

Taking a User Centred Design Approach for Designing a System to Teach Sign Language

Julie Fisher

Email: Julie.Fisher@monash.edu

Kirsten Ellis

Email: Kirsten.Ellis@monash.edu

Louisa Willoughby

Email: Louisa.Willoughby@monash.edu

Jan Carlo Barca

Email: jan.barca@monash.edu

Monash University,

Victoria, Australia

Abstract

User Centred Design (UCD) is today a widely accepted philosophy in systems development. UCD stresses the importance of involving and consulting users throughout the design and development of a system; it puts users and their tasks at the centre of the process. The phases of UCD are not universal and there are many interpretations of how UCD might be applied. Despite the wide acceptance of UCD and its recognised value in terms of designing systems which better meet users' needs, there is little reported research on the application of UCD in actual development contexts. We describe how we employed UCD to develop a system for teaching sign language. We report on how users were involved and contributed to the design of the system at each of the UCD phases. Finally we reflect on what was learned and propose a model for others wishing to take a UCD approach.

Keywords

User Centred Design, sign language teaching, systems development

INTRODUCTION

Sign language (SL) is usually the only fully accessible language available for deaf people who cannot hear sounds of speech. Speech reading is difficult, not least because not all sounds produced in speech are visible in lip shape and movement of the mouth (Scheetz 2012 p. 8-9). Many deaf Australian children use Australian Sign Language (Auslan) to communicate; they are also educated in Auslan in schools. More than 90% of parents of deaf children are hearing and are therefore unlikely to be fluent in Auslan. If Australian parents of deaf children choose to communicate with their children using SL they need to learn Auslan (Komesaroff, 2008). There are however, insufficient SL teachers so many parents, particularly those in regional Australia, are unable to take formal classes. The motivation for this research came from Deaf Children Australia (DCA) who wanted an alternative to SL classes which would enable more parents to learn SL.

A key requirement was that the technology/system solution had to provide feedback to the learner as if they were learning in a SL class. In order to meet the challenge of developing an affordable, reliable and self-sustaining system for DCA and the deaf community it was important that they be involved. From the outset a User Centred Design (UCD) approach was employed. There is limited reported research detailing how UCD has been applied in systems development. We discuss the research undertaken in developing *My Interactive Auslan Coach* (MIAC), our SL learning system with a specific focus using UCD, how input from our users and stakeholders was considered and the value/contribution of this approach to the final design. Our research question was "How can UCD be appropriately used to develop a system to teach SL with feedback to the learner"?

USER CENTRED DESIGN

User Centred Design (UCD), also known as human centred design (Norman, 2005) is not new and today is widely accepted. It is a "philosophy based on the needs and interests of the user, with an emphasis on making products usable and understandable" (Norman, 1990 p. 188). Mao, et al. (2005) define UCD as "the active involvement of users for a clear understanding of user and task requirements, iterative design and evaluation, and a multidisciplinary approach." Gould and Lewis (1985), one of the earliest proponents of UCD, proposed three design principles which are the accepted basis of what we know of as UCD today (Rogers et al. 2012 p. 327). These are that designers focus on users and their tasks early, that there be some measurement of user performance during development and an iterative approach is taken. To achieve the outcomes, Gould and Lewis

(1985) suggest users be interviewed and observed. Empirical measurements include usability testing and prototyping to support iteration. Consistent with these principles, ISO 13407 (Usability, 2014) specifies four activities for what is called human centred design of interactive systems. These are: understanding the context of use, specifying both user and organisational requirements, the solution and evaluation. How and when each activity is performed is depended on the system and environment, the standard however stresses that there is an interdependence between the design activities.

The difference between UCD and other approaches is the focus on users, recognising the importance of taking the user perspective and involving them meaningfully in the design process (Rasmussen, 2007). Although UCD shares some of the philosophical underpinnings of participatory design, that is placing importance on user input, it is not the same. Participatory design does not for example include evaluation; stress the importance of understanding users' tasks or require iterative design (Avison and Fitzgerald, 2003 pp.108-110).

Rogers et al. (2012 p. 327) note that the UCD principles proposed by Gould and Lewis (1985) are more of a philosophy than a design technique. There is no one universally accepted approach to UCD; most approaches however share common characteristics. This is not surprising as any design approach involving users can be difficult to implement and manage (Earthy et al. 2001; Ritchie and List, 1996). Based on ISO 13407 Earthy et al. (2001) suggests the activities in UCD include planning the human centred design process, identifying the user/organisational requirements, specifying the context of use, producing and evaluating the designs. The UCD approach taken by IBM as described by Ominsky et al. (2002) apart from focusing on users and frequent evaluations also includes designing with a multi-disciplinary team and watching what competitors do. Rogers et al. (2012 pp. 327-328) refined the work of Gould and Lewis (1985) describing the principles in more detail. They argue that focusing on users involves: understanding their tasks and goals - this drives development; consulting users throughout; studying users and making design decisions in the context of their work / environment; and making the design process iterative based on evaluation. Our approach, described in the next section is closest to that of Earthy et al. (2001) and Gould and Lewis (1985).

Next we discuss the background to MIAC and the context and motivation for our research.

Sign language and learning

In Australia, as elsewhere, more deaf students are integrated into mainstream schools and kindergartens (Komesaroff, 2008). Integration provides the students with the broadest educational opportunities; however, deaf children integrated into mainstream schools need to be taught using SL. This has significant implications for a child's social welfare if they are unable to communicate with their teachers and peers. Research has found that deaf children in an integrated setting congregate together away from others because of communication barriers (Komesaroff, 2008; Leary & Hill, 1996). One way to alleviate the communication and social barriers is to teach hearing teachers, family, friends and children SL to foster communication and the formation of social groups (Anita & Kriemeyer 2003).

The advent of cochlear implants (CI) has not made SL obsolete. Not all children are suitable candidates (Edwards, 2007) and others receive only minimal benefit from their implant (Scheetz 2012 pp114). Even in the best case scenario, children with CIs often continue to have difficulties following natural conversations (Ibertsson et al 2009). Families thus frequently report using a combination of both speech and sign to communicate with their children who have CIs (Meadow-Orlans, et al. 2003; Yushinaga-Itano 2006) underscoring the continuing need for SL competency. Strong SL proficiency helps families get beyond "survival communication": a common complaint among both parents and deaf young people themselves is that they have difficulty having more detailed or meaningful conversations with each other because they feel it is too difficult to make themselves understood (Gregory, et al., 1995; Willoughby, In Press).

Technology for teaching

Many families cannot attend regular face-to-face classes (Ahmad, et al., 1998). Technology can play a key role in language teaching and learning, for spoken language from the use of audio recordings to modern high-tech systems which may provide feedback on a learner's pronunciation. Auslan learners have utilised technologies such as videos and DVDs; whilst useful for learning to recognise signs they however, do not provide feedback on the accuracy of signs learned and do not vary the pace to meet the learner's ability (Ellis and Blashki, 2004; Peng, et al., 2007). For SL, as with other physical skills, feedback is an important, critical component of learning. Existing technologies are able to show or demonstrate a physical skill to facilitate learning but they have not been capable of providing feedback on the learner's accuracy of their movements.

There are various technologies for teaching physical skills but these are not yet sufficiently interactive and either do not work in real time or still require human input. These technologies usually require expensive, complex equipment and often these systems do not have the teaching of psychomotor skills as the primary goal (Kotranza

et al. 2009). What has been done includes work by Ng et al. (2007), they developed a 3D Augmented Mirror to teach violin and cello using a motion capture system which provides feedback on bowing technique but this is not in real time. Another system was developed for teaching endoscopic paranasal sinus surgery using a “hyperMirror”. Surgery involves using a model and is conducted under the direction of a specialist at a remote location, however, feedback is provided by the specialist not the system (Kumagai, et al., 2008). There is therefore a need for an inexpensive, sustainable technological solution for teaching physical skills in our case SL, which provides real time feedback to the learner.

RESEARCH APPROACH

Interpretive research approaches are particularly valid when looking at rich phenomena that cannot be easily described or explained by existing concepts or theories (Walsham, 1995). Interpretive research involves analysing people’s actions through a detailed study in their ‘natural settings’ which leads to a richer understanding (Neuman, 2003 p. 76). Our research is positioned as engaged scholarship which is described as a “participative form of research for obtaining the advice and perspectives of key stakeholders (researchers, users, clients, sponsors, and practitioners) to understand a complex social problem.” (Van De Ven, 2007 p. ix). This is a particularly useful approach when exploring UCD as a design and development approach. In the context of our research the purpose was ‘Collaborative basic research’ which Van De Ven, (2007 p. 27 describes as researchers and stakeholders sharing research activities to co-produce knowledge with the type of research undertaken is usually something of interest to all partners.. Our research team comprises of insiders (the researcher developers) and outsiders (the Deaf community).

Our research explored the designing and building of a system to teach parents of deaf children and others SL providing meaningful, real time feedback using a UCD approach. Many papers report using UCD in the design of systems, technology, web pages etc. however these frequently do not include details of the activities undertaken or confuse UCD with interface design or user participation. Earthy et al., (2001) describe in detail ISO 13407 as a methodology but only at a theoretical level. Our research employed a UCD approach in the development of a real system to solve a real world problem. The UCD approach described by Earthy et al., (2001) and Rogers et al., (2012) most strongly influenced the UCD approach we took. Figure 1 describes the UCD approach we used.

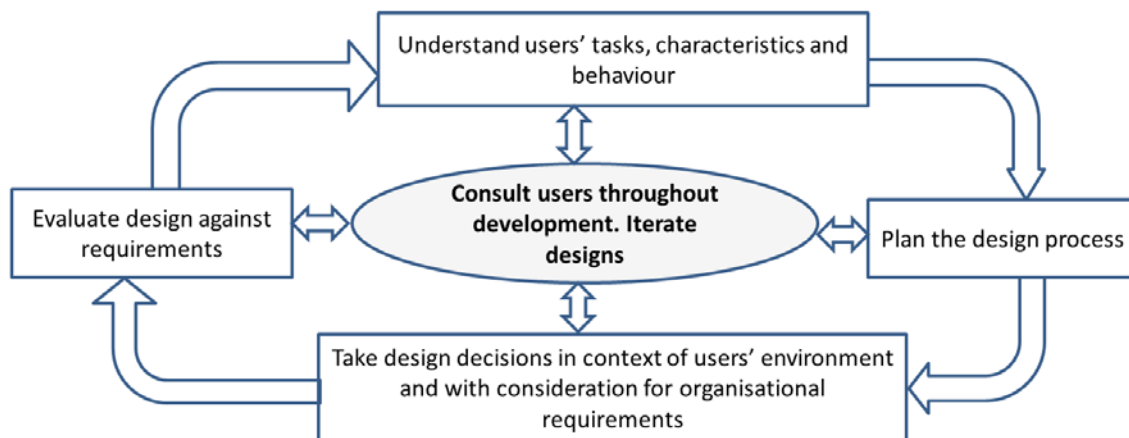


Figure 1 UCD approach to designing *My Interactive Auslan Coach*

Consistent with UCD, the activities were not necessarily implemented sequentially but are presented this way simply for representational purposes. Given UCD stresses an iterative approach with users at the centre of design, Figure 1 highlights the importance of user consultation throughout development and at all stages.

Data gathering

The motivation for the research was a need expressed by Deaf Children Australia (DCA) for a better, cost effective, and sustainable and further reaching approach to teaching SL. DCA were involved very early in the project and provided detailed feedback on their needs. Another partner, Vicdeaf became involved later.

Our research involved gathering data from a range of stakeholders in line with the evaluation and iteration phase of UCD. Consistent with engaged scholarship the ‘inside researchers’, the academics, participated in the design and development of the system, reflected on the process and collected data from other users and stakeholders. Table 1 describes those involved, when, the form that involvement took and the data gathered.

Table 1 Overview of those involved and data gathering

Stakeholders/ Users	Stage of involvement	Type of input and involvement. Data gathered.
Stakeholder and sponsor Deaf Children Australia	All stages including design and development.	Member of the project advisory board, facilitator for focus groups, provided feedback on early designs, tested the system and designed avatars. The sponsor is a linguist and a hearing person who is a qualified SL interpreter. Modelled ideal signs with the avatar. Consulted with the Sponsor throughout development, notes and minutes were kept.
Stakeholder and sponsor Vicdeaf	Throughout the design process	Deaf member of project advisory board, provided feedback on early designs. Provided input on ideal signs. Minutes of meetings kept and notes from consultations.
Staff at DCA	Involved in capturing user characteristics, and understanding user tasks and evaluation	Organised and participated in focus groups, provided feedback on early and later designs, provided input on which signs to include. Focus groups were recorded and transcribed. Some DCA staff are deaf.
Teachers of sign language	At the start and later	Input into which signs to include. Consulted on the feedback mechanism and details of how currently feedback is provided in a traditional SL class. Observations of SL classes, counting errors and correction type made.
Parents of deaf children	Mid-point once pilot system was developed	Participated in a focus group.
Deaf sign language users	All stages	Participated in focus groups, provided input on early and later interface designs, gave feedback on which signs to include. The focus groups were recorded and transcribed.

RESULTS

Current systems designed to teach SL have been unable to provide feedback on the accuracy of the learner's attempts at making the signs. This is critical as inaccuracies can render a sign incomprehensible. A key element of language learning is receiving corrective feedback, to ensure that mistakes do not fossilize (Ellis 2008). Language learners normally receive extensive feedback through their social contact with native speakers; however, families are often isolated from the other Auslan users limiting their opportunities to receive informal feedback on their Auslan acquisition. In brief, the MIAC using an avatar displays a sign to the user, the user makes the sign which is captured and the image is compared with the stored version of how the sign is made. If the user's depiction of the sign is incorrect the system highlights visually the mistakes made. The process is repeated until the sign is correctly made. Figure 2 provides an overview of the system.

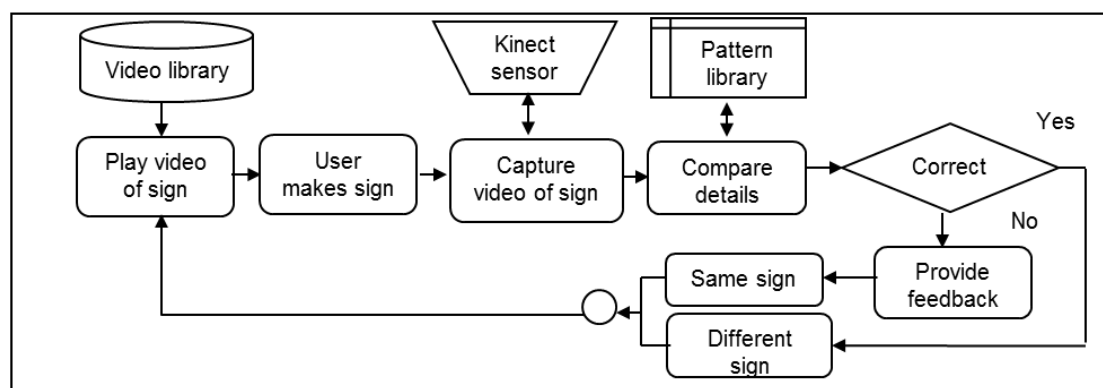


Figure 2: Overview of the learning process

In order to deliver a system which would: meet the needs of our key stakeholders (DCA and Vicdeaf); could be rolled out to a wide group of users and be sustainable over time we had a number of issues which needed to be addressed. The Microsoft Kinect was selected as the tracking device for the system. The Kinect is an affordable mainstream device making it easy for people to gain access to the technology. It supports full body tracking which is not possible to achieve with devices such as Leap Motion, Wii or sensor gloves. The technology has the ability to track movements in 3D space using a camera and infra-red sensor at a low computational cost

compared to stereo cameras and has wide support for further development from the user community which makes the development process comparatively straight forward. We are intentionally pushing the capability of the technology to include finger tracking by using a software solution rather than a hardware solution.

Signs are demonstrated using 3D avatar technology (see Figures 3 and 4). Feedback on the accuracy of expressed signs is made possible by using the Kinect sensor. A drawback with videos is that they do not offer users the freedom to zoom in on body parts of interest or to change camera angles in run time if they want to study details of signs from their own chosen perspective. We were able to resolve this issue using 3D avatars.



Figure 3 Avatar full view



Figure 4 Over the shoulder view of signs

Next we discuss how we implemented each of the UCD principles described in Figure 1; we provide examples of decisions that needed to be made, examples of input from the users and the outcomes with respect to our design decisions. As can be seen, users and stakeholders were consulted throughout design and development.

Understand users' tasks, characteristics and behaviour (who the system is developed for)

Many of the stakeholders and users were consulted as part of this activity. Consultation was in the form of focus groups and through the advisory board meetings. It was particularly important to consult the deaf community; they are the experts in the learning of SL. Further, deaf people need to be empowered in matters concerning them as historically this has not been the case. Given the limitations presented by SL classes discussed earlier, the system is designed for anyone wanting to learn SL. The following quote highlights this: *"I think it needs to be a whole family that needs to learn sign language together as a united front. So I think it's not just parents, it's the parents and their children as well – because it could also include the grandparents too because they care for some of those deaf kids – aunts and uncles for example, as well – so it needs to be the whole family."* (Grandparent of a deaf child)

- Designing the avatar

The avatar is the key visual element of the system as it communicates directly to the users. The selected avatars (Figures 3 & 4) needed to be representative of the users (e.g. a mum and a dad). Neutral dress was required so that the colours did not impact on the visual appearance of the sign. Both blond and dark haired avatars were options provided to ensure our parents could associate with the models. Avatars are available with the Xbox but they do not have the ability to move their fingers, a critical element of our system. To develop an acceptable avatar to present the signs, we developed three sample avatars and presented these to the focus group.

Example response: The users told us that the avatars were too good looking. They wanted to learn sign language from *"a normal person"*. Users wanted to be able to identify with the avatar that was used to present the signs. This included selecting if the presenter was male or female. One participant gave the example *"wouldn't it be great to have a grandfather teach me if I'm a grandfather who is starting to learn this and my first deaf child in the family is now- and I'm 70 already."* The users expressed that they wanted the avatar to be *"more casual and easy-going and less tucked in."* The avatars and their signing had to be clear and engaging. Comments included *"good and clear to me, the background behind it looks good. There's good contrast between the hands and the clothes, it's interesting. I'd want to watch it."*

Outcome: Because users are at the core of the system it has been designed so that users can select their own avatar to represent themselves, this includes elements such as hair, eye and skin colour, and clothes. As well users can select assistive devices such as glasses.

- Alternative views for signs

Normally when a teacher presents a sign, the learner is facing the teacher. The image perspective had to be determined, what did our users expect, to see someone making the sign to them or to see what they would look

like when they are making the sign? This could cause major dissonance. Initially we presented the avatar as a video image as if you were seeing your instructor facing you. We needed to establish if this was what the users wanted. We showed the users a few sample signs made by the avatar to help us make these decisions.

Example responses: Users are happy with the quality of the signs but they raised an important issue. The way that users view the presenter is critical to learning sign language and it is a somewhat unique problem. When the presenter is making a sign for a user to read, the user sees the sign from a different perspective - they see the back of the hands. One of the participants commented, “*I don’t know whether it’s possible to do, but I’d love a view of my own [hand]. So how I am delivering it. So, I can see you do it and I try and replicate that but I’m looking at the back-end of the whole thing.*” What the user wanted was a choice to view from the perspective of the presenter making the sign.

Example response: Another concern related to the depth of the image, which is critical for sign language. Some signs are made with the hand moving away from the body but the distance can be difficult to judge when you can only see a front view. One user suggested “*I think you have to think in 3D – normally you would see things in 3D. Looking at this image, it’s only 2D. So it’s going to be very hard to define the depth of, you know, space between body parts, will there be shadows in the system? I think I’d like to see more depth in the avatar so you can see more of that 3D perspective.*”

Outcomes: We have provided an over the shoulder view (see Figure 4) of the presenter making the sign. To ensure users can see how far in front of the body a sign is made. In addition, we have included the option for the user to see a side on view of the avatar when making the sign.

Plan the design process

Meetings with the advisory board and design team were used to plan the project. A detailed gantt chart was prepared in consultation with the stakeholders at the start. Each meeting the timeline and the project deliverables were reviewed and adjusted if needed. The continued involvement of our stakeholders was an imperative, we needed to keep them informed both so they were confident of our progress and to ensure that they were prepared for any data gathering involving them.

- Identify set of signs early

In consultation with our stakeholders and SL teachers the set of signs to be included in the system were identified early. One Auslan sign does not necessarily equal one English word. Like any language, Auslan has a wide vocabulary, with over 4,300 signs recorded in the preeminent Auslan dictionary (<http://www.auslan.org.au/about/dictionary/>). As our system is a pilot designed to demonstrate that this approach works technically, we needed to identify which signs would be included. A list of potential signs was drawn up which included signs containing the different elements of signs (hand-shape, orientation, location, movement and facial expression), with consideration of their frequency in Auslan and if they are used in an important sign. For example the hand-shape where the little finger is raised from a fist is uncommon but is used in the sign BAD which is common. Another consideration is the likely usefulness in parent-child interactions. For example signs like BED or SLEEP are not used frequently in general conversation, but are good signs for parents to know.

Example data: To inform the development of the feedback aspect of the system students were observed across six beginner Auslan classes. The observations found that 51 signs were incorrectly made, 35 of these involved a single error and 16 entailed multiple errors, giving a total of 67 discrete errors. In 15 cases of multiple errors the hand-shape and movement path of the sign was incorrect and in one case the location and orientation were wrong.

Outcome: We used this information to identify which signs to include and to inform decisions relating to the hierarchy of processing the accuracy of signs and therefore the order in which feedback is given.

Take design decisions in the context of users’ environment and with consideration for organisational requirements

The system presents a sign for the user to learn by mimicking. For this to be successful we need to provide the clearest presentation of the sign as possible.

- Visual look and feel

The background behind the presenter is important. We presented a number of backgrounds to a focus group. The concerns that they raised were related to visibility and contrast but also they highlighted the importance in providing context for sign language learning. The background behind the images was very important to the users especially those with experience of seeing sign language on a screen.

Example response: “The background behind the woman, the background is too light...I use Skype with some students and I know that I have my background set very light and that student often have trouble seeing me because it gives me quite a pasty-white complexion with white background, it makes me hard to look at visually. So the background needs to be a little bit darker to make the body feature, the hands and the face stand out more, because that’s important, it that you can see those features.” (Teacher)

Outcome: The system has been built with a settings page allowing users to change the colour of the background to suit their viewing conditions and preference. We were also mindful of HCI research which argues that backgrounds and colours should be neutral (Shneiderman and Plaisant, 2010 p. 483).

It is envisaged that the users will be interacting with MIAC at home, we needed to explore with them, the best background. The participants suggested that there should not be too much in the background as it is distracting however having a context for learning is important. One of the backgrounds was set in a lounge room.

Example responses: “I’d go for the contextual background because you get clues, ... I just find the plain background not very exciting.” another participant commented, “I prefer the one in the lounge room because it feels like a more natural setting”. However another said that “I think that the important thing is less distraction and more learning.”

Outcome: This has been addressed in two ways. It was clear that we wanted the users to feel that they were in a home environment, one that is interesting and conducive to learning but when there is an image as part of the setting behind the presenter, the signs are less clear. The solution that we implemented is to use a cinema-graphic device called a location shot which shows the whole of the lounge and then zooms in on the presenter with a blank wall behind. The user knows they are in a room without compromising the clarity of the signs. Secondly we divided the words into thematic groups to help to provide a context for the signs that the user is learning.

- Organisational requirements

One project requirement was a system which would be comparable to one to one sign language teaching given the difficulty both stakeholders face in meeting the increasing demands for sign language teaching. The system also had to be accessible and affordable for parents and sustainable.

Example input: As mentioned, to date there is no affordable technology for teaching SL. DCA and Vicdeaf required a system that would be easy to implement, affordable, readily available, sustainable and provided feedback.

Outcome: Kinect was selected because it is accessible and affordable; costing less than \$200. Poser (Smith Micro Software 2014) was chosen as a tool for constructing the avatars as this software is regarded as easy for non-experienced developers to produce animations of signs and to formulate new avatars. We confirmed this with our stakeholders. Staff members at DCA and Vicdeaf were trained to use Poser. Once we confirmed that in fact it was easy for inexperienced developers to use we adopted it. This has enabled the development of a sign library. We considered this essential as it ensures the sustainability of the system. It will enable the sign libraries to be expanded and for our stakeholders to produce additional avatars independently in the future and it ensures the accuracy of the signs as they are experts in Auslan.

Evaluate designs against requirements

Evaluation has taken place throughout development. This was important for a number of aspects of the system such as the background, presentation of signs, the avatars and the views the signs can be shown in. We did this through testing with users, focus groups and observations. Given a primary requirement was for a system which would be similar to people taking a SL class to learn vocabulary without errors. In consultation with our stakeholders we incorporated their requirements. Our regular advisory board meetings provided opportunities for our stakeholders to ask questions and have input into decisions relating to their requirements. It should be noted that more formal usability evaluation will occur at the end of the project to test the effectiveness of the system for learning SL vocabulary.

Example input: our stakeholders expressed a need to be able to create a library of signs and movements that can be reused, we ensured they had input and control over decisions relating to the sign set.

Outcome: A library of signs has been created.

Example input: users indicated that feedback should be provided using several mechanisms.

Outcome: Feedback is provided using different mechanisms, highlighting the incorrect element in the sign made by using colour coding, arrows pointing to that element and highlighting the section of the body (eg hand, arm) where there is an error. In addition, zooming in on the correct hand-shape to highlight errors is provided.

DISCUSSION

To date there is no SL learning systems which provides real time feedback to the learner on the sign they have made. The use of Microsoft's Kinect technology has been used for systems which demonstrate that it is possible to teach sign language (see Mashable, 2014), however these only demonstrate how to make a sign; they do not evaluate the sign made against its correct execution and provide feedback. This is the critical element of our system. Currently the system is specifically designed to teach parents of deaf children, it has the potential however to be expanded to a wider audience including deaf children or those who become deaf later in life. Taking a UCD approach, as compared with other development methodologies, was essential to ensure that we were successful in developing a system that met the needs and requirements of our stakeholders and the deaf community. The UCD approach provided us with critical information which was incorporated into our design. The key outcomes resulting from the UCD activities included:

- Selection of the most appropriate technology. Kinect is an affordable and supported technology.
- Identification of the target audience, families, including extended family.
- Ensuring sustainability. This is critical for systems such as MIAC. Selecting the right solution (Poser) in consultation with our stakeholders has enabled them to develop more signs.
- Identification of the most appropriate sign set. Not all signs could be included in our sign library. To develop and test the system the signs to be included had to cover both the range of signs in terms of usefulness, hand shape, movement, position in relation to the body and the level of difficulty i.e. errors made by learners.
- Design of appropriate feedback mechanisms. Learners vary in how they process feedback, feedback is provided in different ways to improve learning.
- Alternative presentations of signs. The way a sign is presented will impact on how effective that sign is learned. Signs are shown from different angles including over the shoulder and side view.
- Provision of options for customisation. Affect, the emotional response of a user to a system, is an important aspect of HCI (Rogers et al., 2012 p. 130). Providing users with the opportunity to customise their MIAC (background, colours etc) will increase user engagement and improve learning.
- Presentation of Avatars. A user's emotional response and level of engagement with an avatar will impact on the effectiveness of the system (Rogers et al, 2012 p. 184). Users can choose their own avatars, their dress and appearance.

Given the limited discussion in the literature on how UCD activities can be effectively incorporated into a development methodology, it is important to reflect on what we have learned. Figure 5 describes a model of UCD, the UCD activity; those involved and potential outcomes described generically which we believe provide guidance for those planning to take a UCD approach.

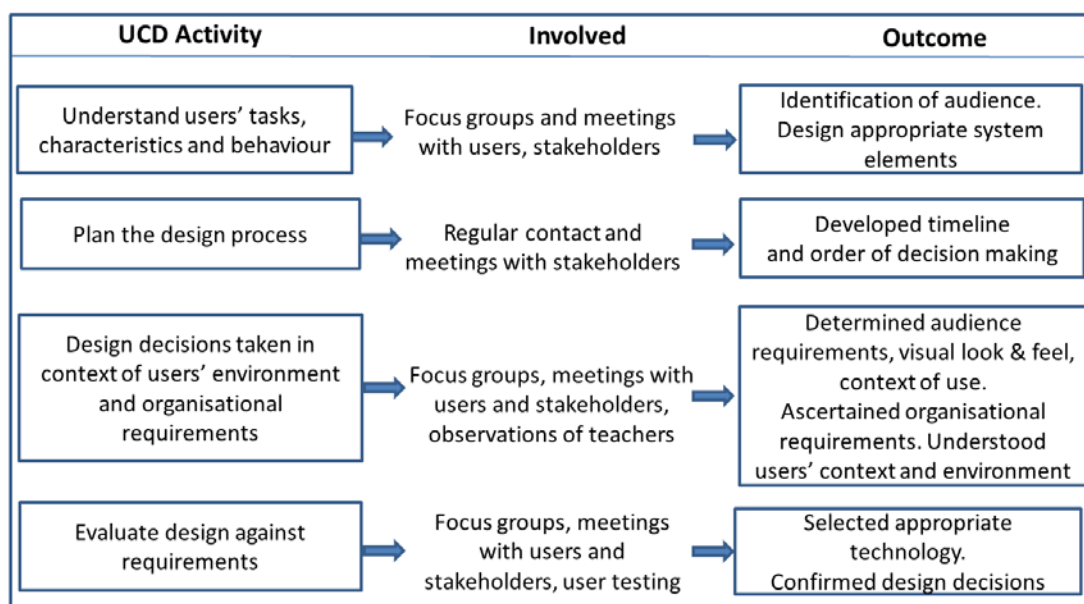


Figure 5 UCD activities, people and outcomes

Research by Mao et al., (2005) found that few experienced UCD practitioners use UCD in all phases of development with the majority of their survey respondents indicating that they refer to UCD just for the user interface. It is not therefore surprising that the literature reports few studies detailing UCD in practice and how taking a UCD approach can contribute to outcomes more widely than the user interface. Figure 5 provides one example of how UCD can be used in practice and the potential outcomes.

CONCLUSION

Designing MIAC using UCD has given us the opportunity to explore the effectiveness of taking a UCD approach in the context of the development of a real system. The importance of involving members of the deaf community or groups, such as DCA and Vicdeaf who support the deaf and their families cannot be underestimated. We needed to understand how SL is taught in classrooms, which designs will help learners more effectively learn SL from a system such as MIAC and their preferences in terms of the visual presentation of the signs and the background. With a UCD approach we have been able to understand the requirements of stakeholders and users.

We positioned our research as engaged scholarship where the researchers, development team, stakeholders, users and SL teachers were involved collaboratively in the design and development of the system. This has proven to be an appropriate and effective research and development approach in the context of UCD. Van De Ven's (2007 p. 10) argues that "research is not a solitary exercise; instead it is a collective achievement". The 'collective' includes those outside the research team. In our case we could not have succeeded in building a system which satisfied the needs of both our stakeholders and users without the continuous and deep involvement of all. UCD offered us the best approach to guide us in our interactions with our 'collective'. If UCD is to be used more widely in developing systems, more published research is needed detailing how UCD can be effectively incorporated in the process and to highlight its value.

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