STEM Teaching-Learning Communication Strategies for Deaf Students

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ABSTRACT: Language is one of the most important features of humanity and an essential element of human existence. Sign language is a solution to meet the verbal and communication needs of the Deaf community as the many spoken languages meet the communication needs of the hearing community. Since unique skills and life experiences shape scientists, each researcher has their own perspective on research endeavors. Consequently, the diversity of life and cultural experiences among scientists has led to the expansion of research directions, and accordingly, to scientific inventions and discoveries. Deaf people, for example, have been successful prospects in scientific research and discoveries. However, the Deaf continue to face challenges in academic science and engineering education. Most Deaf students in Science, Technology, Engineering, and Mathematics (*STEM*) associate with professors who have little experience working with Deaf people and often lack an awareness of Deaf people and their culture. A lack of access to the necessary communication skills can often cause Deaf students to feel dissatisfied or unable to study basic science and engineering subjects. This paper attempts to provide some key solutions to support Deaf students in science and engineering using a descriptive-analytical approach, reviewing the evidence, opinions, and experiences of Deaf experts and scientists. In this study, we discuss potential topics for teaching and coaching research suitable to the Deaf academic environment, concerning the layout of class and chairs, and also point out the importance of Deaf/hard of hearing scientists in deaf-related research. In addition, we address the need and impact of general and specialized sign language instruction in university curricula to enhance the communication skills of interested graduates in the face of the Deaf community.

KEYWORDS: sign language, deaf community, science and engineering education, communication skills

1. Introduction

Promoting and endorsing inclusive education is an essential evolution in the teaching-learning process. Fundamental changes in the teaching-learning process have begun in the last two or three decades in developed and developing countries. These countries have started to address issues such as equitable higher education for all (especially considering the type and extent of people's ability), maximizing each student's participation in the learning process, focusing on student and student-based education, and the establishment of educational justice. As a result, academic planners have begun to pay special attention to students from different socio-cultural backgrounds. Four dimensions are useful as a starting point in the discussion of "inclusive education" in higher education: 1. *Access*; barriers to attending university include disability or medical conditions and appropriate educational environments. 2. *Admission*; students' expectations of the university environment after entering the university, which can be influenced by the views of educators and professors who should give students hope that they will be able to succeed without apparent prejudice. 3. *Participation*; learning is a social activity and knowledge is formed when we participate in activities with others and share common concepts. Therefore, students should be given the opportunity to interact with each other and with professors. 4. *Achievement*; "inclusion" does not mean that all students reach a similar level. "*Achievement*" means that all students should be able to express their educational findings in many different ways, not just in fixed and formal exams. Instead, professors need to allow students to demonstrate their diverse skills, abilities, and knowledge in order to identify and value their

achievements in society. Albert Einstein (1950) states: "Everyone is a genius. But if you judge a fish's ability to climb a tree, it will live a lifetime believing that it is stupid." Therefore, a new leadership style is required to meet the needs of citizens with different capabilities, one that realizes the goals of an advanced society by adapting its educational environments to develop and optimally use its materials and human resource capacities (Beh-Pajooh 1991, 1992). The focus of this study is language, and consequently, communication skills, which are a key element in the teaching-learning process (Alemi & Meghdari et al. 2014, 2015).

With language, people can send their messages to others (Alemi 2016). Sign language is one way to meet the communication needs of the Deaf community. Learning other languages allows people to expand their knowledge, and thus influence their culture, personality, and attitude (Alemi 2016). So, learning a second language, i.e., Persian, Chinese, English, etc. is another way to meet the communication needs of the deaf community.

Through personal experience, scientists draw unique perspectives on their research (Alemi & Ghanbarzadeh et al. 2016). The diversity of scientific specializations, backgrounds, and cultural experiences among scientists leads to the expansion of research orientations and the achievement of new and innovative scientific discoveries and inventions (Meghdari and Alemi 2016). For example, research groups working with Deaf scientists on American Sign Language (Stokoe 1980; Padden et al. 2014) led to a paradigm shift in cognitive neurology (Olulade et al. 2014; Williams et al. 2015). Experience suggests that efforts to integrate *STEM* with a diverse mix of scientists improved the quality of scientific research (Roberge 2013). Interdisciplinary research groups are often more effective in problem-solving and decision making, and thus influence the quality of scientific productions. Research groups with members from a variety of fields are useful in that they usually offer a larger and more diverse set of solutions, and thus find more effective approaches to solving problems than other groups (Meghdari & Alemi et al. 2013, 2017, 2019) and (Pour & Taheri et al. 2018).

At Fereshtegaan International Branch-Islamic Azad University (the only institution of higher education in Iran and the Middle Eastern region for citizens with special needs with a focus on Deaf society), creating a welcoming and inclusive atmosphere in *STEM* fields of study is essential. Previous research has shown that there is no difference in the academic intelligence and academic achievement of students who drop out of these majors and turn to other majors than those who persevere in science and engineering (Seymour and Hewitt 1997). Students leaving the fields of science and engineering, including Deaf students, often complain about the cold and unfriendly atmosphere of the courses in these fields. In addition, Deaf students feel that they need to work harder than other students to stay afloat. A sense of belonging to the science and engineering community seems to be a key factor in their continued and enduring excellence in these fields (President's Council of Advisors on Science & Technology [PCAST], 2012).

Scientists and engineers may be technically brilliant and creative, but if they fail to acquaint their colleagues, customers, and managers with the value of their work, their scientific and technical skills will not be appreciated and will likely remain unused. From this perspective, having communication skills, including familiarity with sign language, is not only useful, but also a tool for success, entrepreneurship, and effective communication with a wide range of underprivileged citizens. Therefore, the question is not whether the knowledge and skills of Iranian and international sign language should be provided and taught in our universities, but rather how to introduce, train, and improve such skills. This is primarily a question for the field of teaching and learning technology on how to adapt academic environments for exceptional citizens. Therefore, this study first tries to address the role and impact of Iranian and international sign language in academic spaces. Then, from the perspective of a hypothetical deaf student, identify the challenges in studying curricula in Science and Engineering in Iran to portray, introduce, and ultimately offer practical strategies for adapting the academic spaces to accommodate this type of student. To achieve this goal, relevant theoretical issues and the opinions of leading researchers in this field have been discussed using the descriptive-analytical method. Therefore, the proposed approach is based on our years of experience in both the

teaching and research in Iranian universities (which generally do not have the necessary facilities to provide services to exceptional citizens) and study of teaching general and specialized sign languages to students/trainees in sciences and engineering at some of the world's known higher education institutions (Taheri & Meghdari et al. 2018-2019).

2. What is the language and sign language of the deaf?

Language is specific to man and is the non-instinctive way of transmitting ideas, knowledge, feelings, and desires through the production of a set of optional symbols (Sapir 1921; Lyons 1981). Language is an institution in which human beings communicate with each other through conventional symbols. Language shapes the way we think and determines what we think so that when we speak another language, we see the world differently. Given that behavioral values and norms differ from one culture to another, it can be concluded that each culture has its own behavioral patterns that are foreign and unknown to people with other cultural backgrounds (Alemi 2016).

Sign language is a special system of systematic and advanced linguistic contracting language that, instead of sound or written patterns, uses patterns of visual cues (a simultaneous combination of shape, direction, and movement of the hands, arms, body, and facial expressions to express the speaker's thoughts) (Bauman 2008). This type of sign language may be varied, but some form of sign language is conducted around the world, with indigenous elements being added to each geographical area. Wherever there is interaction and communication with the deaf, sign languages emerge. Its sophisticated grammars are markedly different from spoken grammars and are uniquely situated to the cultural realm of the deaf. Some sign languages have acquired movements from general cognition, while other languages have no such basis.

A common misconception is that sign languages are in some way related to oral languages, in that they are merely oral languages pronounced by the movements of the hands. Finger spells in sign languages are often used for specific technical letters or specialized words derived from spoken languages. Finger spelling can sometimes be used as a source of new cues called lexical cues. Overall, the languages spoken by Deaf people are independent of oral languages and follow their own development paths. For example, English sign language and American sign language are completely different and incomprehensible, while English and American hearing people share a common oral language. Of course, there are exceptions to this rule, and just as some geographical areas use a commonly spoken language, so do many sign languages. Differences in national sign languages generally depend on the geographical location of the gathering of the Deaf community and their educational institutions (Supalla et al. 1995).

3. Introducing *Shahab*: A hypothetical Deaf student in Iran's university environment

Consider Shahab, a hypothetical freshman Deaf student, who with tireless effort, has been able to successfully compete with hearing candidates and pass the entrance exam barrier to achieve his aspiration of majoring in science or engineering at one of the universities of Iran. *Shahab*'s presence, with his interactive challenges, is unlikely to easily fit into the prevailing mindset and academic community of professors, staff, and other students. Let us assume that more details about *Shahab* are not available, and he is an example on behalf of Deaf students.

Many people have had little or no previous experience interacting with the Deaf and have many misconceptions about them. These preconceived notions of Deaf people often come from books, movies, and TV shows. Deaf students are, in fact, a heterogeneous group with different degrees of hearing, communication skills, academic background, and cultural identity. Some may call themselves "hard-of-hearing". Others may communicate well via spoken language or lip-reading in one-on-one conversations, but lose information in group conversations or noisy environments (Braun & Clark et al. 2017, 2018). Some deaf students are familiar with sign-language and consider themselves "culturally deaf". These students are active members of the deaf community, where deaf culture provides pride, support, heritage, and networking (Hauser et

al. 2010-2013). Preconceptions about deaf students can have an unpleasant cumulative effect on *Shahab*, even on the first day of class, giving him a sense of not belonging to the group. Therefore, it is very important to avoid these pre-existing mindsets during communication. Examples of such problematic preconceived notions are:

• Appointing *Shahab* to do low-level tasks while assigning research projects to his classmates. Whereas the professor needs to provide the same opportunities for *Shahab* by interacting with him through sign-language or a translator.
• Introducing *Shahab* as an inspiring student: "You're so brave to participate in an internship with hearing students." - This encounter alienates *Shahab* making him look like an "abnormal" person who needs special arrangements for success.
• Saying things like, "*Shahab*, it must have been very difficult for you to lose your hearing." This sentence conveys a kind of pity that the deaf community does not like. Instead, accepting that being deaf is a fact of life for *Shahab* and he may be proud of what he is.
• Expressing sentiments like, "*Shahab*, having a sign-language interpreter in class is very annoying for the professor." This kind of comment may make *Shahab* feel uncomfortable. Instead, the professor needs to accept that the sign-language translator is mutually beneficial to both parties (professor and student).
• Requiring *Shahab* to account for his place in class by "Which university regulation mandates that we provide special accommodation and facilities? Can you give us a list of your needs during your studies to see how much they will cost?" These questions make *Shahab* feel uncomfortable and place an undue burden on a young student at the beginning of his school year. He should be focusing on his education and not asked to take responsibility for tuition fees. It is the university administrators and head of the family's responsibility to arrange the proper accommodation and facilities.
• Hearing students and professors may think that sign-language is less competent than oral languages, such as Persian or English, and this may interfere with the learning of various sciences. In fact, all languages can be adapted to communicate unusual or new concepts. It is important to note that there are many successful scientists among the Deaf, whose primary language is sign-language.

4. *Shahab*'s visit to the disability services office (for students and clients with special needs)

Unaware that this office does not exist in Iranian universities, curious and optimistic *Shahab* visits almost all of the university buildings searching for the office or people who are familiar with sign-language to assist and guide him in his educational programs and classroom affairs. As he soon discovers, simultaneous translation of sign-language is not present, not even in new student's orientation meetings.

Conversely, *Shahab* must be able to participate in all available opportunities that are accessible to his hearing counterparts to have equal access to information such as lecture and laboratory sessions, group training/teaching sessions, college seminars, and informal learning occasions. Since each Deaf student communicates in a very different way, the facilities required for *Shahab* must be tailored to his individual needs. These facilities may include simultaneous translation by sign-language, simultaneous subtitling, note-taking services, and/or selection of appropriate classroom seats so that he can better see the instructor. International experience shows that paying attention to the university's infrastructure is effective in providing and distributing appropriate facilities to students. Therefore, the formation of Disability Service offices at universities is very important and an effective method to being more responsive of students with special needs. Students, professors, staff, and administrators all need to be aware that all organizations and universities are clearly mandated to provide reasonable office, educational, research, transportation, and cultural spaces/facilities for citizens with special needs by the laws approved by the Iranian Islamic Parliament in 2004 and 2017.

5. *Shahab*'s first experience in the classroom, important factors to consider

Choosing the right seat in the classroom: *Shahab* enters and examines his needs in the classroom. Certain aspects of classroom design are important for him to communicate, in particular, brightness and clear lines of vision. *Shahab* must be able to clearly see the sources of his information, i.e., the teacher, the screen, the blackboard, the translator, and the subtitles. *Shahab's* professors must work to meet his needs, such as sitting him in a chair located with clear lines of vision. Instructors need to be encouraged to work with deaf students on a case-by-case basis to find out their preferred seats and learn which strategies are most helpful to them. For Deaf students, past research shows that the circular arrangement of chairs enhances vision and social interactions (Bauman & Murray, 2009; Mather and Clark, 2012).

Sign Language Translator: If *Shahab* has requested a translator, he will meet a trained translator at the beginning of the class. After being introduced to the instructor, the translator, dressed unassumingly, is placed in front of the class. The translator may ask the instructor to provide him or her with copies of the training materials prior to the class so that he or she has the opportunity to become familiar with specific technical vocabularies. The role of the translator is to facilitate communication between the teacher, classmates, and *Shahab* by translating what is spoken in Persian into Iranian sign language and vice versa. The translator will also translate any conversation exchanged between students in the classroom. To better communicate and interact with *Shahab,* people need to speak directly to and maintain eye contact with him, not the translator. *Shahab* will experience a 10 to 15 second delay in simultaneous translation. This time lag can make it difficult for him to intervene and ask questions. *Shahab*'s successful classroom experience is greatly influenced by the quality of the translation, so the translator's professional competence is very important (Schick 2005; Grooms 2015).

Simultaneous Subtitles: *Shahab* may also request simultaneous subtitles for slides or conversations. These services are transcribed with a microphone and simultaneous translation access by a person listening to the conversation, what the translator hears appears in writing on *Shahab's* laptop screen. Time delay is also one of the shortcomings of simultaneous translation and subtitling, which makes it difficult for him to participate in class discussions. However, the existence of this delay does not mean that people should speak more slowly because the delay in translation occurs regardless of the amount of speech. By managing time, professors can and should provide an equal opportunity for *Shahab* to ask questions and participate in discussions (National Captioning Institute 2017).

Teaching and Learning Strategies: Researchers in this field have strongly recommended that professors create a positive learning environment in the classroom (Tanner & Allen 2007). Creating a pleasant and inclusive classroom environment is very important for deaf students, often referred to as "disabled", to be able to break the disagreeable cycle of low expectations. Thus, *Shahab* may experience alienation from the group. Marchut describes an example in which a hearing student completely dominates group work, and by not co-working with his deaf classmate, causing him to lose opportunities and reducing the value of his work (Marchut 2017). Therefore, educators should carefully monitor the dynamics of the group, and if necessary, intervene with strategies such as assigning tasks to each student and encouraging the group to provide descriptions of tasks and expectations of each student in achieving the relevant goals. Currently, there is little research on strategies for teaching and learning science and engineering for deaf students. Although, it has been reported that "design concepts" and laboratory strategies for "problem-based learning" are useful for deaf students, causing them to have a more positive attitude towards science and engineering (Solomon & Rashid 2017a, b). Figure 1 shows an example of the group-based Problem-Based-Learning (PBL) method implemented by the first author in the fall semester of the 2019-2020 academic year at the Sharif University of Technology in Tehran, Iran. It has been suggested that this method can also be helpful in the process of teaching, researching, training people with disabilities (Meghdari & Shariati et al. 2018; Zibafar & Saffari et al. 2019).

Figure 1. Teaching the Engineering Dynamics Course by Problem-Based-Learning (*PBL*).

Shahab's Research Experience: *Shahab*, like other students of science and engineering, must participate in at least one research experience under the supervision of a professor. Acquiring research experience under the coaching of a teacher enhances a students' self-confidence and cohesion in the field of science and engineering, especially among the disabled. Coaching and group intervention by the professor are good methods to insure inclusion, especially for Deaf students, who often feel dissatisfied with their degree of participation in group work. Coaching creates a sense of belonging and scientific identity, especially among women and minorities (Wilson et al. 2011; Hauser 2013). *Shahab* may not be aware of the internship/training opportunities available within the country in the fields of science and engineering. Supervisors need to provide additional incentives for *Shahab* to take advantage of research and internship opportunities, especially close to graduation when he is preparing himself for employment interviews where he may face prejudice and discrimination. Recent research has identified four issues of a positive coaching experience with Deaf students: 1) awareness and respect by the supervisor for deaf culture, 2) full access to communication 3) learning how to defend their opinions and views, and 4) pairing at least two deaf student together in a research program (Braun et al. 2017; Majocha et al. 2018).

    Shahab in a Leadership Role as a Young Deaf Scientist: *Shahab* and other deaf students are directly affected by the findings of research studies on deaf people and the deaf community. Hence, such research projects should involve deaf scientists in leadership or at least joint-leadership roles, as they provide the necessary cultural and linguistic knowledge that may not otherwise be considered (Wolsey et al. 2017). Therefore, researchers who are not fluent in the sign-language and culture of a deaf community are not as effective in documenting and describing the culture, interpreting video films, or even evaluating translators' skill levels for employment. In addition, researchers who offer support for research projects related to the deaf community should use colleagues, counselors, and deaf students in their research group. We acknowledge that if we were more familiar with this topic and identified and involved deaf researchers in the arrangement of the Socio-Cognitive Robotics Research Group at Sharif University of Technology, our plan to "Design and Implement a Sign-Language Teaching Assistant Social Robot (*RASA*)" would have been more attractive and practical (Meghdari & Alemi et al. 2019, 2020).

6. *Importance of planning and teaching deaf sign-language in Iranian universities*

Sign-language is a unique way to express a person's thoughts and observations. This language is a powerful tool for communicating views and ideas through the face, hand shapes, and finger spells. Various studies over the past decades have shown that sign-languages in Europe and the United States have their own rules and grammatical structures. Today, some universities offer

this language as an optional foreign language in the curricula of various fields (Wilcox 1991). In the United States, many colleges and universities have officially recognized American sign-language and the deaf culture and accepted it as a necessity for university education allowing students to take them as an option among the other foreign language. As such, sign-language classes have become one of the most popular language classes in American colleges and universities. Students who speak a foreign language often find that their understanding of themselves and the world around them is richer than that of their classmates. Studying a language gives students a different culture and literature beyond what they have in their own world. We appreciate foreign language not only because of its intellectual benefits, but also because of its practical and economic use for learning. Hence, learning sign-language in all respects includes the same challenges and relative advantages of learning traditional foreign languages. Due to the large number of deaf in Iran (about one million individual according to the Iran Society of Deaf People and Family, http://isdpf.ir/), teaching and learning Iranian sign-language in the country's universities and organizations seems essential for various reasons. For example:

- People will be able to communicate with and assist a deaf person.
- Sign-language presents as an innovative skill on a graduate's resume.
- Helps students and staff become familiar with the deaf culture.
- People will be able to have a private conversation in a crowded public space.
- Schools/universities will gradually accept sign-language as a foreign language.
- Entrepreneurship and new jobs for sign-language translators will expand.
- Professors and assistants will gain new skills to better teach deaf students.
- Deaf students will feel better about attending university.
- In important sports matches, sign-language between the coach and the player can be used.
- Social workers, counselors, psychologists, and physicians will benefit from sign language skills.
- Traffic police/city police would excel with sign-language communication skills.

5. Conclusion

Deaf people have provided many contributions and services to science and technology throughout history. The current generation of deaf students, such as *Shahab*, will be no exception. We, the academics of Iran, must fulfil our commitment to creating equal educational opportunities by welcoming this generation and disabled citizens with special needs in general and commit to prepare them for success and to become an effective presence in society. The unique vision that they can bring as scientists and researchers and the research questions they will ask will ultimately lead to inventions and discoveries to improve the quality of life of all citizens. From our study of publications and the little experience gained in close collaboration with deaf students, it can be concluded that:

1. Deaf students, like *Shahab,* often feel dissatisfied in the integrated community of hearing science and engineering students, and often have to work harder than their classmates to reach similar opportunities.
2. Deaf students need educators, professors, and departments with a sense of the Deaf culture to understand their situation. They need trainers who want to support them in order to provide appropriate teaching facilities, job opportunities, and the opportunity to gain research experience. Such educators not only empower Deaf students but also enrich their own capabilities by gaining this experience.
3. With the recommendations provided and description of a narrative of virtual Shahab as a representative of deaf and under-represented students in Iranian universities, we have challenged the higher education planners, to adapt university spaces and employment for citizens with special needs.

Acknowledgment

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