Computer Science Students Learning Co-Design with a Deaf Community

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1. Information and Communications Technology for Development

Information and Communications Technology for Development (ICT4D) is a new sub-discipline within Computer Science that focuses on the impact that computing related technologies can have on issues of socio-economic underdevelopment. ICT4D departs from the rest of Computer Science in terms of the context of the users who are its domain of concern and also in the methods employed in artefact design. ICT4D typically targets users in under-resourced communities in developing countries.

ICT4D aims at digital inclusion, ensuring that all people have access to ICTs and the skills to use them; this is often called "bridging the digital divide". This notion of "digital divide" has been extensively problematized but is useful as an initial concept for students to work with. It signifies the gap between the current state of a society and the envisaged desired outcome of the digital revolution as an Information Society where knowledge resources are equitably distributed. The digital divide is the disparity in access and use of ICT between various groups of people, mirroring and exacerbating existing disparities such as:

- gaps in education (for example, illiteracy);
- location (rural-urban);
- gender;
- race;
- income level;
- personal physical impairment (an issue here).

The South African digital divide arises from our history of division and historical backlogs for large groups of people. The digital divide also arises from global circumstances that apply to all developing countries. Apart from having poor access to digital infrastructure and equipment, another consequence is that people use applications and digital contents with an inappropriate cultural bias.

The need for specific ICT4D research and training is driven by the high failure rate of ICT projects in the developing world (Benjamin, 2002) (Heeks, 2002)[1]. This has led to an approach that had to abandon traditional methods of design in computer science (found in software engineering and human-computer interaction). The engineering perspective is one of creating systems that are 'fit for purpose' but this implicitly depends on users who are able to state their needs clearly in terms that can be understood by technologists. It has become apparent that uncovering the specific purpose for which a new artefact is needed is problematic. Methods that deal with "customers" are not adequate to encompass ICT4D. This is because such approaches assume customers are similarly educated and from the same culture and can express their needs in a language that Computer Science practitioners understand.

We now realize such notions of the aims of design have to be challenged. Designers have to work with users as co-designers and together identify the problem that needs to be addressed, the means of tackling the issues and then together decide on measures of success.

Having described the new field of ICT4D we shall sketch our involvement in a specific project very briefly in the next section. This is with a Deaf[2] community in Cape Town. On the basis of this relationship we were able to offer our fourth year students a unique learning experience. In Section 3 we describe the objectives of the course and in Section 4 we describe the course and our experience in more detail. In our conclusion (Section 5) we highlight the fact that our course had a profound effect on our students' views on disability even though this was not the prime purpose of the course.

2. Long Term Engagement with the Deaf Community of Cape Town

Academic researchers from the Computer Science departments at both UCT and UWC have sustained an involvement over many years with a grassroots NGO, DCCT (Deaf Community of Cape Town) which is

[1] Richard Heeks says in his blog (29 November 2011) "Good data on success/failure of ICT4D projects is embarrassingly limited, and more historical than recent". ICT4D researchers tell many anecdotes to support this assertion. http://ict4dblog.wordpress.com/2011/11/29/can-a-process-approach-improve-ict4d-project-success/

[2] Following convention in the literature Deaf with a capital 'D' refers to a cultural and linguistic community (see the conclusion of Section 2 for more detail).

staffed almost entirely by Deaf people and serves the needs of the larger Deaf community in the Western Cape. It was founded by members of the community in response to a dearth of services and support from mainstream and official sources. Most Deaf adults are semi-literate, at best, due to disadvantageous educational practices at schools for deaf learners. Many are unemployed, but those who are employed are often underemployed in menial jobs. This adversely affects the socio-economic level of the community as a whole. The Deaf Community is underdeveloped in terms of ICT access and participation. In general we believe that ICT can be an enabling technology that supports development and empowerment. Thus this group might benefit from ICT interventions.

It is a common experience of designers that one may design artefacts very carefully for a given purpose but when such artefacts are deployed they get put to uses that the designers never intended and could not have anticipated. This is referred to as *appropriation*. ICT lends itself to this since the technology is malleable and adaptable and can easily be shaped for different purposes. A well-known example of this is the Short Message Service (SMS) of mobile phones that was intended for telephony control purposes but was appropriated for private communications. This leads to the idea that one designs to enable appropriation by creating systems that can be adapted by their users. An extreme form of this would be to create tools with which users can create their own artefacts.

In the Deaf community our initial intent was to support remote communication between Deaf people and hearing people, Deaf to Deaf and Deaf to officialdom. While this has been achieved to a certain extent, of equal interest has been the way the original computer systems have been appropriated. This relates to the unexpected uptake in the use of the computers for general access to information and social networking, e.g., the prolific use of Facebook. Included in these spin-off uses was the demand by the community for the training Deaf people in ICT literacy. We facilitated by the introduction of the internationally accredited ICDL programme[3]. In addition a Deaf person was trained to maintain the computers at DCCT. We gave access to hardware and software and network[4] and in time the system has been adapted for advocacy and empowerment.

This has all been enabled by the ongoing presence of students and academic staff from UWC and UCT. One of the funding bodies, SANPAD[5], required collaboration with a Dutch researcher and thus we have worked extensively with Dr Adinda Freudenthal from the Technical University of Delft. An outcome of this has been the publication of a case study in a leading Computer Science textbook (Blake, Tucker, Glaser, & Freudenthal, 2011). This case study of our ongoing work in the Deaf community illustrates our method of Community-Based Co-Design and shows how it grew out of a synthesis of participatory design and action research. “Community-Based” conveys the fact that we deal with groups of people rather than individuals (in the developed world computers are geared to individual requirements — PC stands for *Personal* Computer). “Co-design” derives from the application of the action research paradigm in a design setting: both the computer experts and the community members are designers on an equal footing and work cooperatively.

There is a well-known tradition in Computer Science of tackling hard problems as a way of driving research by looking at extreme cases. In ICT4D work we viewed the work with DCCT as precisely such a challenge that would lead us to new insights with wider application. We did not consider it very distinct from other developmental and empowerment challenges faced in our field, at most it differed by a matter of degree. There was no explicit notion of tackling disability. We did of course adapt the design process and deliverables to take into account impairments which impact on functioning. We shall see below that this disinterested view is not necessarily the case with the students who took our courses.

Following international convention DCCT describes themselves as Deaf with a capital D thereby denoting membership of a cultural, linguistic group which uses in this case South African Sign Language (SASL) as their preferred language. This is as opposed to deaf with a small d which refers to a medical condition, i.e., loss of hearing. In the latter case the emphasis is only on the impairment. This self-

[3] ICDL (International Computer Drivers License) www.icdl.org.za.

[4] The network costs are now being borne by the community itself.

[5] SANPAD (South Africa Netherlands Research Programme on Alternatives in Development) www.sanpad.org.za

identification as a community moves the discussion beyond disability to one of digital exclusion in a disadvantaged community. When we discuss our experience below we will occasionally distinguish between *general* lessons which would apply in any related community based course and *specific* examples that depend on the fact that we were dealing with a Deaf community.

3. Educational Outcomes

In our role as educators we train students in ICT4D, following on from the role of a University in moving research results into the curriculum. The essence of the course is to train the students in working with and learning from communities who are very different from their own and to teach a form of design thinking where design decisions are held in abeyance until the participant users are able to contribute equally.

Community-based

Computer science can be characterized as a discipline where students are trained in the uses of abstractions and to become fluent in working at different levels of abstraction as the need arises. The essence is one of moving from detailed concrete descriptions to higher level concepts that encompass many details behind the abstract description. Students have not been trained to the same extent in involving people in their work. A detailed example of adding people into network abstractions can be found in the notion of a Softbridge Stack (Tucker, 2009).

Upon this valuable technical training we now set out to sensitize students to major cultural differences and help them develop ways of entering into design conversations with people who do not have these skills but who are knowledgeable on their own needs. Students have to realize too that there is no "one" community with whom we work. In every design situation there are many communities: the elders, the youth, women, migrants, people with disabilities, and so on. Each of these has to be given a voice in design. In order for that to happen students have to be trained to recognize groups of stakeholders, identify gatekeepers and consider how all the diverse needs might be investigated.

Co-design

Once stakeholders have been identified a common language (or metaphor as it is sometimes called in computing; like the ubiquitous desktop metaphor of office computing) has to be developed. With sophisticated users this language can be based on crude mock-ups of a computer interface ("paper prototypes" — see Figure 1) since such people can readily imagine how this might work in an ICT artefact. Where a common understanding of technology does not exist, co-designers have to be given insight into the possibilities offered by the technology by means of approximations implemented using technology.

Figure 1. *Mock-up of a display*. Components can easily be altered. Some find it difficult to imagine the dynamic aspects of a system in a paper version and must be shown active prototypes running on a machine.

A key feature of co-design training is for the students to learn to keep their own design decisions in abeyance. It is a serious mistake to commit (psychologically) to a design solution before the co-designers have found their voice.

Field Work

Our solution was to design an Honours (fourth year) module that exposed students to field work. This is an unusual step in that Computer Science students have had little direct training in working outside the computer laboratory. We attempt to scaffold their understanding by appealing to their previous experience in software engineering and human-computer interaction[6]. It is necessary to provide support since students are anxious about this unusual activity and we also have to ensure that students behave ethically with respect to the targeted community.

[6] In this connection it should be noted that action research apparently grew out of cyclical engineering design approaches and we can refer the student back to their own training in such approaches: know in Computer Science as agile software engineering.

4. New Computer Science Honours Module

The South African Bachelor's degree often has a fourth year course where students specialize in a particular subject (called Honours and based on the Scottish System). In Computer Science the year comprises 160 credits (of which 60 credits are for a major project) and this module, called "Community-Based Co-Design", counted 10 credits under this scheme. The advantage of the honours year is that most of the modules offered are elective and attract only interested students and academics can experiment with different offerings more closely tied to their research interests. Almost all modules, and this one is no exception, require students to create computing artefacts as part of the module. In this case the requirements were driven by the community involved and it was up to the students to design and build a (prototype) system that satisfied their needs. As it turned out in this case it was a content-driven website.

The course started with an exercise to identify which students were really interested in working in the module and then to split them into groups of four students. We only wanted fully committed students who would not abuse our good name in the Deaf community. After the introductory sessions students undertook action research design and implementation cycles involving the DCCT community.

4.1 Introductory Lectures

The module included two mornings of introductory lectures and group exercises. The lectures introduced ICT4D and associated qualitative research methods (action research). The construct of Deafness was introduced along with ways of interacting that are appropriate to Deaf culture; including interacting with South African Sign Language (SASL) interpreters, appropriate seating, the importance of lighting and so forth. The more practical material continued with a review of design principles and process and the elicitation of user requirements by means of expert interview, focus groups, ICT requirements interviews and paper prototyping.

4.2 Cycles of Field Work

The introduction was immediately followed by practical work in the community.

This started with an expert (key informant) interview (jointly conducted by students and facilitator). *Generally* speaking the purpose of a key informant served to give the students detailed information to help them build an understanding of the community and to develop cultural sensitivity. *Specifically* in this case the interview served to problematize the relations of Deaf ↔ Deaf and Deaf ↔ hearing. The central role of a signed language in Deaf culture was emphasized.

Subsequently the students engaged in reflection and preparation for the focus group on the next day. Each group started working on materials for the paper prototype (see Figure 1). They also drew a mind map of their current understanding of the key stakeholders and their relationships. This mind map served to highlight any gaps in their understanding that could be addressed in the meeting.

A focus group with staff members of DCCT was conducted by means of questions from the students. The *general* aim was to discover community needs and wishes and to identify types of ICT applications that might empower or support the community. They were exposed to the ethics of video recording interactions. *Specifically* they experienced the actual practice of working through an interpreter, seeing that two interpreters swapped over because of the demanding nature of the task and how the interpreters conveyed more than just content but also nuances and affect.

The focus group session was followed by a process of facilitated reflection where the facilitator and students reflected on the outcome of the discussion and attempted to identify possible ICT applications and prepare for the next cycle of enquiry. This was important because in these sessions the overall theme and aim of the class was decided and the themes and roles of the groups arranged.

The next day the students engaged in structured requirements elicitation by following up the reflection with further engagement with Deaf members of staff in small groups to investigate needs and design in more detail. Reflection and subsequent design of an executable prototype was followed by implementation as the action for this next cycle. One group had to set up the framework for the other

groups to work within. Groups could send representatives to selected informants to gather further information or materials.

Presentation of the first version of the prototype to Deaf co-designers and the evaluation by Deaf users was done ten days after the focus group. The initial response from DCCT was positive and encouraging. They engaged constructively in a discussion on aspects they liked and features they wanted changed. Interestingly there were many spelling errors, which immediately subverted any perceived power arising from the students' superior education while the fact that such errors could easily be corrected, demonstrated the flexibility of the design. It encouraged the DCCT staff to suggest other changes.

The student groups then prepared a one page summary of their reflections on the reception of the prototype. This served as an explicit opportunity to engage in the reflective phase of action research and also to encourage students to commit their observations to writing. They tend to find this difficult but it was well done across the board.

The preparation of a final prototype, the first deliverable to the community, followed and this also included further work on back-end systems that were not immediately visible to the users. One meeting of the class was set up after a week to report back on progress with the actions. This was to monitor developments and assuage the uncertainties of the facilitators, given the novel nature of this course and process.

The formal presentation of the final prototype to DCCT staff was made about one month after the start of the module. During this session the groups demonstrated the changes and additions they had made based on previous feedback. It also provided a final opportunity for the students and the community members to reflect not only on the product but also on the process of this co-design. It was clear from this last meeting that the extended engagement was beneficial and valued by sides.

4.3 Deliverables from Students for the Course

A University course requires formal assessment. This is partly made up out of group deliverables but also has to include individual elements. For this course the requirements were:

Group Deliverables

1. Report on the design process (including highlighting roles and contributions of individual students) , only this report was formally assessed;
2. First Prototype;
3. One page reflection after the first prototype;
4. Final Prototype.

Individual Deliverable: Reflective essay by students.

This paper was the final (summative) assessment in the module. Students had been encouraged to keep notes and other source documents to provide material for this paper. Marks were based on insight into the impact of the module. Our students would not normally have had such a task before and so fairly detailed guidelines were provided on what is meant by reflection on an experience.

They were asked to address the extent to which the objectives of the course, using headings such as "Community-Based" and "Co-Design", were realized in their case. This was probably one of their first experiences of doing design in a real situation. The impact of the (Deaf) culture they worked with and the group response to the situation were also important topics for reflection. Ethical and professional issues had been emphasized and they were asked to consider those as well as sustainability of the project after the end of their course. Finally they were invited to look at their own growth as professionals and the impact of the lecturers in this course.

4.4 Our Reflections on the Course

While we anticipated that students would be anxious when confronted with such a departure from their normal type of course, we as lecturers also experienced trepidation in the lead up. This was a new peda-

gogic approach for Computer Science and we did not know how the process and the relationship with the community would unfold.

As far as the teaching was concerned, we dealt with the uncertainty by calling in outside expertise to assist in the form of a colleague from an established design faculty in the Technical University of Delft (in the Netherlands). She has extensive experience in such field work in technology, albeit not directly with teaching Computer Science. This relationship had been built up via our research projects over the years. In this sense this was a successful exercise in skills transfer that empowered the local facilitators with the confidence to run the course in future.

In negotiating access and expectations with the community we relied on previous trust and relationships build up in the years of collaborative work with this community. We knew the people we worked with and knew how to get skilled facilitators such as SASL interpreters. It was important to maintain a relationship of beneficial reciprocity.

We structured the course to facilitate conveying an action research based method (namely our community-based co-design method) to the students. In parallel with their cyclical build-up of reflection upon action we were able to develop our own growing understanding of the pedagogic necessities. We also had to ensure that effective deliverables were produced.

We were apprehensive of taking computer science students, with their focus on abstraction rather than people, into a learning experience more usual in the social sciences. It turned out there was a very significant advantage associated with the skills of our students. Central to our field[7] is the need for practical work that produces a usable deliverable at the end. This practical, and we hoped usable[8] artefact, as the output of the student's work facilitated a reciprocal relationship with the community.

As far as co-design was concerned it was clear that the paper prototypes (mock-ups) presented at the initial design session worked well only with the more sophisticated staff members of DCCT. Once we had a working prototype however, everyone felt able to engage and suggest improvements (especially after the computer science students demonstrated their own ineptitude with correct English spelling). Their suggestions included: placing greater emphasis on their traditions and history on the homepage of their website, showcasing the people involved in creating the craftwork that is made and sold by them and showing the front of their building instead of the back entrance. They were also concerned about intellectual property, but agreed to safeguarding their ideas via watermarking of photos of the craftware.

4.5 Students' Reflection on the Course

Many students have never had contact with Deaf people before. Many expressed fear of this unknown. They were unaware of SASL as a language in its own right. They had never considered the issue of low-literacy and the access issues that arise for Deaf people.

It is clear from the reflective essays which the students presented that participating in this course and their active engagement with members of DDCT resulted in significant shifts in their understanding of, and attitudes towards Deaf people.

There was a strong realization that language/communication, poor education and access to technology was the barrier rather than deafness or disability *per se*. "I had my stereotypes of that culture torn down as I realised the truth that deafness is far, far less a disability than signing is the language of that community. Deafness is not what hampered the co-design process; the difference in our and their computer literacy is what had the most negative effect."

Another student commented that there more similarities between the Deaf community members and themselves, with language used being the primary difference. Negative preconceptions were shifted: "I was surprised to discover that most of the staff at DCCT were Deaf, I could not believe it at the time". Another student expressed surprise how extensive the list of services on offer at DCCT was. In addition they realized that "the absence of verbal language did not imply the absence of other cognitive features".

[7] Actually it is central to experimental computer science as opposed to theoretical computer science.

[8] In reality the students produced a prototype system but we committed from the start to paying some of the students to produce a robust deliverable during their vacation.

There was a noted change in attitude to Sign Language which was originally thought to be slow and more limited but with exposure understood it to be “diverse and effective”.

One of the students commented “It was an eye-opening experience working within the Deaf community and learning about their culture from observing their interactions. It was interesting to note how they were all comfortable with each other and not in any way disabled.”

The students expressed interest in understanding the mores of Deaf culture including the use of sign names, lights used as alerts and providing adequate lighting for seeing the facial expressions used in sign language. For many students this was their first experience of working through interpreters, specifically, SASL interpreters. However many commented on the skill of these professionals in making the communication seamless. It was awkward at first but with the interpreters “the longer we spent there, the more normal and comfortable it became”.

It was evidently a challenge for all the students to avoid technical terms and jargon. This was important for two reasons: the Deaf did not understand these terms and nor did the interpreters. They learnt the importance of using video and pictures rather than text.

Students commented that Deaf people have a positive outlook despite challenges and they realized they had the same goals and aspirations as anyone else.

“I figured the Deaf people were exactly that; PEOPLE!”

5. Conclusion

We see our primary achievement as that of giving computer science students an opportunity for direct engagement with a community where the students could deploy and refine their design skills. Students commented favourably that they dealt directly with real users which was precisely the reason they had chosen this module.

Figure 2. *Students, lecturer and DCCT staff.* Students are wearing the T-shirts they were given after the final prototype demonstration.

The people with whom we worked commended our students on their approach; they felt that the people of DCCT were treated with respect and dignity. We believe this is partly due to the humility inherent in the approach of co-design where the people we work with are not so much seen as “users” but rather as collaborators whose views are important in the enterprise of building a satisfying outcome. The community felt listened to and not patronized. During the final meeting they responded with a spontaneous gesture of offering all the students a T-shirt reflecting their pride in their language and institution (see Figure 2).

This course came about because of a fundamental belief in a new way of working in Computer Science together with a number of seemingly fortuitous factors which depended on our network of connections and the history of our collaboration. The following insights may serve as a template of requirements.

1. A community involved will have to accept the invasion by a class of students. Such a relationship is probably established over a long time in a reciprocal relationship. The course must fit into, and build on such a partnership. The academics benefit from being able to offer a high quality learning experience and the community must see some benefit.

2. This kind of course requires funding to pay for materials, interpreters and expert consultants where necessary. In the ideal situation this would be part of general departmental funding but realistically these resources will probably have to be found in research funding.
3. The course involves risks and so will only work in a situation where risks are tolerated: an honours year offers this. The students may regard a situation where assessment is qualitative as risky for them if they have been used to high achievement in quantitatively assessed well determined courses. The planners of the course also cannot predict the exact events and have to be comfortable with a skeleton schedule which is populated as the action research cycles unfold.
4. A course like this requires interdisciplinary expertise and input. In our case, we had the benefit of a long collaboration across a number of disciplines, but would suggest that networking (both within and beyond the university) to set up these collaborations is necessary
5. In general a University may not support interdisciplinary teaching and so the resources, people, and space in the curriculum has to be found in spite of the structures present.
6. While the specific access needs and requirements for Deaf users, e.g., language access via SASL interpreters and cultural sensitivity, were addressed in this project, the principles and process is generalizable to working with other communities of users with other impairments and other development challenges.
7. Experience for Honours Computer Science students of working with the Deaf community has revealed lessons for including disability into the curriculum for ICT4D and related research and practical projects.

This course has been an opportunity to put into practice the dynamic interplay between research, pedagogy and practice in Computer Science.

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