ACQUIRING PHYSICAL SKILLS: EXPLOITING GAMES TECHNOLOGY TO TEACH SIGN LANGUAGE

AIMS AND BACKGROUND

Sign language is the only accessible language available for deaf people because they cannot hear sounds of speech. Speech reading is difficult, not all sounds produced in speech are visible in lip shape and movement of the mouth. Many deaf Australian children use Australian Sign Language (Auslan) to communicate with family and friends; they are also educated in Auslan in schools using sign language. More than 90% of deaf children are born to hearing parents, most of whom are not fluent in Auslan prior to the birth of their deaf child. If parents of deaf children choose to communicate with their children using sign language they need to learn Auslan (Komesaroff, 2008).

Sign Language is also important in cases of autism. It is an alternative form of communication for teaching autistic children who have severely delayed language skills (Brereton & Tonge, 2006). It is also used to assist and encourage language development in children who go on to establish functional language. There are other significant benefits for children with autism who learn to sign, for example, cuing a child with sign to help promote social interactions or giving signals for caution to alert to hazards in the environment. It is well established that children with autism respond better to, and learn more quickly when information is presented visually rather than verbally, this is even true in children with good language skills, as is the case with children who have high-functioning autism (Rinehart, et al., 2002b). Thus, sign language has the potential to have far reaching benefits for this highly prevalent and often debilitating disorder.

However, teaching sign language is a time consuming activity, requiring one to one interaction between the teacher and the learner. There are few trained sign language teachers and most are located in metropolitan areas, parents of deaf or autistic children living in the country have little to no access to sign language teachers.

Research aims

The aim is to investigate the potential for using a games console to teach sign language in an engaging interactive form. Our key research question is:

Can technology such as that designed for games be used to teach sign language?

To address the above question this study will address the following sub-questions:

Q1. Technology: How effective are commercially available games consoles for recording physical actions with sufficient accuracy to provide meaningful feedback particularly for teaching sign language?

Q2. User Interface: What is the most effective interface to enable intuitive use of a whole body interactive system.

Q3. Behaviour: What are the modes of behaviour that users assume when learning a physical skill from a computer system that interprets their movements?

Q4. Computer Aided Learning: What factors influence the accuracy of learning including the rate and sequence of delivery and the importance of the type and timing of feedback?

Q5. Language Learning: In response to the needs and wants of the deaf, parents of deaf children and professionals in the deafness sector, what are appropriate signs for a basic course in Auslan?

Background

In Australia, as elsewhere, more deaf and autistic students are integrated into mainstream schools and kindergartens. Integration provides the students with the broadest educational opportunities; however, it has significant implications for the children’s social welfare as it may affect communication with their teachers and their peers (Smith, 1996). Research has found that both deaf and autistic children in an integrated setting congregate together away from others because of communication barriers (Komesaroff, 1998; Leary & Hill, 1996). Deaf children integrated into mainstream schools need to be taught using sign language. One way to alleviate the communication and social barriers is to teach the hearing teachers and children sign language to foster communication and the formation of social groups.

The advent of cochlear implants (CI) has not made sign language obsolete. Not all children are suitable candidates. Replacing the cochlear with an electronic device will have no effect if the child has nerve deafness or an auditory processing disorder and additional disabilities making a child an unsuitable candidate for implantation (Edwards, 2007). Children with CIs often continue to have difficulties following natural
conversations particularly in group situations (Spencer, 1996). Families frequently report using a combination of both speech and sign to communicate with their children who have CIs (Meadow-Orlans, Mertens, & Sass-Lehrer, 2003) underscoring the continuing need for sign language competency. Strong sign language 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 and may avoid complex or emotional topics because they feel it is too difficult to make themselves understood (Gregory, et al., 1995; Willoughby, 2009).

Progress in the field
Existing technologies while extending the possibilities for teaching physical skills are not sufficiently interactive and still require human help. Also the technology usually requires expensive, complex equipment. For example Ng et al. (2007) developed a 3D Augmented Mirror to teach violin and cello using motion capture which provides feedback on bowing technique but not in real time. Another system was developed for teaching endoscopic paranasal sinus surgery using a “hyperMirror”. Surgery using a model, 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). Existing technologies for learning sign language are capable of showing the sign to facilitate learning but are not able to provide feedback on the accuracy of the signs that the learner has attempted (K. Ellis & Blashki, 2004).

Technology has always played a key role in language teaching and learning, from the use of audio recordings to modern high-tech systems which may provide feedback on a learners’ pronunciation. Attempts have been made to use technology to teach sign language for example data gloves have been used to recognise signs but they are expensive and the gloves cannot easily be worn by people with substantially different hand sizes. Other methods of learning Auslan include using videos and DVDs; whilst useful for learning to recognise signs they do not provide feedback on the accuracy of signs learned and do not vary the pace to meet the learner’s ability (K. Ellis & Blashki, 2004; Peng, et al., 2007).

The current generation of games consoles have shifted expectations in the way that we interact with technology and the type of learning possible. New games consoles are designed to be aware of the user’s fine and gross motor movements with the potential to recognize and give feedback on physical skills necessary to assist with learning. Interactions between computers and people have traditionally been limited to indirect interactions such as via the keyboard or mouse. More recently the new generation of technology such as touch technologies, accelerometers and motion capture devices have become mainstream particularly in mobile phones and games consoles (Peng, et al., 2007). Key characteristics of these types of systems include:

- the use of different input mechanisms such as sensors, video and motion capture (Stach, et al. 2009).
- the level and type of processing the system is required to perform (Shafer & Jacob, 2009).
- the method of interaction and feedback both in terms of type and timing (Sharlin, et al. 2004).

The exciting direction for this new technology is in the potential it has to teach physical skills (psychomotor and cognitive) with feedback which to date has not been investigated but which this project will explore.

SIGNIFICANCE AND INNOVATION
Physical skills are typically taught with a human instructor; one on one or one to many with the instructor demonstrating an action, the learner performing the action and the instructor providing feedback. This is time-consuming, expensive and requires the instructor and learner to work together in the same place. Kotranza et al (2009) argue that often systems using computing technology do not have the teaching of psychomotor skills as the primary goal. Current technologies such as those described earlier which provide feedback are complex and expensive because of the cameras, video capturing technology and processing required (Jung & Bajcsy, 2006).

Our project will design and test a solution that is inexpensive using low budget, readily available technology ie a Microsoft Xbox and Kinect.

Why this research is significant: the problem our research addresses
The outcome of our project is significant because it will:

- Improve the social inclusion of those impacted by deafness or autism by providing an alternative mechanism for teaching sign language. Many families cannot attend regular face-to-face classes for reasons of time, location, work/childcare commitments or transport difficulties (Ahmad, et al., 1998; Meadow-Orlans, et al., 2003). Our solution will enable learning to take place in the home or elsewhere.
• Provide a low cost tutoring system for parents of deaf and autistic children and other sign language learners (families, teachers etc). Face-to-face Auslan classes are expensive, since the trainer must be paid for their time. It is widely acknowledged that adult beginners need at least 1,000 hours of language instruction in order to develop fluency in the target language (Jackson & Kaplan, 1999).
• Demonstrate how a system using feedback can teach sign language and other motor skills without a human instructor helping many deaf and autistic children.
• Address a significant issue for our partner organizations Deaf Children Australia (DCA) and The Victorian Deaf Society (Vicdeaf). Both face significant problems finding sufficient funds and staff to train people in Auslan which like any new language, is difficult and time consuming to master (Jackson & Kaplan, 1999). For example last year DCA were only able to provide Auslan tuition to 23 families, there are many more waiting to access DCA and Vicdeaf services.
• Assist children with ASD. Using the proposed games technology to teach sign language could assist the 50% of children with ASDs who fail to develop functional speech, and only slowly learn to compensate with gesture. This method of teaching children with ASDs will greatly improve the quality of life of young people affected and provide the first, most accessible method of teaching children with autism to communicate.

How the outcomes will advance the knowledge base: what is novel and innovative?
The anticipated outcomes from our research will advance the knowledge base in the following ways:
• In the information technology discipline it will demonstrate and extend knowledge on how games technology can be extended into the important area of teaching physical skills. Identifying the technology capability required, such as resolution, start and end of targeted material, feedback accuracy and modes of interaction adopted by learners.
• In Human-Computer Interaction (HCI) it will extend our knowledge of how people behave when interacting with full body interactive systems, providing insights into the behaviour adopted by learners when learning a physical skill using technology. This is currently not well understood.
• Extending the understanding of interface design and HCI of the outputs such as the quality of the graphics, the user experience user preference and attitudes to viewing themselves on screen.
• In computer assisted language learning knowledge will be extended through testing the suitability of games technology to teach sign language. We will identify a range of factors important for learning with this technology such as the rate of delivery of targeted material, feedback accuracy and modes of interaction adopted by learners.

The project is innovative in the following ways:
• Using games for teaching physical skills such as sign language has not been done before. Systems which have provided feedback on learning physical skills have generally been achieved through mechanisms such as expert commentary, virtual display of actions or data analysis after the event. In particular using this technology to teach and evaluate expressive sign language, that is the making of the signs with the hands and face, not just the recognition of signs is a new approach.
• By demonstrating the applicability of games technology for teaching sign language there is the potential to teach other physical skills through direct system feedback. Sign language is an ideal test bed because each sign is a complex motion involving five phonological parameters of hand-shape, orientation, location, movement and facial expression, all of which must be executed correctly for the meaning of the sign to be understood (Johnston & Schembri, 2007). If sign language can be taught with this technology so can other less complex physical skills such as medical procedures, rehabilitation exercises etc.
• By developing an adaptable and extendable system will enable relatively straight forward changes to be made to the system parameters enabling the teaching of a range of physical skills.
• Current systems designed to teach Auslan have been unable to provide feedback on the accuracy of the learner attempts at making the signs. This is critical as inaccuracies can render the signs incomprehensible. A key element of language learning is receiving corrective feedback, to ensure that mistakes do not fossilize (R. 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.
• Auslan is a visual-spatial language which is suited to being taught using multimedia, however few computer programs have been developed to assist people to learn expressive Auslan skills.
• A major hurdle for the next decade of research is to improve the physical skills of children with Autism Spectrum Disorder (ASD). For autistic children motor deficits impair school performance, participation in physical activities, gait and posture. The outcomes of this project provide a potentially novel, computerized, cost-effective method of teaching physical skills to children with Autism Spectrum Disorders (ASD). A games based intervention would be able to meet a number of criteria that have been identified as important including: that the training needs to be delivered visually and the individual with ASD learns better if they are interacting with a computer interface especially when it provides feedback.

**National Research Priority**

Our project fits within the priority: Frontier technologies for building and transforming Australian industries-Smart Information Use. Our research focuses on building and evaluating an application using games technology.

**New methodology/technology to be developed**

The technological innovation to be developed is a system that can be customised in a way that will enable the teaching of a variety of physical skills using relatively inexpensive games technology. The system will be able to assist the users/learner define all of the morphophonological parameters required for the formation of any particular sign in order to provide feedback on those signs. Examples of this can include but are not limited to the location of the hand in relation to the body or the number of fingers that are extended. One potential for this technology is in creating an engine which could be utilised for providing feedback for teaching a range of other physical skills outside of the sign language pedagogy as long as the required parameters and corrections can be specified and inputted. This would create a powerful and flexible learning tool.

**APPROACH AND TRAINING**

Our project brings together a unique multi-disciplinary team of academics, educators, advocates for the deaf, and authorities in Sign Language and Sign Linguistics. To achieve our research aims we will consult and work with members of the adult Deaf community, parents and experts in the field to establish the needs with respect to teaching sign language and an appropriate sign corpus. We will develop a framework based on current thinking and approaches which will be used to guide development. The aim is to develop an archetypical system using an iterative approach including feedback from the key stakeholders of Auslan training organisations, Deaf community members, parents of deaf children and professionals providing deaf related services. The system will be tested and evaluated with potential users and feedback will inform any changes.

Our research will investigate, build, test and evaluate a system using the Microsoft Xbox games technology and Kinect sensor. The outcome will be a system where a learner standing in front of an Xbox and Kinect will be presented with a sign, the learner will create the sign and the software will assess the accuracy and provide feedback correcting the action where needed.

Auslan will be used as the exemplar for exploring the potential for physical skills to be taught via games technology. The primary research methodology that will be utilised for this research is action research. MaKay and Marshall state that action research involves “the active and deliberate self-involvement of the researcher in the context of his/her investigation” (2001: 47) and in addition it is an iterative process that involves the community being researched in order to solve a real world problem (Nita, 1999). The primary data gathering methods will be focus groups, system testing, observations, semi-structured interviews, pre- and post-tests, video recordings and usability evaluations (Lazar, et al., 2010; Nunan, 1992). An exemplar system will be developed and tested on the intended audience (Nunamaker & Chen, 1990). Usability testing and evaluation will be conducted to ensure that the system can be easily and effectively used by the intended audience (Fisher, et al., 2008). Data on the users’ experience will be gathered via semi structured interviews in addition to observations and data collected by the system (Kellehear, 1993). Data on the learning that occurred will be gathered via pre- and post-tests which will be coded for accuracy by two independent experts (Cohen, et al., 2000). Data on the effects of different components of the system such are feedback and changing the rate of presentation will be explored via testing of multiple groups under specific conditions. The research design includes:

1. **Investigation of current systems and practice** *(addresses research questions 1, 2, 3, 4 & 5).* This will involve a wide ranging review of literature and programs on traditional methods that are currently available for learning sign languages; technological systems that are used for interpreting sign language; and other motion capture and pattern matching systems that are used for teaching physical skills. There are a numerous technical
decisions that will need to be addressed, so it is important that there is awareness by the research teams of the current research and options for addressing any technical challenges. There is also research on best practice in language learning that will need to be used as a framework on which to build the new treatment.

2. **Design of the research material** *(addresses research question 5).* There are significant design decisions that will need to be made in relation to the sign language components targeted by the system. Focus groups and interviews will be used to gather information from Deaf people, parents of deaf children and deafness sector professionals about their needs for a system that will teach sign language. These key stakeholders as the beneficiary of the project, will be involved in the development of the project, both through interviews and an advisory group made up of Auslan and linguistic experts. Physical skills outside the domain of a codified, visual-gestural system do not have such a strong sense of correctness, therefore using sign language as a test case provides an appropriate skill to test the system because it requires a greater level of accuracy. A gap has been identified in the resources that are currently available for learning sign language as none of the current technological systems are able to provide feedback on whether learners are forming the signs correctly. The signs that are targeted will need to be considered carefully for usefulness in communication, ease of learning, commonality of use within the language, multiple meaning of homonymic signs, acceptance within the Auslan community, and uniqueness of each components of the sign. Like any language, Auslan has a series of codified structures that make up the language, that is, in Auslan there is an accepted way to sign a word and incorrect pronunciation may alter its meaning. For each sign that is targeted by the system there will need to be a number of resources that are developed including video, audio, text, meaning and memory aids. In addition an extremely detailed description of the correct production of the sign will be required so that this can be used to compare the users’ attempt to the ideal by the system in order to provide the appropriate feedback. Support in the form of empirical data from the previously published lexicography work of Johnston (1998) and Johnston and Schembri (2007) will attempt to ensure that vocabulary content follows recognised Australian standards.

3. **Design and development of the exemplar system** *(addresses research questions 1, & 2).* The system will require significant design as it is highly technically challenging. The way that the user interacts with the system will need to be designed from scratch as the system utilises a new paradigm in interaction. All components of interaction will need to be considered such as how the user starts and finishes the program and how they move between different sections. There are other technical issues that will need to be addressed. The hand-shape that the user is making will need to be identified and the orientation of the hand in a still position. These hand-shapes will then need to be identified in relation to the location in space around the body, calibration of the system may be required prior to use to solve this. Then the path or movement of the sign will need to be identified including the direction and distance. Facial expression plays an important part in grammatical aspects of signing so it will also need to be identified by the system. The ability to detect multiple intricate components, such as that required for using Auslan, will provide an accurate test of the system. Therefore if the system successfully recognises such nuanced components by being able to correctly identify fine motor movements it would prove its viability by virtue of the fact that it would be simpler to recognise gross motor movements. Once each component of the signs can be identified there are also issues in detecting the start and end of each sign, due to contextual factors influencing the start and end locations of the sign. The system will need to identify a correctly made sign, and identify what component has gone wrong if a sign is made incorrectly, then provide feedback to allow correction of the error. Feedback will need to be provided in real time to provide simultaneous feedback to the learner so that they can adjust and repeat the sign with the required modification.

![Figure 1: Overview of the development](image-url)
4. **Technical system testing** (addresses research question 1). will be required continuously throughout each stage of development. The stages that will be tested include the detection of: hand-shapes; location of signs; orientation of the hand; movement of signs; start of signs; end of signs; facial expression. The testing will check for accuracy of detection and tolerances will be set to monitor the system’s capacity to detect differences within a given range. The speed of each component will be tested to ensure that it can work within an acceptable timeframe. Test specifications will be written with the conditions and expected result, the tests will be conducted with participants who are native Auslan users and other experts and the results analysed and used to inform any required changes. Figure 1 describes how the system will work.

5. **User interface evaluations** (addresses research questions 2 & 3). There will be a requirement for user evaluations at each stage of the development. This work is moving into a new paradigm of interaction and therefore each section will need to be considered and tested to ensure that the system is to be used in the manner that the designer intended. The design of the system will be user tested to ensure that the system is intuitive and user-friendly. A combination of observations of users interacting with the system and semi-structured interviews with participants will be conducted to elicit feedback on the system while it is under development. This research will investigate users’ behaviour in addition to their stated preferences. This testing will also include user acceptance testing to assess the reaction of the key stakeholders. Although audio will be used within the system all content will be made fully accessible to deaf people.

6. **Evaluations of user learning** (addresses research question 3 & 4). These will be a series of experiments conducted with research participants to evaluate various aspects of the systems efficacy as a teaching tool. Research participants will be tested to ascertain the number of signs they can learn over a given period interacting with the system using an experiment with a pre- and post-test design. Experiments will also be conducted using a control and treatment design to investigate if the accuracy of users’ signs is improved when they are given real time feedback by the system on their attempts at signing. To ensure the validity of the results dual coders will be needed to assess the accuracy of the signs made by the users in the two groups. For this testing it will be necessary to use a participant sample outside of parents of deaf children so that the results are not influenced by people who are exposed to signing from other sources.

Our research plan and process is described briefly in Figure 2. It includes the activities for each year and the inputs for each activity.

![Figure 2: Research plan](image)

**NATIONAL BENEFIT**

Teaching sign language requires a skilled trainer and curriculum developer. Learning sign language and potentially other physical skills via a relatively inexpensive games console has national benefits in a number of areas it will:

- Provide a valuable tool to the signing Deaf community to enable more people who interact with the Deaf to learn the only language that is fully accessible.
- Promote the learning of Auslan to create a more inclusive society for Deaf people
- Promote and enhance the learning experiences of children with ASDs
- Facilitate the learning of other visual languages for use in specialist environments such as scuba diving, emergency situations and the military where voice is not an option.
- Potentially save money and time for organisations such as Deaf Children Australia and Vicdeaf as well as other groups training people in signing, as they will require fewer sign language trainers
- Potentially improve occupational health and safety in workplaces through the ability to teach correct techniques such as lifting techniques and manual procedures, to name a few.
- Enable the teaching of a range of other physical skills possibly benefiting large groups of people and potentially saving lives; for example, teaching life saving techniques such as resuscitation and physiotherapy/rehabilitation exercises in the home.
- Have the potential to teach medical procedures more quickly and accurately.
- Provide a mechanism for training children with ASD. Fine and gross movement problems are a recognized problem for children with ASD (Rinehart, et al., 2002a). Motor deficits exacerbate social-communicative difficulties, impair the child’s capacity to interact socially and cause stigmatization (Leary & Hill, 1996). The proposal to teach physical skills via games technology holds significant promise for providing a much sort after physical intervention for children with ASDs.

Larger distribution of the responsive interactive system would be possible as there would not be prohibitive costs associated with the system that would make it unviable to roll out on a large scale.

While the primary audience is hearing parents of deaf children, there are other potential audiences such as: siblings of deaf children; other people interacting with the deaf such as friends and professionals. In addition there is the broader community of people interested in learning Auslan including children learning Auslan as a language other than English (LOTE) at school who could utilise the resource to create a more inclusive society for deaf people.

PARTNER ORGANISATIONS COMMITMENT AND COLLABORATION

This project builds on the partnerships already established between Monash University researchers and our Partner Organisations – Deaf Children Australia (DCA) and Victorian Deaf Society (Vicdeaf), both are not for profit organisations. DCA is a charitable organization that supports deaf children and their families, while Vicdeaf is a charitable organization which focuses on supporting deaf adults.

Contributions and involvement Partner Organisations (POs)

Both organisations have agreed to provide access to their people, facilities and equipment for this project. DCA and Vicdeaf have agreed to provide participants from their respective communities to help with scoping the project and testing and evaluating the system and will provide administrative support. They also have key experts and Auslan specialists and interpreters who they will make available for our project. Both will maintain a project website promoting the project.

How our proposal fits with the strategic directions of our Partner Organisations and its value to them

Both our POs work in advocacy and strive to create a liveable community for Deaf people, by providing Auslan classes to the broader community. Both organisations have a strong commitment to research-based practice. Monash University is a world class teaching and research university with a strong commitment to social inclusion and so for our partners we are an ideal institution to partner with.

DCA and Vicdeaf see the significant potential of the outcomes of this project. Providing an alternative means to teach both hearing and deaf people Auslan will enable both organisations to meet key organisational goals, supporting the deaf. A key stated purpose of DCA is “To facilitate liveability and life-abilities for deaf and hard of hearing people in Australia through all life’s stages.” (http://www.deafchildrenaustralia.org.au/?q=node/241). In 2009 they directly supported 324 Victorian families. Vicdeaf serve over 16,000 Victorians each year. They are a “primary source of reference, referral, advice and support for deaf adults in Victoria”. A key objective they have is to address the needs of their stakeholders (http://www.vicdeaf.com.au/strategic-plan-2010-2015). Providing Auslan classes is one of their stakeholders’ needs.

As can be seen below, Monash and our POs have worked collaboratively over many years on a number of related projects highlighting the fit both between our POs and Monash and our POs strategic directions.

Potential future collaborations and long term alliances

This project has the potential to continue and extend the collaboration between Monash and both DCA and Vicdeaf as this project builds on previous projects. DCA and Monash University have been working together to develop technology based resources to assist people in learning Auslan for the past several years. The latest
innovation is the creation of a game on the Nintendo DS Lite console to learn Auslan vocabulary. Vicdeaf and Monash also share a history of collaborative research, including current projects exploring the aged care needs of Deaf Victorians and the incidence of tinnitus (‘ringing in the ears’) among profoundly deaf people.

REFERENCES


