A Collaboration System Model for Planning and Evaluating Participatory Design Projects

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Participatory design (PD) is the process of expert designers and participants from impacted communities working together to create appropriate solutions. As PD practitioners strive to implement more effective, ethical projects, a focus must be placed on designer-participant collaboration, and the factors that influence this collaboration. Existing studies provide value in explaining the level of participant engagement in collaboration, and the way to evaluate this collaboration. However, a high-level conceptual model is needed to clearly understand the factors most influential to collaboration and how they inter-relate. This article presents the PD Collaboration System Model as a tool for planning and evaluating PD projects. The model was developed through systematic literature review and the completion of two projects (involving six first-hand case studies), undertaken with people with disability in rural Cambodia. The model consists of the following components: designer and participant knowledge, activities (for making, telling, and enacting), design environment and materials, society and culture, and the participants' capacity to participate.

Keywords – Participatory Design, Collaboration, Evaluation, Generative Design Research, Cambodia.

Relevance to Design Practice – This article presents a new conceptual model for understanding designer-participant collaboration. This model will improve practitioners' ability to plan and evaluate PD by better understanding the factors that influence the quality of PD collaboration. The article also provides specific recommendations for facilitating effective collaboration during PD projects.

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Introduction

Understanding the complexity of collaboration is vital to planning and evaluating participatory design (PD) projects. PD has become more popular over the past decade due to its effectiveness in generating appropriate solutions and socially and creatively empowering involved participants. As it has spread into more varied fields of application, the number of documented challenges has also increased. For example, the use of PD with participants with low-education levels in developing contexts has resulted in challenges focused on a lack of experience with formal activities, lack of tenacity, and lack of creative ability (Mazzurco, 2016; Molapo & Marsden, 2013; Winschiers, 2006). Similarly, challenges focused on the technical expert's ability to equalize power relations, use appropriate activities, and work within the relevant socio-cultural context have also been noted (Godjo, Boujut, Marouzé, & Giroux, 2015; Kam et al., 2006; Winschiers-Theophilus, Chivuno-Kuria, Kapuire, Bidwell, & Blake, 2010).

In an attempt to understand the causes of these challenges, an increasing number of researchers have investigated PD collaboration, focusing on participation (Brandt, 2006; Druin, 2002), evaluation of participation (Frauenberger, Good, Fitzpatrick, & Iversen, 2015; Gerrard & Sosa, 2014), and participant empowerment (Drain, Shekar, & Grigg, 2017; Hussain, 2010). However, there is a need for a holistic conceptual model to describe the influential components of PD collaboration explicitly, as well as their interaction. Such a model would allow for more detailed planning of PD projects and evaluation of their effectiveness and help to address criticisms that PD lacks "empirically demonstrable benefits in outcomes" (Wang & Oygur, 2010, p. 357).

This article presents the PD Collaboration System Model, a new conceptual model for planning and evaluating collaboration during PD projects. The article begins by examining extant literature in the areas of PD and PD collaboration. It then presents six first-hand case studies that were undertaken by the first author, designing assistive technology with people with disability in rural Cambodia. Finally, the Collaboration System Model is presented and discussed in relation to both extant literature and case study findings. This article adds to the field of PD through providing a new conceptual model with which to explicitly understand the components that influence collaboration and how these components interact with each other. With this new understanding, we argue PD practitioners can better plan their collaborative activities, by explicitly optimizing each component

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and interaction, and can also report on collaborative quality in a more focused way. To aid in this goal, the article presents specific examples from the first authors case study work as well as more general recommendations for optimizing collaborative activities.

Participatory Design

PD is a collaborative design approach in which technical experts aim to work together with representatives of impacted communities to design appropriate solutions (Holmlid, 2009). This style of project creates contextually appropriate solutions and empowers impacted communities to have increased ownership over the process and end result. PD has become widely used for the design of information systems (Johnson, Ballie, Thorup, Brooks, & Brooks, 2017; Ssozi-Mugarura, Blake, & Rivett, 2017), consumer products (Demirbilek & Demirkan, 2004), workplace layout (Sundblad, 2010), and humanitarian solutions (Hussain, 2010; Winschiers, 2006). It is grounded in the guiding principles of *equalizing power relations*, *democratic practices*, *situation-based actions*, *mutual learning*, and *appropriate tools and techniques* (Kensing & Greenbaum, 2012). Of importance to this article is how these principles are operationalized to create meaningful collaboration between technical experts (termed *designer* from this point forward) and individuals from impacted communities (termed *participant* from this point forward).

Understanding Collaboration in PD

To begin discussion, the traditional model of PD collaboration is presented in Figure 1 (Hussain, Sanders, & Steinert, 2012). This shows how designers and participants (both users and stakeholders) are expected to all contribute towards co-creation. It shows the key actors and how they contribute to co-creation, but does not explain the interaction between each actor or the specific way in which co-creation occurs.

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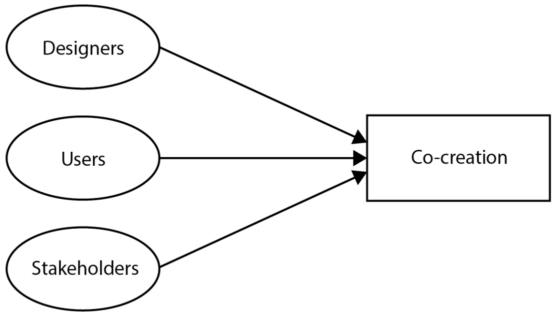

Figure 1. Traditional Model for Participatory Design (Hussain et al., 2012).

Hussain et al. (2012) expanded on this model to show the actual stages required to achieve effective collaboration during a PD project in rural Cambodia (Figure 2). The additional stages were required to address barriers due to power dynamics and cultural hierarchy in the project context.

What Hussain et al. (2012) have not presented in these models is an understanding of what *co-creation* actually entails. Christiaans (1992) provided valuable insights into the specifics of co-creation through the development of three knowledge-sets important for design activities. The three knowledge-sets were *process knowledge*, *design knowledge*, and *basic knowledge.* Christiaans stated 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 mindset 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. This includes knowledge in the socio-cultural and problem domain.
- *Design knowledge*—in-depth understanding of specific industrial design and engineering concepts, existing solutions, methods and techniques.

This model is important to PD practice as it highlights the need for all three knowledge-sets to be present in a collaboration, with different individuals contributing different knowledge. For example, it is likely that a participant would contribute *basic knowledge* in the form of tacit knowledge about their socio-cultural environment, daily activities, and specific wants and needs. Designers would contribute *process* and *design knowledge* in the form of technical skills and project management and planning. Similarly, Lettl (2007) identified three prerequisite participant characteristics needed for effective innovation. 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 participant 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 aligns well with the *basic* and *design knowledge-sets* of Christiaans (1992) but does

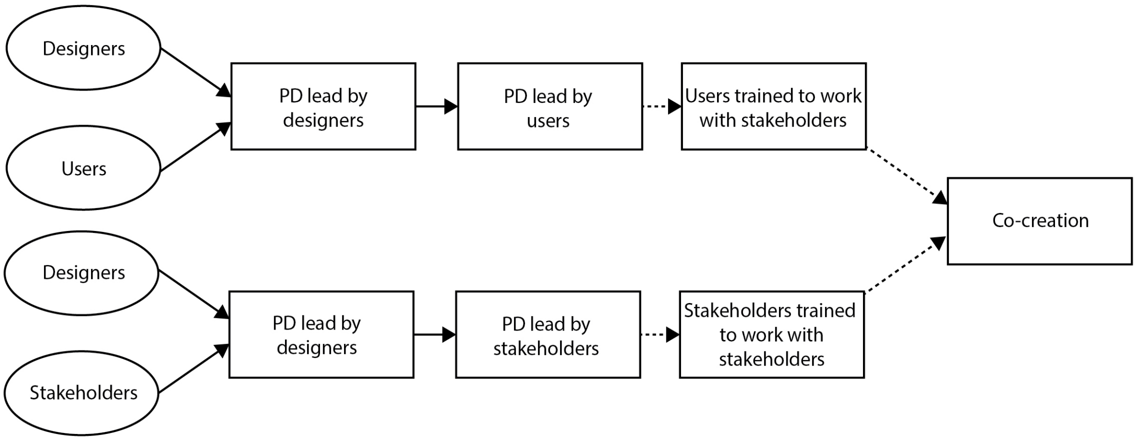

Figure 2. Evolution of Participatory Design projects for marginalized people (Hussain et al., 2012).

not include reference to *process knowledge*. It should be noted that Lettl's work was focused on commercial radical innovation, and so social empowerment outcomes were not a focus of his work. This may explain the requirement of an individual having an openness to new technologies, which may exclude underserved communities from consideration.

A number of different terms have been used in the literature to describe a participant who possesses these attributes. Terms include *ideal user*, *power user*, *empowered use*r, *extreme user,* or even the commercially focused *lead-user* (Coleman, 1994; Fischer & Ostwald, 2002; Hussain & Keitsch, 2010; Von Hippel, 1986). The general concept, of a participant who is highly able to collaborate, is well articulated by Fischer and Ostwald, who stated, "they [participant] are no longer passive receivers of knowledge, but need to be active researchers, constructors, and communicators of knowledge" (p. 3).

Collaboration Frameworks

There are several frameworks for assessing collaboration and participation 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 participants to assess the positive and negative effects of technology implementation into an environment. Schot developed the three criteria of *anticipation*, *reflexivity*, and s*ocietal learning processes* as measures of effectiveness of participation in the technology assessment process. *Anticipation* refers to the collaboration-style providing opportunity for participants to contribute more open, generative feedback than traditional approaches. *Reflexivity* refers to the need to manage conflicts and trade-offs between participants and designers. 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 stated that this collaboration-style 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).

Next, Druin (2002) categorized collaboration by developing four roles a participant can have in the PD process. These were as a *user*, *tester*, *informant*, and *design partner* with each step representing a higher level of autonomy and meaningful input. A separate study adopted the same terminology in the design of assistive learning solutions for children with special needs (Frauenberger, Good, & Keay-Bright, 2011). While these archetypes were designed specifically for projects involving children, they still provide valuable guidance for refining the way in which PD collaboration is understood. Similarly, Hussain et al. (2012) utilized Zimmerman's (1995) model for psychological empowerment as the foundation of the Design Participation Ladder. This framework showed three levels at which participants can collaborate: *included*, *consulted*, and *empowered*. It also showed the potential for a participant to increase their participation through both better facilitation by designers and capacity building of participants.

Finally, Gerrard and Sosa (2014) presented the PartE Framework, which was used to evaluate participation during PD projects. This framework consisted of six attributes with which to evaluate a project. These were *objective*, *practice*, *interaction*, *barriers*, *representation*, and *impact*. Gerrard and Sosa found that this combination of attributes added value as they help to "reveal differences in how stakeholders view participation and design", "explore and develop a personal frame of participation", "articulate ideas previously not made explicit," and "begin to diagnose participation across experiences and suggest actions to resolve specific challenges" (p. 9). We agree that the PartE Framework is a valuable addition to the evaluation of PD. However, there is still the need for a high-level conceptual model to explain how collaboration occurs and specific influential factors that affect the quality of designer-participant collaboration. Without this high-level model, it is difficult to be purposeful during planning or evaluation. For example, the PartE attribute *interaction* would prompt the designer to reflect on the "contribution of resources & information, exchange & awareness of contributions and collaborative contributions" (p. 6). This will most likely yield interesting reflections about the amount of contribution from participants and the way in which opportunity was provided for this contribution to occur. However, it is not clear what specific features of the project led to this level of interaction. Was it the specific activities used? Openness and warmth of the designer? Time-period taken to build trust? The implicit capacity of the participant to contribute?

Progress has been made in the pursuit of a clear understanding of PD and how to evaluate its effectiveness. Frameworks that focus on evaluation (Frauenberger et al., 2015; Gerrard & Sosa, 2014), participation (Brandt, 2006; Druin, 2002), empowerment (Drain et al., 2017; Hussain, 2010), planning (Sanders, Brandt, & Binder, 2010), and creativity (Christiaans, 1992) have all added value. However, a high-level conceptual model, which presents the influential components of PD collaboration, is needed to further improve the rigour and detailed analysis of PD practice. It is in the pursuit of such a model that we present the PD Collaboration System Model (CSM).

Methodology

We utilized a two-stage qualitative research design. Firstly, a systematic review of PD literature was undertaken to identify existing conceptual models and specific influential factors for consideration. Secondly, we collaborated with two NGOs and undertook two separate PD Projects in rural Cambodia, one in 2017 (termed Project 1) and one in 2018 (termed Project 2). Each of these projects, that collaborated with different participants and contained three separate project-briefs, are termed *cases* from this point forward. The research aim of these projects was to learn about specific influential factors and their interaction. All six Inclusive Agriculture projects began with the same project objectives:

1. Improve the ability of people with disability to access agricultural livelihoods through:
   (a) Creation of new technology for use in the community;
   (b) Development of innovation and problem-solving skills in the participants;
   (c) Improved social inclusion for people with disability in the community.
2. Increase organizational knowledge about the challenges faced by people with disability in rural Cambodia.

Details about Project 1 have been published in previous articles. The previous articles focused on specific aspects of PD with people with disability, for example, the development of new creative capacity building sessions (Drain et al., 2017), the challenges of a lack creativity (Drain et al., 2018b), the expected outcomes from PD project work (Drain, Shekar, & Grigg, 2018a), and the first author's PhD thesis (Drain, 2019). The present article builds upon the experience gained through Project 1, as well as Project 2, and focuses on a novel research area, the designer-participant collaborative design relationship. This is a unique contribution to the research field as it represents the first attempt at defining the PD collaboration system, an important step in optimizing collaborative activities during PD projects. An overview of the project structure is shown in Figure 3.

Data collected across the six cases included 37 interviews with designers (after each stage of the design process), 134 interviews with participants (18 long-form and 116 short-form), 123 field diary entries (completed by designers after each activity), observational notes, photographs, and workshop outputs (such as prototypes, models, posters, and drawings).

We used a constructivist ontological view (Cross, 2001; Green, Southee, & Boult, 2014) and a qualitative approach involving iterative thematic analysis, using Nvivo 12, of all available data. Any data collected in Cambodian (Khmer) were translated, and all interview recordings were transcribed to allow for codification (Bryman, 2015; Saldaña, 2009). The aim of this analysis was to identify specific influential factors that should be considered for inclusion in the new CSM. These factors were then compared to the factors identified from the systematic literature review; findings are discussed in the following section.

Participant Overview

Project 1 involved participants with a range of ages and impairments. 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). Forty two percent of participants self-identified as having a disability, including hearing, vision, mobility, and cognition. In contrast, in Project 2, there were 30 participants, 90 percent of whom self-identified as having a disability. The group

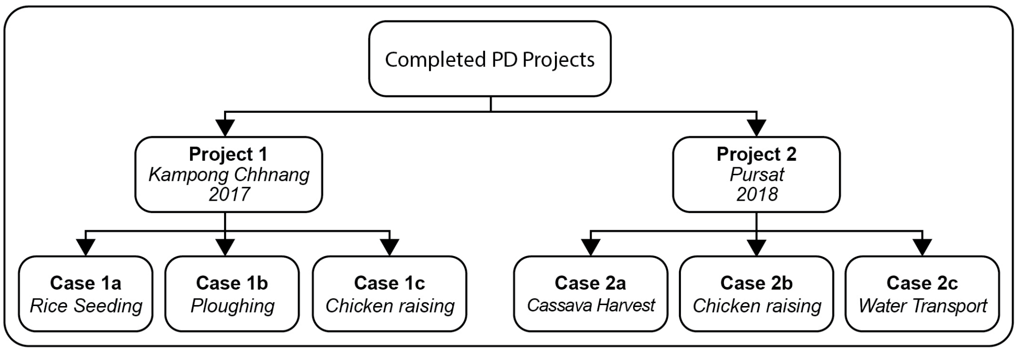

Figure 3. Inclusive agriculture project structure.

was made up of 20 females and 10 males, aged between 20 and 94 years old, with a range of impairments including hearing, vision, and mobility.

In both projects, the selection of participants was left to the local disabled persons organization (DPO) partner to coordinate. The criteria used were:

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 region serviced by the DPO.

Collaboration System Model Overview

The CSM is presented in Figure 4. 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 acknowledging that both the designer and participant have knowledge and experience that are valuable to the collaboration and that this knowledge is contributed through different mechanisms. It then places this collaboration in both the wider socio-cultural environment as well as the controlled design environment in which the project takes place. The shapes represent the various components, while overlapping and embedded shapes communicate where interactions occur (e.g., all components are embedded within the society and culture, while there is no interaction between designer and participant knowledge directly). The cyclic arrows in the center of the model indicate the bi-directional exchange of knowledge that occurs during collaboration and capacity building in PD. The model does not communicate the process, or types of solution which can be generated through PD, only the collaborative relationship which generates outcomes. These outcomes have been the focus of previous research (Drain et al., 2018a; Irestig, Eriksson, & Timpka, 2004). The CSM 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 highlighted *politics*, *users*, *activities*, *context*, and *product* as fundamental aspects of PD.

The Value of the CSM to the Research Field

The CSM provides a holistic view of the designer-participant collaboration in the PD process. Firstly, it proposes that the collaborative relationship must be considered with respect to the society and culture in which it occurs. It then proposes a secondary level of environmental influence caused by the environment planned and facilitated by the designer. This explicit effect of the design environment on collaboration has not been well articulated in previous PD planning guides. Building on the work of Godjo et al. (2015), we argue that the addition of this component will ensure that both logistics and collaborative impact will be considered along with the well-agreed socio-cultural environmental influence. Secondly, the model shows how planned activities, as well as a participant's capacity to participate, act as important conduits for transferring knowledge from the participant to the final design solution; either directly from participant design input or through the designer. It shows that effective PD collaboration is a product of the activities and materials that a designer uses, the participant's capacity to participate, and the environments in which the collaboration takes place.

The CSM can be used to improve future PD projects by explicitly considering each of the components during planning: society and culture, design environment and materials, designer existing knowledge and activities, and participant existing knowledge and capacity to participate. Importantly, the interaction between specific components should also be considered. For example, the interaction between activities and design environment. A role play activity may work effectively if run in a private, friendly environment (such as a participant's home); it may be ineffective if run in a public environment (such as a community pagoda) as particular socio-cultural traits (e.g., saving-face mentality in Cambodia) may restrict participant engagement. Without the design environment component, activity planning may only focus on the interaction between activity and culture.

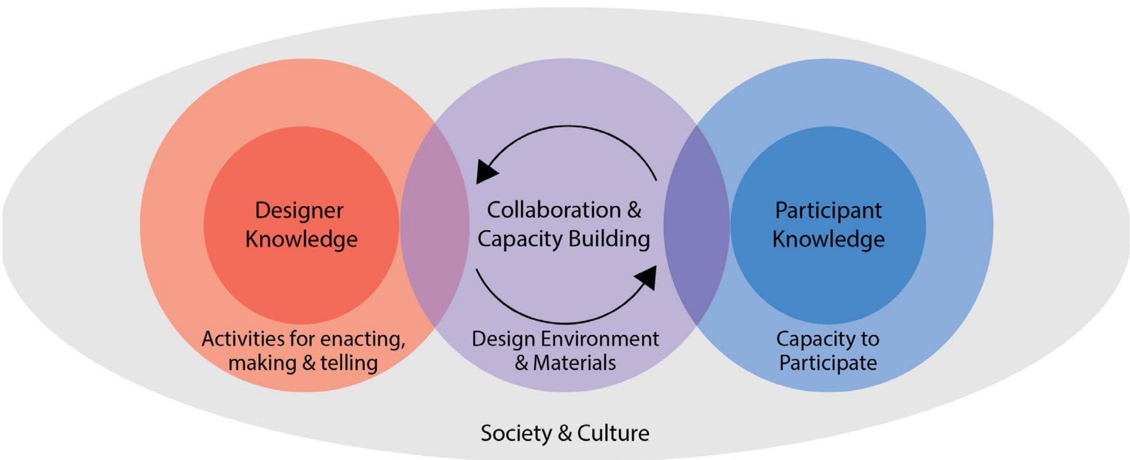

Figure 4. Participatory design collaboration system model.

For clarity, the CSM aims to communicate these interactions visually. During planning each interaction can be explicitly written and then considered (e.g., activities-design environment, capacity to participate-participant knowledge, etc.). We propose a similar process can be undertaken during project evaluation. This will be conducted alongside traditional impact evaluation (Frauenberger et al., 2015), and focus on the quality of the collaborative process. This is highlighted as an important focus in previous research such as the PartE framework (Gerrard & Sosa, 2014).

The next section will explain each of the system components in detail and look to align these with existing research and firsthand case study findings.

Society & Culture

We align this component 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 interpersonal customs, ethnic/race/caste classifications, language, religion, specific territorial claims, and historical conflicts. Societal and cultural consideration is crucial during project planning (Haggar, Ayala, Díaz, & Reyes, 2001), the development of activities (Brandt, 2006), collaboration (Kam et al., 2006), and evaluation (Winschiers, 2006). Its effect is relative to the specific country, community, product type and project plan, and the socio-cultural values of the 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 users and other local stakeholders interacting in a meaningful way (Moraveji, Li, Ding, O'Kelley, & Woolf, 2007; Puri, Byrne, Nhampossa, & Quraishi, 2004; Winschiers, 2006).

In our research, several Cambodian socio-cultural dynamics influenced the way in which PD activities could be undertaken. To optimize activities for Project 1 and Project 2, pilot sessions were undertaken with different communities. A number of insights are given below:

Ensure the presence of both male and female local designers—as female participants were shy around male designers.

Structure activities in a way that includes both group contributions and explicitly individual contributions—as this ensures female participants, and heavily-impaired participants, were given opportunity to contribute. In Project 1, there was a noticeable gender dynamic which resulted in male participants dominating discussions and prototyping unless closely facilitated by a designer.

Provide time early in a PD project for team building activities—as Cambodia is a predominantly Buddhist country. Buddhism views disability in a current life as paying for a sin in a previous life, resulting in lower levels of empathy and social inclusion from able-bodied community members (Gartrell, 2010). This cultural dynamic meant that participants with disability were inherently shy and time needed to be spent developing personal relationships and providing opportunity to build confidence before expecting meaningful design contributions from them.

Design Environment

The inclusion of an explicit design environment component draws from the work of Godjo et al. (2015) who highlighted 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 focuses on the location where the participant and designer collaborate. This may 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, construction, etc.) to be viewed as not only influenced by the wider society but also as a factor influencing the collaborative process. We argue that by taking this interpretivist view, the effectiveness of PD activities can be analyzed not only as a standalone interaction, or an interaction in a wider society, but also as a function of the environment planned and facilitated specifically for the project.

Logistical considerations such as the location of meetings, the time of meetings, length of interactions, size of groups, and involvement of local facilitation staff could then be used as factors to consider when developing the design environment of the PD project (Demirbilek & Demirkan, 2004; Grudin, 1991). Previous 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 end-users in the project. Furthermore, the concept of a *positive social environment* is present in capacity building literature (Liberato, Brimblecombe, Ritchie, Ferguson, & Coveney, 2011) as a key factor for supporting community involvement and action. Finally, Fischer (2004) provided 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)

In our research, the most obvious occurrence of the design environment influencing the quality of collaboration was during Project 1 Workshop 3, where the project venue was shifted from the community pagoda to the local school. The result of this was described by a designer stating,

> Venue has been changed from the pagoda to the school as the religious festival of Pchum 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.

Furthermore, the school venue required participants to sit on chairs, at tables, and not on the ground as desired (Figure 5). This arrangement was unnatural for the participants as rural Cambodians tend to sit on the ground for relaxing and eating in their homes, and most participants worked agrarian roles meaning they were not experienced with sitting in an office environment. Furthermore, the majority had not attended formal schooling past primary school. The arrangement was uncomfortable for the participants and resulted in less engagement than otherwise expected. It also seemed to create a teacher-student dynamic, which resulted in a decrease in open discussion and creativity. Throughout the session, participants became tired and slouched over the desks. This resulted in the design team moving the next session to the outdoor area where participants could sit on the ground. On reflection, the initial decision to use the classroom was misguided and imposed a colonialist dynamic on the collaboration that could have been avoided.

Figure 5. Participants sitting at desks in a hot school classroom resulted in decreased open discussion and creativity.

There were similar findings in Project 2 Workshop 2 when a power cut resulted in the venue becoming extremely hot and participants and designers losing energy and motivation to complete activities. This challenge resulted in the designers changing to less physically demanding activities as well as activities that could be completed outside of the main room in the venue. Hence, it is best to meet participants in a design environment they are familiar with, which allows for locally appropriate seating and social interactions. This may mean designers are required to travel to rural areas and base sessions out of low-tech venues such as pagodas, huts, and shaded outdoor areas. It is likely that some activities will need to be adjusted to suit the practical limitations of the environment (e.g., using a paper-based geographical map for asset mapping and not a computer).

Designer and Participant Knowledge

For this description it is valuable to reflect on the knowledge-sets defined by Christiaans (1992) as well as the concept of *pre-understanding*, as defined by Gadamer (1975). Firstly, there are three components of knowledge required for effective design: *process knowledge*, *design knowledge*, and *basic knowledge.* It is beneficial for all of these components to be present in the designer, as this will enable them to facilitate effective design activities with participants. 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 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.* Secondly, *pre-understanding* 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 participants. A participant's pre-understanding will also influence the way they interact during the collaboration. For example, previous educational, organizational, or creative experience may enhance the way they interact or result in the participant shying away from collaboration. Pre-understanding is essentially the internal, unavoidable condition for understanding, based on all the experiences an individual has had (Hussain & Sanders, 2012). Previous studies have focused on the role of knowledge during evaluation, with a lack of designer *basic knowledge* noted as the reason for product failure (Hall, Matos, & Martin, 2014; Radjou & Prabhu, 2012) as well as a lack of understanding of the importance of affinity, desirability, usability, and affordability (Mazzurco, 2016; Nakata & Weidner, 2012; Whitehead, Evans, & Bingham, 2016).

There were several types of knowledge identified across our six cases. Participant knowledge was demonstrated in terms of an ability to provide contextual insights (*basic knowledge*) and provide design critique of ideas and prototypes (*design knowledge).* Designer knowledge was demonstrated in terms of an ability to provide technical engineering, agriculture, and product development insights (*design knowledge*), and an ability to manage the activities and stages of the project (*process knowledge*). Interestingly, in Project 2 Case 1, two designers stated they were worried they did not possess enough *design knowledge* to be useful in some of the activities and therefore had to rely on the *design knowledge* of specific participants. This case involved the design of a new motorized cart and pulley system that could navigate a cassava farm and lift heavy loads of cassava into the cart (Figure 6). This new design removed the need for dozens of trips carrying buckets of cassava root between farm and house as the full harvest could now be completed in one trip using the new cart. This design involved relatively complex mechanical design as well as appreciation for long-term maintenance and use.

Figure 6. Project 2 Case 1 final product, cassava harvesting cart for people with mobility impairment. This reduces the amount of walking, bending, and carrying of heavy loads during cassava harvesting.

Table 1. Comparison of participant interview answers across Project 1.

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?
Start of project	"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."

Participant *process knowledge* was also assessed throughout Project 1 and Project 2 using short form interviews with participants, designer interviews, and observation. It was found that the initial conceptual understanding of the design process was linear and contained no mechanism for testing and improving a design. Throughout the PD projects, the participant understanding developed to include iteration and improvement. This is shown in Figure 7.

This conceptual understanding improvement can also be seen by comparing interview answers from the same participant across Project 1. This is shown in Table 1.

Understanding the knowledge-sets present during PD collaboration is valuable as it allows for more focused planning as well as more focused evaluation of capacity building outcomes.

Participant Capacity to Participate

The term *capacity to participate* is meant to represent the skills and attitudes required for a participant to communicate and utilize tacit knowledge in an effective way (Spinuzzi, 2005), not the knowledge itself. Zimmerman (1995) posed the terms *intrapersonal*, *interactional*, and *behavioral*, which may go some way to articulating the intended definition. Furthermore, a number of different terms have been used in literature to describe a participant who possesses these attributes. Terms include *ideal user*, *power user*, *empowered user*, *extreme user*, or even the commercially focused *lead-user* (Coleman, 1994; Fischer & Ostwald, 2002; Hussain & Keitsch, 2010; Von Hippel, 1986). There have been several project evaluations which highlighted participants struggling to engage in the collaboration (Mazzurco, 2016; Molapo & Marsden, 2013; Winschiers, 2006). 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 this case, the children's lack of creativity and confidence to express opinion driven by cultural elements such as rote-learning, student-teacher power dynamics, and disability-exclusion were identified as barriers to co-creation. Mazzurco (2016) stated that many of the PD 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 *capacity to participate* is an important aspect of PD collaboration and that its inclusion will allow for proactive planning of activities or capacity building.

In our research, *capacity to participate* was defined using six criteria shown below. An overview of specific capacity assessments for the six cases can be found in each of the project summary reports (Drain, 2018a; 2018b). All data collection tools are provided in a project handbook (Drain & McCreery, 2018).

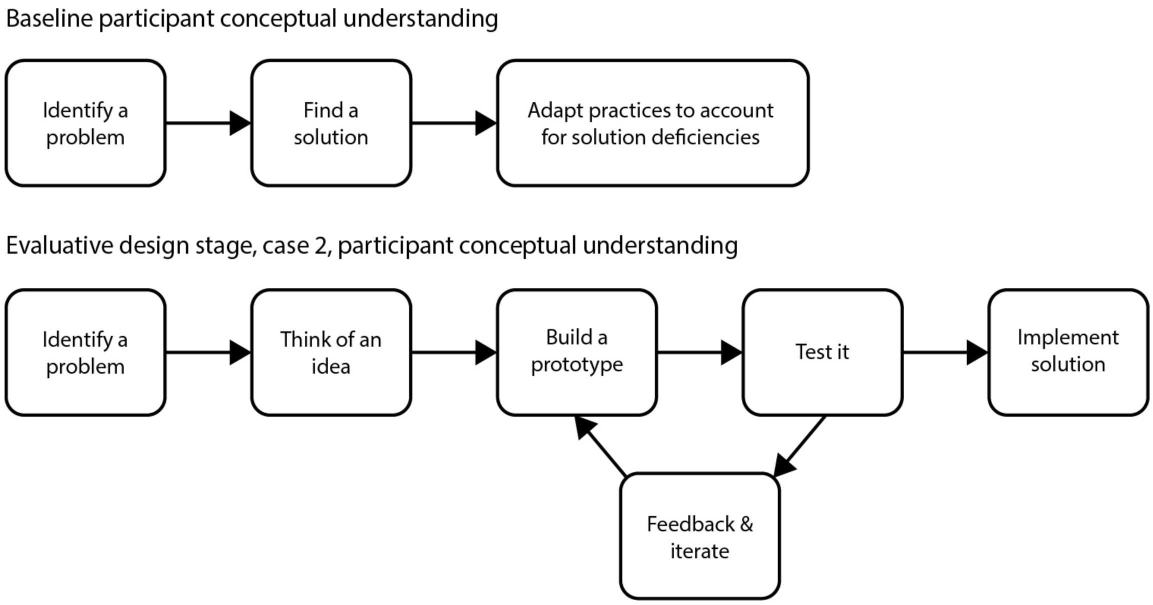

Figure 7. Baseline and evaluative design stage model of participant process knowledge.

1. An ability to express contextual insights (Contextual Insights)
2. An ability to express design critique (Design Critique)
3. An ability to generate insightful ideas (Ideas)
4. An ability to create insightful prototypes (Prototypes)
5. An understanding of the design process (Design Process)
6. A motivation to contribute (Motivation)

Utilizing these criteria for structure, a baseline capacity level was triangulated from extant literature (focused on socio-cultural characteristics, education, experience, and disability) and through first hand data collection (interviews, observations, and activities during the first two days of the project). First-hand data was then codified, and a frequency coding matrix was developed for Project 1 and Project 2 (as cases/project teams had not yet been formed). For example, Table 2 shows the baseline frequency coding table for Project 1.

The frequency coding matrices were then used, along with lived experience of interactions with the participant group, to develop spider diagrams visualizing the baseline assessments for Project 1 (Figure 8) and Project 2. For clarity, the spider diagram shows the resultant description for each of the six criteria which forms the overall capacity to participate during the baseline assessment.

This assessment allowed for the activities to be modified to suit the abilities of the group and for monitoring of longitudinal changes in capacity across the projects. For example, Figure 9 shows the longitudinal assessment of the *Ideas* criterion (criterion 3 above) for both Project 1 and 2. Each data point was triangulated during data analysis using all available data.

This suggested that participants in Project 2 were more capable of engaging in independent ideation than were the participants in Project 1. Thus, whereas Project 1 generative design activities had been planned to be more structured and to support participant ideation, Project 2 generative design activities were planned to provide more opportunity for participant-led ideation and cross-team collaboration (between cases 2a, 2b, and 2c).

Designer Activities

This component describes the activities used in a PD project, which varied based on the aim of the project, stage in the project, and characteristics of the participant group. Sanders et al. (2010) provided a helpful hierarchy, which is shown below:

Table 2. Capacity to participate criteria vs description coding from baseline assessment.

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

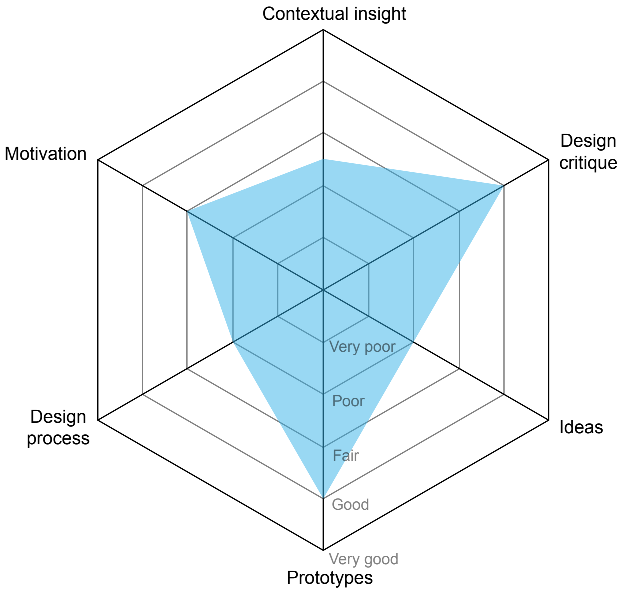

Figure 8. Visualization of baseline capacity to participate criteria.

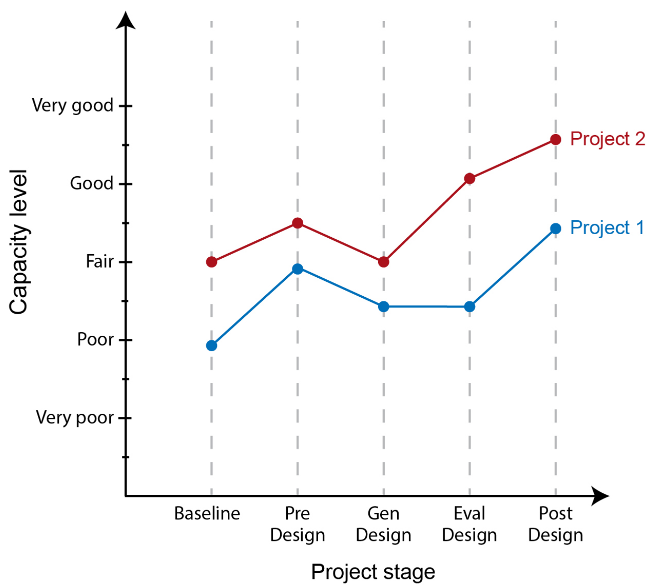

Figure 9. Comparison of ideas capacity level between project 1 and project 2.

- *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) presented *making-style*, *enacting-style*, and *telling-style* as three different categories of activity, each utilizing a different mode of communication. A making-style activity utilizes the construction of an artefact (e.g., a model, prototype, collage, or sketch) to meet the specific objectives of the design stage. For example, in Project 1 a low-resolution making-style activity was used to generate ideas (Figure 10). This type of activity leveraged the rural Cambodian participants' strong practical abilities to build models.

An enacting-style activity utilizes acting (e.g., role play, prototype testing, or demonstrating a local practice) to meet the objectives of a design stage. For example, in Project 2 each of the three project teams (cases 2a, 2b, and 2c) were given a type of impairment (e.g., vision-impairment) and a type of agricultural activity (e.g., fetching water) and asked to role play the challenges that the individual would face. A telling-style activity utilizes dialogue (e.g., structured and unstructured group discussions, interviews, or private individual recordings) to meet the objectives of a design stage. For example, in Project 1 both small and large group discussions were undertaken to identify and prioritize the most important challenges facing people with disability trying to access agricultural livelihoods.

In our research, the tools and techniques described by Sanders and Stappers (2014) were used throughout the pre-design, generative design, evaluative design, and post design stages. At each stage, the tools that were selected varied according to differing objectives, starting with exploratory, contextual learning, and transitioning to creative idea generation, idea screening, prototyping, and long-term planning. A full overview of all activities used in the two projects discussed in this article is available (Drain & McCreery, 2018). During our project work, there was clear evidence that the type of activity chosen affected the quality of collaboration. Figure 11 shows the percentage of total occurrences coded as *Very Poor* through to *Very Good* for the *Motivation* criterion. The coding was generated during the analysis of all data from Project 1. It presents the frequency of coding for each of the three types of activity and the level of participant motivation observed. It shows that making-style activities resulted in the highest levels of motivation, followed closely by enacting-style, with telling-style activities showing the lowest level of observed participant motivation, a finding also seen in Project 2.

This finding was further complicated when looking at how well each type of activity included all participants, some of whom had extreme levels of disability. Figure 12 shows the percentage of total occurrences coded for *disability* inclusion and *disability exclusion* for each type of activity in Project 1. It shows that making-style and telling-style activities had the highest levels of disability exclusion, while enacting-style activities were the most inclusive.

Figure 10. Model making activity used with participants in case 1a. The participant is making a small model of a rice seeder out of plastic straws, cardboard, and tape.

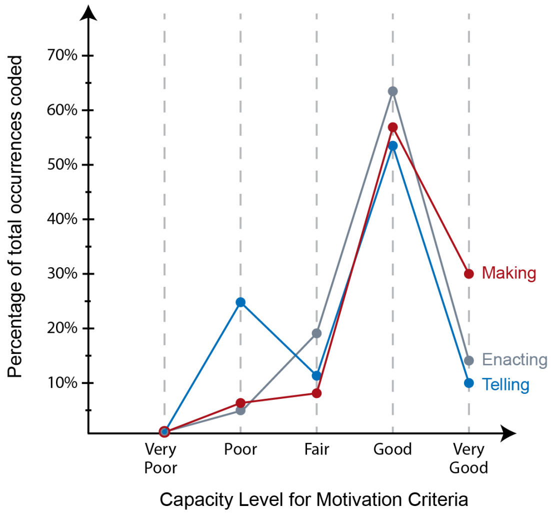

Figure 11. Percentage of total occurrences coded with motivation capacity level for each type of activity in project 1.

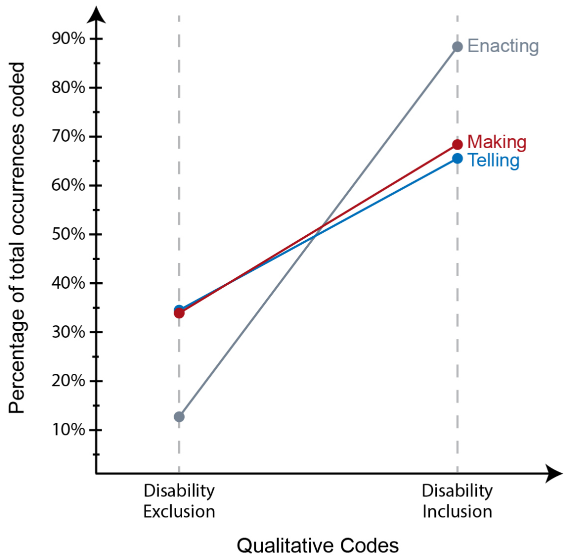

Figure 12. Percentage of total occurrences coded with disability inclusion and disability exclusion for each type of activity in project 1.

This presented a trade-off between using making-style activities, which engaged the largest number of participants, and enacting-style activities, which were most inclusive to people with extreme levels of disability. Of course, the objectives of the specific design stage need to be considered, as it is not always possible to meet the objectives through enacting-style activities alone. For example, it is possible to use enacting-style activities to generate an idea for a new service or evaluate a new mechanical product. However, it is difficult to generate a new design for a mechanical product in this way. For Project 1, making-style activities may have been most effective in meeting the required outcomes. It is clear that the type of activity is critical to high quality collaboration during PD. A recommendation for selecting activity type is provided later in the article.

Balancing Power Dynamics in the CSM

The role of power is not explicitly communicated in the CSM. However, we acknowledge that the use of the CSM during planning could result in a power imbalance between designer and participant, as the designer is in control of planning the collaboration. To mitigate this risk, it is important to understand the role of power, as it relates to creating meaningful, empowering collaboration (Steiner & Farmer, 2017). We agree with Bratteteig and Wagner (2014), who stated:

> We see power as an explanatory concept: it helps see why things are done in a certain way and not otherwise. Power in PD is about how to get a voice and a say in the many design decisions that form the artefact; studying the power relations in a PD project helps understand what the strategies and resources available to the participants in the project are. (p. 2)

It is imperative that PD practitioners reflect on who is actually making important design decisions and how they are empowering participants to contribute to, and lead, the evaluation of alternative project directions. The CSM shows all of the components at play in the collaborative relationship; power is an important underlying factor, which influences and is influenced by all components and interactions. The designer should use the CSM to guide planning and evaluation but should also remain responsive to the local culture and the practical needs of the community (Geertz, 2000).

Recommendations for Practitioners

The CSM is valuable to researchers as it provides a system-level view of PD collaboration and allows for specific components to be focused on during planning, fieldwork, and data analysis. In an effort to provide practical value to PD practitioners, several recommendations were developed based on the CSM components. These are discussed in the following section.

The societal and cultural dynamics of the participants' community need to be understood before you plan your PD activities—This is important, as community-level power structures can be either an enabler or barrier to PD collaboration depending on the structure of the project. For example, strong existing relationships could be leveraged to facilitate high-levels of engagement and confidence. However, these relationships could also result in new participants being isolated from group activities and not being given an opportunity to contribute. It is valuable to plan activities early in the PD project that build relationships between participants and the design team. Activities should aim to strengthen interpersonal relationships between participants as well as aim to address power imbalances between participants, and participants and designers. For example, activities which allow able-participants to build empathy with participants with disability. For a vision-impaired participant, a navigation activity where vision-able participants wear blindfolds and are required to navigate a course would be effective. See the first author's project handbook for examples of activities which could be adapted and implemented (Drain & McCreery, 2018).

It is necessary to understand the participants' initial capacity to participate and, if required, implement capacity building sessions—Capacity building can focus on valuable technical skills, such as computer literacy (Winschiers, 2006) or design process knowledge, such as creative capacity building (Taha, 2011). It is important to be responsive to the specific participant group's capacity early in the project and make changes to the project plan to collaborate. These capacity-building outcomes should be captured during planning and evaluated during project evaluation.

The environmental context needs to be planned for—Special consideration should be given to the physical environment, including the location, materials, and artefacts that are available for making activities, as well as the social environment, including opportunity for team building. It is valuable to identify locations, which are familiar to participants, of practical distance to their homes and meet the functional needs of the design team. Materials provided for the making-style activities should be those that are readily available in the locations.

Telling-style activities are not enough—Other activities such as making-style and enacting-style are more engaging and effective, but potentially less inclusive when working with individuals with mobility impairments. The best approach is to incorporate all three types of activities iteratively while understanding whether specific participant impairments may make engaging in particular activity styles more or less challenging.

Execute the plan while remaining responsive—A clear, well-developed project plan is critical to successful PD. However, designers also need to remain responsive to the needs of the community as well as ensuring the project is progressing in a valuable way. A decision-making protocol should be developed to ensure designers are making consistent decisions during the project and prioritizing actions that align with project objectives (e.g., technology creation, capacity building, or insight generation).

Implement a meaningful monitoring and evaluation plan—PD is a complex design approach with several potential outcomes influenced by both the process undertaken and the solutions created. Several articles provide guidance on project evaluation (Frauenberger et al., 2015; Gerrard & Sosa, 2014). It is important to reflect on both the impact of the solution (e.g., effectiveness, adoption, and generalizability) and the impact of the process (e.g., participant engagement, meaningful collaboration, empowerment, solution ownership, and capacity building).

Future Work

The CSM adds value to the practice of PD by providing a high-level view of collaboration and influential components. The model will need to be tested and refined through future case study research. We suggest this is done through PD practitioners and researchers adopting the CSM for use during planning and evaluation of projects and reflecting on its accuracy at describing the collaborative system in that particular socio-cultural environment and project foci, as well as its effectiveness as a framework for planning and evaluation.

One area of interest is how the type of project influences collaboration. For example, whether the project has perceived value to all participants or only a select few and the complexity of the project relative to the participants' skill-levels. In our first-hand research, there was a positive relationship between the number of participants in a team directly impacted by the solution and the level of motivation to contribute to the collaboration. Finally, we acknowledge that the CSM views collaboration in a very functional way and because of this may seem to place too high an emphasis on the participants' *capacity to participate*. We agree it is vital to reflect on the realistic expectations for participant creativity, along with critical review of colonialist aspects of PD (Mainsah & Morrison, 2014). However, we argue that an explicit focus on this component helps to identify and reduce unfair expectations placed on participants by Western designers. PD is, at its core, the most appropriate process we have for collaborating with communities ethically. By understanding the specific factors that influence this collaboration, we can build capacity and plan effective projects.

Conclusion

In summary, this article presents the PD Collaboration System Model as a way of improving the understanding of designer-participant collaboration during a PD project. Firstly, the authors undertook a systematic literature review to identify the current understanding of PD collaboration. Several conceptual models and frameworks were identified as important to our research (Christiaans, 1992; Druin, 2002; Gerrard & Sosa, 2014; Hussain et al., 2012; Lettl, 2007). Next, first hand research across six PD projects in Cambodia was conducted and compared with extant literature. From this work, the authors developed the CSM to explain the influential components of designer-participant collaboration. These components include *designer and participant knowledge, activities (for making, telling, and enacting), design environment and materials, society and culture*, and the participants' *capacity to participate*. We acknowledge there are further complexities to explore and integrate into the CSM. However, the CSM provides the most holistic view of PD collaboration currently available and enables more focused PD planning and evaluation by directing practitioners towards the most influential factors.

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