User Evaluation of Technology Enhanced Interaction Framework

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Abstract.

This paper focuses on user evaluation of the Technology Enhanced Interaction Framework (TEIF). Questionnaire results from participants using or reviewing the TEIF method to evaluate requirements and design technology solutions for problems involving interactions with hearing impaired people showed that they thought it helped them more than the Other methods and that it would also help them to gather requirements and to design technology solutions for all disabled people if information about other disabilities than hearing impairment was provided. The objective results from the experimental tasks will be analysed to investigate how the participants performed on the requirements evaluation and solutions evaluation tasks with the TEIF method and the other preferred method. These results will be compared with the participants' questionnaire answers which reflected what they thought about the TEIF method. Future work includes extending the Method and Technology Suggestions Table to include information about other disabilities than just hearing impairment.

Keywords: framework, interaction, evaluation, accessibility, hearing impairements

1 Introduction

Researchers have been concerned with how to use technology to support communication between people and improve interactions between people, technology and objects [1-7]. For example, artefact-mediated-communication has been used to support cooperative work [2, 3, 7, 8], a mobile digital guidebook has been used to enhance visitors' interaction with physical objects in museums [6, 9] and mobile devices have been used as mediators for the interaction with a physical object using QR codes, RFID tags and NFC tags [5, 10]. Many publications and projects in human computer interaction (HCI) focus on using technologies as a tool to enhance experiences: in the same place but at a different time (e.g. using systems for supporting group learning such as notice boards, questions and answers, electronic debates and collaborative learning [10]); in a different place but at the same time (e.g. using a Synchronous Communication Tool such as video conferencing, instant messaging and online chats to interact with learners to improve their communication with the Instructor [11]); and in a different place at a different time (e.g. using blended learning, students can access e-learning in order to learn in a different place at a different time [12]). There has, however, been no framework that has helped technology designers

to consider all of the possible interactions that occur at the same time and in the same place although there have been projects concerned with how to use technology to support some of these interactions.

2 The Technology Enhanced Interaction Framework (TEIF)

The TEIF which was adapted from Dix's [13] and Gaines's [14] Frameworks with the aim of supporting designers evaluating and designing technology enhanced interactions involving disabled and non-disabled people. There are seven main components in the TEIF. A person has a role when communicating with others. Roles normally come in pairs such as speaker and audience. People have abilities and disabilities which can affect their use of technology or understanding of language and which can lead to communication breakdown. The components "Object" and "Technology" are used in order to extend Dix's framework to show any type of interaction. Objects are defined as having three sub-components: dimensions, properties, and content. Technology has a cost and can be electronic or non-electronic, online or off-line, and mobile or non-mobile. Furthermore, it may or may not have stored content and may additionally have an interface and be an application or provide a service. Interactions and communication are classified into three groups:

- Direct communication: P-P - people in one way or two way communication with people.
- Direct Interaction: P-T - people can control technology and may also use it to store or retrieve information; P-O -People can control objects and retrieve information from objects.
- Technology Mediated Interaction: P-T-P - technology can mediate communication between people; P-T-O - people can control objects with technology and may also be enabled to use objects to store and retrieve information.

Time and Place can be same or different. Context can include location, signal quality, background noise, and weather conditions. The role played by the interactions and communication may be classified into one of six interaction layers, adapted from Gaines [14]. The TEIF was successfully validated and reviewed by two groups of the experts: designer experts and accessibility experts. The designer experts focused on the main and sub-components while accessibility experts focused on checking the accessibility aspects. The results of this validation and review have been reported elsewhere [15].

3 Technology Enhanced Interaction Framework Method

The TEIF method aims to help designer in two stages of software developing life cycle: *(a) gathering and evaluating requirements*, *(b) designing and evaluating technology solutions* to situations, particularly when disabled people are involved by helping designers think about the user requirements, designing interactions to meet these

requirements and the criteria related to the requirements to evaluate the interactions. The TEIF method does not replace other methods of identifying requirements but supports them by providing examples of requirement-questions and answers. Then, the process links the answers to technology suggestions which lead to the design and evaluation stages. In order to explain how the TEIF method works, the start of an example scenario that only involves hearing impairment and the TEIF steps will be presented as follows:

"Suchat Trapsin allocated some parts of his house to become the Shadow Puppets Museum, in Thailand. There are exhibits of shadow puppets inside the museum, but there is no information provided in text format …"

Designers analyse their scenario and answer the multiple-choice questions [16] to elicit requirements based on the scenario. One example questions is:
What "types" of speech did the presenter use?

a. prepared or rehearsed speech b. spontaneous speech

The answers will suggest relevant technologies with the help of the technology suggestions Table (a small part of which is shown in Table 1) which contains descriptions with indications by ticks and crosses of whether they meet the requirements based upon an analysis of answers to the requirement questions. An online version uses tooltips to display the explanations for the ticks or crosses.

Table 1 Technology Suggestion Table

Technology suggestions	Descriptions	6b speaker speaks Thai	7b audience speak Thai	9a hearing impaired	11a people-people	11b people - objects	12a online technology	13a mobile devices	14a pre-prepared speech	17a noise	18a low cost solution
Flashing light	A flashing light alert gets attention of hearing impaired people. Normally used for room lighting only off-line. High cost wireless systems are becoming available.	✓	✓	✓	✓	✗	✗	✗	✗	✓	✓
Speech recognition	Speech recognition helps clarify using words but sometimes make errors. Number of errors will increase depending on noise. Speak recognition works best if the microphone is close to user:http://www.w3.org/TR/UNDERSTANDING-WCAG20/media-equiv-real-time-captions.html	✗	✗	✓	✓	✗	✓	✓	✓	✗	✓

4 Experiment Pilot studies

Three software engineers conducted face to face interviews with the researcher playing the role of the client in order to investigate whether the engineers could gather and identify requirements in this "realistic" way. They found this task very difficult as they had not had experience of interviewing before. The researcher therefore decided on a different approach using a written document explaining the scenario for a task of evaluating requirements. The researcher developed and piloted two styles of presenting the scenario information: a "report" and an "interview transcript" as research [17] has found that using an interview transcript with direct speech was more realistic and engaging than a descriptive document using indirect speech. The start of the transcript is :

"Interviewer: Could you please tell me about your recent visitor?

Suchat: "Chuty is a very successful Thai businesswoman in her 30s who has lived in Thailand all her life and only speaks Thai. She became hearing impaired in her twenties and depends completely on her hearing aids and lip-reading. She speaks clearly and I had no problem understanding her".

The interview transcript was chosen to be used in the experiment as eight out of twelve participants preferred the interview transcript style to the report style. Six participants were asked to pilot the Evaluate Requirements Task which involved evaluating the best 10 requirements from 27 provided for a technology solution to the disability related problems they identified from the interview transcript. Modifications based on the feedback were clearer explanations, re-ordering the position in the list, and adding one more requirement to the list. To pilot the whole experiment eight software engineers at the university, both English native speakers and non-native speakers, were mixed equally between two groups and four participants were asked to use the TEIF method while the other four were asked to use their preferred other methods. The process for the pilot study was that the individual participant sat down with the researcher and applied the TEIF method steps to complete the Evaluate Requirements Task and then the Evaluate Technology Solutions Task (Evaluating three solutions for each of 10 requirements by rating between 0 and 10) and finally answer a questionnaire. Participants were asked to do the tasks independently and the researcher only intervened to explain an instruction if a participant found it unclear. Improvements as a result of the pilot study included: providing a glossary to clarify words some non-native English speakers did not understand (e.g. shadow puppet, spontaneous speech); shortening and modifying the transcript to make it more realistic and more difficult to identify the requirements; instructions, requirements and transcript were made clearer to understand.

5 Experimental Design

The TEIF method was designed to help improve a designer's awareness of interaction issues involving disabled people and their understanding of how environment context affects the accessibility of interactions and to provide a technology suggestions table to help with designing technology solutions. The purpose of this experiment was to evaluate the TEIF method by asking participants questions about the materials presented. Participants took between one hour and one hour and a half to complete the experiment. Thirty-six experienced software engineers were divided into two equal independent groups of eighteen participants with four English native speakers and fourteen non-native English speakers in each group (section 6.1). One group of the participant used the TEIF method to complete the Evaluate Requirements Task and the Evaluate Technology Solutions Task (section 6.2) while the second group of participants used their preferred other methods to complete the Evaluate Requirements Task and the Evaluate Technology Solutions Task and were then shown the TEIF method to the participants. Both groups of participants were asked questions to check whether the TEIF method helped in these ways (section 6.3).

6 Questionnaire Results and Analysis

As the Evaluate Requirement Task only involved evaluating requirements and the Evaluate Technology Solutions Task only involved evaluating designs. The questionnaires were asked the participants' opinion about whether the TEIF method would help them in gathering requirements and designing technology solutions when hearing impaired people involve or even other disabilities involved.

6.1 Participants' profile

An independent sample t-test shows that there was no significant difference for participants in the two groups in the experience of designing software (4.89 years for TEIF method group and 4.19 years for the Other method group) or designing technology solutions for disabled people (22% for the TEIF method group, 17% for the Other method group).

6.2 Questions asked to the TEIF Method group only

The participants from the TEIF method group were asked to complete the questions related to the TEIF Method they used for the experiment. An one sample t-tests on questionnaire results using a five point Likert scale where 5 meant they "strongly agreed" showed each mean rating for answers was a significantly difference greater than 3 with $p < .001$ and that:

- participants thought the TEIF method helped in Evaluate Requirements Task to evaluate requirements for technology solutions to problems involving interaction with hearing-impaired people better than the Other methods (mean = 4.5).
- participants thought the TEIF method helped in the Evaluate Technology Solutions Task to evaluate technology solutions for problems involving interaction with hearing-impaired people better than the Other methods (mean = 4.3).
- participants thought that the TEIF method helped improve awareness of interaction issues involving hearing impaired people (mean = 4.4).
- participants thought that the TEIF method helped improve understanding of how environment context affects interaction when hearing impaired people are involved (mean = 4.4).
- participants thought that the Technology Suggestions Table helped identify technology solutions to issues involving hearing impaired people (mean = 4.4).

6.3 Questions asked to both groups

The participants from both method groups were asked to completed the questions about their opinion in:

- gathering requirements to interaction problems involving hearing impaired people
- designing technology solutions to interaction problems involving hearing impaired people.
- using the whole TEIF method (both the evaluate requirements task and evaluate technology solutions task) would be needed for designing technology solutions.
- gathering requirements to interaction problems involving other disabilities.
- designing technology solutions to interaction problems involving other disabilities.

The one sample t-test was used to test whether the mean ratings were significantly greater than 3. There was a significant difference of mean ratings was greater than 3 with $p < .001$ and that:

- participants thought that the TEIF method would be helpful in gathering requirements for technology solutions to interaction problems involving hearing impaired people (mean = 4.5).
- participants thought that the TEIF method would be helpful in designing technology solutions to interaction problems involving hearing impaired people (mean = 4.4).
- participants thought that the whole TEIF method would be needed for designing technology solutions (mean = 4.6).
- participants thought that the TEIF method could help in gathering requirements to interaction problems involving a wider range of disabilities than just hearing impairment (mean = 4.5).
- participants thought that the TEIF method could help in designing technology solutions to interaction problems involving a wider range of disabilities than just hearing impairment (mean = 4.3).

The independent sample t-test statistic was used to test whether and how the TEIF method helped in gathering requirements, designing technology solutions and with other disabilities where 5 meant they strongly agreed. The results show that there was no significant difference of mean ratings between the two methods:

- participants in both groups thought that the TEIF method would be helpful to gathering requirements for technology solutions to interaction problems involving hearing impaired people (TEIF mean = 4.6, Other mean = 4.5).
- participants in both groups thought that the TEIF method would be helpful in designing technology solutions to interaction problems involving hearing impaired people (TEIF mean = 4.3, Other Mean = 4.4).
- participants in both groups thought that the whole TEIF method would be needed for designing technology solutions (TEIF mean = 4.6, Other mean = 4.5).
- participants in both groups thought that the TEIF method could help in gathering requirements to interaction problems involving a wider range of disabilities than just hearing impairment (TEIF mean = 4.5, Other mean = 4.4).
- participants in both groups thought that the TEIF method could help in designing technology solutions to interaction problems involving a wider range of disabilities than just hearing impairment (TEIF mean = 4.2, Other mean = 4.3).

7 Conclusion and Future Work

Questionnaire results from participants using or reviewing the TEIF method to evaluate requirements and design solutions for problems involving interactions with hearing impaired people showed that they thought it helped them more than the Other methods and that it would also help them to gather requirements and to design solutions for all disabled people if information about other disabilities than hearing impairment was provided. The objective results from the experimental tasks will be analysed to investigate how the participants performed on the requirements evaluation and solutions evaluation tasks with the TEIF method and the other preferred method. These results will be compared with the participants' questionnaire answers which reflected what they thought about the TEIF method. Future work includes extending the method and technology suggestions table to include information about other disabilities than just hearing impairment.

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