Co-creating Digital Health Service: Activity Theory and Communicative Ecology Framework Analysis

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Abstract

Globally, there has been an increase in digital health interventions over the last decade. These interventions aim to improve maternal and infant health outcomes and treatment adherence, as well as HIV/AIDS education and prevention, immunization rates, and communicable disease prevention. The creation of digital health services that incorporated users' dynamic, multi-level, and complexities are crucial to the advancement of digital healthcare. These services are, at best, co-created by developers, community health workers, and government representatives. However, due to the presence of multiple stakeholders, the co-creation of digital health services is a complex process. The paper presents a case study of the digital health co-creation process, to understand and describe the activities taken by different stakeholders during a co-creation process. Additionally, the use of activity theory and a communicative ecology framework as analytical lenses to identify contradictions, as well as to gain insight into the co-creation of digital health services, are both presented in this paper.

Keywords

Digital health, co-creation, activity theory, communicative ecology framework

1. Introduction

There is a shift in the development of digital healthcare from a top-down focus on clinical effectiveness and resource utilization to data opening and increased opportunities for users of the technology and other stakeholders to be both drivers and targets of digital innovation [1].

Furthermore, users of the digital service as well as other stakeholders are invited to co-create new types of services based digital solutions [2]. When clients participate in the development of digital solutions, the number of key stakeholders in the process grows, including a diverse group of users, varying numbers of community authorities, and software development professionals from digital solution provider companies. In this paper, we present an exploratory, empirical case study of the co-creation process and uncover contradictions and expansive learning in the co-creation of digital health services.

This paper aims to understand/describe the activities of various stakeholders in a co-creation process. And use the theoretical frameworks - activity theory (AT) and a communicative ecology framework (CEF) as analytical lenses to identify contradictions and gain insight into the co-creation of digital health services and understand the complexities associated with it. This results in the following research question: What are the core elements and how do they relate to one another in the activity system to gain insight and understand the complexities of co-creation of new digital service?

8TH International Workshop on Socio-Technical Perspective in IS Development (STPIS'22) 19-21 August, Reykjavik, Iceland

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2. Activity Theory and Communicative Ecology Framework as Theoretical Lenses

AT provides a framework for investigating the complexities of interactions between people and their environments by identifying the elements of an activity system, how they are related, their various voices, their history, flaws, and changes [3]. The theory applies to both what people do and why they do it. According to [4], AT enables people to study and take into account the why as well as the how of the concept of object-oriented activity. To be more specific, if one takes into account the perspective of "why" one also takes into account human desires that motivate activity. These desires differ for many stakeholders, and as a result, there are conflicts of motives that triggers and transform the object - which is to improve maternal, newborn, and child health outcomes. AT has six interdependent elements, and the elements are described in Table 1.

Table 1.
AT elements [5]

Instruments/tools	**The artifacts or concepts used by subjects to accomplish the task.**
Subject	A person or a group engaged in the activities.
Object.	The objective of the activity system as a whole.
Community	Social context and all the people involved
Division of labour	The balance of activities among different people and artifacts in the system
Rules	The guidelines and code for activities and behaviour in the system

The elements of AT can be used as an organizing principle for understanding the immediate context of the complexity of users [3]. According to Good and Omisade [6], the AT framework "uses activity as the basic element for studying human practices". "Activity, or 'what people do,' or ‘why people do it’ is reflected in actions as people interact with their surroundings and their motives." Elements embody activity. The theory's elements are the subject, object, and community, while the artifacts used to determine the context are tools, rules, and divisions of labour. Activity is carried out by a subject who works toward a solution through the use of tools in collaboration with others (community).
Figure 1 depicts the systemic structure of collective activity, according to Engeström’s model [7].

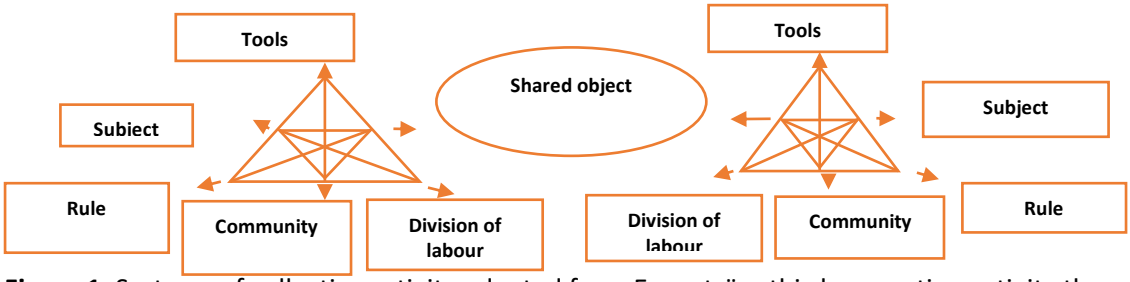

Figure 1: Systems of collective activity adapted from Engeström third generation activity theory (3GAT) [7]

The structure of the activity is shaped and constrained by cultural factors that include conventions (rules) and social divisions (a division of labour) within the context [8]. AT also highlights context factors and the interaction between people and suggests that some context must be taken into consideration in the analysis of human actions since the ultimate cause behind human activities is needs [9]. AT presents a robust framework for studying contextual factors, and it shows us the complexities and fluidity of activities in their immediate context.
AT recognizes that there is a larger community of stakeholders in activity systems who bring their perspectives, views, and culture to the system [10].

There are several activity systems, related to the different stakeholders that share an object. Spinuzzi [11] claims that "without understanding the contradictions that are introduced when two activity systems meet, we cannot understand activity per se" (p. 460). As a result, it is critical to understand not only the perspectives of service providers and users but also the perspectives of all communities involved in the activity system's activities and how they communicate. In this paper, we use the CEF, to understand the relationships of the stakeholders and their communications mappings.

According to the ecological model of communication [12], in Fig. 2, communication occurs at the intersection of four fundamental constructs: messages that are created using language within the media, consumed from media, and interpreted using language serve as a medium for communication between people (creators and consumers).

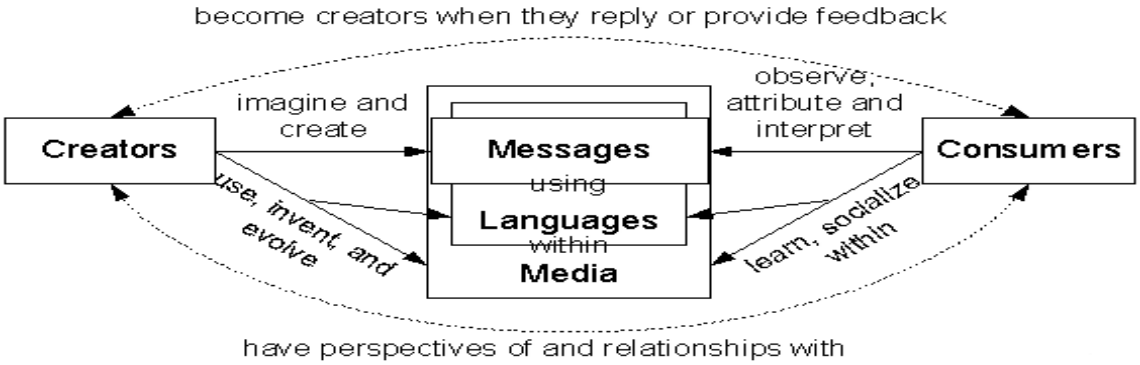

Figure 2: An Ecological Model of the Communication Process [12]

This model is, in many ways, more detailed elaboration of Foth and Hearn's [13] layers of CEF. Foth and Hearn [13] recommend three layers of CEF, to successfully use the conceptual lens of CEF: the technology and media layer, the discursive layer, and the people layer.

The technology and media layer describes the channels via which various individuals and groups can communicate. It comprises all communication tools, analog or digital distribution systems, and the technical frameworks that support them (either software or mechanical). The discursive layer is ideational and focuses on the actual communication's content, particularly the stories, conceptions, beliefs, and symbols that characterize, in this case, the co-creation of digital contents and their uses. The people layer describes the various individuals and groups involved, their social connections, and the institutions and structures that hold those connections together.

The CEF offers insight into extensive learning, understanding the complexities of stakeholders in their socio-cultural contexts of co-creation of digital health services, while AT was used to identify contradictions that occurred in the activity systems (as described in section 4 of this paper).

Figure 3 depicts AT and CEF as theoretical models for understanding the complexities of stakeholders in their immediate and socio-cultural contexts, respectively.

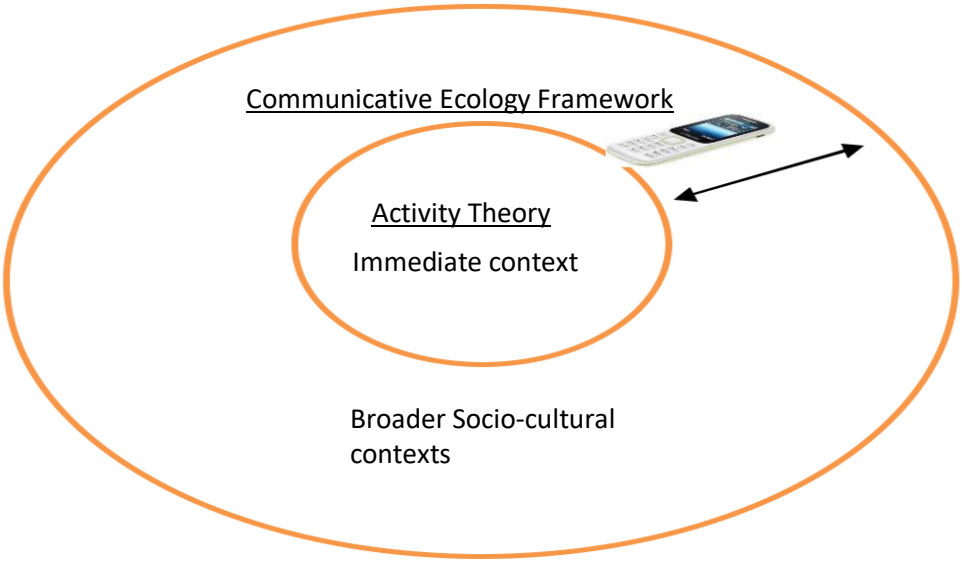

Figure 3: AT and CEF framework model to understand immediate and socio-cultural complexities of the stakeholders in the co-creation process

CEF is composed of three layers [14] as follows. (1) The technology and media layer describes the methods used to communicate between various people and groups, and it includes all communication devices, distribution systems (whether digital or analog), and the technical systems that enable them (either software or mechanical). (2) The discursive layer is ideational and focuses on communication content such as stories, understandings, beliefs, and symbols that define – in this case – design culture and design practices for user engagement. (3) The people layer describes the various individuals and groups involved, as well as their social relationships and the social institutions and structures that link them.

3. Research Methodology

The methodology used in this study is an exploratory case study. We determined that an exploratory case study would be appropriate for this research because the goal of the paper is to gain insights into the phenomenon of digital health innovation of services and understand the complexities associated with it.

3.1 Research context and Case Description

This paper reports on an ongoing project, the Access Infant and Maternal Health Plus (AIM Health Plus) program, which is funded by Irish Aid through the Programme Grant (PG) program, which began in 2015. Through a multi-stakeholder approach, the project is being carried out in collaboration with national and local governments, as well as World Vision Sierra Leone.

AIM Health Plus aims to improve maternal, newborn, and child health (MNCH) outcomes while lowering neonatal and under-five mortality rates by 20% and maternal mortality ratios by 15% across all program sites. Since its inception, the Health Plus project has included a digital health component, CommCare 2017. CommCare has made significant progress in Sierra Leone, with 326 Community Health Workers (CHWs) using it to deliver 7-11/time and targeted counseling (ttC) messages; the CHWs have received effective support and guidance to ensure the application's long-term use.

CommCare was designed using Grameen Foundation's MOTECH (on the back end) and Dimagi's CommCare (on the front end). The design and development process of CommCare was bottom-up, with key stakeholders present at the technical and workflow deliberation meeting. The CommCare mobile application was created to replace paper registers and reporting forms with customized electronic forms that were localized for the native languages. The app was essentially digitisation of the 7-11/time and targeted counselling (ttC) strategy, allowing CHWs to view late or missed household visits, as well as register pregnant women, make clinical referrals to their affiliated health centre and collect household data for transmission to the health facility to support clinical and managerial decision-making. Through the use of a pictorial and local language interface accessible to low-literate users, the mobile component also facilitated emergency response communication and reinforces behaviour change messaging to improve case management. The ability for CHWs to access their patient information even when they are not connected to the internet is critical and considered in the design process. CHWs have access to patient information on their mobile device at all times, allowing them to record updates and receive reminders even when their mobile network connection is unavailable. Figure 3 depicts the main menus of CommCare.

3.2 Data collection and analysis strategies

The study was conducted using qualitative research methods. Semi-structured individual interviews were used in the research to assess and understand the complex case of co-creating digital services because they provided rich perspectives on practical situations. Five semi-structured interviews were conducted between July and August 2021 with people who have been involved with digital health projects in Sierra Leone. Each interview with the participants lasted approximately an hour and was conducted in English. The interviews were conducted by one of the authors of this study. These included interviews with three digital health designers and two representatives of Project Manager and Digital and M&E Officer from World Vision Sierra Leone, which was responsible for CommCare management. They are all involved in the co-creation of the application. These respondents represented various pilot sites for the digital service's implementation. AT and a CEF as analytical lenses were used to identify contradictions, as well as to gain insight into the co-creation of digital health services in the next section.

4 Results of Activity theory and Communicative Ecology Framework analyses of CommCare Co-creation

We chose to examine the CommCare feature development through the AT and CEF framework lenses. The co-creation of the CommCare feature (figure 4) was part of a larger, nationwide digital governance project called AIM health plus.

Figure 4: CommCare menus.

Key stakeholders include a World Vision project office in Sierra Leone whose role it was to carefully test and validate the developed application, the CHWs who use the application, Mobile Network Operators (Airtel Sierra Leone), and Software Developers. In addition, CHWs and health center personnel were part of the stakeholders.

According to AT, several subjects which include CHW supervisors, CHWs, Word Vision staff in Sierra Leone, and Software developers were involved in the co-creation activity system of the CommCare development process. Figure 5 depicts the co-creation process using 3GAT and CEF. The co-creation activity system began with project planning meetings. Meetings, according to interviewees, discussed the introduction of the AIM- Health project and how it would be Organized. The meetings also covered the digital health component, how it would be introduced, the areas where it would be piloted, and a variety of other project-related issues. Following these meetings, it was decided to hold a separate technical and workflow deliberation meeting to discuss the specifics of the mHealth component design and the launch of the Bonthe pilot project. Figure 5 shows how the third generation Engestrom [15] AT is used to uncover contradictions between two activity systems, such as community health workers (CHWs) and designers of digital health applications, who each have different activities but share the same object of improving maternal, newborn, and child health.

Figure 5 presents two activity systems (new digital health co-creation) that include CHWs (subject - left side) and digital health designers (subject – right side) in the co-creation of innovative solutions to improve maternity, newborn, and child health (shared object. In the left activity system, CHWs labour to cyclically transform the object. To transform the object, they use their experience in the use of a paper-based register (mediating instruments). This activity takes place within the Bonthe district (community) and is conducted with the traditional paper-based process (rules) and CHWs seeking to identify the difference between their old paper-based and new digital system (division of labour) related to that community. Additionally, digital health designers strive to cyclically transform the object in the left activity system. They rely on their expertise with technology-based systems (mediating instruments) to transform the object. This activity occurs within the Bonthe district (community), and it is carried out by the digital processes (rules) and their prior knowledge of digital technology (division of labour) relevant to that community.

Tools and division of labour, on the other hand, were perceived to lead to contradictions between CHWs and the digital health designers in the co-creation activities. For instance, **Tools** were perceived to create contractions between the CHWs and the digital health designers in the co-creation of the digital health solutions because many CHWs are motivated to use the non-digital platforms and have motives of using their non-digital experience in improving the shared object. The motive of the digital health designers is to use cutting-edge technology to promote maternal, infant, and child health while CHWs are driven to use their non-digital experiences to advance the health of expectant mothers, new babies, and children.

Division of labour was perceived as contradictions, as CHWs and digital health designers encountered contradictions between the priority of their tasks in improving maternity, newborn, and child health. Digital designers are already aware of how cutting-edge technology may be used to improve maternal, infant, and child health. However, CHWs are motivated to highlight the connection between the introduction of new technology-based systems that they are unfamiliar with and the traditional paper-based ones that they are used to.

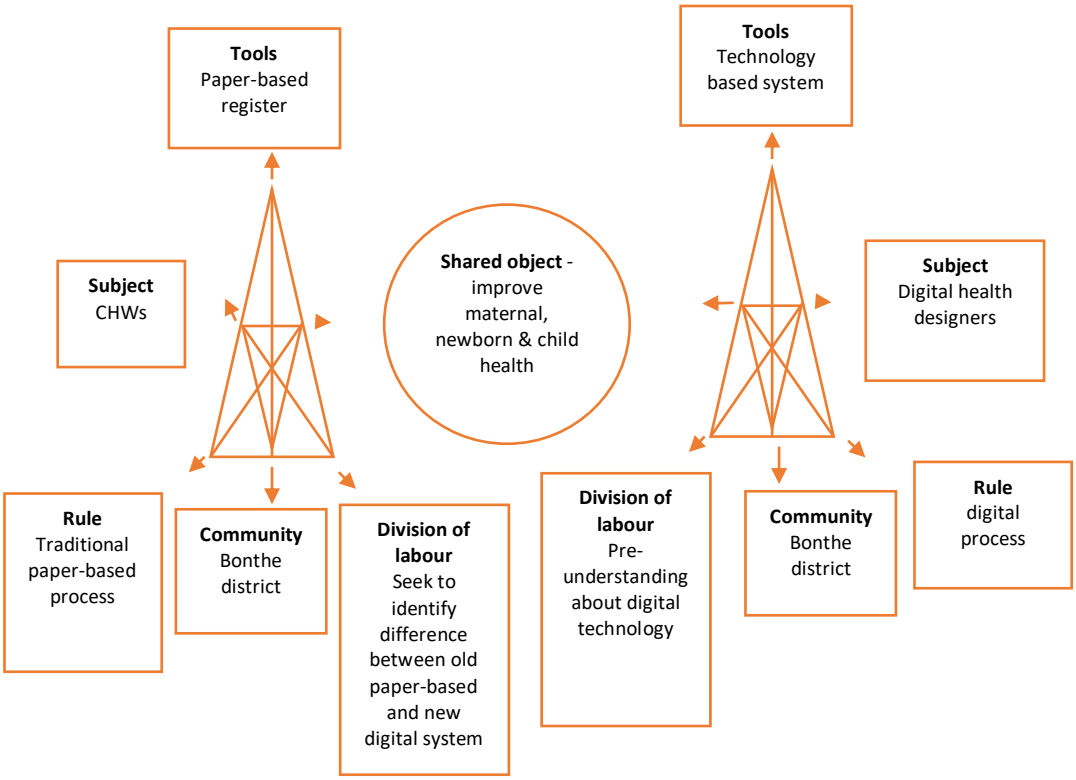

Figure 5: Two activity systems sharing an object.

According to an interviewee, workshops were conducted to address the contradictions between CHWs and digital health designers, *"a 5-day workshop meeting was held. Participants in this 5-day workshop were asked to examine existing CHW and health worker workflows using old paper-based systems. Existing workflows and procedure mappings were then discussed in light of the mobile application's introduction, with consideration given to how this would affect CHW and health worker workflows and responsibilities*" *[P3]*. These discussions were used to revise user journeys and determine what workflow changes would be required as a result of the CommCare application's introduction. Following that, the revised user journeys were prioritized to deliver 7-11/ttC. Prioritization enabled stakeholders to revise and amend which existing user journeys were supported by the CommCare app. According to what was discovered from the interviews, the Bonthe district should employ both paper-based and the CommCare app until CHWs are proficient in utilizing the CommCare app.

The key stakeholders perceived the object, particularly the project plan, to be consistent with the object. Many interviewees mentioned that users' needs in the use of the CommCare app were prioritized. In addition, the workshop also mapped participating stakeholders in the form of user personas (i.e. CHWs, health center staff, pregnant women, the District Health Management Team (DHMT), and so on). According to an interviewee, "*The user persona mapping was completed to think through the various local languages, both written and oral, that would be required for the CommCare application" [P2].*

Figure 6 depicts an activity system (new digital health co-creation) that includes digital health designers (subject) in co-creating innovative solutions to improve maternity, newborn, and child health (shared object). The designers of digital health work to cyclically transform the object. They create personas to understand more about users of digital health services through personas creation (mediating tools). This activity is carried out among their CHWs, pregnant women and their husbands, and relations (community) and is guided by criteria that include setting timed and targeted counselling monitoring (rules) and identifying adherence barriers (division of labour) that are specific to that community.

To uncover contradictions within an activity system, figure 6 depicts communication of users' personas learning (tools) with the community as contradictions inside the user activity system

between subjects (digital health designers) and community (CHWs, pregnant women, nursing mothers, husbands, relations) that triggers and transforms the object (improving maternal, newborn & child health). Digital health designers have the motives of considering how digital interventions might be created to alleviate maternal morbidity and child health issues without taking into account other factors such as communication within each community influencing intervention co-creation. However, how the intervention affects not only the outcome of possibly improved maternal healthcare, but also considers communication between community members (CHWs, pregnant women, nursing mothers, their husbands, and relatives) are deemed to be important for improving the co-creation of the digital intervention.

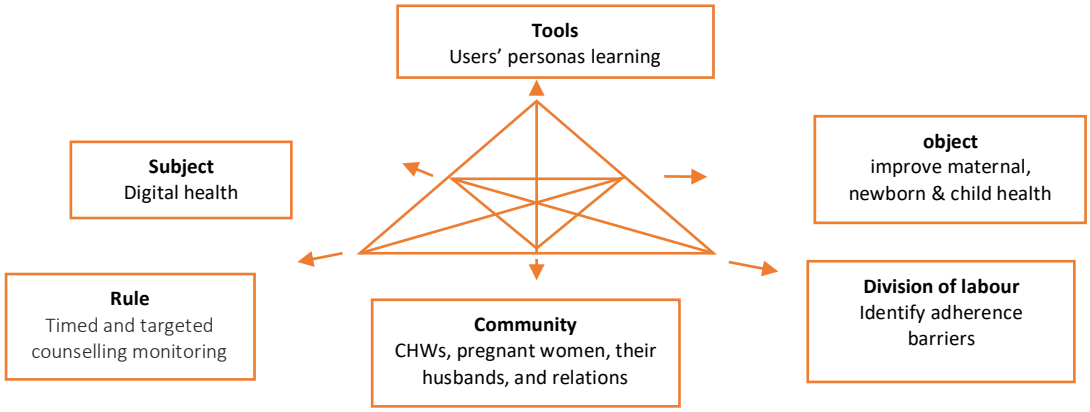

Figure 6: Analysis of the co-creation activity using AT

This has implications for learning design and offers a chance for learning designers to think about how digital interventions can be designed to improve maternal, newborn, and child health as well as how the intervention influences not only the outcome of potentially improved maternal care but also communication between the community, making rules explicit and applying them, and understanding who is responsible for what (division of labour). Hence, the use of communication ecological framework to explore the communication between the community using personas learning in the creation of digital health services.

According to Awang [16], a medium of communication is, in short, the result of several complex interactions between its main constituents: messages, people (acting as creators of messages, consumers of messages), speeches, and spiritualists. Foth and Hearn [13] provide a platform on which communication can be explored. It claims that communication occurs at the intersection of three basic layers: the discursive layer, the layer of technology and media, and the people layer.

The discursive layer involves the circulation and sharing of information, ideas, images, and stories to gain insight into improving maternal, newborn, and child health.

For instance, the CommCare app's local voice recording, and image requirements were considered from users' personas learning. This was an important step because much of Mende's local language used in Sierra Leone does not have a written form. This complicated the development of the mHealth application, necessitating additional translations for Mende from district-level health staff and World Vision employees in Bonthe District. Although Mende does not always have a direct written form. This meant that voice recordings could be in Mende while written text on the phone could not. This was not expected to cause any issues for the CHWs because literate users are used to reading English text.

Technology layers focus primarily on forms of communication technology that are currently being used in digital health systems. The focus was in particular on the use of a range of mobile media forms – phones, SMS, and mobile apps, for example – in the support of material systems of distribution and acquisition for improving maternal healthcare.

It was learned from the interviews that the key stakeholders perceived communicative technology as consistent with the project plan; moreover, an interviewee stated that ". *Using phones that were socially, culturally, and locally appropriate made CHWs feel more at ease with*

the entire process" [P5]. As a result of these considerations, the Nokia C2-01 mobile phones were chosen for the digital health pilot project.

The people layer describes the various individuals and groups involved, their social connections, and the institutions and structures that hold those connections together.

According to an interviewee, "*the first version of the CommCare app was tested for five days by a group of 15 CHWs, half of whom were illiterate. During the testing period, CHWs had the opportunity to ask questions, make suggestions, and practice using the application with key stakeholders. This allowed them to have direct input into the design and development processes" [P1]*. This, along with feedback from other stakeholder groups, guided the design and development of the final version of the CommCare app, which was distributed to CHWs as part of the Bonthe District pilot project. From a learning design standpoint, it was discovered from the interviews that a multi-stage process of developing personas serves multiple purposes and put the designer in direct contact with representative members of the target stakeholders. In addition, calls for the designer to ask to probe, personal questions in order to elicit details of the people's daily lives, lived experiences, and the impact of their family relationships on the people for whom the intervention is being developed.

For this case study, the CEF describes the communication among the community, and mapping of stakeholders to gain insight into the co-creation of digital health services (CommCare app) that improves maternal, newborn, and child health. CommCare was chosen for a variety of reasons, including the fact that it was best suited to the Sierra Leonean context. The three main user interfaces on which the digital health application relies (text, image, and audio) were chosen to make it easy for CHWs to understand and execute the CommCare app functionality. The pictorial and local language interface is accessible to low-literate users, and the mobile component also facilitates emergency response communication and reinforces behaviour change messaging to improve case management.

The ability of CHWs to access their patient information even when they are not connected to the internet is critical to this process.

According to an interviewee, *"This data can be used for a variety of purposes, including providing performance feedback to CHWs and reporting on other CHW and health-related data to a variety of other interested stakeholders" [P4].* CHW supervisors and community health committees can then use these reports to provide feedback to CHWs on both their individual and collective progress. This data allows for real-time decisions and adjustments, resulting in a more effective CHW workforce.

5. Conclusion

The study contributes by utilizing AT and CEF analytical processes in the co-creation of innovative digital health services. The study adds to the literature on digital health innovation by presenting an analysis of digital service co-creation in the context of digital health innovation. The analytical processes can be used to co-create a wide range of other types of digital health services. The use of AT and CEF was important to understand the importance of planning with the key stakeholders and mapping stakeholders in the co-creation of digital health services. AT analysis pinpoints issues in co-creation processes that may not necessarily be problematic from the point of view of one stakeholder, but that may lead to conflicts, delays, dissatisfaction, or sub-optimal performance in the activity system. CEF was used to explore the communication between the community in the co-creation of digital health services. Therefore, identification of contradictions and turning them into expansive learning in the activity system is essential in co-creation processes that involve multiple interdependent stakeholders

6. Acknowledgments

This research was conducted with the financial support of Science Foundation Ireland under Grant Agreement No. grant 18/CRT/6222 at the ADAPT SFI Research Centre at Trinity College Dublin. The ADAPT SFI Centre for Digital Content Technology is funded by Science

Foundation Ireland through the SFI Research Centres Programme and is co-funded under the European Regional Development Fund (ERDF) through Grant #13/RC/2106_P2.
Our special thanks to World Vision Ireland and World Vision Sierra Leone for providing us with the research settings.

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