reliable and unbiased ***understanding****. Furthermore, strategies for* ***communicating*** *and* ***curating*** *of knowledge are fundamental*" (p. 8) [Emphasis ours]. This means that if ICT4D research is to make an impact, there needs to be a strategy for *communicating* this research to all community stakeholders.

The use of the term "ICT4D" has been contested, specifically the "4D" part (or "for development"), since both "for" and "development" are troublesome to reflective practitioners and researchers (Merritt, 2012). That debate is beyond the scope of this paper, which concerns the *use* and *development* of ICT. The term "ICT4D", in this paper, encompasses the fields of ICT4D, Development Informatics and Community Informatics because these areas are interrelated and indistinguishable for the purposes of this research.

To expedite knowledge sharing between different professional disciplines, thereby to facilitate problem solving and informed decision making, is a perennial knowledge-management challenge (Alexander *et al.*, 2015; Johnson, 2004). Advances in technology have opened up new avenues for knowledge sharing and dissemination but, before we can attempt this, we need first a coherent and shared meta-view of the community. Van Biljon and Alexander (2015) contend that the domain of Development Informatics can be described as a fragmented adhocracy since it is a sub-field of Information Systems, a field that Banville and Landry (1989) refer to as a *fragmented adhocracy*. The level of fragmentation in a domain may well change over time. However, the ICT4D context is complex, influenced by political, cultural, economic, infrastructural and technological factors (Turpin & Alexander, 2014). Furthermore, the plurality of the term *developme*nt, which has been described as multifaceted (Walsham, 2017), and often contentious (Qureshi, 2013), exacerbates the fragmentation of the DI field. This, then, is our justification for suggesting the development of a conceptual model of the ICT4D research community in South Africa. Such a model, we anticipate, will reveal: (1) the scope of ICT4D research in South Africa, (2) the people engaged in research, (3) the kind of research conducted, and (4) how researchers interact with other members of the community. A conceptual model of the ICT4D research community would enable researchers within the community to locate others with an interest in the same aspects of ICT4D (Gloor *et al.*, 2003). This is likely to reduce needless repetition of research and encourage community participation (Vassileva & Sun, 2007). By working together towards a common goal, researchers and other stakeholders can advance the research area more effectively than when they work in isolated ignorance of other local endeavours. Moreover, such a meta-view of the community could feasibly open the way to a more sustained and mutually beneficial flow of information between all stakeholders with an interest in ICT4D both nationally and internationally.

South Africa, as a developing country, has a dynamic and growing ICT4D community, as is evident from the inclusion of ICT4D events at leading South African conferences, such as the SAICSIT conference (Van Biljon, 2016). Such events aim to disseminate and publicise the activities of South African ICT4D researchers, thereby strengthening the community and improving impact. As the research field grows, the need to improve visibility and awareness of South African ICT4D research, and the active researcher community, has become apparent. A shared understanding of the South African ICT4D community, which this paper provides in the form of a conceptual map, would clearly be of value. We propose harnessing the power of both information and knowledge visualisations in order to arrive at a visual representation of the South African ICT4D community. Both kinds of visualisations provide a means for people and knowledge to interact, but in a subtly different way. **Information** visualisation uses a visual representation to support pattern detection to enhance *knowledge discovery and creation* (Chen *et al*., 2009; Meyer, 2013). **Knowledge visualisation**, on the other hand, deploys a visual representation to support the inherently social processes of *knowledge*

creation and sharing (Burkhard, 2005; Bresciani & Eppler, 2013). The primary difference between the two visualisation types is that knowledge visualisations exist to support *knowledge* ***transfer***, whereas information visualisations primarily support *knowledge* ***discovery***. The former has a particular relevance to communities of practice, fostering a common understanding and facilitating a mutually-beneficial exchange of ideas. Yet, as we shall explain, information visualisations also play a role in helping us to make sense of the ICT4D community landscape. The need to organize information has led to the development of independent knowledge organization systems with differing attributes, content and structures depending on the domain. Pieterse and Kourie (2014) propose a knowledge organisation system based on increasing structural complexity, which includes classes of lists, taxonomies, lattices, thesauri and ontologies. The information we are using here is more complex than a list, because it contains both items and attributes. It is also hierarchically organised, so closer to a taxonomy or ontology in nature. We incorporate the concepts from the model of a visual ontology, as proposed by Gavrilova *et al*. (2015), but refer to it as a *conceptual framework*, rather than either an ontology or taxonomy. In the next section, we discuss the use of visualisation in the ICT4D community context, as revealed by a systematic literature review of research publications.

2. Visualisation

Grinstein *et al.* (1992) argue that visualisation is important for knowledge discovery systems because humans are much better than computers at discovering patterns in noisy data. Moreover, it supports the discovery of analytical solutions. They also argue that as data, and exploration thereof, becomes more complex, visualisation becomes an essential tool supporting knowledge discovery. McInerny *et al.* (2014) supports the idea that visualisation is fundamental to studying complex subjects and argues that the construction of a mental model of a multidimensional area can only occur when a person is able actively to explore and engage with the subject matter. Visualisation is a powerful tool for supporting this kind of interaction. Having discovered patterns, in effect new knowledge, that knowledge needs to be communicated to others interested in the field. There are some very good examples of the use of visualisation to help people to understand complex networks. The current map of the London underground, effectively a vast interconnected network, is a good example. Maps are one of the oldest forms of human communication; map-making pre-dates both number systems and written language transcending the limitations of private, individual representations of terrain in order to augment group planning, reasoning and memory (Okada, Shum, & Sherborne, 2008). The first maps produced for underground commuters simply superimposed the train network onto a map (shown left of Figure 1). This was an accurate depiction but it was also unhelpful to commuters. What the producers did not initially understand was that different stakeholders had different needs. The maintenance and management teams did indeed need this kind of visualisation but the commuter wanted to interrogate the map for a different purpose: to find out how to get from one point to another. The current visualisation is a model of economy (Figure 1, right). All extraneous details are removed that would interfere with the commuter's need to navigate London, yet all necessary details are included. This, then, is a *knowledge* visualisation, crafted specifically to support knowledge transfer from the creator to the viewer. The initial maps that led up to this one can be considered information visualisations, depictions of the information that were not particularly suited to knowledge communication and transfer.

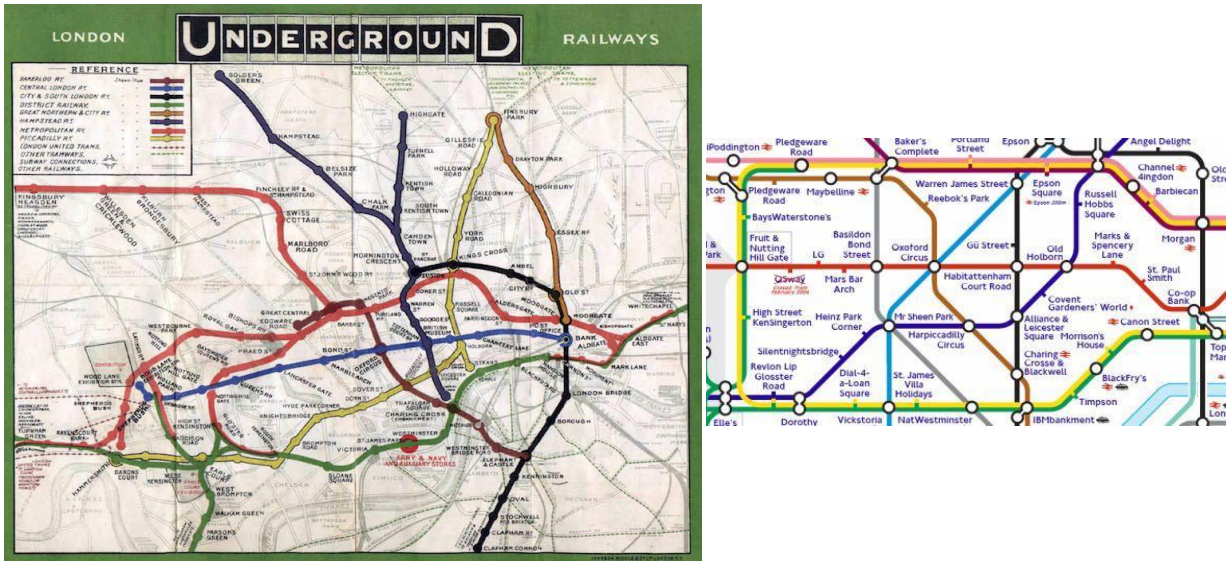

Figure 1: Two Visualisations of the London Underground Network. Initial Map (1908) on the left. Snippet of Current Commuter Map (Pioneered by Harry Beck) on the right.

This highlights an important principle for supporting sense making of networks: the need for different visualisations depending on the stakeholder's needs. Johnson (2004) urges experts from different visualisation communities to come together in order to integrate their tools to lead to greater insights and benefits. This supports our rationale of developing a conceptual model of the multi-, inter- and trans-disciplinary ICT4D research community.

3. Research Approach

The four-cycle design science research (DSR) approach, as proposed by Drechsler and Hevner (2016) informed and steered our study. The clarity of structure, designated relevance-and-rigor cycles and flexibility of data capture selection methods made DSR an appropriate methodology for the development of an OKR on ICT4D research.

- The **first** cycle, comprising the external environment, was investigated through a systematic literature review as detailed in Section 4.1. This stage was guided by a post-positivist philosophy of extracting papers on information and knowledge visualisation from the literature. We also consulted existing, related representations to craft the initial conceptual model as a point of departure.
- The **second** cycle, comprising the internal environment, focused on capturing data about ICT4D researchers in South Africa. The data capturing and selection strategy is described in Section 4.2 with more detail provided in related research by Van Biljon and Marais (2017).
- The **third** cycle involved the creation of the information visualisations, using Kumu as tool, and the derivation of knowledge visualisations from a number of different information visualisations, abstracting the accumulated knowledge into one final knowledge visualisation. This procedure was based on ontology capture that includes four discrete steps, as summarized in Table 1 below (Gavrilova *et al*., 2015).
- The **fourth** cycle concerns the development of the knowledge base. The knowledge base draws on visualisation and community-mapping literature. The findings from literature are conceptualised as the initial knowledge visualisation (omitted due to space limitations) and then

refined by means of insights gained from the information visualisations to culminate in the final visualisation (Figure 4).

Table 1: Steps for ontology capture (Gavrilova *et al*., 2015) as applied to this context

Step A	Goal	Represent the South African ICT4D research community in a way that supports knowledge transfer	
	Strategy	Literature review, data capture, information visualisation, knowledge visualisation	
	Boundary identification:	The South African research community limited to researchers affiliated with academic institutions	
Step B	Glossary development		Section 4.1
Step C	Meta-concept identification		Section 4.2
Step D	Laddering, including categorization and specification		Section 4.3
Step E	Orchestrating or refinement		Section 4.4 (Figure 4)

The community was delineated as *Development Informatics (DI) or ICT4D researchers in South Africa*. The individuals were identified by doing a Google Scholar search using the terms "Development Informatics" or "ICT4D" and 'South Africa'. The search was carried out during September 2016 and repeated during February 2017. The search returned 78 names; each of whom was contacted to obtain consent to use their information; 62 responded positively, two denied permission and 14 did not respond. The following information categories were added to a spreadsheet for the consenting researchers: their affiliation (institution where they were employed), the conference proceedings and journals they had published in, and the domain sub-field(s) of DI, or related fields, that they were active in. A total of 16 institutions were added which included universities and other research institutions such as the Council for Industrial and Scientific Research (CSIR). The rest of this paper aims to apply both information and knowledge visualisation techniques to arrive at a knowledge representation of the South African ICT4D community.

4. Steps towards developing a representation

4.1 Step B: Glossary Development

As a first step, we carried out a systematic literature review to find out what other ICT4D researchers were doing with respect to the use of visualisation of research communities. We selected three journals based on their focus on ICT4D research. Those included the Journal of Community Informatics (JOCI, 2017), the Electronic Journal of Information Systems in Developing Countries (EJISDC, 2017) and the African journal of information systems (AJIS, 2017) as well as two conferences in the Development Informatics field. JOCI and EJISDC were selected for their focus on community informatics and development informatics respectively while AJIS was selected for their focus on the African context. The conferences were IFIP 9.4 conference on the Social Implications of Computers in Developing Countries and the International Development Informatics Association Conference (IDIA). The searches for journal papers were carried out on the 30th to 31st of January 2017 and those for conference papers on 24th to 25th April. The document types included only journal and conference papers. The search string "*visualisation*" OR "*visualization*" AND "*community mapping*" was used. This returned only 3 papers from AJIS and none from the other journals. The scope was then widened by using the search string: "*visualisation*" or "*visualization*". The results, in terms of number of references found, were as follows: AJIS (14), JOCI (31), EJISDC (1) IDIA (14)

and IFIP9.4 (12). For IFIP 9.4 only the years 2011, 2013 and 2015 were available from the official website (http://www.ifipwg94.org/) when the search was conducted on 24-25 April 2017. From scrutiny of the abstracts of the selected papers, the following categories were identified. The papers and references are available as Appendix A from https://goo.gl/KfYBtF.

Teaching and learning (24), **Urban planning** (7), **Knowledge management** (4), **Overviews** (2); **Co-operative behaviour** (7), **Security** (2), **Technology** adoption (3), **Health** (6), **Finance** (1) and **Human-Computer Interaction** (2)

With the exception of Carroll et al. (2015) and Jones (2012), all the papers described the use of visualisation in one particular context i.e. applying visualisation to a particular area. The studies predominantly employed information visualisation to discover and illustrate patterns. Considering those papers categorised under teaching and learning there are some focused on information visualisation e.g. Usability Guidelines for Designing Information Visualisation Tools (Smuts et al. 2015) while others focus on knowledge visualization e.g. advocating visualization as part of an introductory programming (Pretorius et al., 2015). A fully representative literature review of ICT4D literature ought to include a survey of the ICTD conference as well as the Journal of International Development, Information Technology for Development and the Information Development Journal. However, this analysis of four conferences and two journals is proposed as a useful point of departure in exploring the extant deployment of visualisation in the ICT4D context. Based on this analysis we conclude that the concept of visualisation is important as evident from the fact that it was mentioned in all the publications analysed, with IDIA2015 having a specific category for visualisation. However, the analysis reveals that visualisation was mostly mentioned as an advantage of a method, or a way of more effectively presenting results. What is lacking is a coherent narrative on what visualisation is and how it can be applied to improve the understanding of the field of ICT4D research.

Visualisation in ICT4D literature

The conceptual model for ICT4D research, as proposed by Van Biljon and Alexander (2015), describes ICT4D, a research field, in terms of the discipline, research paradigm, underlying theory, research methodology, data capturing strategy and data analysis. The model builds on earlier conceptual models on the disciplinary foundations for development informatics research theories including Heeks (2007) and (Best, 2010). Another way of representing this research area is to utilise the concept of *Communities of Practice* (CoPs). This concept grew out of research into group-based workplace learning. Examples are insurance claim processing, photocopy machine repair, and corporate research (Lave & Wenger, 1991). CoPs are currently being investigated by scholars and practitioners interested in the role of situated practice, learning and knowledge generation (Amin & Roberts, 2008), across a variety of organisational, and spatial settings. For example, Dinter, Kollwitz, Möslein, and Roth (2016) propose a conceptual framework for the design of an online platform, which combines open innovation and knowledge management to represent community informatics as a virtual community of practice. The depiction of the activities of the community members, and their content-generating activities, aid the identification of usage patterns. It thus makes sense to consider and represent the ICT4D research community as a CoP. The first step towards such a representation is an agreement about the language to describe the components. Many techniques and notations are available to define and to visualize conceptual models. Gavrilova *et al.* (2015) used mind mapping to create visual ontologies, the approach is particularly suited to knowledge creation and codification. Given our knowledge depiction *raison dêtre*, representation of the ICT4D CoP community as a mind map seemed worth investigating. Such a model could act as a launching pad towards a more formal notation. Based on the ontology classifications proposed by Gavrilova *et al*. (2015) and the literature

review, some generic categories of the ICT4D research fields were identified; those include the purpose, sub-disciplines, application domains and stakeholders.

- **Purpose**: Information and communication technologies for development (ICT4D) refers to a range of activities, which consider how electronic technologies can be, used towards socio-economic development of developing communities worldwide (Burrell & Toyama, 2009). The technology needs to be designed to operate in a complex social, political, economic, and cultural context and therefore it is necessary to consider the multi-perspective approach of the ICT4D domain ((Thapa & Sæbø, 2014).
- **Sub-disciplines**: The following disciplines were identified as feeding into ICT4D. Computer Science (Best, 2010), Information Systems, Information Science, Communication Studies, Sociology and Economics (Heeks, 2007).
- **Stakeholders**: The following stakeholders were identified during the SAICSIT workshops: Researchers, Practitioners, Government, Non-Government, Funding agencies, Private Sector (based on stakeholders present at the SAICSIT (Van Biljon, 2016; UCT_Centre, 2015).
- **Research Domains**: The following domains have been identified within ICT4D: Health; Education and Learning; Government / Public sector; Agriculture; SMEs and job creation; Creative Industries; NGOs (including universities); Disabled and marginalized; Private Sector; Information Society / Access / Digital divide (Van Biljon & Alexander, 2015). Considering the South African ICT4D field the following have been highlighted: Education, Government, Health, Mobile and Agriculture (Van Biljon, 2016).

Having defined a glossary, the next step is to identify additional meta-concepts.

4.2 Step C: Meta-concept identification

Figure 2 depicts the connections between ICT4D researchers and institutions. This displays the institutions hosting ICT4D researchers and provides some idea of the number of researchers per institution. From observation the University of Pretoria, the CSIR, the University of Cape Town and the University of South Africa (Unisa) have the biggest clusters of ICT4D researchers, with smaller clusters at the other universities. There are links between Unisa and the CSIR, Unisa and TUT and also between CSIR and UCT in terms of researchers being affiliated to both. Given the known flaws in capturing data about an ill-defined, dynamic group, this information cannot be used to draw conclusions but it is useful as a point of departure in identifying attributes relevant to the ICT4D landscape e.g. bi- and multi-lateral connections. Therefore, a new label *Activities* will be added to the initial knowledge visualisation. Due to space limitations, the visualisations of the researchers' disciplines and domains are not included here. Van Biljon and Marais (2017) describe the social community mapping process and the results (in related research) in more detail. We are now ready to commence the next step, namely categorisation.

4.3 Step D: Laddering, including categorisation and specification

Upon analyzing the publications of the selected researchers for identifying their specialty, a number of clusters emerged. The first cluster corresponds to disciplines namely: Information Systems (IS); CS: Computer Science (CS) and: Human-Computer Interaction (HCI). The second cluster corresponds to domains previously identified (see Figure 4), namely Education; Government; Health, Agriculture and Business. The rest includes application areas such as Business Intelligence, Data Analytics, Data Mining, Community Engagement; Cloud Computing, Mobile Application and Smart Cities. Smart Cities was added as a new Doman label but the rest are considered as current topics within existing domains or trans-domain approaches rather than new domains.

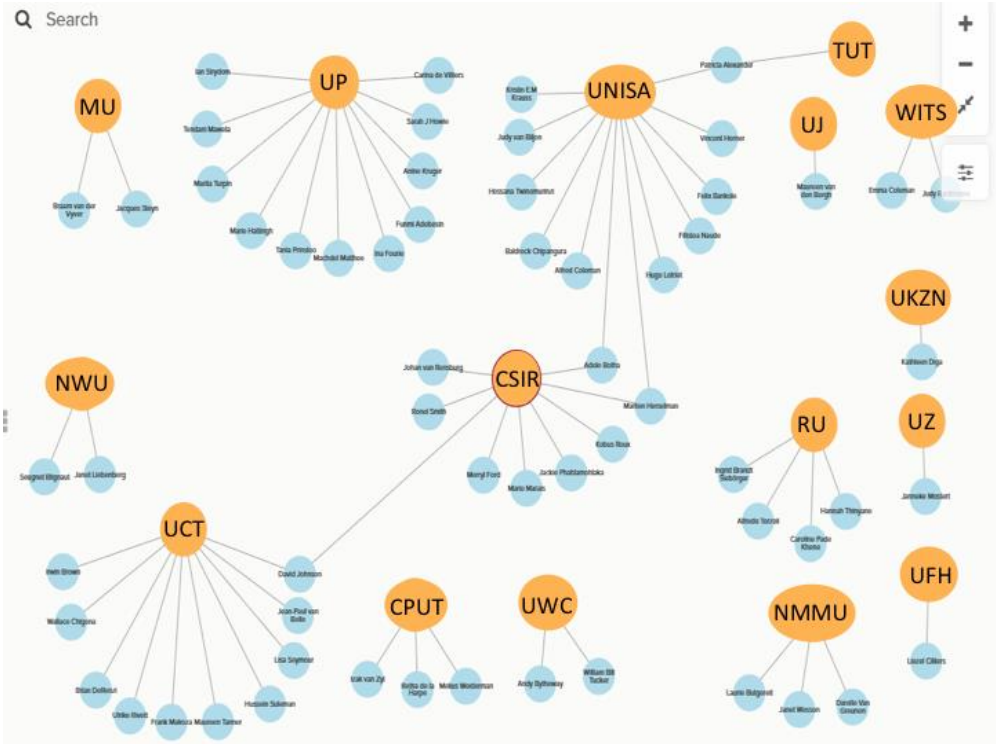

Figure 2 depicts the connection between ICT4D researchers and research domains.

4.4 Step E: Orchestrating (Refined Representation)

This is the final step. Having commenced with an initial glossary, and depicted that as a knowledge visualisation. We then developed the meta-concepts and used information visualisations to support the identification of additional meta-concepts. These visualisations also supported the laddering and categorisation process. We are now ready for the final step: orchestrating our insights. We use a knowledge visualisation for this purpose. Figure 4 is the refined representation, presented here in order to encourage stakeholders to provide inputs. Our aim is to distribute this, once refined, to act as a resource for the community at large.

5. Discussion

Most knowledge management research depicts knowledge production as a linear process moving from data to information and then to knowledge (Rowley, 2007). Likewise, the use of visualisation is often depicted as a progression, with data visualisations delivering information, information visualisations delivering knowledge and knowledge visualisation serving to transfer knowledge and to deliver insights. When trying to implement that in practice it becomes clear that one needs an understanding of the meaning of the information variables and their inter-dependencies, which can be presented using a knowledge visualisation in order to lead to an improved information visualisation. Therefore, the best use of visualisation in research reporting is not necessarily a linear ordering of data, information and then knowledge but rather in selecting the appropriate type of visualisation for the task at hand. This insight of cyclic sense making is shown in Figure 3.

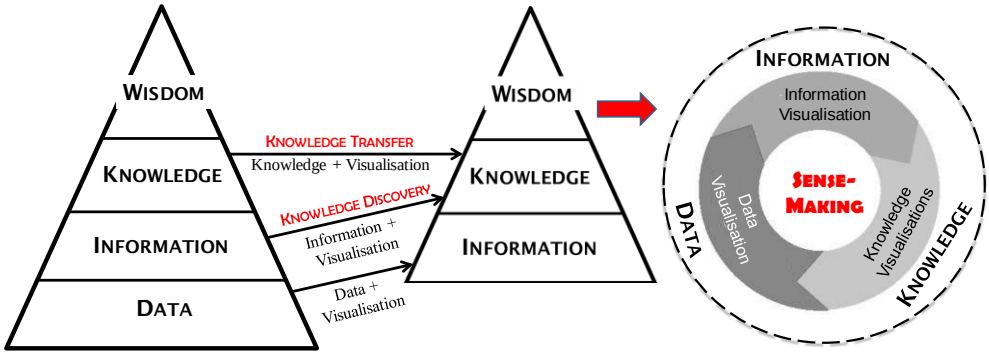

Figure 3. Sense making with Information *and* Knowledge Visualisations

We have now explained how we proceeded to refine the initial representation to arrive at the final orchestration, an evidence-based, though admittedly incomplete, knowledge visualisation of the South African ICT4D community of practice. Our conclusion is that an effective knowledge visualisation of a CoP is a cyclic process, commencing with the crafting of a knowledge visualisation to provide some boundary identification, glossary development and meta-concept identification. This makes it possible to carry out data capturing that can be used to produce successive information visualisations. Those are then explored to create new insights from different perspectives. We utilised the strengths of both information and knowledge visualisations to arrive at the final representation. While this representation is "final" as far as this paper is concerned, we do not claim it to be final in any real sense of the word. Our aim is to use this as a knowledge communication and transfer mechanism, as facilitated by this conference, in order to support refinement and improvement of the representation. Knowledge visualisation is a particularly apt way of communicating this knowledge in an understandable format and hence that supports scrutiny and elicits inputs from all stakeholders. The scope and data capturing criteria limits the generalisation of this research. Defining criteria for identifying ICT4D researchers is not trivial. Due to the interdisciplinary nature of ICT4D there is no standard procedure to ensure that all the relevant people are contacted, the selections harbours a tension between being too specific narrow and too general and therefore involves value judgements. Furthermore, this study focused on academic research institutions, which is only one sector of the ICT4D community. More research is necessary to present the visualisations to ICT4D champions from academia, industry, government and NGOs for evaluation and input towards obtaining a more complete set of South African ICT4D researchers.

6. Conclusion

If any research field is to make an impact, we have to find a way to (1) *understand* the research undertaken and then (2) *communicate* this research to others in the community. What we are proposing is the use of visualisation as a means of constructing a coherent and meta-view of the community for dissemination across the community and other stakeholders. In modelling the South African ICT4D community in this way, we are well aware of the adage that all models are wrong, but that some are useful (Box & Draper, 1987), and essential in enabling people to communicate and make sense of complex phenomena. Our purpose in carrying out this research was to provide a useful model. This paper presents a first attempt to provide an accessible overview of the South African ICT4D community as a point of departure towards promoting insights into the national research landscape. We provide an artefact, namely the knowledge visualisation to be critiqued and improved upon by eliciting feedback from all stakeholders.

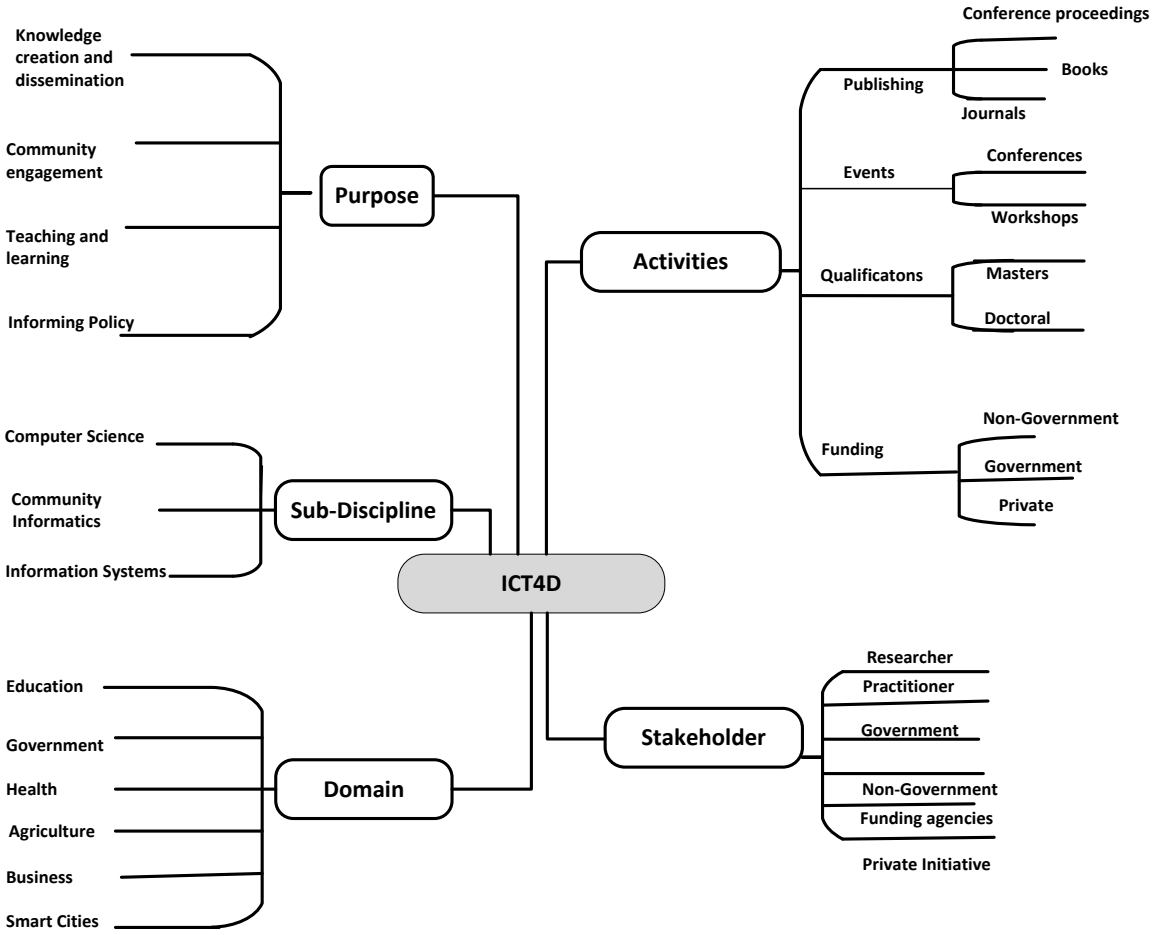

Figure 4: Updated Representation of the ICT4D community

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