Challenges and Lessons Learned in Teaching Software Engineering and Programming to Hearing-impaired Students

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Abstract

Teaching academic courses to students with disabilities is a challenging task, particularly for academics who are presented with the teaching requirements and needs that this implies, for the first time. Courses in the field of engineering and computer science, by requiring a lot of hands-on practices and teamwork, further exacerbate the situation as how to provide an effective learning experience for these disabled students. This situation requires a higher-level commitment than normal, from both the teachers and students. This paper presents the experience gained from teaching courses that involved hearing-impaired students of an undergraduate software engineering and a programming language course in two different universities. Some of the challenges faced by both instructors and the students are identified and some possible solutions are described.

Keywords: software engineering education, programming languages, hearing-impaired students

1. Introduction

Software Engineering courses and computer programming languages courses are integral parts of computer engineering/computer science undergraduate curriculum. Unlike some other computer science courses, such as data structure and algorithms, computer architecture, computer operating systems, the unique characteristics of software engineering, which includes both technical aspects and non-technical aspects, provide quite unique challenges to students who may lack real-world software development experience. The non-technical aspects parts of software engineering, for instance, software process models, process improvement, and quality improvement, seem quite abstract to students. Teaching programming languages requires a lot of hands-on exercises and a deep understanding of program logic.

The need for special teaching approaches and attentions to be adopted when teaching such courses are complicated and amplified when students with disabilities are involved, such as students with hearing disabilities. As an example, abstract terms in software engineering and object-oriented programming courses are hard to find good metaphors for these students. Sometimes the information is lost during translation by sign language interpreter, who may not familiar with scientific and engineering terminology.

Effectively teaching students who are hearing-impaired requires instructors to have extra pedagogical skills and take different approaches from that in a regular classroom setting. Not only should instructors convey the knowledge of the courses, but also they should have special considerations for these hearing-impaired students. For instance, instructors should speak clearly and at a moderate pace, face the class, avoid introducing excessive new jargons, and stick to the lecture topic, use visual materials, present materials in an organized manner, provide clear explanations, and should be friendly and caring [2] [3]. Providing an interactive learning environment by asking and answering questions that elaborate on lecture material is as important

for students who are hearing-impaired as it is for other students. The goal is to help these students to reach a higher achievement in their career and their lives.

This paper reports the experiences in teaching two different courses for hearing-impaired students in two different universities. The impact of these students' learning experiences is discussed from course structure (lectures, assignments, exams, etc.) to classroom interactions. From the observations and lessons learned, several unique challenges faced by both instructors and disabled students were identified. Furthermore, a preliminary list of guidelines on how hearing-impaired students' learning experience could be improved is provided.

The paper is structured as follows. The next section discusses some of the fundamental issues and guidelines related teaching students with disabilities. Section 3 describes the two courses that were offered to classes with hearing-impaired students in two different universities. One course was undergraduate software engineering course that had both hearing-impaired student and other students; the second course was computer programming with Java, which was dedicated solely to hearing-impaired students. Section 4 summarizes the experience gained by the authors in these two courses by describing the challenges faced and lessons learned. Finally Section 5 summarizes the paper, states some limitations and outlines possible avenue for future improvement.

2. Teaching students with disabilities

By the definition of Americans with Disabilities Act of 1990 [6], the term "disability" means with respect to an individual:

(a) A physical or mental impairment that substantially limits one or more of the major life activities of such individual;
(b) A record of such an impairment; or
(c) Being regarded as having such impairment.

To provide assistance for students with disabilities to have an equal opportunity to attain the same quality of education as other students, most of the universities have Office for Students with Disabilities (OSD). The OSDs provide a variety of services and guidelines for students and faculty that make the offering of accommodations fairly easy. These accommodations may include in class accommodations (e.g., volunteer note-taking assistance, and audio-recorded classes, sign language interpreters), and exam accommodations (e.g., extended time for exams and quizzes, and additional practice time).

The Individuals with Disabilities Education Improvement Act (IDEA) [7] is a law that helps to ensure equity, accountability and excellence in education for students with disabilities. This legislative requirement emphasizes the importance to provide the equal access to the curricular material for everyone. Well-developed course material coupled with proper tools and instructional methods are the keys to enable students to have a good learning experience.

Trying to go further in meeting these equal opportunity laws, some universities, besides guaranteeing disabled students the access to all of the offered degree programs and giving them specific support in classroom and during study activity, offer entire degree programs specifically conceived for students with specific disabilities. This is the case of the Faculty of Engineering of University of Sannio, Italy, which offers since 2002 a Bachelor degree in Computer Science for hearing-impaired students.

Hearing impairment is a specific category of disabilities. Some students may have lost hearing over a period of time or of hereditary conditions. Students with hearing-impairment face enormous challenges in academic setting. It is essential that instructors maintain effective communication with these students. Some universities and government organizations provide some suggestions for instructors on how to teach students who are deaf or hard of hearing [5] [8] [9]. Some of the suggestions may include: always directly speak to the students, have visual

contact, avoid giving information while handling out papers or writing on blackboard, provide an advance copy of course material and so on.

Many researchers and instructors have put these guidelines into practice and provided first-hand experience in teaching students with hearing impairments. The Geography Discipline Network project [10] was conducted by a group of geographers, earth and environmental scientists working alongside disability advisers and educational developers. The report provides guidance on how to communicate with students in the field and how to avoid potential hazardous conditions. Mark Lutman [11] described his personal experience in teaching Audiology at Masters level by adapting to the needs of hearing-impaired students. These adaptations include (1) technical adaptations via improving teaching environment, such as double-glazing to exclude external sound, spotlights to highlight the lecture's face for lip reading; and (2) modify lectures to accommodating students' special need. Sobel [3] described her experiences of teaching a CSI course that composed both hearing and deaf students. From her experiences, using an overhead project is discouraged since it requires turning off the overhead lights. As a consequence, the students could not see instructor's face and therefore, could not do lip reading.

The next section will describe the authors' experiences in teaching two difference courses in two different universities for hearing-impaired students. The experiences gained from these two courses were used to identify some of the challenges that an instructor may encounter when teaching similar courses to hearing-impaired students and possible solutions s/he may adopt to face them.

3. The courses

The first course was a software engineering course given at the Department of Computer Science & Engineering of the Florida Atlantic University, USA. This was a normal course but included one hearing-impaired student. The second was a course in Computer Programming with Java given at the Faculty of Engineering of the University of Sannio, Italy. This course was dedicated solely to hearing-impaired students.

3.1 Software engineering course

The Principles of Software Engineering course is one of the undergraduate core courses for both computer science and computer engineering majors. It is an introductory course that covers basic concepts and principles of software. Students need to acquire knowledge of both technical aspects, such as requirements elicitation, architectural design, implementation, testing, etc., but also non-technical aspects, such as project management and development of know-how for a particular application domain.

Most students who took this course were senior students. There is no special session that is dedicated solely to students with disabilities. So if there are any students with disabilities, they enroll in the regular courses, but under the guidance of Office for Students with Disabilities (OSD). This particular offering of the course was composed of traditional students and one hearing-impaired student. Instructors provided accommodations to the students based on an analysis of the current impact of the person's disability on academic or work performance. Some of the accommodations may include volunteer note-taking assistance, audio-recorded classes, sign language interpreters and exam accommodations such as extended time for exams and quizzes, and additional practice time.

This course included individual assignments and group assignments, one midterm and a final exam. Part of the assignments required students to use professional CASE tool – Rational Suite Enterprise [1]. Lecture slides were all posted online for students to review.

3.2 Computer programming with Java course

The Computer Programming with Java course is part of the program for the Bachelor of Computer Science for hearing-impaired students at the University of Sannio, Italy. This bachelor curriculum is specifically intended for students with hearing disabilities. In addition to a course in Java programming, it includes most of the courses common to other bachelors in Computer Science, such as Mathematics, Physics, Fundamentals of Computer Science, Computer Systems, Fundamentals of Software Engineering and Database Systems.

The Computer Programming with Java course is given in the first semester of the second year of the curriculum and aims at providing students with the foundations of Java 2 Standard Edition (J2SE) technology and the bases of object-oriented programming. Through the use of hands-on exercises, students explored the Java language fundamentals and learned the basic concepts of the object-oriented design and object-oriented programming in Java.

During the academic year 2005-2006, the course had four hearing-impaired students, who were competent in C language and knowledgeable of basic programming concepts and practices. The four students had different levels of hearing disabilities; some of them were provided with hearing aids; all of them were able to interpret and speak Italian Sign Language (LIS) and, at different levels, to lip read. Their age was comprised between 20 and 22 years.

The whole course was taught in a laboratory and each lesson was divided into theory and practice: the topic of the day was presented and discussed, then students were asked to practice the explained concepts with exercises and assignments to perform on the computers. Each student had his/her own computer provided with a simple Java IDE – JCreator LE edition [12] but collaboration in discussing exercises and comparing solutions with colleagues was stimulated.

A multimedia projector was used to project slides and laptop screens, but lighting conditions were not such as to impede students to lip read. Teaching material provided to the students included a copy of the slides, exercises and solutions.

Course contents included the following topics: Using Objects and Implementing Classes, Fundamental Data Types, Decisions, Iterations, Arrays and Array Lists, Designing Classes, Testing and Debugging. The final exam consisted in the development of a Java program to satisfy a set of requirements: students were assigned a set of requirements and were requested to design and implement a set of classes meeting the given requirements, testing their program. The time available was limited to 2 hours and the students were allowed to use guides and reference books. The typical number of Java classes a student had to implement to complete the exam was four, with each class including two or three methods. On average, the total number of lines of code of the Java program to implement was approximately 150.

4. Challenges identified and lessons learned

This section factorizes the experience gathered by the authors in giving the two classes described in Section 3. A number of unique challenges that were identified by both the teachers and the disabled students during the courses are presented. Possible guidelines for facing these challenges are proposed.

1) Tackling the poor lexicon and simple spoken language of hearing-impaired students

Identified challenge

Hearing-impaired students often have a reduced knowledge of their own natural spoken language, both in terms of richness of the lexicon and knowledge of grammatical rules. In particular, the students who suffered from a hearing disability before they could learn their native spoken language, demonstrated a limited knowledge of this language and hence a limited ability in interpreting and understanding correctly the language spoken by the lecturer. It is important to

take into consideration that for hearing-impaired students, the spoken language used in the class, can present similar problems to that faced by normal hearing students when dealing with a foreign language. Not comprehending some words of a sentence may result in impaired-hearing students losing the meaning of an entire discussion and arouse feelings of frustration and disappointment.

In both the programming course and the software engineering course, hearing-impaired students ignored the meaning of some words, even non-technical terms, and were unable to assimilate elaborate sentences. Due to the fact that the majority of technical terms related to computer programming and Java are in English, this presented a further problem for the Italian students who could not spell and understand them. English represents for Italian impaired-hearing students a third language in addition to LSI and Italian.

Proposed guidelines

Teachers should keep their language as simple as possible by:

(a) avoiding the usage of uncommon terms, spelling technical and foreign language terms;
(b) keeping the complexity of sentences and language construction as low as possible;
(c) assuring that all the terms they use are already known to hearing-impaired students, in particular clearly introducing terms which are new to them;
(d) continuously checking that students have understood what they explain;
(e) highlighting the most important concepts by writing them on blackboard. This practice can also be used when spelling technical and foreign language words;
(f) accompanying theoretical notions with examples and practical exercises;
(g) always facing students when speaking to enable them to lip read and speaking slowly and clearly.

2) Domain knowledgeable sign language interpreter is a key factor for effective communication between instructor and student

Identified challenge

Although hearing-impaired students can absorb some lecture material by reading lecture slides, instructors' writing on the board, and do lip reading, there are still much more information that need to convey to the students in "real-time" in the classroom, such as examples and class discussions. Sign language interpreters play an important role in facilitating communication between the student and the class. The interpreter communicates through verbatim translation into signs or conceptual interpretations. The interpreter interprets everything that is said in class and vocalizes everything the student signs. Software engineering course and programming language course have many unique technical vocabularies that the interpreter may not familiar with, or some technical term may not have the "normal" meaning as in daily English. For example "software construction" is a synonym with concept of "software development". But when interpreter translated "construction", the student misunderstood to the meaning of "construction" in civil engineering sense, such as "construction of a house". Therefore, the information fidelity loss from the class to the student could be due in part of instructor's lack of domain knowledge.

On the other hand, the presence of a sign language interpreter who is not knowledgeable of the topics of the course is found by students counterproductive. In this case, indeed, students prefer to directly follow the instructor by reading his lips and hearing his voice (to the extent they can) instead of following a sign language interpreter who may misunderstand the instructor messages.

Proposed guidelines

To improve the quality of sign language interpreter's translation, the instructor might need to first explain concepts to the interpreter before he can translate to the student. This may slowdown the pace of the lecture, but student has a solid understanding of the course material, furthermore, improve their learning experience.

Put student with hearing impairment in the front row seating. An unobstructed line of vision is necessary for students using interpreters or those relying upon lip reading and visual cues.

3) Increasing student motivation and participation

Identified challenge

Motivation is a key factor to success in any task. This is true also for students who want to profit from any courses. The impaired-hearing students of the programming course were found to be not very motivated with regard to learning Java and attending the course. They seemed dubious of the practical opportunities that a degree in computer science could bring them, such as finding a qualified job and realizing their own life goals. Students seemed to have been persuaded to enroll and attend a degree course by relatives and by an association which provided concrete and moral support. As a consequence they weren't fully convinced of the benefits to be had from studying and graduating.

At the beginning of the programming course, the impaired-hearing students did not ask questions very often and did not participate actively to the lesson. This was due to their lack of self-confidence, in particular when speaking.

Proposed guidelines

A teacher of impaired-hearing students should continuously put effort and inspire students motivation by convincing them of the opportunities they will be able to obtain in life. A close-contact teaching approach should be used continuously follow the learning progress of impaired-hearing students. Home assignments should be given after each lesson and solutions verified and discussed in the following lesson.

The teacher should encourage students to overcome their fears and anxieties and become active participants in the lessons and take part in the discussions. A peer-to-peer relationship between teacher and student may facilitate this process. It was experienced that if students overcame their fears a healthy competition was created between them to participate in the lesson.

A teacher should also promote student-interaction. When this occurs, attention should be given to enable all students to follow the discussion of a fellow colleague by a) ensuring that all the students can read his/her lips; or b) the teacher repeats to all the other students what has been said.

4) Requesting students attention and eye contact

Identified challenge

During the lesson it is possible to see hearing-impaired students talking amongst themselves using sign language. This, in addition to excluding the teacher, results in students being unable to follow the teacher because they cannot lip read due to the fact that they are not looking directly at the teacher. For impaired-hearing students their eyes are their ears. Therefore it is of fundamental importance that the students focus their eyes on the teacher when he is speaking.

Proposed guidelines

The teacher should try to keep students' eyes directly focused on him when he is speaking and prevent students from using sign language to talk each other by promoting the use of spoken language at all times.

5) Hearing-impaired students may not have a good absorbing percentage of class lectures. So off-class tutoring is very much more valuable to them than to other students

Identified challenge

The learning experience in classroom is from more than just looking at lecture slides, writing on blackboard, and translation by interpreter, but also from body language, eye contact, and facial expressions. Hearing-impaired students may not absorb lecture material as effective as other students. Therefore, off-class tutoring is much more important to them than to other students.

Proposed guidelines

Teachers should put extra effort in organizing off-class tutoring for hearing-impaired students. This service is often provided by the OSD, but students should be urged to profit from attending the tutoring meetings and have much more results from their study.

6) Graphic-based lectures is effective for hearing-impaired students to grasp lecture material

Identified challenge

The students' difficulties in understanding the spoken language and the risks in information loss when a sign language interpreter is available in class make difficult for instructors to explain complex theoretical concepts which are difficult to teach per se. In these situations, the schematic representations of concepts and the usage of animations are extremely useful to highlight concepts and express relationships and temporal dependences among them.

Graphical notations give students a visual clue as how things work, and take less words and less translation, therefore, less information loss. This idea, well stated by the proverb: "A picture is worth a thousand words", holds even more for students with hearing disabilities.

Proposed guidelines

If a graphical notation and/or animation could be used in explaining complex theoretical concepts, instructors should use it.

7) Special care is needed for special-need students. Emotional support and encouragement are the keys for their success in education

Identified challenge

Students with disabilities have natural obstacles to overcome in their education. These obstacles put them at a distinct disadvantage. There usually is a lag of time between conveyance of concepts and the interpreter's signing. When the student is still try to understand previous concept, the instructor may have moved to the next one. Some hearing-impaired students are too shy to ask questions in the class. This scenario will reduce student's learning experience.

On the other hand, teachers are naturally leaning towards being particularly soft and willing with disabled students because of their conditions and special needs. This kind of behavior poses the risk of loosing class control and students' respect. Permissive behavior should be balanced with attention to keeping distinct role of the learners from that of a teacher.

Proposed guidelines

Instructors should be patient with hearing-impaired students and encourage them to ask questions. Giving them positive feedback when they do good jobs. At the same time, when it is opportune, instructors should reinforce the different roles and responsibilities associated with the instructor and the student and encourage students to dedicate to their studies.

5. Conclusion, limitations, and future work

Traditional lecture structures and lecturing style may not benefit the disabled students as much as other students. Adjustments in teaching style should be made and special teaching approaches should be adapted accordingly to accommodating these students' need and to help them to achieve their goals of life. Some of the special teaching techniques and considerations that are fundamentals and suitable for teaching impaired-hearing students include: speaking slowly and clearly, using a very simple language, assuring all terms used (not only technical words) are known, always facing students when speaking, adjusting the teaching "speed" to that what is appropriate for impaired-hearing students. Such special approaches, however, may prove unsuitable, in a long term, for students who have not those needs. These students could find themselves being sacrificed for the needs of others.

For the above reason, guidelines suggested for teaching technical courses to impaired-hearing students may be applicable in practice only in classes where all the students have impaired-hearing disabilities. On the other hand special classes for impaired-hearing students are not always available and when they are, there is a risk to fall into the trap of exclusion and highlighting of students disabilities.

The observations described in this paper were from two different universities that had one impaired-hearing student in the first university and four in the second. Therefore, the findings may not as applicable as in a larger case study. We would like to broaden the observations and findings, and conduct a comparison study to identify some special teaching techniques and styles in software engineering and program languages education.

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