Participation of High School and Undergraduate Students who are Deaf in Research on American Sign Language Animation

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Introduction

The Linguistic and Assistive Technologies Laboratory (the "LATLab") at Queens College of The City University of New York conducts research on computational linguistics and human computer interaction – with a focus on assistive technology and accessibility applications for people with disabilities. We are currently conducting a five-year study supported by a National Science Foundation CAREER Award (NSF Award #0746556). The goals of this research are to significantly improve the state of the art of animations of American Sign Language (ASL), which have important accessibility applications for people who are deaf. (Details of the scientific aims of this project are included below.)

This article describes the educational outreach component of this project – the participation of deaf high school students and undergraduate students in summer research experiences. Our goal in writing this article is to describe how the educational component of our project integrates with the scientific goals and to explain some of the details behind the summer research experiences we have organized. We hope that other SIGACCESS members who are interested in incorporating educational outreach efforts into their research may find this information useful when designing and proposing their own projects.

There are several deaf students and researchers involved in our project. Each summer, two or three students from local deaf high schools or mainstream programs in the greater New York City area participate in three-month research experiences at the LATLab. In addition, we have also hosted a deaf undergraduate student (visiting from Gallaudet University) for a summer research experience, and a graduate-level deaf research assistant coordinates projects at the lab on an ongoing basis part-time throughout the academic year.

We believe that the involvement of deaf ASL-signers in the research will help to train future researchers who have a community and cultural connection to the outcome of the work. Further, only users of ASL who have native level fluency are able to accomplish some of the aspects of the research: analyzing recordings of sign language we collect and conducting experimental sessions in which native ASL signers from the local community come to the lab to evaluate the ASL animations we produce.

Our objective is to attract deaf students to careers in computer science by enabling deaf high school and undergraduate students to experience the research process. Students with disabilities pursue science careers at a lower than average rate (CEOSE, 2004), and our goal is to encourage the interest of these students in pursuing higher education and careers in the sciences, at a time when they may be making decisions about their future

education. While these students have minimal programming or linguistics background, their ASL fluency can allow them to make meaningful contributions to the project. We want them to become aware of applications of computer science with direct relevance to the deaf community – generating animations of American Sign Language to make information sources more accessible to deaf individuals who may have low literacy in written English (see below).

Scientific Objectives of the Research Activities at the LATLab

For one-half million deaf people in the U.S., American Sign Language (ASL) is a primary means of communication (Mitchell, 2006). ASL and English have a distinct word-order and vocabulary; it is possible to be fluent in one language but not the other. In fact, the majority of deaf high school graduates in the U.S. have a fourth-grade (age 10) English reading level or below (Traxler, 2000). Because of this, many deaf people find it difficult to read the English text on computer applications or websites. Software to translate English text into an animation of a virtual human character performing ASL will make more information and services accessible to deaf Americans.

Unfortunately, there are limitations in the state of the art of modern ASL animation technology. The goal of our research on ASL is to study how human ASL signers perform various linguistic phenomena, to build models of their performance, and to use these models to synthesize high quality animations of ASL. We have followed this research paradigm to study the use of speed and pauses in ASL (Huenerfauth, 2009a), the use of the space around a signer's body to represent entities under discussion (Huenerfauth, 2009b), and the way in which signers perform complex movements of ASL verb signs (Huenerfauth and Lu, 2010a).

The research objectives of our five-year project are to create the first annotated collection of ASL movement data collected from native signers (using video cameras, a motion-capture suit, motion-capture gloves, and other equipment), to annotate this corpus with a timeline of information about the signs and linguistic phenomena performed, to use machine learning approaches to analyze patterns in this data, and to incorporate the resulting models of ASL signing into our animation software. To evaluate our progress, we conduct ongoing experimental studies in which native ASL signers evaluate the 3D animations of ASL that result from our models. Details about our current research can be found in the following publications (Huenerfauth and Lu, 2010b; Lu and Huenerfauth, 2010).

Other research projects that have collected sign language video recordings have involved the participation of native ASL-signers as research assistants or linguistic annotators (i.e., the researchers who watch the videos and annotate a timeline of the performance), e.g., (Bungeroth, 2006; Crassborn, 2006; Efthimiou and Fotinea, 2007; Neidle et al., 2000). Our project is unique in that we have chosen to recruit local deaf high school students (between their junior and senior year) to serve as our expert annotators.

Research Personnel Studying ASL Animation at the LATLab

The deaf high school and undergraduate students who participate in our project do so during the summer months – when the laboratory conducts recordings of sign language and linguistic analysis of these data. During the rest of the academic year, there are three members of the research team who continue the work: the project director, a research

assistant, and a CUNY PhD student.

As the project director, it is important that I am able to communicate effectively in ASL with the students who participate in our project. I've taken coursework in American Sign Language, including two summer language programs at Gallaudet University and courses in an ASL interpreter program in Philadelphia. I've developed conversational ASL skills and experience interacting with deaf researchers, experimental participants, and students.

In addition, we are fortunate to have a member of the research team at the LATLab who is a native ASL signer and a member of the Deaf community. He has experience working as a secondary school science teacher for deaf students and has completed graduate coursework in cognitive science at another university. In addition, he works as a professional deaf ASL interpreter. The research assistant and I oversee and advise the research experiences of the undergraduate and high school students during the summer. In addition, the research assistant coordinates the advertisement and selection of students for the summer research experiences – making contact with local deaf high schools and mainstream educational programs with deaf students.

The final permanent member of our research team is a CUNY PhD student in Computer Science who is studying the synthesis of animations of American Sign Language. Prior to beginning her research at CUNY, she volunteered at a school for the deaf in China and gained some proficiency with Chinese Sign Language. While she is learning some ASL, during the summer, she primarily communicates with the visiting high school and undergraduate students through notes, instant messages, e-mails, and other means.

Summer Research Program for Deaf Students at the LATLab

This section will describe related research projects and education outreach efforts with a goal of promoting Science, Technology, Engineering, and Mathematics (STEM) education and careers for deaf students. Afterward, the specific summer research program at the LATLab (in which high school students and undergraduate students participate) will be described.

Relevant Research in Increasing Participation of Deaf Students in STEM

Several programs have focused on deaf student involvement in STEM. Gallaudet University has hosted a summer program for deaf high school students, who participate in programming and math classes, visits to government agencies, and other activities (Gallaudet Research Institute, 2007). A two-day workshop at University of Southern Maine for deaf high school students was led by computer science professors and included a trip to a laboratory and presentations from admissions and disabilities support services (AccessComputing, 2007). The National Technical Institute for the Deaf at Rochester Institute of Technology offers a summer program for high school sophomores and juniors called "Explore Your Future," which exposes students to hands-on activities that relate to different career choices – however, the program does not specifically focus on research experiences in the sciences (NTID, 2010).

The AccessComputing program at the University of Washington has hosted the "Summer Academy for Advancing Deaf & Hard of Hearing in Computing," in which students take computer classes, meet deaf and hard-of-hearing computing professionals, and visit

computing locations (Summer Academy, 2010). In addition, the AccessComputing and the DO-IT programs at the University of Washington offer a variety of resources to support students with disabilities in higher education and computing careers (DO-IT, 2010).

These projects expose students to higher education and computing but have not primarily focused on providing students an opportunity to participate in an ongoing research project. Other projects have created research opportunities for deaf students; for example, the summer Research Experiences for Undergraduates program in Chemistry at James Madison University (JMU) has included deaf undergraduates and high school science teachers (Seal et al., 2002) – although not high school students.

In our project, deaf students have research experiences in computer science – at a time when many of them are deciding what direction to pursue in higher education (just before their senior year of high school). A novel feature of our project is that the topic itself has relevance to deaf students and that there are students at different stages in their academic careers working on the project.

Summer Research Experiences for High School Students at the LATLab

The deaf research assistant at the LATLab works during the spring semester to advertise the summer opportunities for deaf high school students. Applicants must be high school students in their sophomore or junior year who are able to commute daily to the laboratory during the summer. The opportunities are advertised on deaf organization websites, NYC-area deaf mailing lists, and through deaf educational professional organizations. For the summer of 2009, two high school juniors (entering senior year) and one high school sophomore were selected to participate in the project. The summer research includes several activities:

- *Watching video-taped recordings of American Sign Language (with corresponding data collected using motion-capture gloves and suits)*. The students mark locations in the videos when specific ASL signs are being performed or when particular ASL linguistic events occur. This task is essential to our research project, and while it requires expertise in ASL, it does not require programming skills. (Thus it is a good way for deaf high school students to make a valuable contribution to the project and learn about research.)
- *Using 3D animation software to script the movement of some ASL signs.* These signs then become part of the dictionary of signs that are used in the computer animation software for our research project. The students also use software at the lab to produce animations that use the signs they have created during the summer. These animations are posted on the laboratory website so that the students can share them with friends and family.
- *Interacting with deaf research subjects who come to the laboratory during on-going experiments in which ASL signers evaluate the quality of computer animations.* Since it is important to create an ASL-immersive environment during these experimental studies, the students' ASL signing skills help to create an ASL-conversational environment. The high school students also learn about the experimental process, research study design, data collection, and other typical activities of a research laboratory. In addition, they

can observe the use of several forms of motion-capture equipment (cybergloves, body suits with sensors, eye-gaze trackers, etc.) in the laboratory that digitize sign language performances. These tools are often used in the movie and video game industries, and the students may not be aware of the research applications of these tools for sign language.

- *Taking a campus tour and meeting faculty members and administrative staff members of Queens College*. The goal of these activities is to encourage the students to begin thinking about their future plans and attending college.
- *Producing video blog entries and ASL animations.* The students used a video camera to record a "tour" of the laboratory (in ASL, with English transcript typed after-the-fact). They walked around the lab and explained the research that was being performed. The goal of this activity was to encourage the students to ask questions prior to filming about all the aspects of the laboratory's research – so that they would be able to give this "virtual tour." These videos (and the ASL animations students produced, discussed above) were posted on the laboratory website – this was a visual way for them to demonstrate their accomplishments and contribution to the project for their family and peers. The goal of posting these videos was also that the students would show these videos to their classmates at their high schools after the summer was finished – as a way of creating additional interest and excitement about the research project. In this way, we hoped to have an impact on students who were not directly participating in the summer research experiences. Videos are available here: http://latlab.cs.qc.cuny.edu/news.html

To make our summer research experience effective, the students are regarded as full members of the research team, are given project responsibility, are able to see what they have accomplished by the end of the project, and are able to fully access the communication in the laboratory. During the summer, the primary means of communication in the laboratory was ASL – thus it was important that the project director had conversational ASL skills and that a deaf native ASL signer was part of the research team.

Tiered-Mentoring: Research Experience for Undergraduate Student

Recent research has focused on the use of tiered-mentoring – using role models that are "one step ahead" of the mentored student for encouraging the participation of students with disabilities in STEM (NSF Award #9800201, Duke U.). For this reason, we were interested in providing the high school students on our project with an undergraduate student role model with whom they could interact during the summer. Thanks to a Research Experiences for Undergraduates (REU) supplement to our project provided by the National Science Foundation, we were able to host a visiting undergraduate researcher from Gallaudet University during the summer of 2009. The student chosen for this research position was a junior at Gallaudet with a very strong G.P.A. who was majoring in psychology and who had experience working in a laboratory setting on a linguistics/literacy related research project at her home institution. The undergraduate

student served as a link between the high school students and the graduate-level research assistant working on the project.

The undergraduate student arrived 2 weeks before the high school students, and she helped plan how to train and guide the high school students. During those 2 weeks, she learned about the project, met the PhD students and research assistants at the LATLab, met faculty members in the Computer Science department, learned about the equipment and software at the lab, and helped to plan the training and activities for the arrival of the high school students later in the summer. When the high school students arrived, the undergraduate took a leading role in training and mentoring them. In addition to giving the students formal direction in day-to-day activities in the lab, she also informally shared her experiences about being a deaf undergraduate in the sciences.

During any linguistic data annotation project (in which experts in a language watch a recording of a sentence and mark when specific signs or events occur in the video), it is common for more than one person to view each video to *annotate* the performance. There can often be disagreements in the way in which the two annotators have labeled information in the videos, and it is then necessary for a third party to organize an "arbitration meeting" in which the annotators sit down to discuss the right way of encoding the data. During this meeting, the three individuals discuss the best way to mark the data and then vote on a final encoding. During the summer, the undergraduate student took a leadership role in organizing these meetings each week.

Our goal was for the undergraduate student's experience to give her confidence in her leadership abilities in a research setting, knowledge of the workings of a research laboratory, practical experience in computational linguistic and motion-capture research in computer science, and insight into the process of applying for and succeeding in graduate study.

Evaluation of Our Project at the End of the First Summer

As part of our on-going evaluation of the research experiences of the high school and undergraduate students who participate in the project, we conducted an end-of-participation survey. The three high school students and one undergraduate student who have participated on the project in the summer of 2009 completed a survey based on the SURE II (Lopatto, 2004), a standard metric used to evaluate undergraduate research experiences in the sciences. In addition, the questionnaire asked about their views of computer science careers, future academic plans, and future choice of major for college. Results for these students are shown below. In future years of the project, additional participants will continue to complete these surveys.

On a question that asked students to rate their "overall satisfaction with their research experience," three respondents selected "very satisfied" and one selected "neither satisfied nor dissatisfied."

Another section of the survey asks students to evaluate how much they have learned during their experience: *"Tell us what you have learned as a result of your research experience. Please rate the extent to which you feel you learned each of the following items as a result of conducting your research project. For each item, use the following scale: 1 = did not learn anything at all, 2 = learned a little, 3 = learned to a moderate*

degree, 4 = learned quite a bit, 5 = learned a substantial amount." The students' responses are shown in Table 1.

Question	***Average Score***
Understanding of the research process:	5.00
Understanding how scientists think:	3.75
Understanding primary literature:	4.25
How to work effectively with others:	4.50
Laboratory techniques:	5.00
How to work independently:	4.75
Tolerance for obstacles:	4.33
The importance of ethical conduct:	4.75
Ability to analyze data:	4.75
Skill in the interpretation of results:	5.00
Skill in giving a presentation:	3.67
Skill in science writing:	4.75
Self-confidence:	4.75
Readiness for more demanding research:	4.00
Clarification of a career path:	4.50

Table 1: Results of Survey of High School and Undergraduate Students, Summer 2009

Of course, the results above are for a very small sample size – the few students who have participated in the project thus far. It would be inappropriate to draw generalized conclusions from these results. They are presented here merely to show the current progress of our project.

Students could also write responses to the prompt: "Please list anything else you feel you've learned or gained in this area." Their responses included:

- "I am a native ASL user and I feel I learned a lot about my own language that I did not know before this project. The linguistics part of ASL is so complicated but very interesting."
- "How to contribute to help make stuff accessible to deaf and [hard-of-hearing] people."
- "Take responsibility. Able to complete task. Able to listen well and analyze mistakes."

In free-form comments sections at the end of the survey, some students indicated that future students would benefit from even more explanation of the larger goals of the research project or further technical explanations of motion-capture. They also indicated that they would have found it interesting to get to try on the motion-capture equipment themselves and go through the calibration and data-collection process from the perspective of a research participant. Several students expressed positive attitudes at knowing that there were computer science laboratories that were specifically studying issues related to the deaf community.

In addition to conducting this survey, we also maintain e-mail contact with students for three years after the project is completed to inquire about their plans after graduation and whether they are still pursuing careers in computer science. Both of the high school juniors who participated in the project last summer intend to enroll in college in the fall of 2010. The high school sophomore is continuing his high school studies.

Future Work

We have already recruited students to participate in summer research experiences at our lab during the summer of 2010, and we plan on continuing to do so during the five-year ASL animation research project. Based on the feedback and experiences of the students in summer 2009, we have made some modifications to our summer plans. For instance, we have recruited an undergraduate student majoring in linguistics for the summer of 2010; having additional expertise in linguistics should allow the undergraduate student to provide even more feedback and advice to the high school students during their research. Also, we plan on allowing the students to interact further with the motion-capture equipment at the laboratory; the students from summer 2009 mentioned that they would have liked to have even more hands-on experience with the motion-capture body suit and gloves used in our research.

Conclusions

Several aspects of our project have facilitated our summer research experiences:

- We have several ASL signing members of the research team.
- We are conducting a research project focusing on ASL in which students' ASL signing skills allow them to make a valuable, expert contribution to the project.
- The research tasks that the students are required to perform during the summer can be taught in a few days, and they require no special programming skills.
- We are based in New York City and are surrounded by large deaf community and several deaf high schools and mainstream educational programs.
- ASL animation technology is fun to discuss with a non-technical audience, is visually-appealing, and resonates with an interest many students may already have in video games. Thus, it can serve as an excellent "hook" to catch students' interest and encourage them in careers in computing.

While these aspects of our project have facilitated our work, we believe that summer research experiences for deaf students can be conducted successfully in other settings without all of these properties. For example, the University of Washington's Summer Academy program has hosted visiting high school students from across the U.S. to stay at the university for the summer (Summer Academy, 2010). The program at JMU (Seal et al., 2002) was based on chemistry topics (not specifically related to ASL or deafness). The key elements that we feel are the most important are that the students feel they are making a real contribution to the project and that they feel that they have full access to the communication environment of the laboratory. Thus, it is important to identify research activities that are appropriate to the skill level and experience of visiting high school

students and to ensure that the communication environment is highly accessible (with ASL signing or other appropriate form of communication).

We also believe that some of the energy and excitement of the high school students in our project came from their realization that their work was essential to the success of the project; their native-level expertise in ASL allowed them to linguistically annotate the videos and motion data we collected. During the summer, the students realized that without their contribution to the project, it could not move forward. While it is not always possible for the educational outreach components of a research project to directly support the scientific aims of the research in this way, we believe that when they do, then the resulting experience for participating students is more exciting. As we continue to monitor the progress of the participating students in our project, we hope to see that this experience makes an impact on their future educational and career trajectories.

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