, there are projects that aim to balance technology and empowerment outcomes while also striving to work collaboratively using a *design with* approach. As would be expected, all projects have some technology focus (given the scope of present research) and all projects that have empowerment outcomes utilize a *design with* or *design by* collaborative approach. Now that the focus of each project has been discussed it is important to discuss the challenges faced during PD projects as this represents the current state of HTD-using-PD.

Challenges Faced in HTD-using-PD

Finally, it is helpful to understand the current challenges being faced in the implementation of HTD-using-PD projects. This topic is discussed in detail in Section 2.3.4, Table 3 summarizes the important findings. The present study aimed to reduce the impact of challenges related to participants' having limited design experience.

7.1.5 Summary

In summary, the present research has answered RQ1 by identifying three important descriptive themes*, type of collaboration*, *type of project*, and the *challenges faced*. Through discussing each of these themes, an overview of the current ways community members are involved in HTD-using-PD has been presented.

7.2 Research Question 2

What are the key competencies required to enable individuals from underserved communities to participate effectively in HTD-using-PD?

7.2.1 Key Evidence

Evidence for RQ2 came from a systematic literature review of current PD, collaboration and creative capacity (see Chapter 2). The review identified enablers and barriers to meaningful participation, required knowledge for engaging in design activities and other factors that may influence the collaborative environment. Important to this discussion are the works of Christiaans (1992), Fischer and Ostwald (2002), Byrne and Sahay (2007), Diehl (2010) and Hussain (2011). From this review, a set of collaborative competencies were developed. These were used to guide analysis of Project 1 and have been refined based on findings from this study.

The answer to RQ2 is presented in the form of the refined collaborative competencies. However, participation, and collaboration, is not solely linked to the capacity of the participant. Many factors can influence this interaction and result in different levels of collaboration. To communicate the different factors at play, a new conceptual model is presented.

7.2.2 Finding 1: Collaborative Competencies

Initial development from extant literature

From a systematic literature review, five collaborative competencies were developed. These were:

1. Ability to express opinion about the project
2. Ability to generate insightful ideas
3. Ability to create insightful prototypes
4. Understanding of the design process
5. Motivation to contribute over an extended period of time

The competencies were developed as an attempt to define what competencies an *empowered* participant might possess. This was driven by research into participation ladders (Druin, 2002; Hussain, 2010), design knowledge (Christiaans, 1992; Diehl, 2010) and *ideal* participants (Von Hippel, 1986; Fischer & Ostwald, 2002). Finally, studies which discussed enablers and barriers to effective participation or collaboration where reviewed, with common enabling factors synthesised (see Chapter 2). To explain what each level of the above competencies may look like, a description matrix was developed. This is shown in Table 37.

Changes to Collaborative Competencies from Field Research

From data analysis and discussion of Project 1 (see Chapter 5 and 6) only one of the competencies required changing. The *opinions* competency and its required changes are discussed below.

An ability to express opinions

Throughout Project 1, there was clear evidence that *an ability to express opinion* was a key competency required to contribute to a project. However, when evaluating an activity with this competency, it was found that there were two sub-themes that more accurately described the collaboration occurring. Furthermore, the two sub-themes were often present in different ways and so reflection on the higher-level competency did not accurately describe the situation. The two sub-themes are *an ability to express contextual insights* and *an ability to express design critique*. The need for the two sub-themes is well articulated when viewing the frequency-coding matrix, shown in Table 58. It can be seen that focusing on either *contextual insights* or *design critique* can result in drastically different outcomes.

Table 58 - *Opinion* sub-themes vs description coding from CCB sessions

	Very poor	Poor	Fair	Good	Very Good
1: Opinion	0	9	4	11	1
1a : Contextual insight	0	3	1	2	0
1b : Design critique	0	1	1	8	0

An ability to express contextual insights

This sub-theme describes the ability of an individual to share knowledge about their socio-cultural, geographical environment as well as knowledge about their own personal circumstances. This knowledge could be related to general community information or focused on a particular challenge that they face. The important characteristic of this theme is that it relates to the sharing of exploratory information.

An ability to express design critique

This sub-theme describes the ability to provide feedback about a specific design concept. This concept could be in the form of a spoken idea, drawing, model, prototype, or any other form that communicates an idea. The important characteristic of this theme is that the opinion given is centred on a particular design concept, and is therefore very guided and focused.

The present researcher acknowledges that the collaborative competencies lack consideration of a participant's technical knowledge and therefore are focused on *design for,* and *design with,* collaborations, and not *design by*. This is discussion below.

Technical Knowledge

The above collaborative competencies focus on the understanding of design concepts, the ability to undertake the tasks required during PD projects and the motivation to be involved in a specific project. These are the important competencies for collaboration in PD, i.e. designing *with* an expert designer. However, given much of PD literature discusses the role of PD as a pathway to empowerment and independent design, the role of technical knowledge is important to discuss. For clarity, the present researcher aligns with the knowledge and design activity model, developed by Christiaans (1992), shown in Figure 12. When related to this model, the collaborative competencies focus on the participant's ability to contribute *basic knowledge* (general community, socio-cultural, problem-domain knowledge, etc.) and have enough *process knowledge* (understanding about the design process, rationale for activities, expected outputs at each stage, etc.) to be able to complete the required activities effectively. The competencies do not include a focus on *design knowledge* (technical knowledge relevant to the engineering requirements of the project); apart from the implied knowledge needed to create prototypes. As briefly discussed in RQ1, many PD projects do not require participants to contribute design knowledge, as this will be provided by the expert designer. This approach is effective when utilizing a *design for* or *design with* collaboration, but creates a barrier to true *design by* outcomes.

There was evidence in Project 1, that a lack of technical knowledge was a barrier to long-term *design by* status. During exit interviews for case 1 and case 2 there was evidence that all collaborative competencies were present at *good* levels; however, participants stated that they still required designer support to refine the technical aspects of their prototypes. Text units illustrating this point are shown in Table 59. The present researcher argues that projects that aim for *design by* status need to invest time into developing participants' technical ability (in domain-specific areas) as well as their creative capacity. Without this focus, projects should aim for *design with* status, and ensure expert designers are available for long-term design support. Interestingly, many researchers support the view that the ideal collaborative relationship for effective PD is *design with* (Wang & Oygur, 2010).

To understand all of the factors at play in collaboration during PD projects a new conceptual model is presented in the next section.

Table 59 - Text units for RQ2 - Technical skills theme

Case/stage	Technical Skills – Text Unit Examples
Case 1	“*For the female one, they never do, they never do such and not the job like that*” (D9, Post-design) “*I think they need extra building skill, more like they can try and build it themselves… …sometimes they need some more skill and some proper tool*” (D8, Post-design) “*I only know how to use the tool. But the ideas of making the rice seeding tool are from them. So, they help with technical ideas. I only have force and some materials*” (P12, Exit Interview)” “*If there is anything inappropriate, I would like the staff to correct us. I am happy to continue working on it*” (P14, Exit Interview)
Case 2	“*Some work that they do, the activities like, drilling hole or cutting steel to attach with the cart or something, like that quite difficult to them. Because as we know, most of them, they no skill or they never do it like this job before so that a bit hard to teach them*” (D3, Post-design) “*I don’t have any strategies to design the product myself. I only have the design like the sample*” (P15, Exit Interview) “*I’d like to have one more strategy about the design. Another design of another type of cart. The cart that we can sit on without having it clamped on our thighs*” (P15, Exit Interview)

7.2.3 Finding 2: Participatory Design Collaboration Model

The new Participatory Design Collaboration (PDC) Model is presented in Figure 116. The model aims to describe the components that make up a collaborative partnership, between designer and participant, during a PD project. It does this by identifying that both the designer and participant have knowledge that is valuable to the collaboration and that this knowledge is contributed through different mechanisms. It then looks to place this collaboration in both the wider cultural and societal environment as well as the controlled design environment in which the project takes place. The model draws inspiration from the traditional collaboration model (Sanders & Stappers, 2008), the knowledge transfer conceptual model (Diehl, 2010), the hermeneutics-orientated design model (Hussain & Sanders, 2012) and the concept of *designer space* and *user space* presented by Godjo et al. (2015). It also utilizes the extensive review of PD projects undertaken by Halskov and Hansen (2015), which highlights politics, users, activities, context and product as fundamental aspects of PD and uses these terms to analyse a range of research presented between 2002 and 2012.

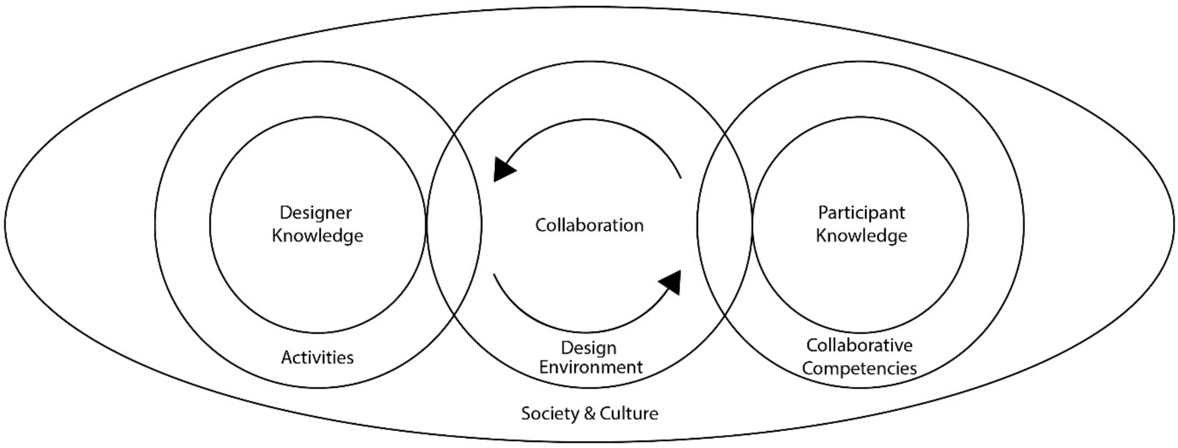


Figure 116 - Participatory Design Collaboration Model

The Value of the PDC Model to the Present Research

The present researcher has included this conceptual model in the doctoral research as it shows the most influential factors in collaboration during a PD project. This is important as it demonstrates that the researcher is explicitly aware of these factors, and their potential effects. This means that discussion around CCB and its link to collaboration and project impact can be undertaken in a more meaningful way, as other influences have been identified and understood.

The Value of the PDC Model to the Research Field

The PDC Model aims to provide a holistic view of the designer-participant interaction in the PD process. Firstly, it proposes that the collaborative relationship, termed *two-way learning* in some literature (Fischer & Ostwald, 2002), must be considered with respect to the society and culture in which it occurs. It proposes a secondary level of environmental influence caused by the design environment planned and facilitated by the designer. This will be elaborated on in the next section but essentially can be used to categorize the many comments in literature pertaining to the importance of creating a supportive and encouraging atmosphere for interaction (Brandt, 2006; Frauenberger et al., 2011).

The second function of this model is to show how planned activities, as well as specific participant's collaborative competency, act as important conduits for transferring knowledge from the participant to the final design solution; either directly from participant design or through the designer. It shows that effective PD collaboration is a product of the activities a designer uses, the participant's capacity to participate and the environments in which the collaboration takes place (both the controlled design environment and the wider society).

The next section will explain each of the system components in detail and look to align these with existing research for clarity.

Society & Culture

Operational definition

The present research aligns with the definition presented by Eade (1997) that the society and culture refers to the socio-cultural profile of the participants, influenced by the region, country, local area, age and gender. Other socio-cultural variables include inter-personal customs, ethnic/race/caste classifications, language, religion, specific territorial claims and historical conflicts.

Literature

The need for societal and cultural consideration has been clearly articulated as being crucial during project planning (Haggar et al., 2001), the development of design tools (Brandt, 2006), design collaboration (Kam et al., 2006) and the analysis of findings (Winschiers, 2006). The inclusion of this component into the PDC Model aligns with the hermeneutics-oriented design paradigm discussed previously and should be viewed as a component unique to each project. Its effects will be based on the specific country, community, product type, project plan and the cultural and societal values directly related to the design context. Cultural power structures, or more specifically a lack of consideration for them, are highlighted time and time again as a barrier for PD collaboration with marginalized individuals, as well as a barrier for end-users and other local stakeholders interacting in a meaningful way (Puri et al., 2004; Winschiers, 2006; Moraveji et al., 2007). Furthermore this component is well supported in wider international development literature (Eade, 1997).

Field research

Analysis of Project 1 yielded 96 occurrences of the code *socio-cultural dynamics*. This included sub-themes such as *age, gender, local power structure, religion, saving face mentality* and *shyness*. Examples of text units are shown in Table 61.

Design Environment

Operational definition

The inclusion of an explicit design environment component draws from the work of Godjo et al. (2015) who highlight the importance of identifying *designer space* (where the design team meet, work, model and prototype) and *user space* (where the user performs the real-world activities of relevance to the project). The term design environment is unique to this new model and focuses on the location where the participant and designer collaborate. This may well be in the designer space or user space but could also be in a separate predefined community meeting area. The introduction of this term allows for planned interactions (meetings, workshops, observations, etc.) to be viewed as being not only influenced by the wider society but also as a factor influencing the collaborative process. The present researcher argues that by taking this interpretivist view the effectiveness of PD activities (such as brainstorming for example) can be analysed not only as a standalone interaction, or an interaction in a wider society, but also as a function of the environment designed and facilitated specifically for the project.

Literature

Logistical considerations such as the location of meetings, the time of meetings, length of interactions, size of groups, and involvement of local facilitation staff are factors to consider when developing the design environment of the PD project (Grudin, 1991; Demirbilek & Demirkan, 2004). Several studies have highlighted logistical and environmental factors as barriers for meaningful collaboration (Leahy, 2013), with Kam et al. (2006) even highlighting the trade-off between long, valuable design sessions and the ability to recruit and retain participants in the project. The idea of a *positive social environment* is present in capacity building literature (Liberato et al., 2011) as a key factor for supporting community involvement and action. Finally, Fischer (2004) provides a well-articulated view of the importance of the design environment stating,

"*Much human creativity arises from activities that take place in a context in which interaction (distributed over space, time, and with other people) and the artefacts that embody group knowledge are important contributors to the process*" (p. 152)

Field research

The most obvious occurrence of the design environment influencing the quality of collaboration was during Workshop 3, where the project venue was shifted from the community pagoda to the local school (see Section 5.5). This change meant that many of the participants had to sit on chairs, and not on the ground as desired. The result of this is described by D11 stating,

> "*Venue has been changed from the pagoda to the school as the religious festival of Pchum Ben [religious ceremony] is running in the pagoda for the first two weeks in September. The school venue is small and hot, this may make it challenging to engage all participants throughout the day*".

Examples of text units are shown in Table 61.

Designer and Participant Knowledge

Operational definition

For this description it is valuable reflect on the components of knowledge, as defined by Christiaans (1992) as well as the concept of *pre-understanding*, as defined by Gadamer (1975). Firstly, as discussed in RQ2, there are three components of knowledge required for effective design; *process knowledge, design knowledge* and *basic knowledge*. These three components need to be present in the designer for them to have the ability to lead, or facilitate, design activities with a participant. While the designer may not possess all aspects of *basic knowledge* (such as socio-cultural and local knowledge), a level of experience in the specific context, and ability to identify areas of knowledge gaps is important. Furthermore, the participant should also have valuable knowledge to contribute to a project. This may not be the same *design knowledge* that a designer contributes, but should be valuable *basic knowledge* (such as socio-cultural and local knowledge). Secondly, *preunderstanding* is recognized as an important factor to the gathering and interpretation of findings, and will influence a designer's internal processing of information and their ability to respond to the needs of the participants. A participant's preunderstanding will also influence the way they interact during the collaboration. For example, previous educational, organisational or creative experience may enhance the way they interact, or result in a participant shying away from collaboration. Preunderstanding is essentially the internal, unavoidable condition for understanding, based on all the experiences an individual has had (Hussain & Sanders, 2012).

Literature

Many studies that have focused on the role of designer and participant knowledge. In some cases highlighting a lack of designer contextual knowledge as the reason for product failure (Radjou &

Prabhu, 2012; Hall et al., 2014). Past research also highlights a lack of inherent understanding of the specific community, such as understanding the importance of affinity, desirability, usability and affordability (Nakata & Weidner, 2012; Whitehead et al., 2016; Mazzurco, 2016). In fact, this particular aspect (designers not having enough *basic knowledge* about the context) has resulted in the development of design processes (Sianipar et al., 2013) and the adoption of PD processes into a wider range of engineering projects. The role of *design knowledge* in developing countries has also been explored in depth in doctoral theses by Diehl (2010) and Hussain (2011).

Field research

There were many examples of both designer and participant knowledge influencing the collaboration. Firstly, the experience and ability of the designer to engage the participants was identified as an important factor in collaboration. During coding, facilitation-themed codes were coded 390 times, with *active facilitation* coded 142 times. This included sub-codes such as *encouragement*, *providing examples, female-inclusion, focusing discussion, link with previous experience* and *probing*. It was clear that the facilitator's ability to encourage and include participants in an activity directly linked to the quality of the collaboration. Furthermore, as relationships developed between designers and participants, collaborative competencies, such as *contextual insight* and *ideas* seemed to improve. For example, D2 stated after Workshop 2, "*I feel the participants, they feel very closely to us and our teams, and they feel confident. But for the first time, they are a bit silent after, we explain more, they can understand*".

Secondly, it was important that the designers had a strong understanding of the design process, as this directly affected the understanding of the participants in their team. Given the design team was made up of both Western and Khmer experts from fields such as engineering, disability inclusion, architecture and community engagement, it was not assumed all designers had a detailed understanding of the design process. Instead, pre-workshop training was undertaken, as well as the creation of a handbook. Even so, there were times during the project when some designers seemed to misunderstand the design process, and intended outcomes. For example, in Workshop 2 case 1, D5 moved quickly through pre-design and generative design activities resulting in the team deciding on one particular design quite early in the process. During day 2 of Workshop 2 the present researcher asked each of the facilitators where they thought we were up to in the design process, noting the following in their observational notes:

> "*At the end of lunch time the three facilitators were asked where they thought they were up to in the design process. As I expected D5 thought we were up to 'choose the best idea' and 'work out the details' while D3 and D2 stated we were still in 'think of ideas'. As D5 has not*

been briefed to the same extent as the others, it seemed he thought the goal of the brainstorming was to ideate and select the one idea to continue with. This may have been due to confusion during the facilitator briefing, but did not pose any real issue to the project as participants were very engaged and the idea showed promise"

Participant knowledge was evident through *basic knowledge*, about existing solutions, local practices, and general contextual insights. Examples of this can be found throughout the *contextual insights* sections in Chapter 6. There were also occurrences when *design knowledge* was evident, such as the utilization of local techniques during the construction of prototypes. Examples of this include the use of rope fastening techniques and the ability to process bamboo to be used in multiple ways (such as structural members and flexible seats).

Examples of text units for both designer and user knowledge are shown in Table 62.

Designer Activities

Operational definition

This component describes the tools, techniques and activities used in a PD project. These vary drastically based on the stage in the project, aim of the activity and characteristics of the participant group. Sanders et al. (2010) provides a helpful hierarchy, which is shown below:

- *Activity* – the literal interaction between designer and participant
    - *Tools* – the material components that are used in the activity
    - *Techniques* – how the tool is actually utilized

It is also helpful to think of the term *activity* as a way of categorizing the interactions between designer and participant into descriptive groups. For example, Sanders and Stappers (2014) present *making-style, enacting-style* and *telling-style* as three different categories of activity, each utilizing a different mode of communication.

Literature

Previous research has looked at the particular activities, techniques or tools available to designers. This research has focused on both IT design (Bødker & Iversen, 2002; Kujala, 2003) and wider product development (Sanders et al., 2010; Ali & Liem, 2015), with some focusing on an analysis of activity effectiveness through case studies, and others looking to develop new, more context-relevant activities for specific projects. It is clear that the design and evaluation of contextually appropriate activities has been a strong focus of the research field. Mazzurco (2016) categorized humanitarian engineering activities into three categories, based on their interaction with the participant. Firstly, *passive* was used to describe activities, which aimed to gather information about a participant and their environment with low levels of two-way interaction. Secondly, *consultative* was used to describe activities, which aimed to gain feedback about ideas generated by the designer. Finally, *co-constructive* was used to describe activities that actively involved the participant in the formulation of the project and the design of the solution.

Field research

The present study showed that the majority of participants engaged best with *making-style* and *enacting-style* activities. Table 60 shows the coding frequency of each activity and the description of the *motivation* competency. It is clear that both enacting-style and making-style activities had a higher frequency of occurrences of *good* and *very good* than telling-style activities.

Table 60 - Type of activity vs motivation competency descriptions

	Very poor	Poor	Fair	Good	Very Good
Enacting	0	1	4	14	3
Making	0	4	5	37	19
Telling	0	12	6	26	5

This is also presented as a graph of occurrence percentages for each activity style (Figure 117).

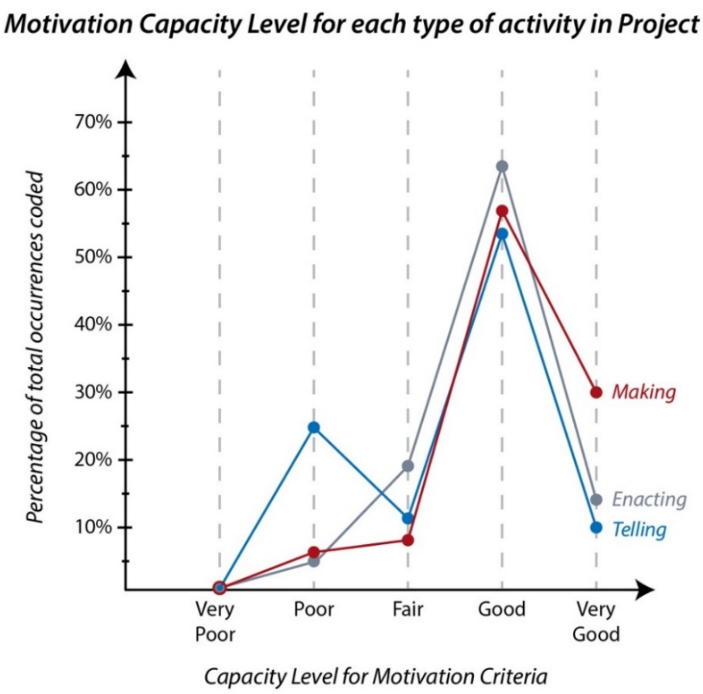


Figure 117 - Percentage of total occurrences coded with Motivation for each type of activity

Interestingly, as discussed in case 3, heavily-impaired individuals (in case 3 this related to a vision-impaired participant, P8, and a mobility impaired wheelchair user, P16) may find it difficult to engage in such physically-active activities. Similarly, individuals with hearing-impairments may find it difficult to engage in telling-style activities. This dynamic creates a challenging planning process, as activities need to be carefully developed to maximize inclusion, engagement and project progress. Alternatively, team formation could be used to enhance inclusion, as discussed later in this chapter.

Examples of text units are shown in Table 63.

Participant Collaborative Competency

Operational definition

A detailed definition of each competency is provided in RQ2. The term *collaborative competency* is meant to represent the skills required to communicate and utilize tacit knowledge in an effective way (Spinuzzi, 2005); not the knowledge itself. Zimmerman (1995) posed the terms *intrapersonal*, *interactional* and *behavioural* that may go some way to articulating the intended definition. Furthermore, a number of different terms have been used in literature to describe a community member, or end-user who possesses these attribute. Terms include *ideal user*, *power user*, *empowered user* or even the commercially focused *lead-user* (Von Hippel, 1986; Fischer & Ostwald, 2002; Hussain & Keitsch, 2010).

Literature

There have been many examples of projects focusing on challenges that arose from participants struggling to engage in the collaboration. While this may have been due to poorly contextualized activities, un-supportive design environments or poorly trained designers, it could also have been influenced by the participant's capacity to participate. For example, Hussain et al. (2012) emphasized that it was not until the PD project was near completion that she felt the participants ready to fully collaborate in a participatory process. In this case, cultural elements, related to children's creativity and confidence to express opinion, were identified as barriers to co-creation. Mazzurco (2016) stated that many of the participatory design methods he researched "*require materials, unrealistic levels of community engagement, facilities, costs, and a level of education that may limit their use*" (p. 138). It is clear that a participant's collaborative competency is an important aspect of the PDC Model.

Field Research

Evidence of this component of the PDC Model will be presented in detail in RQ3 and RQ4, it has also been presented in Chapter 6. Examples of text units are shown in Table 63.

7.2.4 Summary

In summary, the present research has answered RQ2 by identifying a set of six competencies supported by both literature and field research. The competencies are clearly justified and have been refined through Project 1. Next, the researcher has identified the other major factors that influence the quality of collaboration. These are presented through the PDC Model and have been described and illustrated in both existing literature and field research. The relevance and value of the model is its ability to enable meaningful discussion, around CCB and its link to collaboration, as other influences have been identified and understood.

Table 61 - Text units for RQ2 – PDC Model components

Case/stage	**Society and culture – Text Unit Examples**	**Design environment – Text Unit Examples**
Case 1	"*I think they're not really there to talk with the group, with the big group, because when we ask them into the big group, some of them they feel very shy and they said they're not there to talk in front of the whole group*" (D1, Pre-design) "*I can't raise chickens because I adhere to Buddhist principles. I know how to raise chickens, but I can't. Raising chickens is for younger generation*" (P12, Exit Interview)	"*Venue has been changed from the pagoda to the school as the religious festival of Chom Ben is running in the pagoda for the first two weeks in September. The school venue is small and hot, this may make it challenging to engage all participants throughout the day*" (D11, Generative design)
Case 2	"We *have a little bit of a problem because some people, they still cannot like, some people they are still quiet and they feel shy sometime, so that's why we change the way we want to get information from them*" (D3, Pre-design)	"*I found it challenging working in the classroom environment this time, because we did it at the school in Kampong Tralach rather than the pagoda*" (D4, Generative design) "*Participants all explained that they wanted to be sitting on the floor, but it was a concrete floor with no mats and it was a bit dirty so nobody was able to*" (D4, Generative design)
Case 3	"*For that disability people at first they feel scared to express their idea to the whole group but we inspire them and motivation*" (D2, Pre-design)	"*Participants seem hot and tired. Venue is challenging to be creative and energetic. Perhaps this is a barrier to co-design in developing countries*" (D11, Generative design)

Table 62 - Text units for RQ2 - PDC Model components

Case/stage	Participant knowledge – Text Unit Examples	Designer knowledge – Text Unit Examples
Case 1	"*What we talked the other days, the rice seeding tool can be used on both soft and hard land. But, in my opinion, I think it is impossible to work on a soft land. It's because what I learned for the radio, the land must be dry. We cannot plough and do rice seeding on the same day*" (P12, Exit Interview)	"*At the end of lunch time the three facilitators were asked where they thought they were up to in the design process. As I expected D5 thought we were up to 'choose the best idea' and 'work out the details' while D3 and D2 stated we were still in 'think of ideas'... …This may have been due to confusion during the facilitator briefing, but did not pose any real issue to the project as participants were very engaged and the idea showed promise*" (D11, Generative design) "*D11 showed team the rotating doser as they did not have an idea about the mechanism*" (D11, Generative design)
Case 2	"*They have low education and sometimes when we speak to them they cannot follow us from what we want them to do or from what we want them to comes up with their idea or to spread their idea*" (D3, Pre-design)	"*D1 then exampled each stage in the process in detail. D3 uses the example of choosing either organic or chemical fertilizer*" (D11, CCB)
Case 3	"*Let's say they are high graduate like grade nine or grade six they come ups quickly idea yeah*" (D2, Generative design) "*I ask them do they make something for their home or their community. They said they come up with like an ox cart, they used to do the boat*" (D2, Generative design)	

Table 63 - Text units for RQ2 - PDC Model components

Case/stage	Designer activities – Text Unit Examples	Collaborative competency – Text Unit Examples
Case 1	"*The banana session, I think because our proposal was difficult, what we want, we want them to draw for us. Just like most of them, they could not draw so they just start to do the prototype*" (D1, CCB) "I feel that it's modern and very good" (P13, Exit Interview)	"*They are doing their prototyping, even though they only stick to the one idea but during the making, everyone seems to give their idea and also ask question*" (D8, Evaluative design) "*[They are] sharing the discussion and ask the woman with the mental disability to try to carry the tool when they prototyping it, so mainly the idea coming from them, it's not from me*" (D5, Evaluative design)
Case 2	"*So that's why we try to make timing, schedule and mapping for construction. So that we make sure what step we going to do and who will responsible for what*" (D3, Evaluative design)	"*They have a lot of ideas, and different ideas about making mango cutter and some of the group, they like, it's difficult for them too that I can see*" (D3, CCB)
Case 3	"*They had like a lot of time and space for them. They were creating something and we were not imposing ourselves with telling 'you have to do this and this and this' you could see that they really wanted to co-create and generate ideas together*" (D6, CCB) "*Written activity not as engaging as visual*" (D11, Generative design)	"*Also it's the aptitude of the people if they are like, they are good at talking so they will come up with the idea, if they, if the, some people not good at talking then so they keep quiet*" (D2, Generative design)

7.3 Research Question 3

How can CCB be utilized to build the required competencies in participants?

7.3.1 Key Evidence

RQ3 has been answered through two different approaches. Firstly, through the documentation of a CCB content development process, including the identification of key planning questions, and secondly, through the development of a practitioner handbook. These two approaches are explained below.

7.3.2 Finding 1: CCB Content Development Process

The CCB content development process, developed in this research, utilized learning from the programme development processes of Oxfam (Eade, 1997), the Rwandan Government (Mutoro, 2013), and the CCB content of the MIT D-Lab (Taha, 2011). It also utilized the collaborative competencies discussed in RQ2 as a basis for needs analysis. The documented process of designing CCB content and refining it through pilot studies is presented in Drain, Shekar, and Grigg (2017) and explained in detail in Chapter 4. The process followed is outlined below:

1. Identify an existing CCB program to use as a starting point. For example, the work of Taha (2011) in Uganda.
2. Identify specific socio-cultural characteristics and needs, following the programme development process defined by Eade (1997).
3. Utilize contextual understanding (from step 2) to modify the CCB content to create a more appropriate program (termed CCB version 1).
4. Refine the modified CCB content with experienced development practitioners in the socio-cultural environment (termed CCB version 2).
5. Pilot CCB version 2 with a representative community in the socio-cultural environment. Utilize feedback from this pilot to refine the CCB program (termed CCB version 3). See Appendix B for the CCB version 3 developed in the present research.

The process can be refined to the diagram shown in Figure 118.

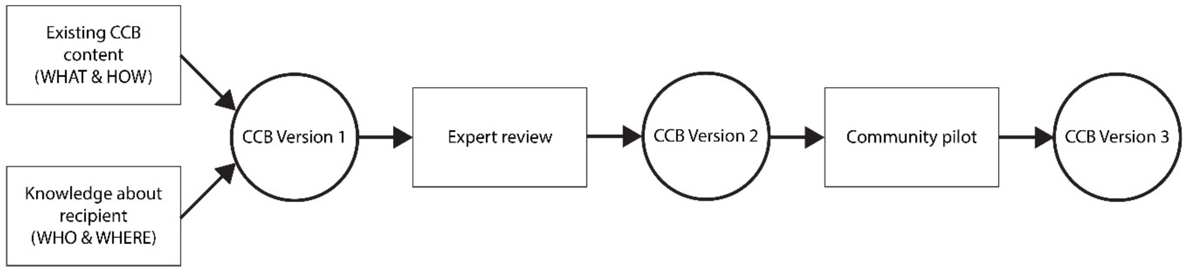


Figure 118 - CCB content development process

Key Planning Questions

Through analysis of the pilot study, six key themes emerged, three related to the content itself (*flexibility, relevance* and *clear communication*) and three related to the recipient (*experience, learning capacity* and *socio-cultural background*). These themes are especially important during planning, as it is during the formation of the training sessions that *flexibility, relevance* and clear *communication* can be designed into the programme. To do this effectively, the participants group's pre-understanding (Gadamer, 1975) must be well understood. This includes exploring the participant group's *experience, learning capacity* and *socio-cultural* background. The importance of this understanding is reiterated in recent adult learning publications (Merriam, 2008) and in PD literature (Spinuzzi, 2005; Lee, 2008; Hussain & Sanders, 2012). During future CCB design, the present researcher recommends that practitioners focus on answering the following questions during planning:

Understanding the participant

1. Learning capacity
    a. What previous formal education has the participant undertaken?
    b. What style of pedagogy will be inclusive and effective?
    c. How confident are they to engage in open discussion?
2. Previous experience
    a. What previous development projects has the participant been a part of?
    b. Has the participant been exposed to similar concepts before?
    c. Has the participant implemented similar concepts before?
3. Socio-cultural background
    a. Is there a clear power-hierarchy present in the participant group?
    b. What is the history of education in the socio-cultural environment (local and national)
    c. What are the priorities of the participant group? (daily and long-term)

Ensuring appropriate content

1. Clear communication
    a. Does the content leverage the strengths of the participant group?
    b. Is all content clearly described? (post translation)
2. Contextual relevance
    a. Are concepts and examples relatable?
    b. Are learning outcomes aligned with participant priorities?
3. Flexibility
    a. Can the content be delivered in sections if required?
    b. Is there a plan for re-engaging participants after disruptions?

These questions are supported by the PD principle of *situation-based actions*; the idea that all aspects of a PD project should be contextually appropriate (Simonsen & Robertson, 2012). Explicit consideration for socio-cultural aspects of the context, as well as a participant's pre-understanding must be included in the CCB development process. Creating content that is relatable and clear will allow more time focused on mutual learning, trust building and solidifying concepts and less time focused on clarification and keeping participants engaged.

7.3.3 Finding 2: Practitioner Handbook

Finally, the final CCB content (CCB version 3), and full PD project plan, was documented into a practitioner handbook to be used by the design team in Project 1. It was also refined after Project 1 to ensure learning was captured before being disseminated through the EWB Australia Humanitarian Engineering Network. Activities drew inspiration from Freudenberger (1999), PeaceCorps (2007), Chevalier and Buckles (2008), Ferguson and Candy (2014) and IDEO (2015). The content of the handbook is shown below:

Workshop 1: Creative Capacity Building

- Session 1 - What is design?
- Session 2 - The design process
- Session 3 - Small scale design
- Session 4 - Work out the details

Workshop 2: Pre Design

- Group discussion
- Roleplay
- Daily activities
- Calendars
- Resource flow
- Guided tour
- Asset mapping
- Revisit challenges
- Select project

Workshop 3: Generative Design

- Local precedents
- Materials
- Brainstorming
- Construction techniques
- Model making
- Existing solutions
- Revisit brainstorming
- Screening ideas

Workshop 4: Evaluative Design

- Design review
- Technical training
- Prototyping
- Testing
- Feedback & iterate
- Activity Quick Reference

Workshop 5: Evaluative & Post Design

- Design review
- Process mapping
- Construction
- Testing
- Feedback & iterate
- Implementation plan

Games & Icebreakers

- Animal instincts
- Counting popcorn
- Follow the leader
- Hoops
- Make it move
- Marco polo
- Pass the ball
- What is this?

Monitoring & Evaluation

- Baseline interview
- Morning interview
- Macaroni feedback
- Afternoon interview
- Exit interview
- Facilitator field diary
- Technology evaluation

The layout of the handbook drew inspiration from previously development practitioner handbooks from IDEO (2015), Ferguson and Candy (2014) and Taha (2011). An example layout of a page from the handbook is shown in Figure 119. The same layout was also used for all of the PD project activities.

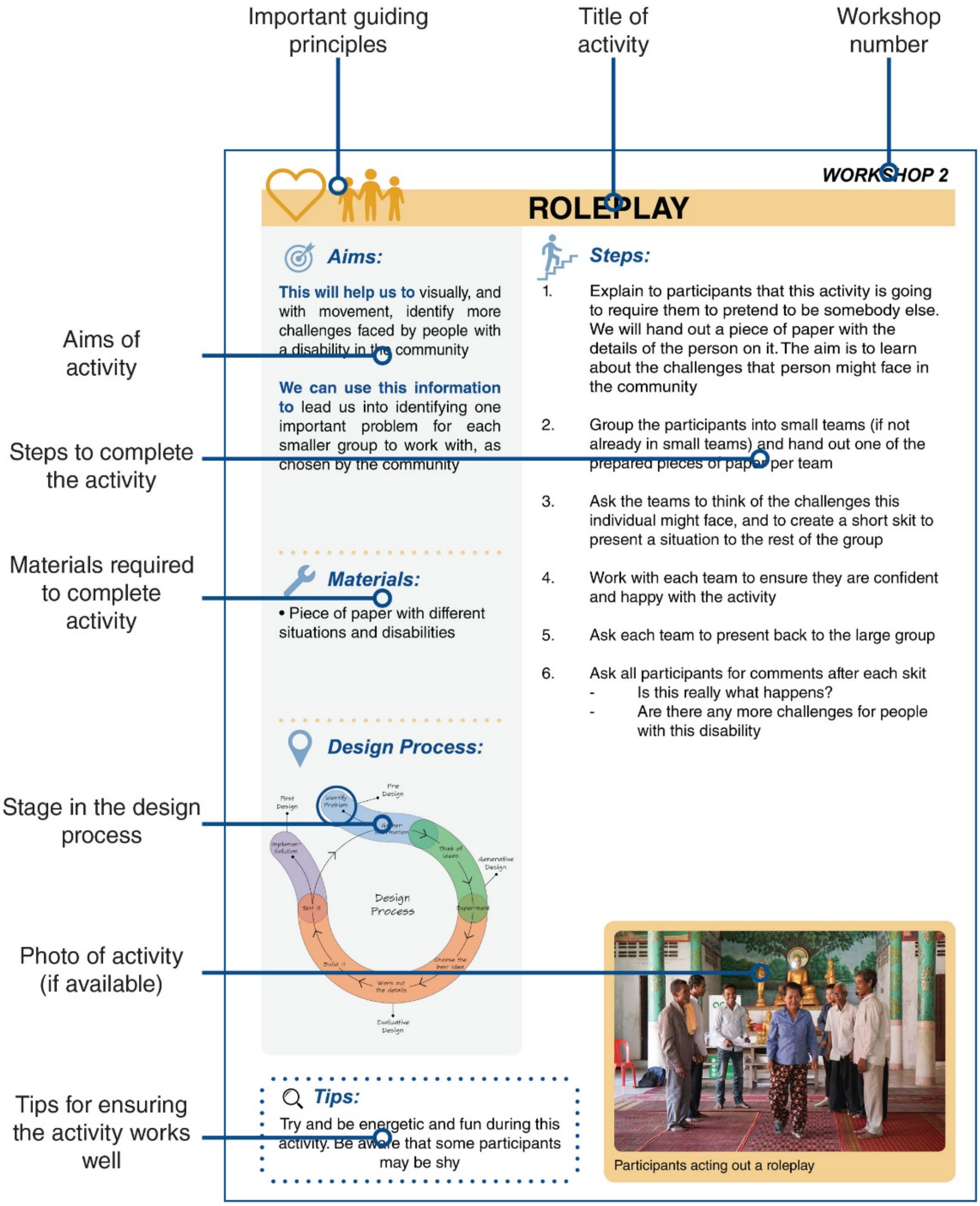


Figure 119 - Practitioner handbook example page

7.3.4 Summary

In summary, the present research has answered RQ3 by identifying key aspects of CCB content development, including an effective development process and key planning questions. The researcher presented a practitioner handbook that clearly communicates the ideology and teaching plan of CCB, for use in HTD-using-PD projects.

7.4 Research Question 4

Does the implementation of CCB enhance the quality of collaboration between designers and participants during HTD-using-PD?

To answer RQ4, the present researcher has utilized existing research about Cambodia, and previous PD projects, as well as first hand data from Project 1. The researcher initially developed the Adapted *Making* Framework (Figure 14) as a way of communicating where CCB should sit in the PD process to enhance HTD-using-PD practice. This modulation represents the combination of two fields of research (PD and capacity building) and has synergy with the field of international development (as both PD and capacity building aim to improve the lives of communities in developing contexts). Once developed, the present research aimed to validate this model through a multi-case research project. The following section discusses the ways in which CCB had impact on Project 1. Therefore, the findings can be viewed as a first attempt to validate whether the Adapted *Making* Framework represents the most effective PD process for use in HTD.

Project 1 data analysis included detailed qualitative analysis of each of the six competencies, across the three cases and five project stages (CCB, pre-design, generative design, evaluative design and post design). To understand the link between CCB and collaboration, collaborative competency profiles were developed for the participant group at each stage of the PD project (baseline, pre-design, generative design, evaluative design and post design). The present researcher investigated the change that occurred across the CCB workshop (baseline to pre-design step change) and how this change influenced the quality of collaboration across the project. Finally, other factors that may have influenced the quality of collaboration are discussed in relation to the findings.

7.4.1 Key Evidence

There are two separate areas of research utilized in answering RQ4. Firstly, the baseline collaborative competency profile utilized the demographic information of the participant group (see Section 6.2) along with educational research (EPDC, 2012), disability research (WHO, 2002; Gartrell, 2010) and socio-cultural research (Hallinger, 1998; Hussain, 2010). This allowed the specific participant group to be understood and inferences made using existing research.

Secondly, collaborative competency profiles from each of the PD project stages were developed based on interviews (with participants and designers), designer field diaries, observations of workshop activities, workshop documents, photographs and first-hand experience from the present researcher. These multiple data sources allowed multiple perspectives to be explored, on both sides of the designer-participant relationship, as well as the analysis of tangible workshop outputs, such as prototypes. A full description of data analysis is given in Chapter 6.

7.4.2 Finding 1: CCB Improves the Collaborative Competencies *Contextual Insights, Design Process* and *Motivation*

To begin with, Figure 120 shows the collaborative competency profiles for the participant group during baseline evaluation and during pre-design. This represented the participants before and after the CCB sessions. Note that the competencies *design critique and prototyping* were not present during pre-design, therefore, the next time the competency was present (generative design) was used in Figure 120.

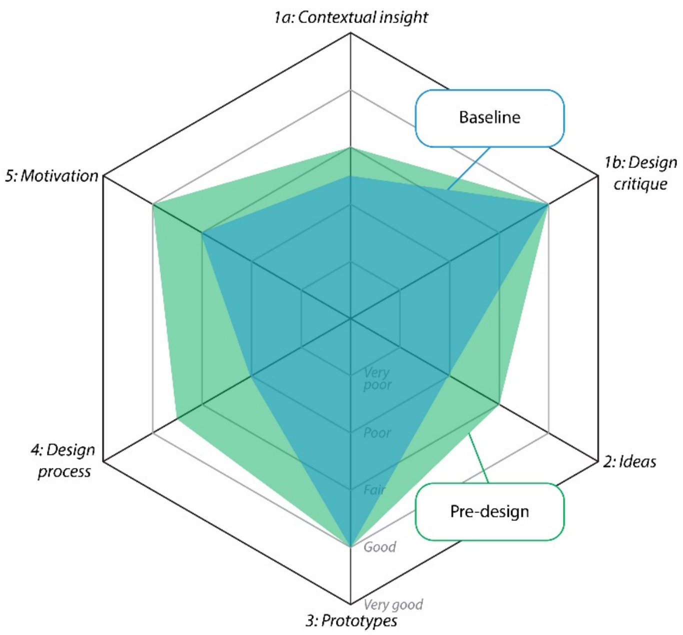


Figure 120 - Visualization of baseline and pre-design collaborative competencies

It seems clear that all competencies, other than *prototypes and design critique* have shown improvement across CCB. However, caution must be taken when discussing the *design process* and *ideas* competencies has these fluctuated throughout the project, as shown in Figure 121 and Figure 122. This fluctuation was most likely because the perceived competency was enhanced during CCB, due to the simplicity of activities and required outputs. Therefore, once the real-world project was initiated, the complexity and ambiguity of the activities resulted in designers perceiving the competency lower than previously. Because of this, Finding 1 will only focus on the positive changes to the *contextual insights, design process* and *motivation* competencies. These are discussed below.

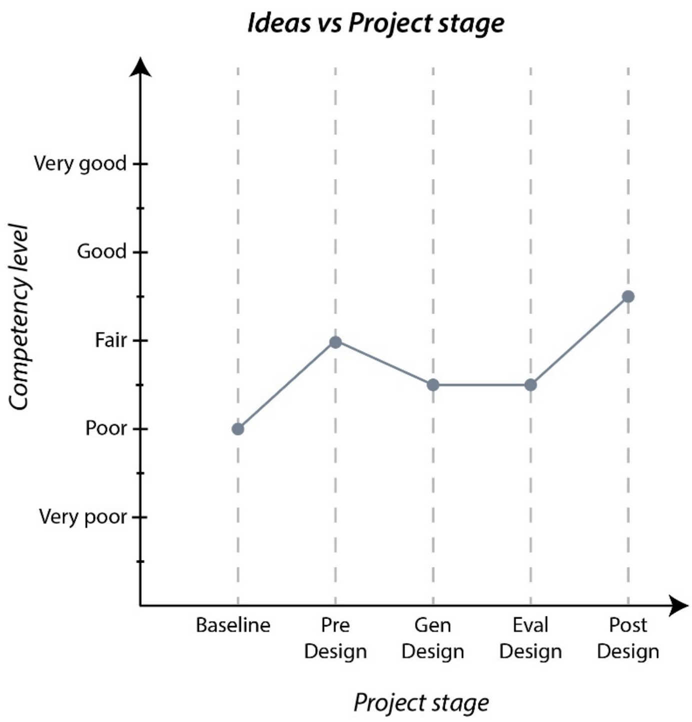


Figure 121 - Visualization of *ideas* competency across the project

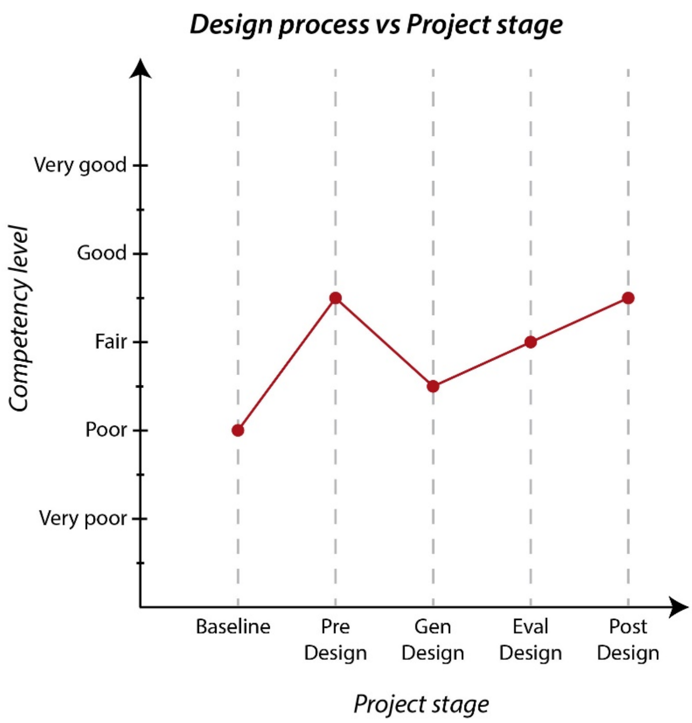


Figure 122 - Visualization of *design process* competency across the project

An Ability to Express Contextual Insights

This competency has shown improvements across the CCB session, with much of this improvement being linked to participants becoming more comfortable with the designers and fellow participants. Therefore, in this case, the value of CCB was that it provided a two-day team-building programme, which allowed participants to work together on small, relatively easy projects. An example of the change in *contextual insights* can be seen by comparing comments made by D1 during CCB and pre-design.

> D1, CCB - "*I think they're not really there to talk with the group, with the big group, because when we ask them into the big group, some of them they feel very shy and they said they're not there to talk in front of the whole group*"

> D1, Pre-design - "*I think yesterday [pre-design] is better than the day before [CCB], because they more like, at first, in the beginning in the morning they not really active. But after that they more active, they give more ideas, something like that*"

This addresses one of the challenges documented by Hussain et al. (2012), that the "*Designer's relationship to participants*" (p. 104) can create a barrier to effective PD early in the project. Hussain et al. noted that it was at the very end of their PD project that, "*Raising user ability and confidence to communicate their own ideas and to engage in design processes*" (p. 104) was identified as an outcome. In the present study, the ability and confidence to communicate was evident much earlier in the project. Furthermore, Kam et al. (2006) concluded that they needed to form a relationship with their participants that was different to the power dynamic of teacher and student and involved a more balanced power structure. This idea is one of the fundamental guiding principles in the PD ideology (Kensing & Greenbaum, 2012; Mazzurco & Jesiek, 2017).

A second reason for this improvement was that CCB provided participants with a chance to practice collaborating on smaller projects (*banana boost* and *mango picker*) before engaging in collaboration that was more complex. This allowed for activity outcomes and expectations to be clearly communicated and practiced. For example, discussion with participants during the mango picker activity focused on what materials might be available in the community, how large the design should be and who would need to use it. The concept discussed here is similar to the concept of project-based-learning (PBL), common in engineering education in Western countries. PBL is defined as an approach that "*engages learners in exploring important and meaningful questions through a process of investigation and collaboration*" (Frank et al., 2003, p. 276). The present researcher suggests that the CCB workshops act in a similar way and better prepare participants for real world projects, such as involvement in the PD project with designers.

In the PD realm, there is also support for the link between practice and effective collaboration. Dearden and Rizvi (2008) stated, "*Users need understanding; and learning in order effectively to take part in the process*" (p. 7). Hussain et al. (2012) stated, "*we recognise that if we have had more time and funding, we could have given participants more training in design methods and encouraged them to have a more active role in the product development process*" (p. 99). Others have focused on the link between practice and developing abilities to create independently (Diehl, 2010; Taha, 2011).

Table 65 shows example text units from both CCB and pre-design. It is intended to illustrate the improvement in participant ability across the two stages.

Understanding of the Design Process

As mentioned previously, improvements to the *design process* competency should be approached with caution due to the large fluctuations in perceived ability throughout the project (see Figure 122). However, there was evidence of improvement occurring across CCB, hence, this competency is included in Finding 1.

During baseline assessment, it was clear that while participants had a limited understanding of the term *design*, and were not able to articulate a design process, they did have a basic design/problem solving understanding. This involved the three-step process shown in Figure 84. There was no understanding of key design concepts of the *importance of testing many ideas* and *the importance of iteration*.

After CCB, participants had a slightly improved understanding of the term *design* and of the design process. Furthermore, participants now realised that many of them already practiced a basic form of *design* in their everyday lives. For example, participants stated that they had designed a "*garden at school*" (P6), "*made a boat*" (P9) and "*made fishing rods out of bamboo and string as well as 'bamboo holes' for catching fish"* (D11, observational notes). Table 64 shows interview responses from P7 during baseline, pre-design and generative design. This highlights the changes in understanding of the design process.

Table 64 - Text Units showing change in understanding of design process

Stage of project	What do you think the term 'design' means?	If you were going to solve a problem, what steps would you go through?
Baseline	*"to create something new, make by ourselves"*	*"Don't know. Maybe ask someone for help"*
After *pre-design*	*"make something easy to use"*	*"identify the problem, and find the solution"*
After *generative-design*	*"Make something better to use than before from ourselves. If it's not working, do it again and test it."*	*"Identify the problem, gather information, think of idea which one is good and after that take it to use."*

An important aspect of this competency is that participants began to realize that they already practiced design in their everyday lives. This was important for both participant empowerment and confidence to collaborate, as they realised that they were already skilled in this work (Taha, 2011). Building the awareness of local skills, is at the heart of many development processes, as it allows community strengths to be identified and leveraged to address challenges (Mazzurco & Jesiek, 2017). Building this knowledge, and awareness helps to strengthen the *process knowledge* component of the collaboration (Christiaans, 1992). This, in turn, improves the participants' holistic ability to contribute meaningfully during future activities.

Table 66 shows example text units from both CCB and pre-design. It is intended to illustrate the improvement in participant ability across the two stages.

Motivation to Contribute

To understand this competency a cognitive map of perceived motivation was developed (see Section 6.2.2). This is shown in Figure 85. CCB had a positive effect on both intrinsic and extrinsic motivation of the participant group.

Firstly, participant intrinsic motivation was improved through team building opportunities, improved understanding of their role in the overall project and realization that their involvement in the project would be enjoyable. All three of these elements resulted in participants becoming more engaged in the project, and becoming excited to be involved. For example, D2 stated, "*Normally they don't have the NGO or the company to come here and train them in design process, this is their first time and they enjoy a lot*". Furthermore, at the end of the project, participants communicated that they enjoyed the project, stating, "*No, I don't think there is any weakness. I am totally satisfied*" (P7), "*I don't have anything I do not like about the seminars*" (P12), "*I feel that it's modern and very good*" (P13). This is supported by the Schwartz Theory of Basic Values (Schwartz, 2012). This theory states there are ten values that are important to an individual, and that by aligning with these values, an individual will be implicitly motivated. Of note to this discussion are the values *hedonism*, *stimulation* and *self-direction*.

Focusing on addressing these values through CCB promotes an openness to change, and creates individual satisfaction through "*independent thought and action*" (Schwartz, 2012, p. 5), "*excitement, novelty, and challenge*" (p. 5) and "*pleasure or sensuous gratification*" (p. 5). This shows that the fun, excitement and hands-on work in CCB had a motivating effect through aligning with these values.

Secondly, the extrinsic motivation of the participant group was improved as CCB built a stronger understanding of the type of project being undertaken, type of collaboration and the intended outcomes (technology and empowerment for PwD). Once the participants understood these intended outcomes, they were more engaged, and driven to complete the project. For example, D3 communicated that the community enjoyed the practice activities and now realised that they could use recycled materials during the project. D3 stated:

> "*But they still happy with the prototype, the mango picker, from their opening they're like, 'this is good.' There is another good idea that can get the recycled material to use it as a useful thing. Because they never think they can use recycled materials to be more useful, that's what we did today*"

Researchers have stated the importance of communicating clear expectations, and ensuring that projects selected align with the needs and wants of the specific community (Eade, 1997). For example, Arensberg (2017) stated that a project needed to be identified and driven by the community to ensure motivation. Otherwise, it was likely that "*the local people [were] merely going through the motions of cooperation but doing nothing when he or his agents [development workers] are not present*" (p. 112). This supports the finding that building an understanding, in the participant group, that they would lead the project and develop the project briefs, would lead to higher levels of motivation.

Table 67 shows example text units from both CCB and pre-design. It is intended to illustrate the improvement in participant ability across the two stages.

Table 65 - Text units for Contextual insights – Positively affected collaborative competencies

Case/stage	**Contextual insights – Text Unit Examples**
Baseline	"*I think they're not really there to talk with the group, with the big group, because when we ask them into the big group, some of them they feel very shy and they said they're not there to talk in front of the whole group*" (D1) "*Yes, of course, the activity ['what is design?' discussion], just have, I can remember that one group, they just have only three people talk in the group*" (D2) "*A discussion was then generated about 'what challenges do you face in your community?'. This was done with the entire group and focused on any challenge that the community faces (not specifically PwD). The discussion was very slow and only a couple of individuals spoke about challenges*" (D11, Observational notes)
Pre-design	"*I think, generate some ideas. Like, accessible thing for them, just like the buildings, the pagoda, something like that. When they have the rain, it's difficult for the old people. Like one of the guys in my team, they had the one neighbour who still hurt in his house, sit in the wheelchair and when they want to come anywhere it very difficult*" (D1) "*She do a good role play, because, why's that a good role play? Because we can see it's a real situation for people that are blind, that affects with their mobility*" (D2) "*Lots of dialogue about farming*" (D11, Field Diary)

Table 66 - Text units for Design process – Positively affected collaborative competencies

Case/stage	**Design process – Text Unit Examples**
Baseline	"Just like, one team, they not really follow the design process, so they just like, when they start, they not really, I mean they identify their problem, but after that they start to, like very quickly they (inaudible 2:40), they start to collect all the information from the team. They just start to do the prototype" (D1) Interviewer: "*If you were going to solve a problem, what steps would you go through?"* "*Go to find other job" (P1)* "*Ask someone who can help" (P4)* *"Think about the problem and ask someone for help, like teacher or friends" (P6)*
Pre-design	"*Yes, I think that most of them understand, but not all. I mean, not all steps of the process, but they understand how they make through the example that we go through with them"* (D1) *"From what I think, it look like they are more improved from the day that we've just done [CCB sessions]. Because the day that we've just done, the workshop, when we present the design process, totally they don't know it, they don't know what is design process, they don't know what step of design process is, they don't know. Today, working together, they understand that. But also, they not 100%, like 70% or 80%"* (D3) Interviewer: "If you were going to solve a problem, what steps would you go through?" "*Always use design process"* (P3) *"Identify the problem, gather information, think of idea, experiment, choose the best idea, work out the details, build it, test it, implement solution and if it not working, build it again and test it again until we get the result"* (P6) *"Find the problem, gather information and solve it. If is not working try to do it again"* (P9)

Table 67 - Text units for Motivation – Positively affected collaborative competencies

Case/stage	**Motivation – Text Unit Examples**
Baseline	"*About motivation, I think that they also need more motivation from the team, especially from their team when we divide into the group. Because, we saw some of the members of the team say, 'oh we don't want you to join'*" (D1) "*They feel tired. So if people feel, what's the problem, the memory, or other, it's difficult to go together*" (D3) "*Only [P7] spoke to the group about her design work. The others may have been shy, or more likely had not engaged in design activities before*" (D11, Observational notes)
Pre-design	"*This [motivation] varied a bit but the participation from group members was generally really good*" (D4) "*Some people were clearly leaders in each group and others did not contribute much but generally good contribution*" (D4) "*Some disengagement when not talking but overall it was okay*" (D11, Field diary) "*Similar to design activity, good motivation when talking about their life*" (D11, Field diary)

7.4.3 Finding 2: CCB Does Not Improve the Collaborative Competencies *Design Critique*, *Ideas* or *Prototyping*

Three of the collaborative competencies were not positively affected by CCB. The *design critique* and *prototyping* competencies were assessed as *good* during baseline evaluation and remained strong throughout the project. Contrastingly, the *ideas* competency was assessed as *poor* during baseline, and was actually assessed as *fair*-to-*good* during pre-design. However, the perceived competency level dropped back down to *poor*-to-*fair* once generative design was initiated. This suggested that once the competency was meaningfully required in the collaboration, the perceived ability of the participant group dropped. These competencies are explained below.

An Ability to Express Design Critique

This competency was assessed as being strong during baseline assessment and continued to be perceived as a strength throughout the project. Therefore, it is not possible to conclude whether CCB would have an effect on a participant group with lower levels of ability in *design critique*. Similar to the *contextual insights* discussion above, the CCB session may well provide an opportunity for less experienced participant groups to practice the *design critique* competency and therefore be more able once the PD project begun. However, this cannot be verified in the present study.

Linking this to existing literature, there are two specific areas relevant to this discussion. Firstly, literature shows a range of opinions about a participant's ability to express *design critique*. For example, literature in commercial product development activities has focused on effective user involvement for decades. Lettl (2007) suggests that the initial layer of user involvement consists of the user contributions to "*the articulation of needs and/or problems and the evaluation of concepts and prototypes*" (p. 63). This aligns with what was observed in each of the present cases. Lettl also states there are two higher levels of involvement, but that these require high levels of technical knowledge, not possessed by the present study's participant group. Conversely, literature in HTD-using-PD shows some participants struggled to give *design critique* early in the project (Hussain, 2010), due to shyness, or during testing (Winschiers, 2006), due to frustration with the prototyping method. This suggests that the strength in this competency may have been a function of the specific participant group, the specific project being undertaken and the socio-cultural context.

Secondly, Cambodian socio-cultural characteristics can be reflected upon. For example, the only exposure participants have had to formal education was in the form of rote learning during primary and possible secondary schooling (EPDC, 2012). This style of schooling supports the development of convergent thinking, which is the mind-set used when providing *design critique* (as opposed to divergent thinking, which is used in activities that are more exploratory). This focus of the Cambodian educational system suggests that convergent activities should be easier to engage with than divergent activities.

The present researcher suggests that the link between CCB and the *design critique* competency be investigated in future research. This could be done by identifying a participant group with low levels of ability in the competency and utilizing a similar methodology to collect data and evaluate the quality of collaboration. Table 68 shows example text units from both CCB and generative-design (as no evidence was found in pre-design). It is intended to illustrate that the participant ability across the two stages is similar.

An Ability to Generate Insightful Ideas

This competency was assessed as being *poor* during baseline assessment. Firstly, existing literature suggested that a Cambodian participant group would not be competent in idea generation as Cambodia has no formal education institution offering design education (Hussain et al., 2012). Furthermore, the role of *design* is not well understood in Cambodia. For one thing, the term *design* directly translates to the Khmer word for *decoration*. This is linked to cultural dynamics of Cambodia such as an emphasis on rote learning and highly centralized decision making (Hallinger, 1998). Creative skills also require practice to become competent. During initial interviews, it was found that no participant had engaged in a design project with an NGO before, meaning there had been little opportunity to build this competency. The *poor* level of the *ideas* competency was verfied during CCB activities. For example D1 stated during the banana boost activity, "*They just follow each other in the team. Just like one person do the circle then all the person do the circle. So they have to like, follow each other*".

There was little opportunity for participants to demonstrate *ideas* during pre-design with some unsolicited ideas shared during pre-design activities. This resulted in the *ideas* competency being viewed as *fair*, which was an improvement over baseline. However, once formal generative design activities were undertaken the participants seemed to struggle with idea generation and relied on the designers for creative input. Participants then tended to provide *design critique* and build from the designer-led ideas. D11 stated in their field diary "*Designer [D2] drove ideation. Some ideas from participants but nothing overly new and insightful*". D2 corroborated this during an interview explaining, "*They have their own idea, but they don't want to talk it out. And after that, I explain and come up with my idea and come up with an example and then they give me their answer*".

This suggests that the competency did not improve to any reasonably verifiable extent. D7 insightfully commented, "*Ideation seems to be the hardest part of co-creation, we train students [Australian university students] so much on how to ideate but you can't do that with community*". The present researcher agrees that the ability to generate insightful ideas takes years of practice in a western socio-cultural setting, where individualism is championed. In a collectivist socio-cultural setting such as Cambodia, combined with a lack of expose to creative practices in formal education, it seems creativity is extremely challenging to nurture. Table 69 shows example text units from both CCB and pre-design. It is intended to illustrate that the participant ability across the two stages is similar.

This finding is in agreement with much of the extant literature. For example, there are several previous HTD-using-PD studies, which highlight participant creativity as a challenge (Kam et al., 2006; Winschiers, 2006; Winschiers-Theophilus et al., 2010; Hussain et al., 2012). Others also highlight that a lack appropriateness of the design activity can create a barrier (Godjo et al., 2015). Given little noticeable improvement of the *ideas* competency during CCB, the present researcher agrees with researchers that highlight the importance of carefully developed activities (Brandt, 2006; Molapo & Marsden, 2013). It is now clear why there is such a focus on contextually appropriate generative design activities.

Support for this finding can also be found in wider literature, such as commercial product development. Lettl (2007) found that openness to, and awareness of, new technologies was a key prerequisite characteristic for end-users who were the most innovative. Given participants did not have a strong awareness of new technologies during baseline assessment, and that CCB did not address this deficiency, it seems likely that this became a barrier to creativity. This is supported by Fischer (2004) who stated, "*The power of the unaided individual mind is highly overrated*" (p. 152), referring to the need for wider knowledge and support in creative activities.

There is a contrasting view in literature that all people contain creativity and given the right opportunity will generate innovative ideas. For example, Taha (2011) explains that their work in CCB was grounded in the principle that "*once unleashed and supported, community-based creativity and ingenuity has the potential to become a transformational force that is sustainable, highly efficient, and far reaching in its impact*" (p. 24). This is similar to the vision of creative confidence presented by IDEO (2015), that "*anyone can approach the world like a designer. Often all it takes to unlock that potential as a dynamic problem solver is a bit of creative confidence*" (p. 19). The present researcher agrees with the ideological value of this view, as it ensures participants' voices and input is valued. However, practically, there are many other influencing factors than just *creative confidence* (such as those mentioned in the PDC model in RQ2). On top of the components mentioned in the PDC model, the present researcher argues that the following conditions can create a barrier for creativity:

1. Lack of awareness of new technologies
2. Lack of knowledge in the required technical domains
3. Lack of knowledge in the required user domains

An Ability to Create Insightful Prototypes

Similar to the *design critique* competency, this competency was assessed as being strong during baseline assessment and continued to be perceived as a strength throughout the project.

During baseline assessment, it was clear that participants had experience working with basic tools and were comfortable with making-style activities. Most participants self-identified as being farmers and were much more comfortable working on *making*-style activities during CCB than *enacting*-style or *telling*-style. For example, D1 stated, "*The banana session [banana boost activity], I think like, because our proposal was difficult, what we want, we want them to draw for us. Just like most of them, they could not draw so they just start to do the prototype*". This is further explained by the fact that Cambodia is a country of over 15 million people with 79% living in rural farming areas (Worldbank, 2016). These large rural populations survive through pastoral activities such as farming rice, corn, cassava and mangoes as well as raising animals when possible. This agrarian lifestyle also suggests that hands-on skills would be a strength of the rural population.

During the present study, it was found that *making*-style activities were most effective at engaging participants (see RQ4 finding 3). Several previous studies have also tried to create *making*-style activities that address objectives traditionally met using *telling*-style activities. These include the use of collages (Hussain, 2010) and cardboard activities (Ehn & Kyng, 1992). However, there are others who do not share this view, stating either the need for a balanced plan with *making, telling* and *enacting*-style activities (Brandt et al., 2012) or highlighting the challenges of abstract prototyping activities (Molapo & Marsden, 2013). The lack of consensus in this area suggests that socio-cultural dynamics, as well as the project focus, need to be considered when deciding on the exact type of activity. Again, the PD fundamental principle of *situation-based actions* holds true (Kensing & Greenbaum, 2012).

It should be noted that a clear trade-off emerged from the analysis. This centred on the effectiveness of *making*-style activities in engaging more able-participants, and the potential for exclusion of heavily impaired individuals during prototyping activities. Given the need to construct prototypes (for testing and implementation), the present researcher suggests that care is taken to ensure heavily impaired PwD are given opportunity to lead the generative design and testing stages, but not prototyping activities. While inclusion and empowerment are the goal of any PD project, this finding suggests that there will be practical limitations to the ideology such as time, safety and technical ability.

Table 70 shows example text units from both CCB and generative-design (as no evidence was found in pre-design). It is intended to illustrate that the participant ability across the two stages is similar.

Table 68 - Text units for Design critique – Unaffected collaborative competencies

Case/stage	**Design critique – Text Unit Examples**
Baseline	"*When one of the team, they come up with an idea the others say, 'this would not be happen like that, this would be happen like this,' they try to correct each other, and they say that*" (D1) "*We ask them for recommendations like, ok the prototype that they use [mango picker], it have another problem like, yeah we ask them and some of them say 'it's a little bit heavy for old people'*'" (D3) "*The bamboo stick that we use [for mango picker], is different, it's not the dry one, and also is a little bit bigger and too big for them. And another problem, is a little bit short*" (D3)
Generative-design (as no evidence in pre-design)	"*Yeah, from what I see that people, they have a lot of good ideas to come up with and also they share they discuss with each other to do more things*" (D3S3INT2) "*Saying an idea was good or bad was easy. Saying why needed prompting but people still had ideas*" (D4 Field diary)

Table 69 - Text units for Ideas – Unaffected collaborative competencies

Case/stage	**Ideas – Text Unit Examples**
Baseline	"*I think they still have the limit. Because they still follow each other. I know that, most of them, they really have the creative idea, but when they start to make something on their own, then they start to look to other people, they start to change, they start to follow each other*" (D1) " *Some of them they also have no ideas but we try to get understanding from their mind-set*" (D3) "*The fourth team struggled to decide on an idea and did not want to look at the sketches*" (D11 Observational notes)
Pre-design	"*Interesting ideas about existing farming but no new ideas*" (D11, Field diary) "*Lots of new challenges emerging. Difficult to focus on screening. Good for insights but bad for progress in to generative design*" (D11, Field diary)

Table 70 - Text units for Prototypes – Unaffected collaborative competencies

Case/stage	**Prototypes – Text Unit Examples**
Baseline	"*An older lady (with a leg disability, AKA Meng) then said she makes hats and had to try lots of times to get the hat design correct. She also makes traps to catch lizards. Meng said you must identify what the problem is and then find the solution*" (D11, Observational notes) "*Another participant then said that they have made fishing rods out of bamboo and string as well as 'bamboo holes' for catching fish*" (D11, Observational notes) "*They know how to build a prototype but they don't know the meaning. They used to do with the prototypes but they just don't know what is the design process*" (D2)
Generative-design (as no evidence in pre-design)	"*Team building, everyone help to prototype to each other. Even the blind guy, he also involve this activity also. The guy in the wheelchair looks so happy while building the prototype. They're enjoy a lot and with their very good presentation, including their smiling*" (D2S3FD) "*Yes, to create the prototype for the other participants, we see that it is good. We see that people like they all join, 'like 95% 90 – 95% of people they join*" (D3S3INT2) "*The prototyping, we see that the old people, they enjoy doing that, even if the people there say that before the people are not motivated. But they still come and work with everyone, like they want to share their experience, or they want to join*" (D3S3INT2)

7.4.4 Finding 3: Involvement in a PD Project Improved the Collaborative Competencies *Contextual Insights*, *Design Critique*, *Design Process* and *Motivation*

From examining Figure 110, it is clear that *contextual insights*, *design process* and *motivation* improved over the course of the PD project. There was also a small improvement in *design critique*. The collaborative competencies are discussed holistically in this section and other factors that may have influenced collaboration are introduced.

Positive Relationship between Project Progress and Collaborative Competency

As the project progressed, the participants improved their understanding of the design process and their ability to collaborate (through *opinions*, *ideas* and *prototypes*). This improvement may have occurred due to both the CCB sessions and involvement in the PD project. Hussain (2011) stated in her PD project, "*it is first now, after completing all the work in the four field studies, that the designer and participants are ready to undertake a PD project together*" (p. 28). This showed that true co-creation was not reached during their project. However, participants grew in confidence and creative capacity.

As discussed in Section 7.4.2, the participants understanding of the design process improved from a basic linear understanding to one that included concepts such as iteration and testing.

Positive Relationship between Collaborative Competency and Strength of Participant-Designer Relationship

As the project progressed, the participants and designers developed a relationship. This connection may have enhanced the quality of collaboration through all individuals being comfortable and confident to give input into each activity. This explanation is similar to that provided for the *contextual insights* competency in RQ4, finding 1 and is supported by previous research. For example, Hussain et al. (2012) stated, "*The children, who had been participating in the project since 2008, seemed to be much more self-confident when talking about their own opinions. They did not need as much reassurance as earlier when answering questions*" (p. 102).

A similar change was evident in the present project; with participants growing in confidence as the relationship with the designer strengthened. This is evident through two statements from D2 shown below.

> D2, CCB - "*So from the first time we went we are strangers, because our team, it is the first time for them. They feel not confident to say it out*"

D2, during PD Project - "*I feel the participants they feel very closely to us and our teams, and they feel confident, but for the first time, they are a bit silent after, we explain more, they can understand*"

Positive Relationship between Collaborative Competency and Utilization of Making-style and Enacting-style Activities

As mentioned previously, *making*-style style and *enacting*-style activities were most effective at engaging the general participant group (see Table 60). As the project progressed, a larger proportion of time was spent on *making*-style and *enacting*-style activities resulting in an increase in the collaborative competencies. Table 71 shows each type of activity as a percentage of total activities for each of the design stages. Post design is an exception to this as it only involved group discussion and exit interviews.

Table 71 - Design stage vs type of activity

		Percentage of activities (%)		
		Making	***Enacting***	***Telling***
Design stage	Pre-design	0	17	83
	Generative design	38	0	63
	Evaluative design	33	33	33
	Post design	0	0	100

Inverse Relationship between Collaborative Competency and Group Size

In this project, two rounds of team formation were undertaken. Firstly, teams were arbitrarily formed to complete the pre-design stage. Secondly, participants were given the opportunity to choose which of the three defined project briefs they wanted to work on during generative, evaluative and post design. This meant that participants were given control over their project focus, and that the teams contained a range of different impairments. This process could have resulted in particular impairments grouping in the same teams (as the project brief may be most aligned with a particular impairment); however, this was not evident in case 1, 2 or 3. The team formation process was discussed in length in the design team and two options were proposed:

1. Use the process described above as it would ensure PwD-inclusion, opportunity for community development and empowerment and a range of participants with different strengths.
2. Group participants based on impairments. This would allow for activities to be tailored to the particular communication style of the team and for PwD to take a leading role in the team. It may also help keep projects focused on a particular challenge. This approach aligns with a

traditional view of segregating individuals based on impairment and does not give participants a chance to engage with the wider community.

While both options have strengths and weaknesses, the design team decided that teams which combined a range of participants, best aligned with the empowerment outcomes of the project; even if developing a focused technology output, became more challenging. This decision influenced some of the participant's opportunity to participate and in turn the quality of collaboration.

Team size may have also had an effect on collaboration, as participants seemed to increase in confidence when there were fewer people involved. To illustrate this, D1 stated the following about their observations of large group discussion (approximately 45 people)

> "*I think they're not really there to talk with the group, with the big group, because when we ask them into the big group, some of them they feel very shy and they said they're not there to talk in front of the whole group*"

Conversely, smaller group activities (approximately 15 people) yielded more conversation and evidence of meaningful collaboration. Table 72 shows the coding frequency of descriptions for the *opinions* competency for both large and small group size.

Table 72 - Group size vs opinions competency descriptions

	Very poor	Poor	Fair	Good	Very Good
Large group	0	6	1	4	0
Small group	0	4	4	15	1

One obvious question that arises from this analysis is *why were the groups not made even smaller?* It seems likely that even smaller groups would result in even more confidence to collaborate. This was evident during the post-design exit interviews where participants demonstrated *very good* abilities in the *design critique, ideas* and *motivation* competencies. However, smaller groups were not possible in Project 1 as our local DPO partner managed recruitment. This organization tried to balance our request, for a small number of participants, with the large demand to be involved in the project. This real-world challenge was unavoidable.

There is a range of views related to creativity and team size expressed literature. To start Hussain et al. (2012) decided to work with only three participants as this allowed her to build stronger relationships and meet with each participant in their own homes, a large distance apart. Contrastingly, Godjo et al. (2015) analysed four HTD-using-PD projects and found that project success was most likely with 14 to 18 team members. They suggested that 15 participants was an effective number, similar to that utilized in the present research.

The Quality of Collaboration is Influenced by the Type of Project

There was evidence that type of technology focused on in a PD project has an effect on the quality of collaboration; this includes the type of technology, level of complexity and expected level of involvement of participants. For example, in the present study, participants were involved in all aspects of the project (research, design, testing, iteration, and implementation); whereas in previous projects, participants have only been involved in certain aspects of the overall project (i.e. usability of computer interface, aesthetic of prosthetic limb). This difference can be described as a difference in technical design involvement, as participants can be involved in the user-facing elements of a project or the behind-the-scenes technical design elements, or both. In case 1 and 2, many of the challenges mentioned stemmed from a lack of technical design ability (*design* knowledge). Kam et al. (2006) involved their participants in the design of the computer game interface and story line. Byrne and Sahay (2007) followed a process similar to Kam et al. Moving outside of IT design, Demirbilek and Demirkan (2004) performed conceptual design with elderly participants but no technical design or construction was undertaken. This contrast is interesting as it may contradict the universal message that PD *empowers* participants, depending on how the term *empower* is viewed. Clearly, social/political empowerment can still be achieved through focused PD involvement. However, design empowerment, where the participants can start to design independently, would not be possible without engaging in the holistic design process. The present researcher suggests this is an area of conflict, in PD research, that needs to be resolved.

When focusing on holistic involvement in the design process (as evident in the present research), the *complexity* of the solution also created challenges for project collaboration. For example, case 1 contained high levels of participant engagement, and even evidence of independent design and prototyping. However, the dosing system (to drop the seeds) was complex and was not effectively developed by the participants. To overcome this, the design team developed an effective dosing system. This was challenging to introduce and hand over to the participant group due to construction and design complexity. The designed dosing system was considered the simplest mechanism that met the performance requirements. Linking to the work of Christiaans (1992), this discussion can be framed by stating that previous PD projects have focused on collaboration at a *basic knowledge* level, where the present research has looked to collaborate at a *process* and *design knowledge* level also.

HTD-using-PD is most effective when the project has potential to impact all of the community members involved in the collaboration

There was evidence throughout case 1, 2 and 3 that PD activities were most effective when the participants believed the final output would be beneficial to their lives. This can be seen by contrasting case 1 and case 3. In case 1, participants were very motivated to participate in the project and showed a desire to independently continue the project. The rice seeder design was small, cheap, easy to replicate and relevant to all participants (whose families all engaged in rice farming). Contrastingly, in case 3, participants focused on a one-off modification project focused on improving P8's access to his family's chicken coop. The project struggled to pick up momentum with designers leading the project throughout. There was also expectation misalignment as participants chose ideas that could be constructed in workshop time, while designers expected the most effective idea to be chosen regardless of the amount of time needed. This suggested that projects focusing on a single individual should use a process that focuses on one-on-one interactions and less on democratic decision making in large groups.

This finding links to the intrinsic and extrinsic components in the cognitive map of the motivation competency (shown in Figure 85). It seemed that in case 3, participants did not perceive any direct benefit from the project, meaning there was little extrinsic motivation present. Because of this, the participants motivation needed to be driven by intrinsic values (Schwartz, 2012). Given the lack of empathy for PwD in Cambodia (Gartrell, 2010), it seems likely that intrinsic values were not strong enough drivers to motivate the participant group - in particular the values of benevolence (enhancing the welfare of individuals close to you) and universalism (appreciation and protection of welfare for all people), as defined by Schwartz (2012).

7.5 Understanding the Value of CCB

As with all research, there will be findings that conflict with existing research. Some of these conflicts have already been discussed along with findings from the present research. However, two major areas still require reflection for completeness. Firstly, whether the time spent for CCB could have been used for other PD activities, resulting in similar outcomes. Secondly, ethically, whether the use of CCB is an appropriate approach to PD project work. These are discussed next.

7.5.1 Time for CCB vs Other Activities

The question must be asked, *if the time spent on CCB sessions were reallocated to general PD project activities, would the same value be achieved*? In the present study, the CCB sessions took approximate 1.5 days out of 8 formal community workshop days (approximately 20%). If the PD project was just initiated at the beginning of this time, and had an extra 1.5 days allocated to it, would the quality of collaboration have been demonstrably different?

Firstly, there was no control study run in parallel to the present study. As previously explained, it would not have been valuable, as the number of external, uncontrollable factors (participant, location, project type, designer, etc.) would have made the findings invalid. Therefore, a reflection by the present researcher has been developed from both lived experience and data analysis.

Researcher Reflection

When reflecting on the above questions, the intended outcomes of the project need to be discussed. The project aimed to produce impact through both product (new assistive technology) and process (creative capacity and social empowerment). It was clear that both designers and participants wanted more time together to refine the prototypes that were designed. Project timing and funding did not allow for this; however, the partner organisations in Cambodia have committed to ongoing technical support with the community to ensure effective technology is developed. It seems that in this regard an extra 1.5 days would have been helpful for progressing the technical design.

In terms of process impact, there was real value in running the CCB sessions before the project began. Engaging with all of the participants before the formal PD project allowed for relationships to be built and for expectations to be clearly defined. Furthermore, the CCB activities were carefully developed to involve multiple hands-on, creative activities. These seemed to be enjoyable for all participants, including heavily impaired participants, and gave participants their first experience of engaging in design activities. Feedback from all participants suggested that there was no perceived negative effect of CCB by the participants. It seemed that CCB did not have a strong influence on specific design skills (such as *ideas* or *prototyping*) but it did influence competencies that supported the smooth progression of the PD project (such as *motivation* and *design process* knowledge). This resulted in few of the previously documented process challenges being evident, apart from the previously discussed creativity skills. Of course, there were also socio-cultural characteristics that influenced the collaboration, such as a lack of empathy for PwD, limited exposure to divergent thinking and shyness. These characteristics were still evident during the PD project, but did not result in major challenges in case 1 or case 2. Notably, case 3 did fail due to the individual-focus of the project, lack of motivation of participants and a lack of buy in from a key decision maker. It seems unlikely an extra 1.5 days would have changed the outcome of case 3.

It is likely that replacing CCB with PD activities would have allowed the technology to be further developed than was evident in the present research. However, this would have been at the expense of a *design for* and *design by* collaboration as it was the CCB stage that seemed to boost motivation and empower participants. This, in turn, would have reduced the impact of the process, as less creative capacity building or social empowerment would have occurred.

In summary, replacing CCB with 1.5 more days of PD activities may have furthered the development of technology, but would have reduced the process impact on the community. It is the present researcher's opinion that CCB was much more valuable than 1.5 more days of PD activities as it resulted in more engaged participants, independent design work being undertaken by the community as well as more meaningful *design with* and *design by* collaboration occurring. This, in the end, will result in more product impact through independent and collaborative design work.

7.5.2 Ethical Concerns

In an effort to be holistic, and critical, in the analysis of the present study, a discussion about the ethical implications of CCB and PD is presented. This draws guidance from the work of Mainsah and Morrison (2014), who investigate the use of PD for humanitarian purposes through a post-colonial lens. Their work highlights that researchers commonly neglect to focus on power relations and tend to view culture as homogenous and static. The present researcher with reflect on each of these points in this section.

Power Relations

There are many interactions throughout this project that could be discussed in this section. For example, the relationship between researcher and designer (Western and Cambodian), the relationship between researcher and participant, the relationship between designer and participant and the relationships among the participant group and the designer group. Of most importance to the ethical discussion is a focus on how both the researcher and the designers interacted with the participant group.

The intention of this project was to create a level power structure in which participants were comfortable and confident to collaborate at equal levels to designers, or even take over the design process. The use of CCB was intended to aid in this goal by equipping participants with the collaborative skills needed to contribute meaningfully. Overall, a level power dynamic was achieved, as expected. There was clear evidence of participant input, as well as participant enjoyment and gratitude for being involved in such a unique style of project. One challenging aspect of this power structure was managing who drove decision making during the generative design stage. Participants struggled with the *ideas* competency and so relied on designers for creative input. This may have led to participants developing a dependency on the designers to navigate the ambiguous, divergent stage. The present researcher acknowledges this could have been completed in a more balanced way; however, timing constraints meant that designers were required to drive generative design activities forward to ensure intended outputs were met.

Overall, participants seemed able to provide honest, critical feedback (as evident in the exit interviews) and designers and participants developed a close bond that enhanced the quality of collaboration.

How Culture was Viewed

Viewing culture as homogenous and static is difficult to avoid when conducting PD research. A socio-cultural understanding s initially formed through literature review and is used as the basis for designing CCB and PD activities. The present researcher followed the same process, focusing on Cambodian history, society, culture, geography and the life of PwD. This formed a clear, but unfortunately static, view of two different groups of Cambodians: able people and people with disability. Next, a detailed understanding of disability was built through a literature review of disability theory. This helped to form a more meaningful understanding of disability and the complexities and differences associated with each impairment.

In order to overcome the pitfall of homogenous and static understanding, two field trips to Cambodia were undertaken before the main research project began. Both of these trips involved learning about Cambodian culture and history as well as meeting dozens of Cambodians, and undertaking two homestays in rural Cambodia. During these trips, the present researcher contributed to engineering projects being undertaken by local organisations. These experiences were invaluable for building a more meaningful understanding, and connection, to the land and people of Cambodia. Furthermore, relationships with several Cambodians living in New Zealand were developed. While this only involved infrequent meetings, it was valuable to discuss new cultural characteristics that may have emerged through planning and data analysis.

Finally, the present researcher undertook five more field trips across the remainder of the project - one trip to develop and pilot the CCB content and four trips to attend the CCB sessions and PD project. This large number of field trips has allowed for a detailed understanding of Cambodia, its history and its people to be developed. The present researcher has built many meaningful relationships with Cambodian people and has developed a strong connection to the country, and desire to collaborate with its people.

7.6 Chapter Summary

This chapter presents the key findings from the present research. These include a summary of the current state of the research field (RQ1), the important attributes for effective collaboration (RQ2), how CCB content was designed and piloted (RQ3) and what effect CCB had on the quality of collaboration (RQ4). Of note are the findings that CCB has a positive effect on *contextual insights, design process* and *motivation* competencies, and no demonstrable effect on *design critique, ideas* or *prototypes* competencies. Furthermore, involvement in the PD project had a positive effect on most of the collaborative competencies, highlighting the previously documented finding that PD involvement has an empowering effect on participants. Finally, it was shown that the type of activity, size of group and stage in the PD project all have an effect on the quality of collaboration.

In summary, this chapter has drawn from a large amount of data gathered across three cases and five design stages, to present valuable findings in the field of humanitarian technology development, participatory design and creative capacity building.

CHAPTER EIGHT

CONTRIBUTION TO THEORY AND PRACTICE

CHAPTER OVERVIEW

Chapter 8 concludes the current investigation of designer-participant collaboration during HTD-using-PD. It begins by reiterating the focus of the study, its importance to the wider research field and its uniqueness. Next, the contributions the research has made to theory and practice are discussed, followed by implications to practitioners in PD and humanitarian engineering. Finally, the chapter discusses the reliability, validity, limitations and future research direction for this research.

8.1 Focus of this Study

The general purpose of the present research was to investigate whether the design and implementation of CCB sessions would enhance the quality of collaboration between designers and participants during a HTD-using-PD project. This focus was in response to several studies that stated a lack of design knowledge and experience of community members, as a barrier to meaningful collaboration. At the outset of this research it was clear that most PD research utilized a single-case, single respondent (usually the designer) research design, which involved undertaking a PD project then reflecting on the process, enablers and barriers. This style of research has been criticized for its inability to produce "*tangible, new outcomes: documentable, replicable and valid*" (Wang & Oygur, 2010, p. 366) and "*empirically demonstrable benefits in outcomes*" (p. 357). Therefore, a focus of the present study was to develop a rigorous, multi-case, multi-respondent research design that allowed for clear, detailed analysis as well as a solid foundation for future work in this space. To do this, a set of collaborative competencies were developed, along with a conceptual model showing the integration of CCB into PD (Figure 14). Next, the researcher collected data during three cases in rural Cambodia, to understand the nuances of PD and the role that CCB could have in a PD project.

In relation to the data collection and design, the research employed a data triangulation process that utilized the perspectives of designers (through interviews, field diaries and reflection sessions), participants (through interviews) and the present researcher (through field diaries, observational notes and lived experience). These perspectives were compared with the objective workshop outputs (such as posters, prototypes and models). This data was analyzed using a systematic, qualitative coding process, followed by an examination of relationships and patterns in the coded data. This yielded the visualization technique shown in Chapter 6, and the findings presented in Chapter 7. The project was unique to the research field as it utilized a much more detailed research design than previous work. Furthermore, it was the first study to investigate the use of CCB in PD and the first to focus on using PD for assistive agricultural technology development in rural Cambodia.

These findings are discussed below in relation to their value to theory and practice.

8.2 Contribution to PD Theory

The following section summarizes the contribution to theory that the present research has made. A discussion on validity, reliability and limitations of this contribution is presented later in the chapter.

8.2.1 Categorization of the Current HTD-using-PD Research Field

There have been multiple attempts to categorize PD, and wider design approaches based on the participant's role in collaboration (Kaulio, 1998; Sanders & Stappers, 2008) and the specific activities and design stages used (Sanders & Stappers, 2014; Mazzurco, 2016). However, no research has shown the layout of research against the type of project and the type of collaboration. This provides a useful tool for discussing the interplay between the two factors and highlighting new configurations that may be effective.

8.2.2 Development of Collaborative Competencies

The development of the collaborative competencies adds value to this research field as it represents a synthesis of previous creativity-focused research and recent HTD-using-PD research. These competencies provide guidance during CCB content development, PD project planning and data analysis and reporting. While they having only been tested in one socio-cultural context (Cambodia), their grounding in extant literature provides assurance as to their usability. These have already been published in a journal article (Drain, Shekar, & Grigg, 2017).

8.2.3 Development of the PDC Model

Similar to the collaborative competencies, the development of the PDC model adds value as it provides a holistic view of collaboration in PD. It builds on a linear view of collaboration by utilizing an interpretivist view to articulate the dynamic nature of the collaborative environment and the various factors that influence collaboration during PD. The PDC model can be used to structure discussion about PD, communicate the specific focus of new research (relative to the wider system) or build awareness of the various factors present in any PD project.

8.2.4 Improved Understanding of the Role that CCB can Play in Enhancing the Quality of Collaboration

The present study represents a first attempt to combine CCB with PD. It drew inspiration from research stating the value of CCB (Taha, 2011) and research stating the challenges of conducting PD with participants that lack creative capacity (Kam et al., 2006; Winschiers, 2006; Winschiers-Theophilus et al., 2010; Hussain et al., 2012). While the present researcher acknowledges the project did not run perfectly (as no project does), it did show that there is some value to the use of CCB sessions before a PD project. Future researchers can now build upon these findings and research design as the field strives towards more effective processes for HTD and community empowerment. Findings relating to the PD project itself have been published in a journal article (Drain, Shekar, et al., 2018b) and conference paper (Drain, McCreery, et al., 2018).

8.2.5 Summary of Publications

Knowledge developed through literature review, first-hand research and product development experience, during doctoral study, has been disseminated through three published journal articles, (Drain, Shekar, & Grigg, 2017; Drain, Shekar, et al., 2018b), one conference paper (Drain, McCreery, et al., 2018), two conference presentations (Drain & Jones, 2017; Drain, Shekar, & Jones, 2017) and several popular-media articles. One further journal article is currently under review. Alongside the doctoral research presented in this thesis, the present researcher also utilized their experience to contribute to several other publications in the research field of engineering education (Drain et al., 2016; Shekar & Drain, 2016) and commercial product development (Pangputt et al., 2018; Shekar & Drain, 2018). Table 73 shows a summary of all publications produced during the period of doctoral study.

Table 73 - Summary of publications during doctoral period

Journal Article	**Conference Paper**	**Conference Presentation**	**Book Chapter**
PhD Output: - 3 Published/Accepted - 1 Under-review *Non-PhD Output:* - 1 Published	*PhD Output:* - 1 Published *Non-PhD Output:* - 2 Published	*PhD Output:* - 2 Presented	*Non-PhD Output:* - 1 Published

8.3 Contribution to Practice

Along with contributions to theory, this research has contributed to real world humanitarian engineering practice. As such, this section discusses the contribution of the research and provides examples of how the work has already been utilized in the real world.

8.3.1 Development of CCB Content Development Process, Illustrated through Project 1

The CCB content development process was created and implemented during the design of CCB for Project 1. This process was published in a journal article (Drain, Shekar, & Grigg, 2017). The process has also been used to refine the CCB content used in Project 1, for a second Cambodia-based project being undertaken by Massey University, EWB Australia and LFTW in 2018. This project is outside the scope of the present research but will be published in separate research outputs.

8.3.2 Development of a Practitioner Handbook

Similarly, a practitioner handbook was developed for use in Project 1. This was refined to create a final handbook to be used in future projects and was disseminated to humanitarian engineering practitioners through the EWB Australia and New Zealand practitioner network (Drain & McCreery, 2018). The handbook was openly available under a creative commons license and shared with as wide a community as possible to ensure it provides value. This handbook represents one of many handbooks available (Diehl, 2010; Ferguson & Candy, 2014; IDEO, 2015). Its value lies in its alignment with PD ideology, its Cambodian application and its CCB content. As of the 21st January 2019 the handbook had received 1482 reads on Research Gate.

8.3.3 Development of Monitoring and Evaluation Plan that Allows for Rigorous Reporting on Impact of Process

In an effort to address the criticisms that the PD field lacks tools for rigorous monitoring and evaluation (Wang & Oygur, 2010), multiple data collection tools were developed through this project. These include a range of interview scripts (to track participants engagement and empowerment), field diaries (to record designer feedback about each activity) and technology evaluation templates (to document the effectiveness of designed technology and document future improvements). These tools are also included in the practitioner handbook. The tools aim to provide a different approach to the industry standard *theory of change* approach (i.e. *most significant change* reporting). The development of a new evaluation framework has been published in a journal article (Drain, Shekar, et al., 2018a).

8.3.4 Examples of Real-World Value

There are several examples that illustrate the real-world value of the present research. Firstly, as mentioned above, EWB and LFTW have begun a second project, utilizing the CCB, project activities and monitoring and evaluation that was developed in the present research. This shows that these organizations see value in the process, and were satisfied with the value delivered through Project 1.

Secondly, the present researcher has become a valuable member of the humanitarian engineering community in Australia and New Zealand. This is evident through his involvement in humanitarian engineering and social impact conferences (EWB NZ, Link Festival Australia and the International Social Innovation Research Conference) as well as their consulting work for EWB Australia in India and Cambodia. Furthermore, the present researcher has taken on a role as an advisor to EWB NZ, providing guidance on the use of human-centered and participatory design techniques for humanitarian engineering projects, as well as providing insights from multiple projects undertaken in NZ, Cambodia and India. The present researcher has been inducted into the Asia New Zealand Foundation Leadership Network (a network for emerging leaders in Asia-New Zealand relations).

Thirdly, the present researcher has begun to build a presence outside of Australia and New Zealand. For example, they participated in the United Nations UNLEASH Workshop (a workshop for global emerging leaders to engage with others and develop solutions to the Sustainable Development Goals). They have also undertaken a 12-month role as a Contributing Editor to the Engineeringforchange.org website. Others in this role include senior lecturers, government officials and experienced development practitioners.

Finally, the present research received funding support from the New Zealand Government (NZAID Postgraduate field research award), the Asia New Zealand Foundation (Leadership Network Travel

Grant), EWB Australia (Australian NGO Cooperation Program) and Massey University (Massey University Research Fund and the Ken and Elizabeth Powell Bursary). This wide range of project support also suggests the research has value.

All of these opportunities have stemmed from the present research and experience gained in engineering design and monitoring and evaluation activities.

8.4 Practitioner Implications

8.4.1 What is the Focus of the PD Project?

Findings for RQ1 and RQ2 suggest there are two different foci in PD projects: technology and empowerment. Each will lead to different project impact and different priorities during the project. Therefore, the present researcher suggests that designers are aware of these two different foci during planning and development of program logic. The intended focus can be used to guide planning, implementation and evaluation as well as allow specific case studies to be used for guidance.

8.4.2 When is CCB Valuable?

The present research suggests that CCB will be valuable in projects where confidence to express opinion and motivation to contribute may be qualities lacking in the participant group. The wider generalizability is discussed later in this chapter; however, it seems valuable in contexts that possess a collectivist culture, with strict hierarchical structures and a saving-face mentality. It may also be useful when working with specific marginalized groups, such as PwD, as they may be more heavily affected by negative cultural dynamics than general populations.

It is not possible to say whether CCB would improve the *design critique* and *prototyping* abilities of a community that was not initially strong in these areas. However, there is no evidence of any negative effect of running CCB, therefore, if time allows for it, CCB should be included in projects of this nature. Of course, the content needs to be modified to ensure it is contextually appropriate; guidance for undertaking this process is provided in RQ3.

Findings suggest that a participant group that is already strong in all of the competencies would not benefit greatly from the CCB training. Therefore, in this case the extra 1.5 days of time may be better allocated to general PD project activities.

8.4.3 How to Maximize Collaboration in PD

The present research has highlighted the wide range of factors that can affect collaboration (shown in the PDC model and in RQ4, finding 3). Firstly, the relationship between designer and participant can influence the quality of collaboration. This suggests that designers should focus efforts on developing warm, meaningful relationships with participants as early as possible in the project, as this will lead to better collaboration and design outputs.

Secondly, the use of *making* and *enacting*-style activities were much better at engaging participants than *telling*-style activities. This suggests that designers should aim to prioritize these types of activity when possible. Of course, consideration for the particular participant group, and any impairments, needs to be taken into account.

Finally, the type of project had a strong influence on participant motivation, particularly, whether the project had potential to benefit all participants or only a select few. Findings from this research suggest that a PD approach works well when all participants believe they will benefit from the project. When the project focuses on a particular individual, the rest of the group did not demonstrate such high levels of motivation. This was linked to the lack of empathy for PwD in Cambodia.

8.5 Reliability

The term reliability refers to the repeatability and reproducibility of the data collection and analysis in the present study. In terms of repeatability, the longitudinal nature of the research design ensured that multiple repetitions of data collection and analysis occurred. This repetitive process improved the likelihood of repeatable findings by ensuring the present researcher reflected on each observation and finding across each case, stage and collaborative competency.

While reproducibility is challenging in qualitative research, due to the subjective nature of coding and data interpretation, several steps have been taken to improve reproducibility. Firstly, a detailed description of data collection and data analysis procedures is provided in Chapter 3. Chapter 5 provides a detailed overview of the PD project itself to ensure that all of the nuances of the project are captured and described. Chapter 6 provides discussion for every case, every stage and every collaborative competency. This level of detail was purposely included to ensure future researchers are explicitly aware of the process used and the rationale for each of the findings generated. Finally, a discussion of the findings was undertaken with both the researcher's supervisors and one of the lead designers from Project 1. These discussions allowed for assumptions to be challenged and multiple perspectives to be included in analysis.

8.6 Validity

To discuss the validity of the research, both internal and external validity need to be addressed. Internal validity is essentially a measure of how well the data collection and analysis methods actually measure the intended phenomenon and not other, unknown variables. External validity refers to how well the research can be generalized outside of the specific context in which it was grounded.

Internal validity was enhanced in four separate ways. Firstly, the researcher spent large amounts of time in the socio-cultural context. This allowed the researcher to gain a deep understanding of the environment and be more aware of other influencing factors that needed to be considered. Next, data triangulation was used to cross-reference all findings, with only findings that were supported by multiple data sources included in the research findings. This process ensured that a particular invalid data collection tool did not result in invalid research findings. Next, all data collection tools were externally reviewed and piloted before use, this ensured that any confusing questions, misleading concepts or ineffective aspects could be refined before being utilized in Project 1. Finally, a search for disconfirming evidence was undertaken in both the present research and extant literature, this is provided in Chapter 7 by actively discussing contrasting views in literature

External validity was enhanced in four separate ways. Firstly, the research design involved three separate cases (inside of the same overall project). These separate cases were discussed explicitly in Chapter 6, with similarities and differences noted. The use of three cases improved validity as it allowed for emergent themes to be cross-referenced to ensure they were generalizable inside of the project. Three cases also drastically increased the amount of data collected (compared to a single case design), this allowed for more meaningful coding and data analysis. Secondly, an extensive literature review was carried out to understand the current state of the research field and the research findings already documented in different projects. This was used to guide the design of research tools and confirm and disconfirm findings from the present research. Thirdly, the specific socio-cultural context of the present research is clearly stated in this thesis. The specific participants and designers have been described as well as the specific type of project undertaken. This level of detail allows future research to reflect on the findings of the present research while understanding the exact situation in which the project was grounded. Similarly, the present researcher has stated their ontological and epistemological views, ensuring that any bias created from these views is noted. Finally, the present researcher acknowledges that these findings are only generalizable within a specific socio-cultural and technological domain. The generalizability of the research is discussed in the next section.

8.7 Generalizability

The present research contains the following unique aspects that should be noted:

1. Was based in rural Cambodia in 2017

2. Worked with a participant group made up of adults with impairment and able adults, both male and female

3. Focused on the design of simple, mechanical agricultural technologies

4. Utilized a team of Cambodian and Western designers, both male and female
5. Worked within a 7 month period, involving four formal two-day workshops
6. Followed a participatory design ideology with both product and process impact objectives

Cambodia is such a unique environment with a complex combination of conflict history, pseudo-democratic government, poor infrastructure and education, high levels of disability and a Buddhist underpinning. Therefore, it is clear that much of the detail of this project is specific to this environment. Reflecting on the research questions, RQ1, RQ2, and RQ3 are widely generalizable in the domain of HTD-using-PD, and potentially add value to the wider field of PD. RQ4 requires more discussion around each of its findings.

Finding 1: CCB improves the collaborative competencies contextual insights, design process and motivation

The specific socio-cultural characteristics of this participant group meant that these three competencies were assessed as poor initially. This is likely to be the same in countries that have strict hierarchical structures, limited design education and a saving-face mentality. Many developing countries fit this description, with the Hofstede model providing guidance on this point. As discussed in Section 7.5.2, to treat an entire culture as homogenous is inaccurate. Therefore, the present researcher would like to reiterate the need for the specific participant group to be understood.

Finding 2: CCB does not improve the collaborative competencies design critique, ideas or prototyping

Two of these competencies, *design critique* and *prototyping* were assessed as being strong initially, and throughout the project. There is evidence in commercial product development literature to support the claim that *design critique* is a basic competency present in most end-user across the world (hence why many projects only engage the end-user in feedback sessions and testing). The present researcher agrees and suggests that this is a universal strength of participants that could be leveraged further in future projects. The competency *prototyping* was also deemed as strength, and was linked to the agrarian lifestyle of the participant group. This suggests that the finding would be generalizable to other participant groups who practice agriculture and work in *hands-on* livelihoods. Finally, the *ideas* competency was assessed as *poor* initially and remained poor throughout the project. There was evidence that this was a function of strict hierarchical structures, limited design education and a saving-face mentality. Wider literature in HTD-using-PD noted similar challenges in Cambodia, India and Namibia, suggesting similar creativity challenges would be present in most developing countries.

Therefore, the present researcher suggests this finding is generalizable across the HTD-using-PD domain.

Finding 3: Involvement in a PD project improved the collaborative competencies contextual insights, design critique, design process and motivation

Finding 3 provided a more general set of findings focused on collaboration across the overall project. It stated that participants improved in most competencies and that collaboration was influenced by the stage in the project, type of activity, relationship with designer and type of project.

Firstly, improvement in competencies across the project has been reported in previous HTD-using-PD projects in several different countries. Furthermore, PD is positioned as a design approach that looks to empower the participants through involvement in the process. Initially, this was in the form of political empowerment, but more recently, it has taken the form of social and creative empowerment. Therefore, these findings fit the general narrative of the research field and can be generalized. One point to note is that four of the competencies were initially assessed as low, meaning there was plenty of opportunity for development, while the two competencies that were assessed as *good* initially did not change during the project. This suggests that a participant group with strong ability across the competencies initially may not demonstrate the same level of development across a PD project.

Of the remaining findings, the link between the type of activity and quality of collaboration is the only one that may not be widely generalizable. Previous research has suggested that an even number of *making, enacting* and *telling*-style activities provides the most effective process for meaningful collaboration (Brandt et al., 2012). However, the present research found that the use of *making* and *enacting*-style activities was much more effective than *telling*-style activities. This finding seems closely linked to the agrarian lifestyles of the participant group (resulting in a strong *prototyping* competency) and the lack of formal education in the participant group (meaning it was hard to engage in classroom style discussion). Therefore, the present researcher suggests this finding is generalizable inside of participant groups with agrarian lifestyles and low levels of formal education. Such groups are widely present in many developing countries.

8.8 Limitations

Despite careful planning and adherence to the research design, the present research is subject to certain limitations. These are stated below.

1. Whilst every attempt has been made to eliminate this limitation, it must be stated the nature of qualitative research means the present researcher's preunderstanding, philosophical views and bias can influence the data collection analysis and findings.

2. It would have been valuable to track the technology projects, and involved community over a period of several years to understand the real value of the technology and the level of creative and social empowerment. However, this was not possible due to funding and time constraints associated with the PhD research plan. The present researcher has committed to supporting the community and local organisations as the technologies are further refined. This is outside the scope of the present research.

3. The present researcher does not speak the Cambodian local dialect (Khmer). Speaking this language fluently would have improved the researcher's ability to observe interactions during each workshop and perhaps collect data that are more meaningful. However, this is a challenge in many cross-cultural projects. The effects were minimized by having a translator present for the majority of time and the researcher undertaking Khmer classes to learn basic Khmer words and phrases.

4. Across Project 1 there were 11 designers involved (including the present researcher). This was due to several designers leaving either ADG or Cambodia, meaning the changes were unavoidable. While this did not seem to affect the project in any major way, it did mean that only three designers were present for all four workshops, and two were present for three workshops. The limitation of this is that more consistent longitudinal data was not available for all designers. However, the large amount of data, and longitudinal data from five designers meant this did not affect the reliability of the findings.

8.9 Future Research

Despite these limitations, this study has improved the field's understanding of collaboration during the HTD-using-PD process, and the role that CCB can play in enhancing this collaboration. The foundation provided by this research present several avenues for future work. These are detailed below.

Firstly, further investigation of the link between CCB and collaboration during PD needs to be undertaken. This could focus on either how to refine and improve the current CCB sessions to better target the limitations of the participant group (such as the *ideas* competency) or to implement the same design process in a different socio-cultural context and investigate whether the findings of RQ4 are supported. Similarly, future research could look at the effectiveness of the approach in projects with different foci (empowerment vs technology or the type of technology).

Secondly, it would be valuable for the PDC model to be tested in a range of PD environments to validate its usefulness and accuracy in describing the collaborative system. This could involve a wide review of PD projects, to see if the components and relationships between components are present or a detailed study of a new PD project using the PDC model as guidance for planning and analysis.

Thirdly, RQ4 finding 3 suggests that the type of activity is linked to the quality of collaboration. This has proven true in this particular context, but future research should aim to test the strength of this link in other agrarian communities.

Finally, the trade-off discussed in Section 7.4.3 needs to be investigated. This centred on the effectiveness of *making*-style activities in engaging more able-participants, and the potential for exclusion of heavily impaired individuals during prototyping activities. This represents a challenge in the use of PD in HTD projects involving PwD.

8.10 Concluding Remarks

This thesis aimed to understand what collaboration meant in HTD-using-PD, and how it could be enhanced through the design and implementation of CCB. This was in response to several studies that stated a lack of design knowledge and experience as a barrier to meaningful collaboration. Through this investigation, a clear understanding of collaboration was developed and the role of CCB was defined.

The present research has increased the understanding of designer-participant collaboration in the research field and created a solid foundation for future research in this area. Furthermore, the research has had real world impact due to the research design and partnership with multiple organizations. The adoption of a qualitative methodology has allowed for an inductive analysis and the emergence of many important themes. A multi-case approach has improved the validity of the findings and allowed insightful projects to be documented for future practitioners and researchers.

It is clear that there is much more to learn in this research field. However, the present researcher believes that the insights generated from this research will benefit many communities and ensure more inclusive, empowering approaches are used in future engineering projects.

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Appendix A - Research Tools

Interview Script: S1Int1 Initial Interview with ADG Designers (Conducted by PhD Researcher)

Interviewer: Respondent: Date:

As you know I am an engineer from New Zealand looking to learn about community development and participatory design in Cambodia. This project will be part of my studies at Massey University and will help me to conduct better projects with communities in the future. This interview is for me to learn a bit more about you before we begin the development project together. There is no right or wrong answer; I really just want to understand your point of view.

What is your role at Agile Development Group?

What kind of work do you undertake in this role?

How long have you been employed at ADG?

What was your job before this role?

Have you worked on any capacity building projects?

Can you explain one of these projects briefly?

What was your role in this project?

What challenges did you face during this project?

What was the final output of this project?

I would like to move onto a different topic now

Have you worked on any participatory design projects?

Can you explain one of these projects briefly?

What was your role in this project?

What challenges did you face during this project?

What was the final output of this project?

Do you find it difficult to work with communities on development projects?

Do you think that most development workers find it difficult to work with communities?

How important is community input when designing a solution?

Not important at all	Slightly important	Moderately important	Very important	Extremely important

How important is it that community members have a good understanding of design?

Not important at all	Slightly important	Moderately important	Very important	Extremely important

Thank you very much for your time, I look forward to working with you.

Interview Script: S2Int1 Initial Interview with Participants before and throughout Project 1 (Conducted by Cambodian Designers)

Interviewer: Respondent: Date:

Thank you for agreeing to be interviewed. This interview will be short and is only used so that we can better understand your experience. The questions will be about the idea of design.

What do you think the term 'design' means?

Have you ever used design in your life?

Have you ever been involved in a design project with an NGO before? Can you please explain? (Only ask during first interview)

If you were going to solve a problem what steps would you go through?

Thank you for your time, we will see you during the next design session.

Interview Script: S2Int2 Interview with Designers after CCB Workshop (Conducted by PhD Researcher)

Interviewer: Respondent: Date:

Thank you for agreeing to be interviewed. This interview will focus on the four capacity building sessions just undertaken. It is used to gain insights into your opinions about the content, what worked well and what could be improved. There is no right or wrong answer so please be as honest as possible.

Overview

Were you present for all four of the capacity building sessions?

Did you present any of the content? If so can you please explain what?

What are your initial thoughts about each of the sessions? ('Intro to design', 'the design process' 'design activity', 'transition to pre-design')

Competency-focused

How would you describe the participants' ability to express opinions during each session?

How would you describe the participants' ability to generate ideas during each session?

How would you describe the participants' ability to create prototypes during each session?

How would you describe the participants' understanding of the design process during each session?

How would you describe the participants' motivation to be involved during each session?

Group dynamic

Did you notice any differences in individual participant's ability levels? If so can you please explain why you think this has happened?

Conclusion

In general, do you think the capacity building sessions have improved the participants understanding of the design process?

Interview Script: S3Int1 Interview with Designers throughout Project 1 (Conducted by PhD Researcher)

Interviewer: Respondent: Date:

Thank you for agreeing to be interviewed. This interview will focus on the pre-design stage and corresponding activities that have just been undertaken. It is used to gain insights into your opinions about the activities and the collaboration with participants. There is no right or wrong answer, so please be as honest as possible.

Overview

Can you give a brief overview of all the pre-design activities you were involved in?

What are your initial thoughts about the pre-design stage?

What challenges did you face in collaborating with participants in the pre-design stage?

Competency-focused

How would you describe the participants' ability to express opinions during each session? Can you give an example?

How would you describe the participants' ability to generate ideas during each session?

How would you describe the participants' ability to create prototypes during each session?

How would you describe the participants' understanding of the design process during each session?

How would you describe the participants' motivation to be involved during each session?

Group dynamic

Did you notice any differences in individual participant's ability levels? If so can you please explain why you think this has happened?

Conclusion

Do you feel the project has progressed to an acceptable stage?

Interview Script: S3Int2 Interview with Designers throughout Project 1 (Conducted by independent Cambodian Interviewer)

Interviewer: Respondent: Date:

Thank you for agreeing to be interviewed. This interview will focus on the project you have worked on over the past year with Agile Development Group. The purpose of this interview is to learn about how you felt about the project, what was good, what was not good and what we could do better in the future. Please be honest and tell us how you felt.

Overview

What is your name?

How many of the workshops did you attend?

Which project was your team working on?

Did you enjoy being part of this project? Why?

What is the most important thing you remember about the workshops? Why?

What did you not like about this project? Why?

How has your life changed since attending the workshops?

Do you feel like you can design products by yourself now?

Would you attend workshops like this again in the future?

FOR individuals with the products

Have you used the product yet?

How many times?

Would you use it again?

What have you learnt about the product from using it that you didn't know before?

Thank you for your time

Goodbye

Field Diary: Completed by all Designers and PhD Researcher throughout Project 1

Facilitator Field Diary Template

Facilitator:	Date:	Session/activity:	Design project:

Please select one of the answers on each scale based on perception of the participant group and add a comment if appropriate.

Ability to express opinions about project					
Very poor	Poor	Fair	Good	Very good	No Evidence
Comment:					

Ability to generate insightful ideas					
Very poor	Poor	Fair	Good	Very good	No Evidence
Comment:					

Ability to create insightful prototypes					
Very poor	Poor	Fair	Good	Very good	No Evidence
Comment:					

Understanding of the design process/ activity					
Very poor	Poor	Fair	Good	Very good	No Evidence
Comment:					

Motivation to contribute					
Very poor	Poor	Fair	Good	Very good	No Evidence
Comment:					

What has worked well this session?

What has not worked well this session?

Any additional comments:

Appendix B - Capacity Building Content Version 3

Content

This session plan contains content adapted from Taha (2011) as well as original content developed to be contextually appropriate.

Session 1: Greeting, introduction and 'what is design'

Goals:

1. Begin to build relationship with community
2. Explain what the workshop is about and what the time requirements are so that community members can make an informed commitment to participate in both the PDCB and the full PD project
3. Confirm that there is an alternate location that could be used in case of rain
4. Ensure that any materials needed from the community are available and will be brought to the workshop when needed
5. Allow time for unplanned activities such as in-depth introductions or community ceremonies
6. Introduce participants to the concept of 'design'
7. Generate discussion around similar/familiar concepts for community members

Materials:

- ☐ Poster of schedule
- ☐ Pens and paper for anyone to take notes
- ☐ Item for 'what is this?' activity

Things to prepare in advance:

- Make sure participants and venue are finalized
- Finalize curriculum and schedule so that they can be clearly communicated during the session
- If material is being given by more than one person decide how it will be divided
- Ensure required materials are available (Ensure schedule includes correct translation)
- Ensure food is available if appropriate

Presentation:

1. Greetings and welcome (allow all participants to introduce themselves if appropriate)
2. Introduction to the full Participatory Design project. Highlight the overall objectives, the stages of the project and role of PDCB. Ensure the timeframe is understood and expectations are well managed
    - *This project aims to work with you to design new, easier ways of growing and harvesting vegetables. We hope that we can help you by teaching you about the design process and work with you as we go through the process and make new solutions which will help you meet your goals*

3. Introduce icebreaker activity
    - *Before we get started we would like to get to know you and to introduce ourselves to you. Let us do around the group and introduce our name and where we are from.*
    - Facilitators introduce themselves first
4. Introduce the 'what is this?' activity
    - *In order to create new solutions for you we will all need to be creative and think about things in many different ways. To practice this we are going to play a game called 'what is this?'. I will pass this item around the group and each person will need to think of a new use for the item. The use can be serious or silly, it is up to you.*
    - Facilitators discuss their uses first
    - Facilitator explains the actual use of the product
5. Begin discussion about 'what is design'. If no answer, ask one of the following:
    - *Has anyone heard of the term design before? What do you think it means?*
    - *Design is essentially the process of identifying problems and creating solutions, for example:*
        - *Have you ever made a tool to use on the farm*
        - *What is your most important tool and why?*
        - *Have you ever fixed anything before?*
        - *Have you ever thought that something could be done better?*
    - The important concept was the idea of 'identifying a problem' and 'trying to solve it'.
6. Explain that when you have lots of problems you need to use a good process to solve them quickly and effectively, this is the design process!
    - *When you have one problem and you know the answer sometimes you can just come up with a solution straight away. However, most of the time there will be many problems and many solutions to choose from. To help you with this process you can use a process call the design process. This is a set of steps that you can follow each time you start a project. We will cover this in detail in the next session along with an example of how to use the process.*
7. Close the session and outline the next session which will provide a detailed example of the design process from identifying a problem to design a solution.
    - *Thank you for attending this session. We have 3 more sessions before we begin the main project. The hope is that we can all learn about each other and about the design process and use it help solve some of your problems.*

Teaching notes:

- Make sure people are committed to attend all four of the session and understand the length of the project. There will be a gap between each stage.
- We will provide snacks for everyone but they are expected to go home for main meals. There will also not be money provided for involvement in this project

Session 2: Full design process example

Goals:

1. Provide an example of the complete design process
2. Show the value of repeating the cycle to improve the design
3. Demonstrate a technology that may be of interest

Materials:

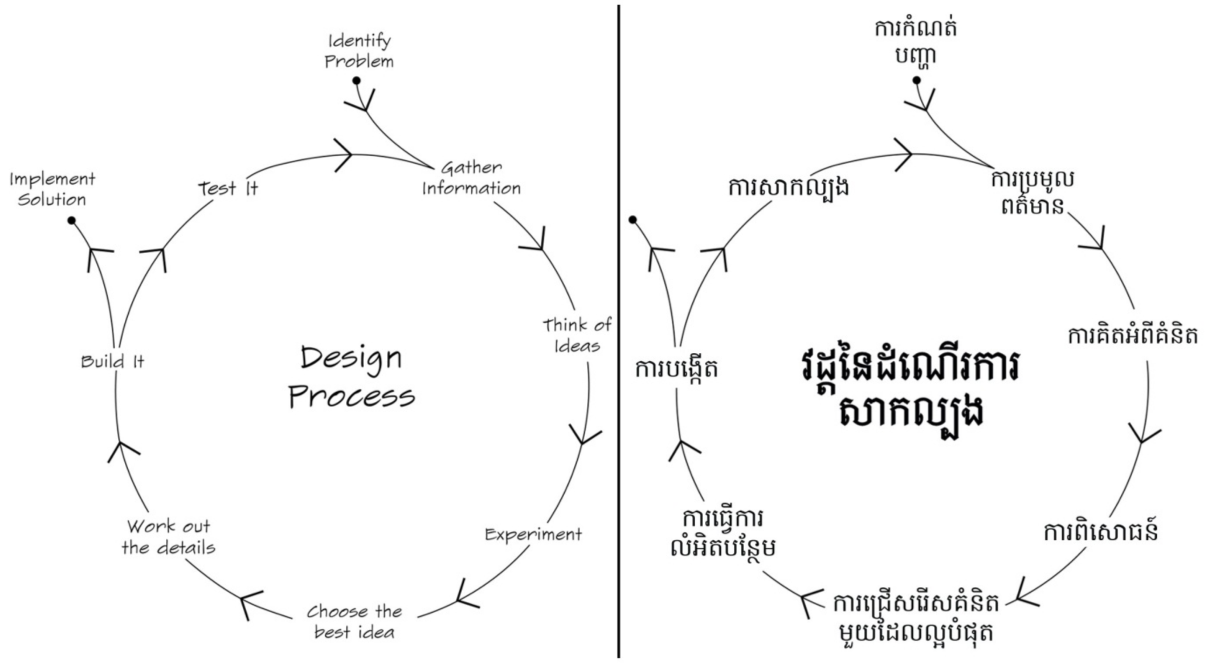
- □ Poster of design process
- □ Example material
    - o Photos of problem
    - o Example products

Things to prepare in advance:

- Ensure all parts of all products are there
- Prepare any demo material
- Ensure that all demonstrations have been practiced in advance
- Draw poster of design process (Ensure correct translation)
- Draw several idea sketches on pieces of card

Presentation:

1. Greet participants and explain the purpose of this session
    - o *The purpose of this session is to introduce you all to the design process. This is a number of steps you should follow to try and find the best solution for a problem you have. It is made up of lots of steps and sometime you need to go through the process more than once. The reason we use the process is to help remind us what we should do next so we don't miss anything.*
2. Introduce each stage of the design process using poster
    - o *Identify problem, gather information, think of ideas to solve problem, experiment, choose the best idea, work out the details, build it, test it, get feedback and repeat.*



Design Process Diagram

3. Start by introducing the 'Identify Problem' stage
    - *At the beginning of the process you will need to find a problem you want to solve. You should look for lots of problems and then decide as a group which problem is the best to solve first. This should be based on your ability to solve the problem and the impact that the solution will have on the community.*
2. 'Gather information'
    - *Next you will need to gather information about your problem. This information will help to make your solutions more effective and more likely to succeed. You should ask questions like:*
        - *How long have this problem been happening?*
        - *Are there any current solutions? If so why aren't they working?*
        - *Who has to deal with the problem at the moment?*
        - *When does the problem occur? (yearly, monthly, daily?)*
        - *Why does the problem happen?*
4. 'Think of ideas'
    - *Once you have gathered information, you will need to come up with lots of ideas that could solve the problem. It can help to look at what has already been done in other places or at similar types of solution in your village that could be helpful. You should talk about ideas, write them down and draw them so you can record all the ideas you think of.*
5. 'Experiment'
    - *Once you have lots of ideas you should choose the best few ideas to make. You should choose the ideas by discussing exactly what the solution needs to do and what will be easiest to make and implement. Do not choose too many ideas, usually 3 ideas will be enough. You should then try and make prototypes of the ideas and test them out. You*

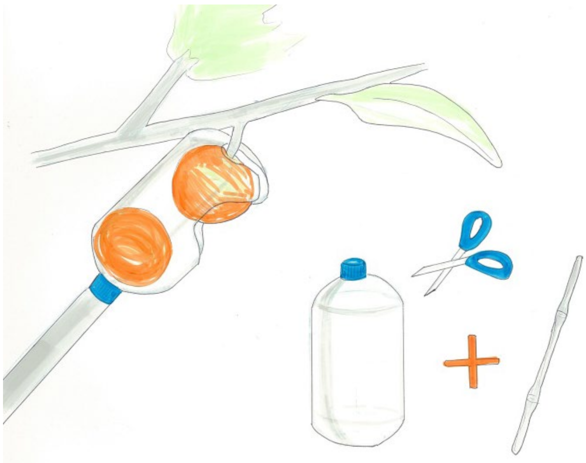
can use this time to make changes to the ideas and learn more about whether they will work or if something needs to be changed.

6. 'Choose the best idea'
    - *Next, you should use the testing you have done to decide which idea is the best one. To do this you should discussion the good and bad parts of each idea and how the idea will benefit the community. Think about how expensive each idea will be to make and how long it will last for. Also, think about how safe the idea is and whether it could hurt someone accidently.*
7. 'Work out the details'
    - *Now you have the final idea chosen you will need to decide on all the details. How big does it need to be? What should it be made from? Who will make it? How heavy should it be? How fast should it work? Does it need to be maintained? How expensive can it be? You should think carefully and make any changes needed. You can try and make some more prototypes or drawings if needed.*
8. 'Build it'
    - *You will now need to build the final design, based on the idea you came up with and the details you have decided on. You may be able to make this yourself out of materials in the community, or you may need to ask someone to make it for you.*
9. 'Test it'
    - *If you have not tested the idea at all you should now try and test it out. This could be testing small parts of the solution or trialing the whole solution with one person before implementing it in the community. There will definitely be things that can be improved! Try and use it in as many ways as possible like with different users, in different weather conditions, at different times of day and for long and short periods of time. If it is not perfect that is okay, you can make changes in the future.*
10. Start again!
    - *Now it is time to use the information gathered from testing to improve the solution. You should ask the questions: what worked well during testing? What did not work well? What could be improved? By going through this process many times you can create great solutions to problems and improve your community in the ways you want to.*
11. Implement Solution
    - *Once you have been through the process a few times and believe your solution is as good as it can be you will now need to implement the solution into the community. This will involve working with other people to build a full sized version of your solution.*
12. Introduce example solution (Mango Picker)
    - *To help you understand the process we will show you a design that has used this process.*
13. 'Identify Problem'
    - Generate Discussion: *What is the problem with getting mangos off the tree?*
    - *It is hard because the mangos can be high up in the tree. This means it can be difficult and slow to get them down.*
    - *The problem is 'It is difficult to get mangos off the tree'*
14. 'Gather information'
    - What information do you think you should learn?

- Size of tree
- Size of mango
- Number of mangos needed each day
- Location of trees

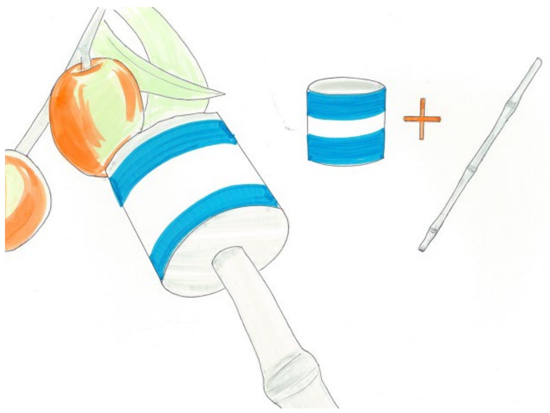
15. 'Think of ideas'
    - *Can you think of any ways of getting the mangoes out of the tree?*
    - *Have you used any tools to help get the mangos?*
    - Show each of the ideas on the cards and explain each one briefly

Concept: Tree Climbing



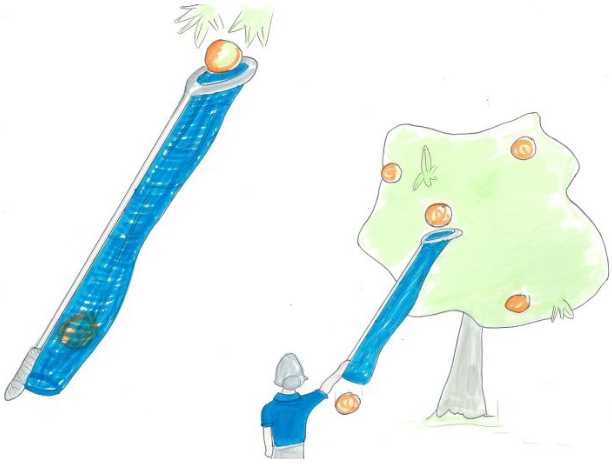
Concept: Bottle Grabber

Concept: Ladder

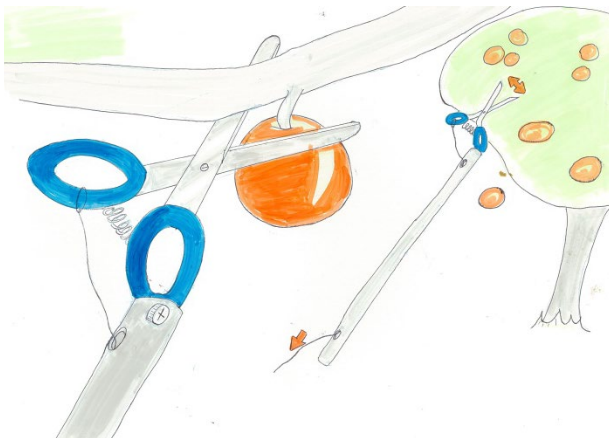


Concept: Can Cutter

Concept: Small Net



Concept: Large Net



Concept: Scissor Cutter

16. Explain that three of the ideas needed to be chosen for testing, present the three ideas
    - Allow for suggestions from the group but also ensure that at least two of the chosen ideas match the materials you have available for prototyping:
        - Can Cutter
        - Bottle Graber
17. ‘Experiment’
    - Show the three prototypes. You may want to have one of the prototypes in pieces and make it with the community. They should not be complete units but instead only have the end parts ready for testing on low down fruit
    - Get the community to try each of the three prototypes and give feedback. If possible, use a mango tree to test the ideas. Otherwise just ask participants to pretend to use it
18. ‘Choose the best idea’
    - Generate a discussion about which idea is the best

        - *Which one is the easiest to use?*
        - *Which one would be the easiest to make?*
        - *Which one will last the longest?*
        - *Which one is the fastest to use?*
        - *Which one is the safest?*
        - *Which one should be choose?*

19. 'Work out the details'
    - Now that the final idea is chosen we will need to work out the details so that it will work well when we build it.
        - *How long should the pole be? How can we figure it out?*
        - *How large should the basket be? How can we figure it out?*
        - *What should the pole be made from? What should the basket be made from?*
        - *How should we join the pole and the basket?*
20. 'Build it'
    - Show/build the final prototype and ask participants to try it out if possible
21. 'Test it'
    - Ask participants to comment on what could be improved in the future?
        - Speed of the product (efficiency)?
        - Number of times it broke down?
22. Explain that now it is important to go through the process again and again to continue to improve
    - *Once you have completed the cycle you will have a solution that might work well. Even if it works well it is important to think about how it could be improved in the future. That could be through using it for a while and recording any problems you have had. Or running some testing to see if it works as well as a previous design you have used. This is how your communities can get better and better at creating technology by yourselves*
23. Highlight the importance of three steps:
    - Coming up with many ideas
    - Experimenting and choosing the best idea
    - Going through the cycle many times
24. Ask if there are any questions
25. Ask some reflective questions
    - *How did you find this session? Was it enjoyable?*
    - *What did you learn? Is anything confusing?*
26. Introduce next session – small scale design exercise

Teaching notes:

- Do not rush through the stages; allow as much open discussion as possible
- Focus on the 'work out the details' stage and generate discussion about the exact dimensions and materials of the design

Session 3: Small scale design exercise

Goals:

1. Allow community members to practice working together
2. Allow community members to practice the stages of the design process
3. Show community members the value of prototyping and testing

Materials:

- ☐ Paper (approximately 12 sheets per group of four people: 10 of white paper and two of colored paper)
- ☐ Pens
- ☐ Maize or equivalent (as many as possible)
- ☐ Poster of design process
- ☐ Poster explaining activity

Things to prepare in advance:

- Prepare paper for each team
- Ensure maize, or equivalent, is available
- Ensure activity poster is complete (Ensure correct translation)

Presentation:

1. Greet participants and example the purpose of this session
    - To start with let's think about the stages of the design process:
        - *Can you remember what we covered in the last session?*
        - *Can you remember any of the steps of the design process?*
        - *Why is it important to come up with more than one idea?*
        - *Why is it important to make prototypes to test your ideas?*
        - *Why is it important to go through the process multiple times?*
2. Recap previous session – generate discussion about the stages used
    - Identify problem
    - Gather information
    - Come up with ideas
    - Experiment
    - Choose the best idea
    - Work out the details
    - Build it
    - Test it
    - Implementation of solution
3. Introduce the small scale design exercise
    - Maize Raise
4. The Challenge:

- In order to prevent pests and flood water from destroying your grain, you must store your maize at least 15 cm (height of pen) off the ground. Using only two pieces of paper
    - Be sure that everyone understands what the task is, and explain again to clarify if necessary
5. Instructions:
    - Recall the design process, the starting point is to identify a problem. This is that pests and flood water is destroying your grain. To stop this the grain needs to be raised to 15cm off the ground
    - Start by thinking of ideas, you have 10 sheets to practice and experiment with; think of as many different ideas as you can
    - As a group, look at the different ideas you have come up with and choose the best one. Discuss how you will build it
    - We will give you two new pieces of paper (possibly colored to differentiate it from the practice sheets) and you will build your device
    - Time to test!
    - You can discuss what could be improved and make one more version of your design
6. Give each community member ten sheets of paper and allow them to start experimenting
7. After 15 minutes, call the group together and tell them to choose their best idea and make it out of the colored paper
8. After about 10 minutes call the teams together to present their design
9. Comment on what was good about the designs, and what could be improved
10. Review the design process and how it was used in this activity
11. Ask if there are any questions about the session

Session 4: Transition to Pre-design stage

Goals:

1. Show how the design process could be used in the community
2. Ensure community members understand the goal of the design process and this particular project
3. Transition focus from simple examples to potential opportunities in the community
4. Define a particular opportunity and basic requirements

Materials:

- ☐ Poster of design process
- ☐ Paper and pens

Things to prepare in advance:

- Poster of design process
- Ensure any knowledge exchange activities requiring planning are addressed
- Bring templates for design opportunity/brief if appropriate

Presentation:

1. Greet participants and explain the purpose of this session
    - *The purpose of this session is to think about how we could use the design process in your community*
    - *In this session we will discuss the problems you would like to work on*
2. Recap previous session – generate discussion about the stages used
    - To start with let's think about the stages of the design process:
        - *Can you remember what we covered in the last session?*
        - *Can you remember any of the steps of the design process?*
        - *Why is it important to come up with more than one idea?*
        - *Why is it important to make prototypes to test your ideas?*
        - *Why is it important to go through the process multiple times?*
3. Focus on step 1 – 'Identify Problem'
    - *Firstly let's think of all the problems/opportunities you currently have in the community*
        - *Agriculture*
        - *Health*
        - *Shelter*
        - *Food Security*
        - *Enterprise*
        - *WASH*
    - Write all of these problems down onto one large sheet of paper
4. Knowledge exchange

    - Next ask to go on a tour of the village or of someone's house. Allow a lot of time for this as multiple participants may want to lead a tour of their homes
    - If any new problems arise write them onto the paper
5. Once the tours are complete, return to the training area and lead a discussion about all of the problems.
    - *Now that we have a good list of opportunities it is important to discussion which ones we should look at first as it is not possible to look at all of them at the same time. We need to think about what will have the most impact on the community and which projects do we have the skill to complete.*
    - Ask the participants to try and decide on the 3 problems to take forward into the project, if discussion is not democratic try:
        - A red dot voting technique
        - A hand-raise vote
    - Make sure all participants understand why the particular projects were chosen
6. Explain that now we will enter the design process and continue to learn more about the problems we have chosen.
    - *We will spend the next day 'gathering information' about the chosen projects. This will allow us to learn about your community and understand exactly what the solution needs to achieve. We will come back in one month and work with you to 'come up with ideas' and 'experiment'.*
7. Discuss schedule for next visit
8. Recap the design process:
    - *Identify problem*
    - *Gather information*
    - *Come up with ideas*
    - *Experiment*
    - *Choose the best idea*
    - *Work out the details*
    - *Build it*
    - *Test it*
9. Thanks and farewells

Teaching notes:

- This session may take more than one hour due to the guided tours, however, this is acceptable as it will allow other members to relax or tend to other matters
- It is important to finish the session with 3 ideas, or a strong group decision towards 1 or 2 ideas

Appendix C - Challenges identified by community in Project 1

Challenge identified by community
Limited access to water
Hard to walk to get water in the morning, hard to carry water back
Legs are sore from walking to get water
Sit at grandmothers house for 5 hours every day doing nothing
Hard to know if the chicken are big enough to sell
Need to ask children to do all the planting and harvesting of rice
Have to walk for one or two hours to find grass for the cow to eat in the forest
Can only look after grandchild during the day. Cannot do anything else
Limited agricultural tools
Difficult to access house
Lack of clean water
Flooding makes farming difficult, even if they have cow-mechanic
Hurt leg makes it difficult to farm
Difficult to travel when flooded
When old energy is lost
Don't have savings for when they are sick
Have the older people stay with them and he doesn't have energy so every movement he want to do he has to have the people help him
Blind, deaf. They lack money to afford their family
Difficult to travel
Difficult to do activity (go to farm/walking)
Difficulty to travel
Difficult to navigate independently
Difficult to climb tree to get mango
Need others to help with physically demanding work
Plan herbs, morning glory, watermelon, cucumber around the house
Three types of rice, one short-grow (3-4 months, 1300r/kg), medium-grow (4-5 months, 800r/kg) and long-grow (5-6 months, 800r/kg)

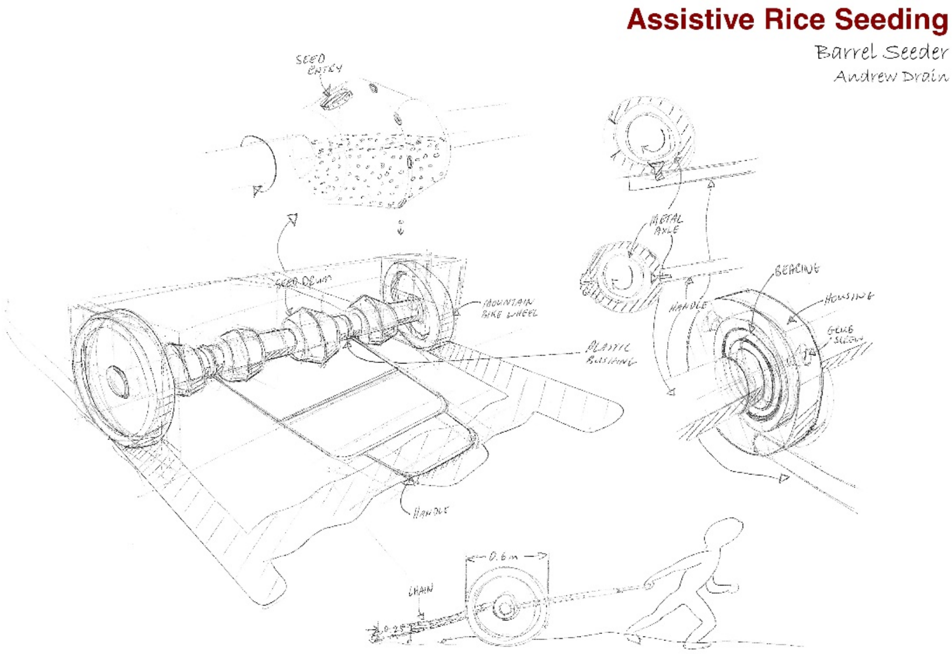
Limited water in April, May and June
PwD cook rice
PwD weave baskets at home
Grow flowers to sell at market
Cannot find market to sell livestock, sell for too cheap
Lack of wholesale market for vegetables
Livestock gets disease and dies
Limited technical knowledge for agriculture
Do not know how to feed livestock, just follow traditional
Lack of seeds
Lack of toilet
Limited knowledge in village
No pension
High blood pressure
Digestion/stomach sickness
Arthritis
Easy to get angry (mental disease)
Nose, throat and heart
Debt
Selling livestock is cheap selling meat at market is more expensive
People do not experiment with different ways to sell, just follow others
Difficult for PwD to do agriculture
Cannot afford for children to study so they cannot get a job
Lack of skill in community, cannot find job
Easy for livestock to get sick
lack of market/don't know where to sell
farm is far away from village
lack of seeds
lack of tools to farm
Don't have enough rice for the whole year. Not enough during rain season (6-10)
Blind

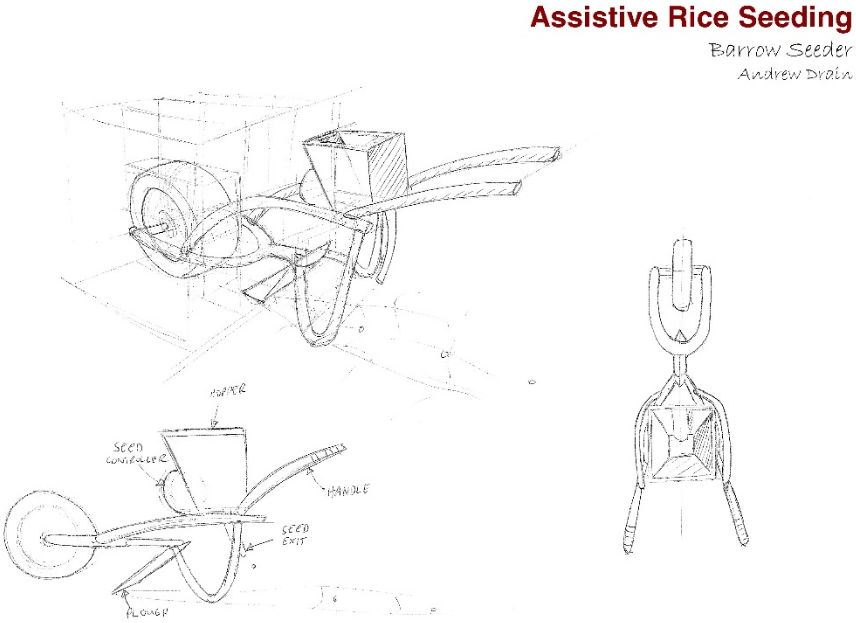
Deaf
General disease (cold)
difficult to see the doctor (maybe far away)
Home is leaking in the rain
Lack of water in village
Lack of well in village
Price of livestock is too cheap
When older their eyes cannot see
Man stays alone with no children to look after him at night and cannot hear
When we want them to do something we need to speak softly, use body language or show pictures
PwD can understand if you speak quiet but if you yell they get confused and scared
Cannot receive the information from outside (other people). Deaf
When it is too hot outside, eyes cannot see clear and tears come out
Blind, visually impaired and elderly visually impaired
Discrimination from other people
Society does not give the value to them
Don't have the right to involve in other activities
A lot of people look down on them
Difficult to live with the community
Difficult to study
Difficult to study
Difficult to eat
Difficult to eat
How they feel about themselves
How they feel about themselves
Difficult to go up and down stairs
Difficult to go to toilet
When born, they are different from other people
Difficult to speak
Difficult to work

Cannot see
To sum up, PwD never have a good living
Difficult to wear clothes
Emotional
Problem with high buildings, don't have ramp
Don't have water resource
Difficult to hear
Difficult to understand
Difficult to communicate
Difficult to find money for family
Difficult to bow and pray
Eye cannot see clear
Deaf students do not know what the teacher is saying
Deaf students are excluded from lunchtime activities
Deaf students do not know when to go away from class
Difficult to be involved in social events (wedding)
Difficult to eat and drink independently
Difficult to buy things from the shop with money
PwD throw things at chicken to keep them away from crops
PwD carry rice and put it in storage bags
PwD feed cows, walk cows to graze
PwD feed chickens

Appendix D - Idea generation for Project 1

Team 1 – Rice Seeder

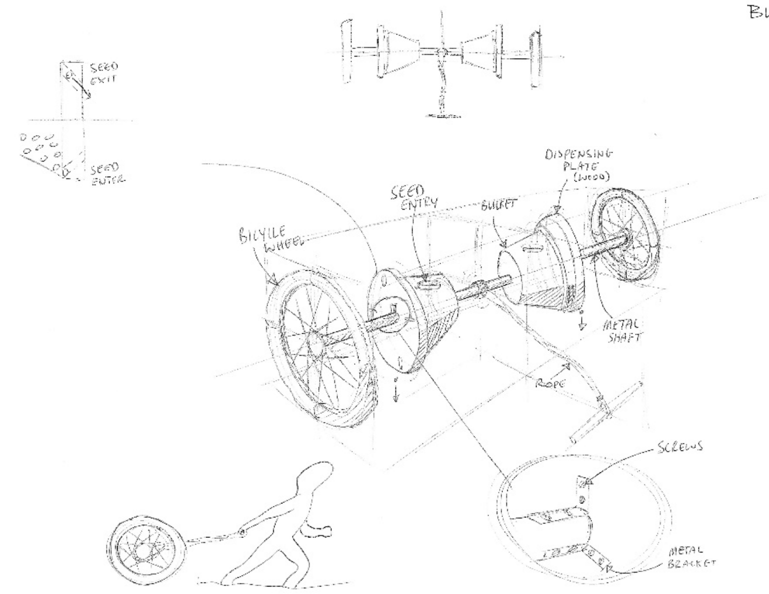




Assistive Rice Seeding

Bucket Seeder

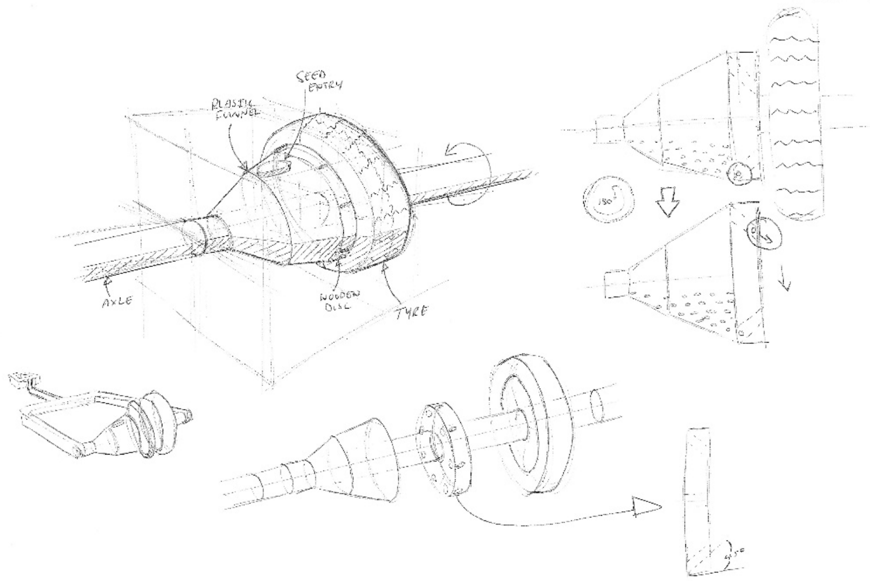
Andrew Drain



Assistive Rice Seeding

Funnel Seeder

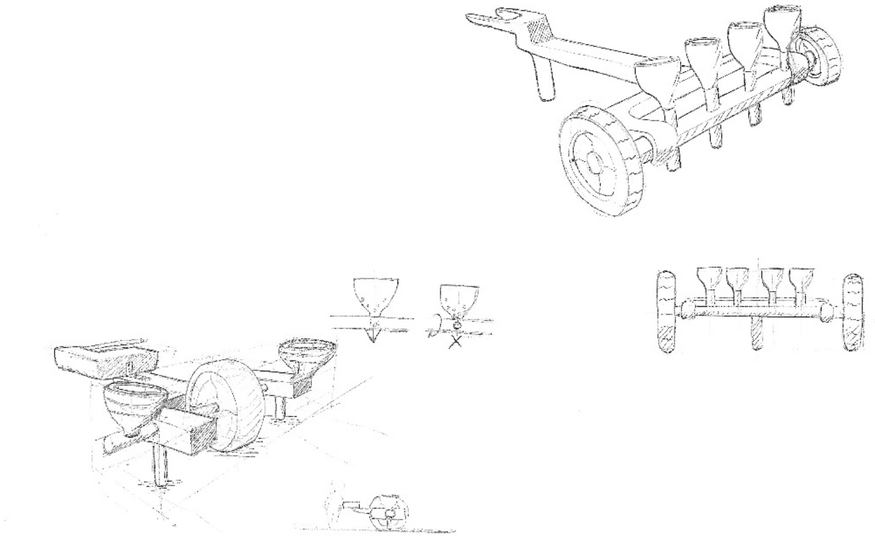
Andrew Drain



Assistive Rice Seeding

Hopper Seeder

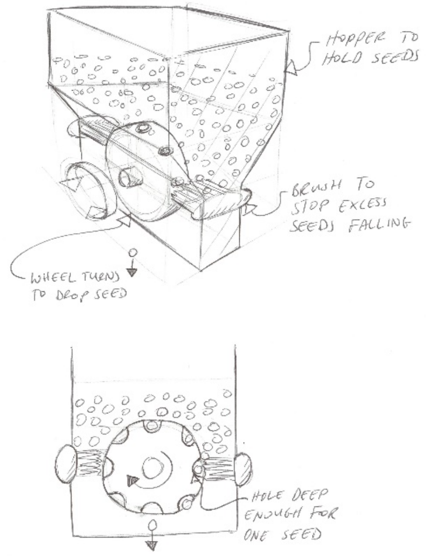
Andrew Drain

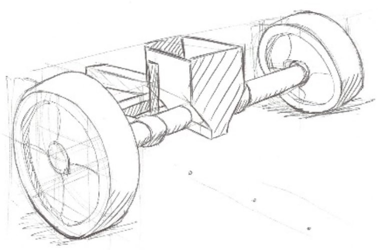


Assistive Rice Seeding

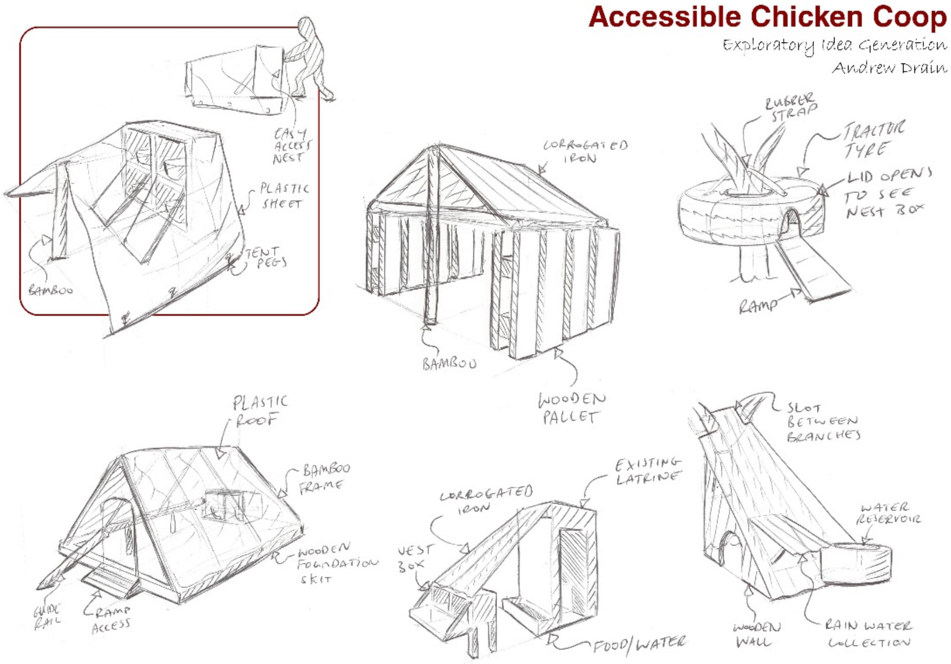
Small Wheel Seeder

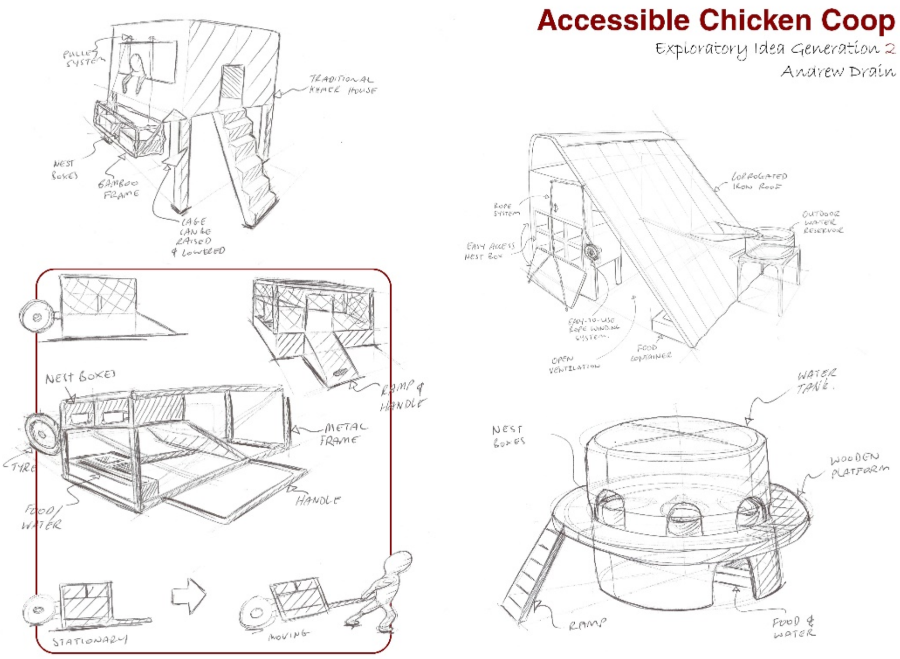
Andrew Drain





Team 3 – Chicken Coop

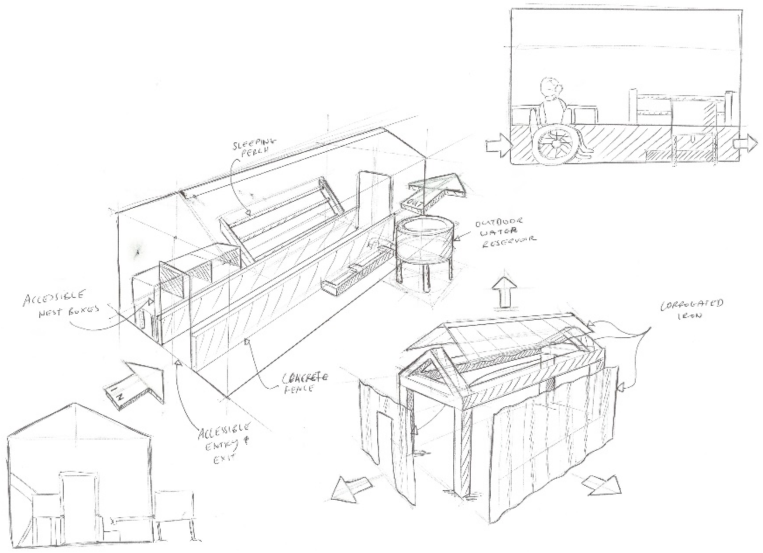




Accessible Chicken Coop

One-way Coop

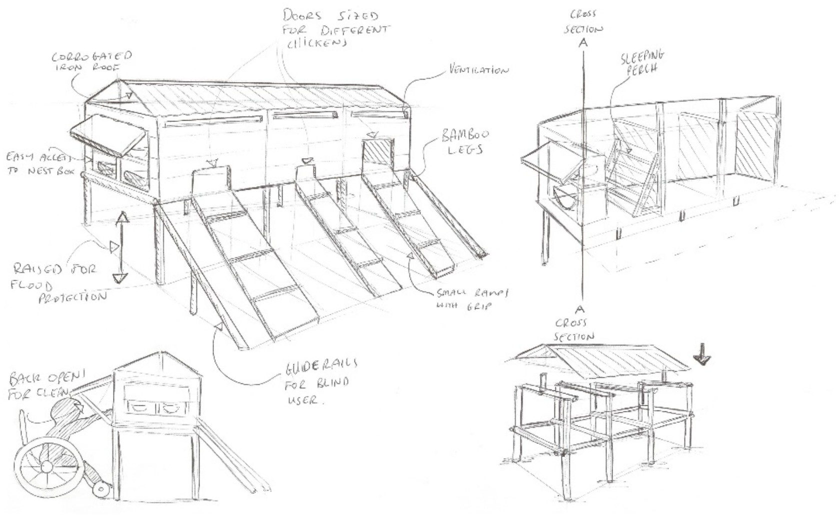
Andrew Drain



Accessible Chicken Coop

Stilt Coop

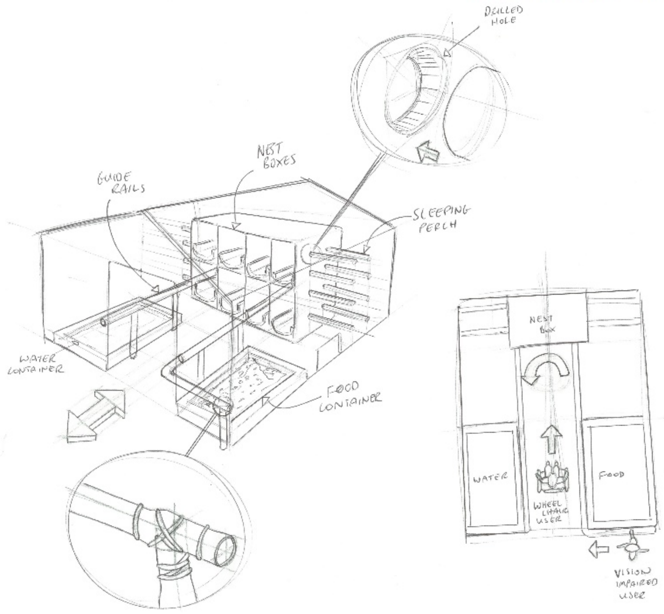
Andrew Drain



Accessible Chicken Coop

U-shaped Coop

Andrew Drain



Appendix E - Project 1 Technology Evaluation

Case 1 – Rice Seeder Community Design

Project name:		
Rice Seeder 2017 – Community Design		
End-user of technology:		
People with disability (elderly, mobility and amputee) in Kampong Chhnang, Cambodia		
Effectiveness of solution (to meet identified requirements)		
Requirement	Achieved? (yes/no/unsure)	Evidence (if available)
Must drop seeds 25cm apart	No	Dosing system did not work effectively and no consideration for hole placement demonstrated by community
Must be pulled by one elderly user	Unsure	Requirement met when product was tested on dry ground, however, no testing performed on muddy ground or with full load of seed (12kg)
Must be usable in flooded fields	Unsure	Not tested in flooded field due to seasonality. Suspected that product would not be usable in flooded field due to small wheels and weight of unit when full of seed
Seed dispensing must work in dirty environment	Unsure	Not tested in dirty environment due to seasonality. Suspected that product would not be usable in dirty environment due to the small wheels resulting in the dosing units dragging on the ground
Must hold 12 kg of seeds	Yes	The volume of buckets used allows for 12 kg to be stored
Easy to transport to farm	Yes	Design has wheels and a large handle, so can be pulled by person or motorbike. Metal harrows may cause issues during transport as they make contact with the ground at certain angles
Must be constructed and maintained locally	Yes	This unit was designed and constructed by the community with no additional materials supplied by facilitation team
Product improves universal design characteristics of the environment	No	If dosing system worked as intended, there would be a reduction in physical effort due to the removal of the

		transplanting process. However, pulling the rice seeder unit through mud may well result in increased physical effort. Furthermore, the unit must be pulled (due to harrows) and must be pulled at a consistent rate to ensure consistency of seed dosing. There is little tolerance of error if the unit is pulled at an inconsistent rate or stationary with a dosing hole facing downwards (as seeds will flow out of the unit)
Community satisfaction with solution		
Satisfaction rating (circle one)	Details (if required)	Evidence (if available)
Very dissatisfied Dissatisfied Neither Satisfied Very satisfied	Community members like the design and continued to refine it outside of the workshop. However, dosing system needs to be refined to ensure functionality	Observations and testing during Workshop 4 and exit interviews
Adoption of solution		
Timeframe	Achieved? (yes/no/unsure)	Evidence (if available)
End of project transfer of ownership	Yes	Prototype was taken by community member at end of Workshop 4
Short-term adoption	Unsure	Testing on dry ground showed need for improvement but unsure whether testing in muddy ground would be undertaken. This is due to seasonality of agriculture
Long-term adoption	NA	NA
Generalizability of solution		
Areas of importance	Appropriateness of solution	Evidence (if available)
Local	No	Too many requirements are not fulfilled in current product. Improvements are required
National	No	Too many requirements are not fulfilled in current product. Improvements are required
Other:		

Case 1 – Rice Seeder Design Team Design

Project name:		
Rice Seeder 2017 – Design Team Design		
End-user of technology:		
People with disability (elderly, mobility and amputee) in Kampong Chhnang, Cambodia		
Effectiveness of solution (to meet identified requirements)		
Requirement	Achieved? (yes/no/unsure)	Evidence (if available)
Must drop seeds 25cm apart	Yes	Geometry of dosing unit and diameter of bicycle wheel
Must be pulled by one elderly user	To be assessed	Requirement met when product was tested on dry ground. However, testing still needs to be performed on muddy ground or with full load of seed (12kg)
Must be usable in flooded fields	To be assessed	Not tested in flooded field due to seasonality
Seed dispensing must work in dirty environment	Yes	Large wheels allow for dosing units to sit above the ground
Must hold 12 kg of seeds	Yes	The volume of buckets used allows for 12 kg to be stored
Easy to transport to farm	Yes	Design has wheels and a large handle, so can be pulled by person or motorbike
Must be constructed and maintained locally	To be assessed	The dosing plate requires a precise circular profile and the dosing holes require the use of a jig to ensure precision. All other aspects of the product can be made locally
Must be affordable by community members	Yes	The use of a simple dosing unit and local materials means the unit will cost approximately USD $20 with cheaper configurations also available
Universal design	Yes	The dosing system allows for *flexibility-in-use*, as the product can be pulled at any speed.
Community satisfaction with solution		
Satisfaction rating (circle one)	Details (if required)	Evidence (if available)
Very dissatisfied Dissatisfied Neither Satisfied Very satisfied	Community members like the design and continued to refine it outside of the workshop. However, the frame needs to be refined to ensure rigidity in use	Observations and testing during Workshop 4 and exit interviews
Adoption of solution		
Timeframe	Achieved? (yes/no/unsure)	Evidence (if available)

End of project transfer of ownership	Yes	Prototype was taken by community member at end of Workshop 4
Short-term adoption	Unsure	Testing on dry ground showed need for improvement but unsure whether testing in muddy ground would be undertaken. This is due to seasonality of agriculture
Long-term adoption	NA	NA
Generalizability of solution		
Areas of importance	Appropriateness of solution	Evidence (if available)
Local	Yes	Local farmers use the same farming processes and have the same resources available locally
National	Yes	Small plot farmers most likely use the same farming processes and have similar resources available locally
Other: Small plot farmers in rural communities in developing countries	Unsure	Dependent on local farming processes

Case 2 – Plough Cart

Project name:		
Plough Cart 2017		
End-user of technology:		
People with disability (elderly, mobility and amputee) in Kampong Chhnang, Cambodia		
Effectiveness of solution (to meet identified requirements)		
Requirement	Achieved? (yes/no/unsure)	Evidence (if available)
Must be attachable to any existing plough	No	Coupling was not fully developed due to lack of access to community ploughs during the design process. This lead to incorrect sizes of u-bolts being sourced and lack of availability of larger sizes at local markets
Must be able to be pulled, along with plough, by two ox	Unsure	Testing showed it was difficult to pull on dry ground, but no testing performed on muddy ground due to season
Must be usable in muddy fields	Unsure	No testing
Must be able to stand, kneel or sit on the cart	No	Specific plough used for testing had a long handle that obstructed the users position on the cart. The cart itself may allow for these positions with a longer coupling or different plough handle size
Must maintain users level of plough control	No	If user is standing, plough handle is very low down. If sitting, the user is very far forward on the cart with little control of the downward pressure being exerted on the plough. Coupling causes plough handle to be in awkward position for user
Easy to transport to farm	Yes	Attached to motorbike easily
Must be constructed and maintained locally	Yes	Design is made from locally available materials, however, welding needed to be out-sourced to local markets
Must be stable during use	Unsure	Testing required in use environment (muddy field) to determine this criteria
Product improves universal design characteristics of the environment		Product does not meet all of the universal design principles. However, there are no obvious disadvantages for use by

		people with disabilities. Therefore, aspects of the product are universally accessible.
Community satisfaction with solution		
Satisfaction rating (circle one)	Details (if required)	Evidence (if available)
Very dissatisfied Dissatisfied Neither Satisfied Very satisfied	Feedback shows that the product could be useful but requires refinement. Community members showed strong engagement with the process and are motivated to continue refinement	Observations during workshop 4 and exit interviews
Adoption of solution		
Timeframe	Achieved? (yes/no/unsure)	Evidence (if available)
End of project transfer of ownership	Yes	Prototype was taken by community member at end of Workshop 4
Short-term adoption	Unsure	Testing on dry ground showed need for improvement but unsure whether testing in muddy ground would be undertaken. This is due to seasonality of agriculture
Long-term adoption	NA	NA
Generalizability of solution		
Areas of importance	Appropriateness of solution	Evidence (if available)
Local	Yes	Local farmers use the same farming processes and have the same resources available locally
National	Yes	Small plot farmers most likely use the same farming processes and have similar resources available locally
Other: Small plot farmers in rural communities in developing countries	Unsure	Dependent on local farming processes

Case 3 – Chicken Coop

Project name:		
Chicken Coop 2017		
End-user of technology:		
Vision-impaired community member in Kampong Chhnang, Cambodia		
Effectiveness of solution (to meet identified requirements)		
Requirement	Achieved? (yes/no/unsure)	Evidence (if available)
Must reduce occurrence of errors when entering the existing chicken coop	Yes	Doorframe raised to above the users height, therefore, it is difficult for the user to hit their head during entry. This reduces the likelihood of errors. This was validated during testing of door prototypes
Must improve the time taken to enter the existing chicken coop	Unsure	It is likely this requirement is met, however, no testing was done to validate this
Must improve the satisfaction of the entry process to the existing chicken coop	Yes	User was satisfied with conceptual design and door prototypes. Handrails were expected to improve comfort by providing clear guides allow access pathway. However, as there was no implementation, there was no opportunity to gauge satisfaction of final product
Must maintain required functional components of existing chicken coop	Yes	Conceptual design was expected to maintain existing functional components. However, as there was no implementation, there was no opportunity to validate this
Must retro-fit to existing chicken coop	Yes	Conceptual design aimed to retrofit to users existing chicken coop as opposed to building a new structure
Must be constructed and maintained locally	Yes	Design utilized bamboo, wood and locally available fasteners
Product improves universal design characteristics of the environment	Yes	Most of the universal design principles are met by the conceptual design. However, while not negatively affected, *equitable use and size and space for approach and use* were not met for wheelchairs users. This was due to the narrowness of access way, location of door (due to security

		concerns) and lip on bottom of doorway.
Community satisfaction with solution		
Satisfaction rating (circle one)	Details (if required)	Evidence (if available)
Very dissatisfied Dissatisfied Neither Satisfied Very satisfied	Family decision makers worried about risk of damage during modification and therefore rejected the design. Access for a PwD was not perceived as valuable enough for the associated risk.	Conversation with vision-impaired individuals mother before the workshop and conversation with vision-impaired individual during workshop 4.
Adoption of solution		
Timeframe	Adopted? (yes/no/unsure)	Evidence (if available)
End of project	No	Family decision makers did not allow for project to be implemented
Short-term revisit	No	
Long-term revisit	NA	NA
Generalizability of solution		
Areas of importance	Appropriateness of solution	Evidence (if available)
Local	No	The highly custom nature of the project means the challenges identified may not be present in other households
National	No	The highly custom nature of the project means the challenges identified may not be present in other households
Other:		

Appendix F - Full coding table for Project 1

Name	Sources	References
Capacity building	5	7
Change in thinking	13	18
Education	9	16
Barriers	5	6
Illiterate	1	1
Reiterate	15	23
Empathy	11	21
Improvement in design skills	19	43
Co-design ideology	1	1
Democratic decision making	5	7
Design by	17	50
Design for	5	6
Design with	14	29
Equalize power	5	6
Mutual Learning	7	9
Utilize local knowledge	14	44
Collaborative competency	0	0
1. Ability to express opinion about project	24	120
Contextual insight	15	58
Design critique	19	49
2. Ability to generate insightful ideas	29	138
Barriers	0	0
Cannot sketch	3	3
Copying each other	3	6
Lack of exposure to existing solutions	2	2
Lack of originality	5	10
Creativity	12	21
Divergent thinking	2	2
3. Ability to create insightful prototypes	30	132
4. Understanding of the design process or activity	35	234
Design concepts	23	50
Identify problem	1	1
Importance of iteration	14	20
Know concept but not terminology	10	12
Understanding place in design process	8	10
Existing community practice	12	20
Know some of the steps	6	6
Operational	15	35
Challenges	1	1
Hard to remember order of steps	3	3
Require facilitator guidance	1	1
Understanding activity instructions	14	34

Slow to understand	8	14
5. Motivation to contribute	37	395
Attendance	14	27
Commitment outside of workshop days	3	8
Would attend future workshops	6	9
Community buy-in	19	75
Contribute materials from home	3	4
Transfer of ownership	7	16
Community continue development	7	22
Lack resource to continue	4	7
Too busy	1	1
Engagement	23	87
All team members involved	11	25
Most but not all team members involved	8	12
No response	1	2
Only engaged when facilitated	5	6
Slowly increased in motivation	3	5
Some team members involved	4	9
Enjoyment	22	46
Expectations	3	5
Gratitude	10	21
Description of competency	0	0
1. Very poor	4	6
2. Poor	28	125
3. Fair	22	83
4. Good	37	294
5. Very Good	28	89
Design Environment	2	3
Distraction	6	6
Type of environment	4	6
Accessibility of venue	1	3
Classroom style	2	2
Pagoda	0	0
Product-use environment	1	1
Weather conditions	3	4
Design output	16	34
Engineering design	11	22
Poor engineering decision	4	12
Universal design	9	12
Useful product	10	19
Design process	14	20
Problem identification	14	82
General community challenges	10	15
Project ideas	2	2

PwD-specific challenges	14	61
Warm up activity	6	12
Facilitation	12	22
Active facilitation of activity	23	142
Encouragement	11	13
Facilitator provides example	10	24
Female-inclusion	2	4
Focusing discussion	8	15
Link with previous experience	8	14
Probing	2	3
Activity resources	0	0
Facilitator handbook	2	2
Balance	4	6
Difficult to protoype and facilitate	1	1
Facilitator performs technical task	2	3
Hard to find designer-community balance	1	2
Communication	22	103
Inter-facilitator communication	1	2
Language barrier	3	5
Western facilitator using translator	3	4
Participants don't listen to facilitator	4	4
Pwd communicate through carer	6	9
Sit quietly and listen	4	4
Facilitator-participant relationship	7	12
Groups	0	0
Group formation	6	8
Large Group	8	13
New participants	4	6
One-on-one	1	1
Small group	12	64
Lack of technical skill	1	3
Participant-led	11	28
Planning	25	74
Appropriateness of activity	12	14
Facilitator understanding	11	17
Instructions	13	32
Schedule	3	3
Flexibility	10	17
Change in product design	3	7
Change in rules of activity	6	14
Change in schedule	9	11
Change in seating arrangement	1	2
Lack of knowledge of participant skills	1	1
Lack of required resource	11	18

Lack of time	5	8
New facilitator	2	3
New participant	2	2
Variability of materials	1	2
Participation	13	49
Dominant participants	9	11
Lively discussion	13	23
PwD-exclusion	22	49
PwD-inclusion	23	76
Type of participant	22	127
Able-bodied	2	2
Person with disability	22	125
Family dependence	6	8
Insights	3	8
Pwd- community differences	2	4
PwD-job	1	3
Lack of decision-maker buy-in	1	2
Nothing else to do	3	4
Types of impairment	19	69
Amputee	4	5
Blind	7	7
Cognitive	3	3
Deaf	8	19
Dumb	9	16
Elderly	6	14
Mobility	4	5
Variety of participant ability	18	42
Project Progress	4	4
Seasonality	6	12
Slow	9	14
Under-developed product	8	18
Researcher thought	3	8
Socio-cultural dynamics	4	5
Age	1	1
Gender	12	34
Female	6	9
Female-exclusion	3	3
Male	3	6
Local power structure	8	8
Religion	1	1
Saving face mentality	5	8
Shy	17	39
Technical skills	15	49
Facilitator teaches participant	4	11

Time consuming	1	2
Local skills	13	32
Health and safety concerns	4	8
Low level of skill	5	8
Type of activity	0	0
Enacting	25	90
Prototype testing	15	30
Making	30	395
Hand tools	2	4
Model making	4	4
Power tools	1	1
Sketching	4	5
Telling	31	430
Writing down notes	1	2
Visual	2	2