Towards Applications of

Capability Sensitive Design of Technologies

Mira Slavova, Elmarie Venter, Gugulethu Baduza
SAP Mobile Empowerment, Pretoria, South Africa
Corresponding author: mira.slavova@sap.com

26 February 2013

Abstract: The Capability Approach (CA) introduced by Amartya Sen (A. Sen, 1988, 1990) is focused upon the moral significance of individuals' capability of achieving the kind of lives they have reasons to value. Within the CA framework, information and communication technologies (ICTs) can be seen as tools for expanding individual capabilities. By expanding informational capabilities, technologies can contribute to users' social empowerment (Johnstone, 2007).

Presently, the functionings enabled by ICTs and their impacts are increasingly social. Consequently, technology design is increasingly centered on people and human-computer interactions. Designing software with local relevance and suited to the African context, is a priority within the Mobile Empowerment R&D unit of SAP-Research (Pretoria). As part of the Advanced Development Unit, SAP-Research (Pretoria) in South Africa has adopted design thinking as a method for the design of contextualized ICTs.

In this paper we align the theoretical underpinnings of CA with the innovation methodology of design thinking. We argue that design thinking can be applied as a method, a set of research tools, behaviors and activities, for carrying out 'capability sensitive design'; a term merging CA with 'value sensitive design' which was originally introduced by (I. Oosterlaken, 2009). We also argue that CA offers a framework for the development of a body-of-knowledge which can inform design thinking activities, within the scope of projects aimed at developing technologies in a capability sensitive manner.

Keywords: capability approach, design thinking, capability sensitive design

1. INTRODUCTION

1.1. CA as a Framework for Human Development

Within the CA framework, measuring the quality of life of individuals is consistent with an assessment of their progress towards achieving their valued *functionings*. The latter are valuable 'beings and doings' which are not necessarily evaluated in terms of commodity-based accounting. They may involve being in good health or having loving relationships with others. By extension, human development is understood as a pluralist phenomenon, rather than the expansion of a homogenous magnitude such as income or utility (A. Sen, 1990). Central to the framework is the individual's *capability* i.e. the freedom to achieve valued functionings. Development takes place through the expansion of human capabilities which allows people to do or to be the things that are important to them. Within the CA framework, many human rights can be understood as rights to particular capabilities (A. Sen, 2005). Within the CA literature can be found various interpretations of capabilities (Robeyns, 2006). Whereas in Sen's work the notion of capabilities is primarily that of a freedom, a real or effective opportunity, consistent with social choice theory; Nussbaum's

notion of capability pays more attention to people's skills and personality traits as components of achievement and aspects of capability.

CA has been used within numerous human development interventions. Development policies and their implementation have been framed as policies aimed at expanding human capabilities. Similarly, ICTs have been viewed as enabling the achievement of personal goals and objectives through extending informational capabilities (Gigler & Platform, 2011). The impact of the technology is determined by individuals' perceptions of how ICTs support their valued beings and/or doings.

1.2. Relevance to ICT4D design

In this paper, we consider how the CA can be introduced as a body-of-knowledge, informing the design of information technologies through the process of design thinking. As a pluralistic framework, CA captures human values and allows them to become relevant within the design process, in addition to engineering values such as functionality, reliability and cost efficiency. We consider CA as a theoretical approach, which can be aligned with the methods of design thinking (Brown & Wyatt, 2010; Brown, 2008; Plattner, Meinel, & Leifer, 2010), in order to spur the emergence of capability sensitive design. The latter is consistent with value sensitive design. It is a holistic, human-centered design approach, rather than a use-centered one. It allows the incorporation of human values such as privacy, security, equality, freedom of information, etc. within the design of ICTs.

We proceed by considering critically in Section 2 how within the existing literature ICT4D interventions are aligned with the existing social context (0), how such interventions are designed (2.2), monitored and evaluated (2.3). Providing a comprehensive overview of the literature on the use of CA within ICT4D interventions remains out of scope[1]. Yet, we draw a parallel between contextual factors and the prominent CA concept of *conversion factors.* We trace the role of context in converting resources into capabilities through the interplay of agency and social structure. In Section 3, we sketch out a CA method for the design of information technologies, based on design thinking tools for processing complex problems and social innovation (Brown & Wyatt, 2010). We bridge to the previous section by re-introducing the CA concepts reviewed earlier within the design thinking method. In Section 4 we illustrate the potential of the approach within the work of SAP-Research (Pretoria).

2. LITERATURE ON CA USE IN ICT4D

The CA can be used ICT4D interventions for the purposes of constructing interrelated economic narratives. The main three narrative types, scoped out by (A. Sen, 2004), include: (1) prediction, (2) description and (3) evaluation. CA captures the existing information use and technology context in the form of a descriptive exercise (0); as a predictive exercise, CA can be used in order to design ICT4D interventions suited to the captured context (2.2); while as an normative tool, CA can be used towards the evaluation of the capability expansions achieved through the introduction of new ICTs (2.3). Below we consider the descriptive, predictive and evaluative aspects of the use of CA towards ICT4D.

2.1. CA for Context Research

Through the concept of *conversion factors*, are captured structural states and agency events of the present, which are tightly linked to predictions and casual explanations, as well as to normative evaluations at a later stage. CA points to factors influencing the conversion of resources into capabilities within five areas. Economic, social, political, informational and security capabilities

[1] See (Ilse Oosterlaken & Hoven, 2012) for a comprehensive overview. For illustrative examples of state-of-the-art research, consider *Ethics and Information Technology*, 2011, vol. 13, issue 2; and *Information Technology for Development* 2012, vol. 18, issue 1.

can be defined as freedoms to achieve and are shaped by context (De', 2006; Heeks & Molla, 2009; Amartya Sen, 1999). Capabilities in those areas, at the individual and the community levels, are shaped by the social context. Context also influences personal values and preferences, thereby it influences motivations to take advantage new opportunities, such the ability to access government services, technology, finance, etc.

The literature on information systems for developing countries is focused on transformative innovations, on the path towards deep socio-economic change and development (Avgerou, 2008). The transformative discourse views the use of ICT systems as embedded within the context of local social practices, economic relations and power balances. Yet, these social structures are considered changeable. A dialectical understanding of social change is consistent with understandings how transformative technologies are shaped; and how their impacts are realized (Engestrom, 1987; Lave & Wenger, 1991). The success of ICT innovations is shaped by their adaptation to the localized conditions of social practice; while simultaneously the introduction of ICT systems has the potential of spurring changes to the local social context.

The CA concept of conversion factors is consistent with the notion of contextual factors used in information systems. Context can be defined roughly as the setting or circumstances in which an event or behaviour of interest occurs. Context affects how we interpret the world around us (Keppie, 2006). Context defines the realm over which information is drawn and assumptions are made for the design of a study. It sets the spatial and temporal limits within which our interpretations are meaningful (Keppie, 2006). Therefore, according to (Shin & Edington, 2007), there is a need to understand the factors affecting ICT implementations. The field of factor research has emerged in order to increase the value derived from context research. It is aimed at defining a variety of critical factors for technology implementations in different contexts. Factors such as management ability and political environment are critical components of performance variance, when comparing similar technologies. Conducting an analysis of the contextual factors, (McKone & Schroeder, 2002) show that 47% to 59% of the variance in the value of IT implementation is due to contextual factors. In order to strengthen the transformative potential of ICT innovation, there is a need to integrate research on contextual factors within the design of technology interventions.

The role of context in shaping capabilities can be understood through an interpretation of the Choice Framework (CF) (Kleine, Light, & Montero, 2012) with regards to ICT4D interventions. On the basis of literature on empowerment and sustainable livelihoods, (Kleine, 2010a) develops the CF for application of CA, thereby operationalizing the capability approach and visualizing the elements of its systematic conceptualization of development. According to CF, conversion factors are determined by the interplay of agency and social structure. Agency is based on the resource needs and the resource portfolio of individuals. Portfolios consist of personal characteristics, financial, educational, psychological, social, natural, material, as well as information resources. Resource constraints outline the scope and the boundaries of the fields where individuals can take action. On the other hand, social structure captures the existence of opportunities for use of the available resources. It consists of institutional contexts, organizational fields, existing discourses, policies and programs; formal and informal laws; technologies in use and innovations. The conversion factors relevant to ICT4D interventions consist of the need for resources, complementary to the information and technology ones; as well as the contextual opportunities enabling user to take advantage of ICTs. Thereby, the interplay of agency and structure determines the conversion of available resources into freedoms to achieve.

2.2. CA Use for Project Planning and Intervention Design

The use of CA towards the planning and design of ICT4D interventions is consistent with the prospective economic narrative (A. Sen, 2004). Prospective analyses carry an emphasis on causality, probability and assumptions. They are geared towards identifying policies, actions,

recommendations and activities likely to produce streams of extened capabililties and improved welfare. Within the planning and design of ICT4D interventions, the leading predictive questions are what incremental changes to the existing structural and agency constraints, could produce capability expansions. Moreover, intervention planners are concerned with ensuring that those expansions are durable, equitable and sustainable (Comim, Qizilbash, & Alkire, 2008).

The dilemma of applying CA in a meaningful way to the design of ICT4D interventions, remains locked in the fact that interventions need to be designed with a view towards extending the capabilities of their beneficiaries. Yet, the chosen capabilities and development outcomes need to be identified by the beneficiaries. The challenge in designing interventions using CA, remains maintaining a development framework which does not pre-impose capability choices and thereby development outcomes. Consequently, CA can be credited with spurring a move away from *a priori*, top-down thinking in development planning and intervention design, and towards more participatory modalities. Among the advantages of employing participatory methods in the planning process can be included its moral superiority; the local and cultural appropriateness of the potential outcomes; the advancement of collective action and institutional stability due to participation; the potential to diversify development objectives beyond purely economic outcomes, and include environmental, social and cultural aspects, consistent with the diversity of human values and the potential of multi-purpose technologies (Kleine, 2010a).

CF suggests that impacts of ICTs occur in "systemic, pervasive and transversal" ways. Therefore, consistent with CA, the impacts should be defined by individual beneficiaries. This can be an immediate limitation to the use of CA for project design, as funders tend to prefer clearly defined and measurable outcomes. Among the limitations of CF can be included its focus on individuals, rather than their indigenous communities. Furthermore, CF addresses comprehensively matters of agency, structure and empowerment. Individuals operate with agency within the limits of their resource constraints; agency is shaped within social structures and contributes to empowerment in terms of choice: its existence, the sense of it, its use and the achievement of it. Yet, the comprehensiveness of the framework, leads to forsaking some of its theoretical depth.

The following example of the e-procurement system Chilecompra, clearly demonstrates the challenge of assessing capabilities by means of their proxy functionings. The procurement process was based on the ideological principles of open-market economy, transparency and maximum competition among vendors (Kleine, 2010b). Local public servants operating the system in the name of the local community of tax payers exercised choice in procurement, this choice was aided by the increase in transparency the system offered. However, firstly, local microenterprises were excluded by the system because of their lack of access to technology and lack of skills. Secondly, the excessive emphasis on price led to price wars at the expense of quality, which actually reduced the choices that local public servants had. Indeed, it was not possible to translate aspects of the life that people wanted to live, like having local jobs and an intact environment, into procurement choices, because of the econometric emphasis written into the system. Thus, there was an increased risk that the predetermined direction the system was geared to was not sufficiently overlapping with the choices users would have made without the system. Arguably, local people and their representatives would have sought to use procurement in a way that balanced price criteria with the social and environmental impact of particular products (Kleine, 2010b).

2.3. CA Use in Project Monitoring and Evaluation

As an evaluative narrative, CA provides a normative framework for assessing the extent to which alternative policies, programs or interventions have succeeded in extending freedoms, in the direction of achieving valuable functioning (A. Sen, 2004). CA compares freedoms to achieve (i.e. capabilities), achievements (i.e. functionings) and well-beings reached as a result of the

intervention, with respect to a limited set of variables (Comim et al., 2008). Comparative assessments are used in order to indicate subsequent normative choices among alternatives.

As the main limitation to the use of CA in the impact assessment of ICT interventions, (Kleine, 2010a) identifies that the majority of monitoring and evaluation efforts feature capabilities as a normative basis, while for pragmatic reasons they resort to the measurement of functionings as a proxy for capabilities. The critical challenge to the use of CA remains applying the approach in a meaningful way while maintaining the project objectives and outcomes contingent on selection by the target beneficiaries.

Designing, developing and piloting capability-sensitive ICTs which result in mobile empowerment is a leading concern within SAP-Research (Pretoria). (Alsop & Heinsohn, 2005) develop a framework based on CA, and consistent with an emphasis on empowerment. They define empowerment as "*a person's capacity to make effective choices; that is, as the capacity to transform choices into desired actions and outcomes*". They consider how empowerment indicators can be developed and present a sample module for measuring empowerment. Different *levels* (macro, intermediary and local), within different *domains* (the state, the market, society) of an individual's life, carry varying *degrees* of empowerment. Interdependent factors such as the *agency* of the actor and the *opportunity structure* within which the actor operates, help to explain his/her empowerment.

(Alampay, 2006) looks to reconcile the emphasis on economic growth in development interventions with the pluralistic view of CA, by relating economic growth to the concept of access to ICTs. Economic growth can expand people's choices and can thus be an end or a means to another end, and could afford other human rights. For example, access to information can be seen as adding to people's capabilities to take advantage of the potential benefits that the information society brings. Therefore, it is also a prerequisite for participation in 'digital democracies' and supports people's rights to communicate and access information and knowledge. (Alampay, 2006) argues that people have different ways of transforming the same bundle of goods into opportunities for achieving their plans in life. Access to information resource bundles is governed through complex restrictions on the effective demand for ICTs. Examples of the various capabilities which have been enhanced through development interventions involving ICT include the ability of a person to operate a small business through the use of ICT's. For instance, within a micro-credit programme women working with Grameen development applications have been empowered to start up enterprises as village phone operators (Alampay, 2006).

Literacy is crucial to the effective use of technology. It is another capability that can be enhanced by the availability of technology. A reason why the better educated are more likely to benefit from ICTs is because literacy is sometimes made a prerequisite to using the technology. For example, the Grameen Village Phone in Bangladesh requires that operators should be literate or at least have children who can read and write (Richardson, Ramirez, & Haq, 2000). As such, it is also expected that the more educated and more literate will be using ICTs more than the less educated and illiterate (Alampay, 2006). Age also influences strongly the use of technology. Internet and mobile phone users are not necessarily the same group of people, with the difference being attributable to the fact that mobile phones and the Internet do not necessarily fulfill similar needs or utilities (Alampay, 2006). Context and location also determine the level of access. With respect to location, it has been shown that information divides not only exist between countries but also within them, between urban and rural areas (Alampay, 2006). Such divides are further exacerbated by its slower adoption of ICTs in rural communities (Gomez, Hunt, & Lamoureux, 1999). According to (Niles & Hanson, 2003), a person's social and spatial situation provides them a context through which they gain the needed skills to learn to use a technology and interpret the information it provides. Thus, it is expected that ICTs will be more accessible in urban areas and locations closer to the center of development will see people having greater access and use for ICTs.

(De', 2006) evaluates the impact of CA along five freedom dimensions:

- Political freedoms: did ICTs increase political participation in setting policy/governance agenda?
- Economic Facilities: did ICTs help user's access economic resources such as credit, markets?
- Social Opportunities: did ICTs improve access to education, health, justice, information?
- Transparency Guarantees: did ICTs improve transparency of citizen dealings with government?
- Protective Security: did ICTs enable security against natural disasters?

(Zheng & Walsham, 2007) list some of the capabilities that have been enhanced through the use of ICTs. These include the capability of being included in the district health information system; being able to collect and exploit information; being able to take advantage of computer technology, being connected to resources and more. (De', 2006) highlights some ICT projects in India which have assisted people to do more. These include the Bhoomi-Kiosks which assists in farmer records, applications, certification; the Card-Digital storage and digital land records storage; the Gyandoot-Access to computers to generate employment; the Akshaya- computer training and e-government services; the Lokvani- Access to government records, grievances filed online; and lastly, the SARI- access of e-government services through wireless technology. The availability of these ICT's in order to assists in capabilities has also led to expanded capabilities which include people being able to obtain records anytime, the ability to file grievances online, to access the health information system, and to access more information on the existing health status.

2.4. Strengths and Weaknesses

The various capability frameworks employed towards the evaluation of ICT-enabled development, have different strengths and weaknesses. Among the strengths, (Alampay, 2006) includes the underlying focus of CA on individual differences. Whether or not individuals are capable of using different ICTs, whether or not they can access ICTs through private ownership or public facilities; lead to realised and unrealised functionings. The former consist of actual use that individuals make of ICTs; and the latter consist of freedoms/constraints that prevent capability development or use. (Zheng & Walsham, 2007) highlight among the strengths of CA that it stresses the notion of agents (i.e. what stakeholder groups have/lack capabilities); and it focuses on capability deprivation, as well as capability development.

The main strength and the leading reason for adopting the CA framework towards the design of technologies within the Mobile Empowerment sub-unit of SAP-Research in Pretoria (South Africa) is tied to the relevance of CA to the study of empowerment. The CF framework (Kleine et al., 2012; Kleine, 2010a), introduces the notion of "degrees of empowerment" and builds on earlier attempts to operationalize empowerment. (Alsop & Heinsohn, 2005) locate empowerment at the intersection of agency (i.e. "the capacity to make meaningful choices") and the existing opportunity structure. The term "degrees of empowerment" is used in CA (Alsop & Heinsohn, 2005; Kleine et al., 2012) in order to reflect different dimension of choice, such as the presence of viable alternatives, the usefulness and appropriateness of the choice. Development outcomes from from the execution of the available choices and thereby CA presents a systematic framework for understanding empowerment via ICTs.

Among the weaknesses of CA framework for the planning, design, monitoring and evaluations of ICT interventions, (Heeks & Molla, 2009) include the following:

- Limited practical use of CA framework to date for ICT4D projects. Consequently no consistent approach for impact assessment has been developed.

- Applying CA in practice requires interpretation. The original framework says nothing explicit and is quite "academic" and flexible (i.e. unclear).
- Applying CA requires definition of what aspects of freedom are valued; e.g. ICTs often provide the freedom to access pornography. Is that a developmental freedom?
- Applying CA requires understanding of the potential freedoms NOT chosen, as well as the actual freedoms chosen.
- CA carried complexity due to the fact that capabilities are both inputs to and outputs from any ICT4D intervention.
- CA has the potential for adding a complicated foundation to an otherwise simple issue: how do ICT4D users use or don't use the technology provided.

(Zheng & Stahl, 2011) identify two weak aspects of the use of CA with regards to ICT4D and introduce critical theory in order to shed light on them. Firstly, CA interpretations frame technology as value-neutral good/ resource/ commodity. The neutrality assumption is simplistic and there is room for considering more sophisticated and critical views of technology. Secondly, CA assumes individual agency and is reluctant to theorize how it may be restricted. Critical theory of technology (CTT), amalgamated into CTICT, is capable of alleviating those weaknesses by introducing a view of technology as socially shaped; and bringing in a rich theoretical repertoire about constraints on action and the boundedness of human agency.

Overall, considering critically the literature on the use of CA within ICT projects geared towards development, it is worth remarking the conceptual richness of the approach. The pluralistic notion of development, aligned with the human values of potential beneficiaries, allows for broadening the concept of development. This strong conceptual foundation brings in its wake practical limitations to operationalizing CA for development research and practice.

3. THEORIZING THE DESIGN PROCESS

Within SAP-Research (Pretoria), design thinking informs the development of new technologies. Design thinking is a human-centred approach to assist in defining problems and understanding requirements in order to design useful technology solutions (Plattner et al., 2010):

> *Design Thinking is about the creation of, as well as adaptive use of a body-of-behaviours and values. This goal stands in sharp contrast to, while complimentary to, the predominant disciplinary model based on the creation and validation of a body-of-knowledge.*

We argue that as a body of research behaviours for innovation, design thinking can be aligned with the body-of-knowledge derived through the CA. CA can be employed as a methodology for the analysis of the social context in disadvantaged communities. By documenting resources, capabilities and functionings within communities at the empathizing stage, CA allows us to consider the limitations on conversion factors and agency, thereby allowing the definition of the problems which could be addressed through the introduction of ICT solutions. CA can serve as a useful framework for scoping out the problem space for the design of transformative ICTs. Design thinking operationalizes the translation of the problem space, captured via CA; into well-defined 'point of view' problem statements. Through ideating and prototyping on the basis of the conducted analysis of the problem space, we are able to conduct capability sensitive design by exploring the solution space. Testing of designed solutions and understanding of the social impacts of technology serve as stages in the process of iterative alignment of both spaces. By informing methods for monitoring and evaluation, CA can serve as method for further empathizing.

Design Thinking	Capability Approach	Scope
Empathize	CA informed context research (descriptive)	Socio-technical problem space
Define		
Ideate	CA sensitive design (predictive)	Socio-technical solution space
Prototype		
Test	M&E using CA (evaluative)	Iterative alignment of problem and solution spaces
Empathize		

Table 1: Aligning design thinking and the capability approach. Source: Authors

3.1. Design Thinking

While academic disciplines such as astronomy, quantum mechanics and computer science, pursue problem-solving by analytic means, within clearly specified theoretical and methodological domains; design problems are closer to everyday life and in solving them, resources from multiple knowledge domains and multiple stakeholder perspectives, are pulled together. Designers synthesize and creatively transform existing knowledge into innovative service and product concepts. The process and the strategies involved in doing so are known as *design thinking* (Plattner et al., 2010). The main principles of design thinking include adopting a human-centric point of view; encouraging freedom from fear of failure and relaxing the constraints on the design space; continuously updating and re-designing; and using prototypes as a communication media.

Overall, the design process can be summarized as an iterative series of the following five major steps: empathize, define, ideate, prototype and test (Brown & Wyatt, 2010; Brown, 2008).

- ***Empathy*** is the foundation of the human-cantered design process. Through compassionate understanding, designers learn about the needs of the people for whom they are designing. In order to successfully design innovative products and services, designers need to build empathy for those for whom they are designing and understand what is important to them. Applied within this stage, the systematic framework of CA allows technology designers to understand the details and structure of end-users experiences.
- Then through interviewing and observing users, designers synthesize their findings of meaningful needs in the user community and discover insights. The syntax of a well-defined problem statement includes, (1) a user group, (2) their need, as well as (3) an insight into their values and the motivations which would allow them to achieve improved functionings, once their needs have been met. With its emphasis on choice and freedom, CA is well-positioned to facilitate the development of useful insights, and to assist in ***defining*** the design challenge.
- ***Ideate*** is the phase of the design process where the leading aim is to generate radical design alternatives as possible answers to the "how should we…?" question, defined previously. The goal of ideation is to explore a wide solution space – both, in terms of the quantity of ideas and diversity among those ideas. From this vast depository of ideas can be built prototypes for testing with users. Linking the idea generation process to the expansion of the existing capabilities of the different user groups can be a useful guide at this stage. The ideation process is intertwined with idea selection. Therefore, considering the capability expansions implied by various ideas can give structure to the process and improve its substance.
- At the ***prototyping*** stage, the designers' ideas and explorations are externalized into the physical world. *Anything* that takes a physical form can be a prototype– be it a wall of

post-it notes, a role-playing activity, a space, an object, an interface, or even a storyboard. The essence of the prototyping stage is communication with end users regarding the affordances of choice presented by different ideas. When the design thinking process is informed by CA, the framework can provide designers with the tools for translating the prototyped solution into meanings end users are familiar with.

- ***Testing*** with users is a fundamental part of the human-centred design approach. Testing serves the purpose not only of refining the solution with the users, but also of refining designers' understanding of the user needs and constraints (Institute of Design at Stanford, n.d.). At this stage, CA can contribute by enabling designers to validate the use of choice by end users, as a result of extended capabililties.

3.2. Capability Sensitive Design

According to (I. Oosterlaken, 2009), adopting the capability approach is strongly compatible with knowing and improving the contribution of technology and engineering products to development. However, we still anticipate technologies to add to our capabilities, e.g. capabilities to survive in the case of medical equipment, and to participate in public deliberation in the case of Internet applications facilitating political discussions. This point is reiterated by (Coeckelbergh, 2010) who states that the usual way to define the relation between capabilities and technology is, to consider technology as one of the means to reach the aims (capabilities). CA can serve not only as a framework for exploring the extended socio-technical problem space, but also as a framework for exploring the solution space, with a sensitivity towards individuals' capabilities.

(I. Oosterlaken, 2009) considers the example of a bicycle. It gives a person the ability to move speedily, in a way he may not be able to do without it. That capability may give the person utility or gladness if he seeks such speed or finds it pleasurable. There is an inherent gradation from a commodity (in this case, a bike), to its characteristics (in this case, transportation), to capability to function (in this case, the ability to move at speed), to utility (in this case, pleasure from moving). Therefore, CA forms part of the design by introducing considerations how to assist people without other modes of transport, in achieving the desired functioning of moving at speed. People are presented with the opportunity to ride the bicycle, which helps them realize their capability and thus realize their functioning of getting to a place faster.

While CA charts out resources, conversion factors, capabilities and functionings; design explores the technical solution space. The challenge for capability-sensitive design of ICT4D consists of finding ways to translate between the problems found in the socio-economic context and the capability extension possibilities, within the socio-technical solution space. To conceptualize this transition, it is necessary to link CA to theories of technology adoption, innovation or sociology of technology. In order to integrate the roles of both, humans and technologies within CA, (Janssen, 2010) extends it by including contributions from Actor-Network Theory (ANT) and domestication theory. ANT considers humans and technologies as associations of actants, forming associations through which activities are performed (Latour, 2005). Actants form a mutual relationship and jointly perform an action, a phenomenon often interpreted as mediation via technology. 'Socio-technical constellations', consistent with associations in ANT (Akrich & Latour, 1992) lead to expansion of capabilities. Design thinking provides a fairly loose framework and a very practical innovation process within which such theoretical constructs can be fitted. Whereas CA, in conjunction with theories of technology, can guide ICT4D innovators towards describing the contextual factors, predicting causality and capability extensions, as well as evaluating the impact of ICT interventions; design thinking can provide an applied structure within which theoretical constructs can guide the process of idea generation, idea selection and innovation decision-making.

In considering the use of design thinking towards social innovation, (Brown & Wyatt, 2010) review the example of Shanti, a housewife from Hyderabad, India, who is forced into continuously making a suboptimal choice over the space of possible solutions for procuring safe drinking water. Even though Shanti has walking access to a near-by treatment plant, she continues choosing to bring home water from an untreated borehole. The choice is determined by her capabilities to take advantage of the water provided at the plant, limited by the social, contractual and technical tools at her disposal. Shanti is able to carry 3 gallon containers on her head, rather than the 5 gallon jerrycans mandated for use by the plant. She does not have a bicycle, nor an extended family who could help her in carrying the water. Furthermore, Shanti's family does not require 5 gallons of water every day, as required by the contractual conditions provided by the plant. Entering an arrangement of paying 10 rupees for 5 gallons of water, every day is considered profligate and is opposed to Shanti's conservative approach to managing money matters. Consequently, she makes the consecutive decisions of not agreeing to the contract offered by the treatment plant of purchasing fixed daily amounts; not paying the requested price even though it is within her budget; and preferring not to carry the 5 gallon jerrycans on her own.

The example provides a case of a missed opportunity to enable Shanti and her family to drink safe water. The problem space reflects some resource limitations, but by no means insurmountable ones. Shanti does have considerable capabilities: she can walk to the plant, she can afford to pay for treated water, and she can also carry 3 gallons of water. Yet, she is not capable of making use of the opportunity to drink treated water. The example shows that development problems require systematic solutions that are grounded in the needs and wants of customers. The solution space of the problem is the compounded space consisting of innovative technologies for carrying water, as well as innovative pricing and contractual tools. A pure technology solution to the problem would involve designing 5 gallon containers which Shanti would be capable of carrying on her own. A pure business innovation solution would require developing a new business model for the treatment plant, so it is able to offer customers a "pay-as-you-go" option. In SAP-Research (Pretoria) we are concerned with scoping out solutions in both spaces. A design thinking approach to the problem would involve enumerating all possible solutions and zooming in on an optimal one. As a holistic problem-solving approach, design thinking synthesizes diverse aspects of the problem space, into the technology solution.

4. DISCUSSION AND CONCLUSIONS

CA provides us with an approach for studying the problem space and developing a body-of-knowledge detailing it. Furthermore, by emphasizing the role of capabilities as a boundary object, CA allows us to consider the solution space and investigate how technology can be used in order to expand capabilities. The interaction of CA and design thinking understandings has the capacity of structuring and leading the process of designing ICTs aimed at addressing development challenges. Broadly, this process consists of defining socio-economic challenges, enumerating the solutions within the socio-technical solution space, identifying an optimal one and validating its usefulness. The design thinking approach refers to these steps as empathizing, defining, ideating, prototyping and testing, where prototyping does not necessarily involve technology implementation and can be regarded as a method for the communication of an idea. The contribution of CA within the process of designing capability sensitive technologies, is largely rooted within its comprehensive explanatory power.

Having aligned the capability approach with design thinking, SAP-Research (Pretoria) is in a position to develop innovative technology solutions, based on a body of research findings about the needs of disadvantaged South African communities, achieved by means of CA. SAP- Research (Pretoria), in collaboration with the Centre for Democratising Information (CDI) carried out a detailed capability study during the first half of 2012. It focused on nine priority topic areas (see Figure 1) and relied on a mixed method approach. The fieldwork consisted of deploying household

survey questionnaires and conducting focus group discussions (FGDs). The research was focused on five communities, located in five provinces (Randfontein, Gauteng; uMthwalume, KZN; Bushbuckridge, Mpumalanga; Thabazimbi, Limpopo and Joe Morolong, Northern Cape). The sites of the study were selected so that the studied populations include people with varying socio-economic status who can be classified as poor, less poor or upwardly mobile. At each study site, were drawn samples of 400 survey respondents. Twenty focus group discussions (FGDs) with sub-samples of the survey respondents were carried out at each of the study sites.

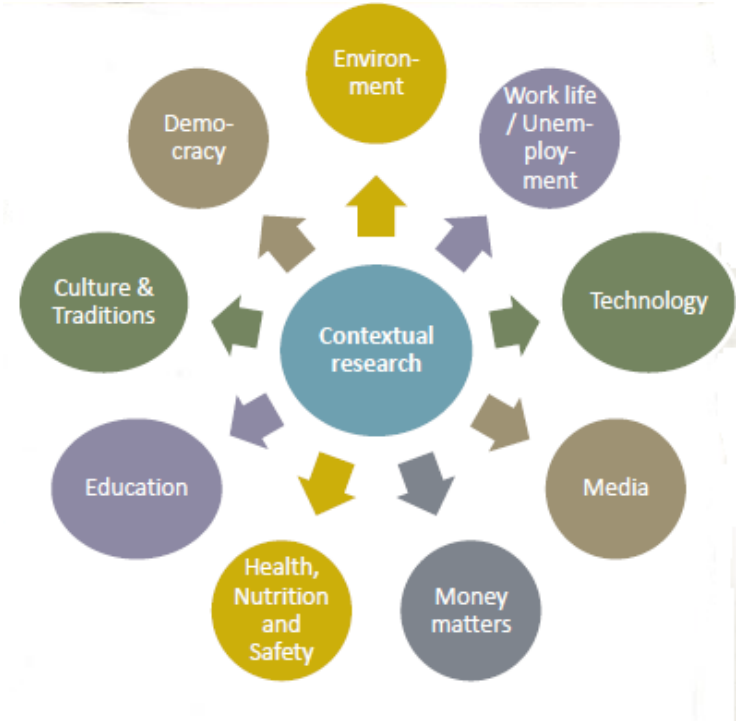

Figure 1: South African capabilities study topic areas. Source: CDI

The study resulted in a series of descriptive reports of culture and traditions (Mazibuko, 2012)Democracy (Lorgat & Garrich, 2012), education (Vawda, 2012), environment (Geyser, 2012), health and nutrition (Dhlamini & Van Wyk, 2012), media (Simms, 2012), money matters (Prinsloo, 2012), technology (Dhlamini & Govender, 2012), and work life/ unemployment (Vawda, Lorgat, & Garrich, 2012). Only a preliminary analysis of the collected qualitative data, carried out using CA (A. Sen, 1980, 1988, 1990) is currently available.

Preliminary findings (Prinsloo, 2013) focus on the capability impact of the Community Work Programme (CWP), introduced by the Department of Cooperative Governance and Traditional Affairs; and bring insight to the dynamics of capability expansion in the studied communities. Capability expansions such as extended social networks, opportunities for active citizenship, opportunities for collective work, raised awareness of government interventions, access to knowledge and technical training information, exposure to health information and safety practices, etc; and their related achieved valuable functionings, can serve as indicators guiding the capability sensitive design process of ICT4D. Understanding and reinforcing the role of technology in expanding the capability set of people in disadvantaged communities provides a valuable input into the process of designing suitable technology solutions. Currently, we are in the process of developing capability sensitive design methods, consistent with the capability approach and with design thinking, so that we are able to develop, prototype and test innovative technologies for education in the studies communities.

ICT can be viewed as an enabler to achieve valuable goals and objectives. The actions of an individual is constantly shaped by preferences, resources and capabilities as freedoms. Human development takes place when humans do or are the things they are free to do or be (capabilities); and achieve the goals and values important to them (functionings). Adopting the capability

approach as a framework for developing body-of-knowledge of socio-economic problems, seems to be strongly compatible with adopting design thinking as a body-of-practices for designing appropriate ICTs. Allowing the two approaches to overlap and complement one another within the scope of ICT4D innovation, appears as a reliable strategy for operationalizing and practicing capability sensitive design.

5. REFERENCES AND CITATIONS

Akrich, & Latour, B. (1992). A Summary of a Convenient Vocabulary for the Semiotics of Human and Nonhuman Assemblies. In *Shaping Technology / Building Society: Studies in Sociotechnical Change*. Retrieved from http://www.conceptlab.com/notes/akrich-latour-1992-convenient-vocabulary.html

Alampay, E. (2006). Beyond access to ICTs: Measuring capabilities in the information society. *International Journal of Education and Development using ICT*, *2*(3).

Alsop, R., & Heinsohn, N. (2005). *Measuring Empowerment in Practice: Structuring Analysis and Framing Indicators*. World Bank Publications. Retrieved from http://elibrary.worldbank.org/content/workingpaper/10.1596/1813-9450-3510

Avgerou, C. (2008). Information systems in developing countries: a critical research review. *Journal of Information Technology*, *23*(3), 133–146.

Brown, T. (2008). Design thinking. *harvard business review*, *86*(6), 84.

Brown, T., & Wyatt, J. (2010). Design thinking for social innovation. *Stanford Social Innovation Review*, *8*(1), 30–35.

Coeckelbergh, M. (2010). Human development or human enhancement? A methodological reflection on capabilities and the evaluation of information technologies. *Ethics and Information Technology*, *13*(2), 81–92. doi:10.1007/s10676-010-9231-9

Comim, F., Qizilbash, M., & Alkire, S. (2008). Using the capability approach: Prospective and evaluative analyses. In *The Capability Approach: Concepts, Measures and Applications* (pp. 26– 50). Cambridge University Press.

De', R. (2006). The Impact of E-Government Initiatives: Issues of Poverty and Vulnerability Reduction. *Regional Development Dialogue*, *27*(2), 88–100.

Dhlamini, M., & Govender, R. (2012). *Technology*. Pretoria, South Africa: Center for Democratising Information.

Dhlamini, M., & Van Wyk, E. (2012). *Health*. Pretoria, South Africa: Center for Democratising Information.

Engestrom, Y. (1987). *Learning by Expanding*. Helsinki: Orienta-konsultit.

Geyser, T. (2012). *Environment*. Pretoria, South Africa: Center for Democratising Information.

Gigler, B. S., & Platform, E. T. K. (2011). Informational Capabilities-The Missing Link for the Impact of ICT on Development. *E-Transform Knowledge Platform, World Bank*. Retrieved from http://siteresources.worldbank.org/INFORMATIONANDCOMMUNICATIONANDTECHNOLOGIES/Resources/InformationalCapabilitiesWorkingPaper_Gigler.pdf

Gomez, R., Hunt, P., & Lamoureux, E. (1999). Telecentre Evaluation and Research: a global perspective. In *Report of an International Meeting on Telecentre Evaluation*. Hills Inn, Québec, Canada: International Development Research Centre (IDRC). Retrieved from http://www.crdi.ca/uploads/user-S/10244248430Farhills.pdf

Heeks, R., & Molla, S. (2009). *Impact Assessment of ICT-for-Development Projects: A Compendium of Approaches* (No. Paper No. 36). IDPM, University of Manchester, UK. Retrieved from http://www.dfid.gov.uk/r4d/PDF/Outputs/ICT/R8352-EnterpriseResearch.pdf

Institute of Design at Stanford. (n.d.). Home. *d.school*. Retrieved November 19, 2012, from http://dschool.stanford.edu/

Janssen, P. (2010). Kamuchina Kemombe: Opening the black-box of technology within the Capability Approach. Retrieved from http://essay.utwente.nl/61182/1/Janssen,_Pim_-_s0209260_-_Master_Thesis.pdf

Johnstone, J. (2007). Technology as empowerment: a capability approach to computer ethics. *Ethics and Information Technology*, *9*(1), 73–87. doi:10.1007/s10676-006-9127-x

Keppie, D. M. (2006). Context, Emergence, and Research Design. *Wildlife Society Bulletin*, *34*(1), 242–246. doi:10.2193/0091-7648(2006)34[242:CEARD]2.0.CO;2

Kleine, D. (2010a). ICT4WHAT?—Using the choice framework to operationalise the capability approach to development. *Journal of International Development*, *22*(5), 674–692. doi:10.1002/jid.1719

Kleine, D. (2010b). The capability approach and the "medium of choice": steps towards conceptualising information and communication technologies for development. *Ethics and Information Technology*, *13*(2), 119–130. doi:10.1007/s10676-010-9251-5

Kleine, D., Light, A., & Montero, M.-J. (2012). Signifiers of the life we value?–considering human development, technologies and Fair Trade from the perspective of the capabilities approach. *Information Technology for Development*, *18*(1), 42–60.

Latour, B. (2005). *Reassembling the Social: An Introduction to Actor-Network-Theory*. Oxford University Press, USA.

Lave, J., & Wenger, E. (1991). *Situated learning*. Cambridge University Press.

Lorgat, H., & Garrich, M. (2012). *Democracy*. Pretoria, South Africa: Center for Democratising Information.

Mazibuko, N. (2012). *Culture and Tradition*. Pretoria, South Africa: Center for Democratising Information.

McKone, K. E., & Schroeder, R. G. (2002). A plant's technology emphasis and approach: A contextual view. *International Journal of Operations & Production Management*, *22*(7), 772–792. doi:10.1108/01443570210433544

Niles, S., & Hanson, S. (2003). A New Era of Accessibility? *URISA Journal*, *15*(APA I).

Oosterlaken, I. (2009). Design for development: A capability approach. *Design Issues*, *25*(4), 91–102.

Oosterlaken, Ilse, & Hoven, J. van den. (2012). *The Capability Approach, Technology and Design*. Springer.

Plattner, H., Meinel, C., & Leifer, L. (2010). *Design Thinking: Understand – Improve – Apply*. Springer.

Prinsloo, M. (2012). *Managing Money*. Pretoria, South Africa: Center for Democratising Information.

Prinsloo, M. (2013). *The South African Community Capability Study* (Draft). Center for Democratising Information.

Richardson, D., Ramirez, R., & Haq, M. (2000). Grameen Telecom's village phone programme in rural Bangladesh: a multi-media case study final report. *Consultado el*, *21*. Retrieved from http://www.t-forum.org/mausklick/background/Grameenfinalreport.pdf

Robeyns, I. (2006). The Capability Approach in Practice*. *Journal of Political Philosophy*, *14*(3), 351–376. doi:10.1111/j.1467-9760.2006.00263.x

Sen, A. (1980). Equality of what? *Tanner lectures on human values*, *1*, 195–220.

Sen, A. (1988). The concept of development. *Handbook of development economics*, *1*, 9–26.

Sen, A. (1990). Development as capability expansion. *Human Development and the International Development Strategy for the 1990s*, *1*. Retrieved from http://tek.bke.hu/regikorok/sen/docs/development.pdf

Sen, A. (2004). Economic Methodology: Heterogeneity and Relevance. *Social Research*, *71*(3), 583– 614.

Sen, A. (2005). Human Rights and Capabilities. *Journal of Human Development*, *6*(2), 151–166. doi:10.1080/14649880500120491

Sen, Amartya. (1999). *Development as Freedom*. Oxford University Press.

Shin, N., & Edington, B. (2007). An Integrative Framework for Contextual Factors Affecting Information Technology Implementation. *Journal of Information Technology Theory and Application*, *8*(4), 21–38.

Simms, M. (2012). *Media*. Pretoria, South Africa: Center for Democratising Information.

Vawda, S. (2012). *Education*. Pretoria, South Africa: Center for Democratising Information.

Vawda, S., Lorgat, H., & Garrich, M. (2012). *Work Life/ Unemployment*. Pretoria, South Africa: Center for Democratising Information.

Zheng, Y., & Stahl, B. C. (2011). Technology, capabilities and critical perspectives: what can critical theory contribute to Sen's capability approach? *Ethics and Information Technology*, *13*(2), 69–80. doi:10.1007/s10676-011-9264-8

Zheng, Y., & Walsham, G. (2007). *Inequality of What? Social Exclusion in the e-Society as Capability Deprivation* (No. Working Paper Series 167). London School of Economics.