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Introducing Accessibility Requirements Through External Stakeholder Utilization in an Undergraduate Requirements Engineering Course

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Abstract

Undergraduate software engineering courses aim to prepare students to deliver software in a variety of domains. The manner in which these courses are conducted varies, though team projects with real or imaginary stakeholders are common. While the key course concepts vary from the entire lifecycle to specific aspects of design, concepts like accessibility are rare.

This paper will present a study of team projects in a requirements engineering course. One group of students conducted projects with accessibility requirements while another group of students delivered projects without accessibility requirements. The course content was the same, including discussion of accessibility. To support the understanding of accessibility, stakeholders with disabilities were included in the requirements engineering process. Both teams benefited from the experience as indirect knowledge acquisition occurred. Students from a previous offering of the course, with no external stakeholder interaction, demonstrated lower levels of accessibility understanding.

1. Introduction

Software systems in the home, the classroom, and industry have enabled users from diverse backgrounds to participate in society. To prepare prospective software developers, course projects are commonly used in software engineering courses. Stakeholders are identified at the onset of a course project, along with the initial statement of needs. As part of course planning, the instructor may act as the primary stakeholder(s), and/or external stakeholders are recruited. Both stakeholder approaches have been utilized by the author in an undergraduate Requirements Engineering course.

The undergraduate program in Software Engineering at the Rochester Institute of Technology (RIT) is a 5-year program that includes a Requirements and Specification course. The course is typically taken in the 4th or 5th year, before the student enrolls in the capstone sequence. The course is 10 weeks in duration, with 2 meetings per week for 2 hours per meeting. The course includes a strong hands-on component in the form of in-class activities and a team project that runs the duration of the course. The project provides students the opportunity to traverse the requirements engineering process through a hands-on, iterative approach. Due to time constrains, no design or implementation is conducted.

As part of the course students conduct user analysis, elicit requirements, develop system prototypes, and specify both functional and nonfunctional requirements. Accessibility requirements and the inclusion of users with disabilities as part of user analysis are presented as part of the course. The topic of accessibility has made some inroads in computing education, mostly in the area of web development [5, 7]. Such courses require student projects to meet accessibility requirements, such as the World Wide Web Consortium (W3C) requirements with measured success [12].

The delivery of systems that accommodate users with disabilities facilitates participation of users who are often neglected in traditional requirements engineering activities. Users with disabilities are current and future students, employees, consumers, and citizens. As the population ages, the need will increase. To meet the needs of the disabled population, accessibility should be included in all parts of the software development lifecycle, including the requirements phase. A course lecture was insufficient as students subsequently neglected instances where users with disabilities should have been included in the requirements process. This paper presents a study conducted over two offerings of the course, investigating the impact that projects with accessibility requirements and disabled stakeholders have on students' understanding of accessibility and of users with disabilities.

2. Related Work

In computing education, accessibility is represented by the dual need to:

1. provide accessible education for students who are disabled.
2. provide all students the skills to deliver software that can be utilized by users with disabilities.

In regards to the first goal, a critical mass of investigators has emerged to share experiences and discuss results. Researchers at St. Mary's University and Winona State University have been collaborating on a project to investigate how the computing curriculum can be made more accessible to students with visual impairments, through the use of commercial assistive technology and through the development of a tool to support Java programming [4, 10]. Researchers at Curtin University have worked with Cisco Systems to develop an accessible version of the Cisco Network Academy Program's e-learning environment [8]. In both cases, students with visual impairments were the stakeholders and user analysis and testing was undertaken by those who developed the tools in the research setting. Stakeholders with disabilities provide an honest portrayal of disabilities and needs.

The second goal is being undertaken by researchers as well. A number of institutions investigated approaches to prepare computing students to deliver accessible systems. At the University of Massachusetts, Boston researchers have studied the inclusion of accessibility in the introductory CS course (CS1) [2]. The resulting guidelines and sample projects provide instructors with the means to introduce accessibility using a hands-on approach. Such early introduction distills habits that students can carry with them as they develop future systems. Web design courses have been modified to include accessibility topics and the inclusion of projects that must meet accessibility criteria and support screen readers [7, 9]. In one such course, a speaker who is blind demonstrated her use of assistive technology to the class [9]. At the capstone level, students from various institutions have undertaken projects that have accessibility requirements [5]. These endeavors demonstrate that accessibility concepts can be successfully integrated into computing courses at the undergraduate level.

This paper presents an investigation into how successful accessibility can be presented, through the use of stakeholders, as part of a software engineering course. This work builds on the prior work of others to include elements such as real users and real world projects [1, 6, 11]. Many courses, include real world projects, including the participation of industry, especially during capstone courses. The Software Engineering program also includes real world projects in the capstone sequence. Students also complete a year's worth of cooperative education. Yet the need for accessibility is often not included as part of these experiences.

3. Research Questions

The course project and the use of stakeholders with disabilities were critical to the research questions. There were two main questions were:

1. Would the use of stakeholders with disabilities cause the students to have a greater understanding of the stakeholders and to include them as stakeholders in other potential systems?
2. Would the discussion of the stakeholder interaction and artifact dissemination with the students who did not have stakeholders with disabilities result in greater understanding through passive instruction for these students as well?

4. Course Projects

On the first day of class, project concepts are introduced immediately. Two project descriptions were provided to the students, and each team had a week to select which project it wanted for the quarter. The instructor devised each project beforehand, providing equal detail and context.

The **BPC Project** (Broadening Participation in Computing Project) was an online forum and collaboration environment for individuals interested in finding peers interested in broadening participation in computing by members of underrepresented groups. Users would typically be members of the academic community, industry, and non-profit organizations. The goal for the site was that collaborations among those with similar interests would result in grant applications to help fund outreach activities or support programs. The system was also required to be accessible to the visually impaired. While the theme was new, the notion of online social and networking sites is part of their student life (e.g. MySpace, Facebook).

The **TYD Project** (Tune Your Design Project) was an Eclipse plug-in to provide UML support to developers and students who are visually impaired. Dual audio and visual representation was critical in order to facilitate collaboration between developers who are visually impaired and those who are sighted. While all of the students were familiar with Eclipse

and UML, the user populations were new and far outside of whom they would consider a typical software developer or student.

5 Project Structure

The course project consisted of several deliverables, each consisting of a set of artifacts. As the students traverse through each increment, the requirements evolve and mature. Each team receives feedback from the stakeholders and the instructor at each increment. The general deliverable outline is presented in Table 1.

Table 1. Course Project Components

Increment	Due	Artifact
1	End of Week 4	Vision & Scope Document
		Risk Management Plan
		Project Schedule
2	End of Week 6	70% of use cases (high level), 30% of use cases (detailed)
		Prototype
		Class diagram(s)
		Draft of SRS
3	Beginning of Week 10	90% of use cases (high level), 60% of use cases (detailed)
		Revised Prototype
		Data Dictionary
		Detailed class diagram(s), and sequence diagrams of high priority tasks
		Final draft of SRS
Reflection	End of Week 10	Project Presentation, Lessons learned report (3-4 pages)

The majority of stakeholder interaction occurred during the first 2 increments. However, interaction continued through the entire quarter.

Templates are provided to the students for use in structuring their artifacts. The students were able to choose the best software and technologies to use to develop their prototypes. For the Spring 2006 quarter, the teams utilized Photoshop, Visio, PHP, Java, and Ruby on Rails.

6. Students and Stakeholders

Both the students and the project stakeholders bring unique perspectives that together are needed for the delivery of a successful project. In addition to delivering a successful project, the goal is for students to learn the skills and internalize meaningful lessons about working with people that promote subsequent project successes.

In this section, the students and stakeholders are discussed in terms of characteristics and perspectives.

6.1 Student and Team Background

The student population is generally homogeneous in terms of gender, ethnicity, and socio-economic background. The student sample enrolled in the course reflects the overall student population in the Software Engineering program. No students with a disability were enrolled during the Spring 2006 quarter.

During the first week of the course, students were allowed to self-select teams of 4 to 5 students. The Spring 2006 class consisted of 4 teams. By the end of the first week, 2 teams had selected the BPC project and 2 teams had selected the TYD project.

Requirements engineering, was new to nearly all of the students. Out of the 18 students in the course, 2 students had some experience in the requirements engineering process, including elicitation. One of the students worked in a TYD team while the other worked in a BPC team.

A side effect of team self-selection is potential self-segregation. One of the BPC Project teams consisted of students in the university's Honors program. The team contained extremely bright students, with very high GPA's. All of the students from this team were friends. A subset of the students from the other BPC team knew one another prior to the course.

One of the TYD Project teams consisted of a subset of students who were friends prior to the course, while the other team consisted of four students who did not know one another. This second team included the only female enrolled in the course.

Both projects had accessibility requirements to support users with visual impairments. The TYD Project had significant accessibility requirements, as the primary users would be those who are visually impaired. By comparison, the BPC project accessibility requirements are moderate when compared to the accessibility needs of TYD project.

6.2 Project Stakeholder Profiles

For both projects, the stakeholders consisted of both the course instructor and at least one designated, external stakeholder. The author recruited the external stakeholders from colleagues met at conferences, meeting, and past projects that were related to the domain of the course projects. Stakeholder

participation was voluntary and was not compensated. Both external stakeholders were external to the university, thus providing realistic stakeholder interaction. A pattern emerged from previous offerings of the course, whereby students felt that the stakeholder (the instructor) was easily accessible since he/she was in the same building as the students. The stakeholders for the projects are described as follows:

- **BPC Stakeholder 1.** The external stakeholder for BPC Project is a computer science professor from a nearby university. The stakeholder is interested in BPC and was in the process of preparing a grant in this area. The stakeholder has several years of experience as a computer science professor, though not in software engineering.
- **TYD Stakeholder 1.** A professor from the department (who was not the instructor). The departmental stakeholder regularly teaches an introductory course in software engineering. The expertise as for what is important in the classroom setting was significant for the project. He also has taught the requirements course in the past, making him familiar with the general pace and structure of the project work required in the course. He has not had any students with visual impairments, but he could relate the needs of teammates and the instructor.
- **TYD Stakeholder 2.** A software developer from Europe, who is blind. He is familiar with the requirements engineering process, and part of his job is in this area. A 6-hour time difference added another layer of realistic complexity. The stakeholder speaks English fluently. He shared his perspective on how the blind use computers and develop software, including the necessities of teamwork. Like many developers, he was working long hours during the timeframe of the course.
- **BPC Stakeholder 2 and TYD Stakeholder 3**. The course instructor also served as a stakeholder for both projects primarily in the role of the project manager. The instructor is visually impaired (not blind), and has taught the course several times. The instructor's perspective is as a professor, but also as a potential user who is visually impaired. The instructor's perspective differed from the developer as she has some vision, including the ability to read magnified print.

7. Lessons Learned by the Students

During elicitation, both teams were required to elicit requirements and domain knowledge from various stakeholders and other resources. Initiative was critical as the information was not handed to them by the instructor or located in their textbook.

Several key areas emerged as having a great impact on the TYD Project teams' abilities to successfully convey the appropriate requirements of the system. The TYD project required the students to acquire new domain knowledge in accessibility in order to communicate an effective specification. This new knowledge was shared not only represented in the artifacts but also in how they spoke about the project to others in the class.

7.1 Basic Domain and User Knowledge

None of the students on the TYD project teams were familiar with how the visually impaired used computers at all, much less to develop software. Such knowledge was essential in order to communicate with the stakeholders and to successfully complete the project. Both TYD Project teams spent time researching the technologies used by the blind and learning from the external developer stakeholder how he personally used such technology. Due to the personal connection of the knowledge to the stakeholder, many of the TYD team students expressed repeatedly how they respected him and his perspective.

Examples of knowledge that was memorable to the students included:

- The blind do not use the mouse when interacting with the computer.
- Memorization is a key skill to many computer users who are blind.
- While audio can be useful, it needs to work with the user's environment.
- The feeling of independence and self-reliance is important for blind and visually impaired users.
- Software is most useful when it works with screen readers or other assistive technology that is already in use.
- The use of the same software that sighted developers' use is preferred over "special" software.

Neither of the BPC Project teams made any notable effort to gather background or requirements in the area of accessibility from their stakeholders. However, the BPC Project teams did express more interest and curiosity about accessibility after the TYD Project teams presented their initial system prototypes mid-way through the course.

7.2 Overcoming Personal Stereotypes to Enable Effective Communication

While stereotypes transcend disability, the TYD Project demonstrated how stereotypes about the disabled persist and such stereotypes can impact software developers. Stereotypes and misconceptions

were issues that the teams needed to overcome in order to have meaningful communication with the developer. Such topics are often not touched upon in a technical course, but the instructor offered advice to the TYD Project teams about the issue when it was evident that the level and quality of communication was being affected.

For example, by Week 3 a noticeable lack of requirements elicitation was apparent for one of the TYD Project teams. After meeting with the team, an issue surfaced that if not addressed would doom the project. The members of the TYD Project were not sure how to address the developer who was blind or how refer to his blindness in the context of using computers. Such interaction was critical, and avoiding the topic impacted their understanding and completion of the project. The team felt uncomfortable asking the developer how he used computers or using the words "blind", "see", "view", or "visually impaired" either to him or in the documentation. The concern that the students had was that they did not want to offend the stakeholder. There was also some question as to how someone who is visually impaired can even use a computer. During conversation, the instructor was not surprised at their concerns, as she has encountered it several times herself. The instructor's advice was for the students to ask questions of the stakeholder in a professional manner, and that the terms "blind" and "visually impaired" are appropriate though there are differences in meaning.

On a similar note, both TYD Project teams did not know how to refer to users who were not blind. This issue was in contrast to the first one as the students used the terms "normal vision" or "normally sighted". These terms can be quite offensive in and of themselves.

After discussing the issues directly, the students felt remarkably more comfortable communicating with the stakeholder and with the project as a whole. The students' newly found confidence in discussing the use of computers by the blind and visually impaired was demonstrated in project artifacts and during class demonstrations and presentations to peers.

During the initial prototype presentation, the TYD Project teams were educating the BPC project teams about accessibility and correcting misconceptions that they had about visually impaired computer users. Such exchanges have never occurred in past offerings of the course, although the instructor did include accessibility as a course topic.

The personalization of the experiences of someone in industry had a strong meaning for the students, which they integrated in the class presentations and later in their exam.

7.3 Flexible Stakeholder Communication

The fact that the developer stakeholder was remote reinforced the need for flexibility in communication. However, the TYD Project teams quickly realized that all of their communication needed to be text-based. The consequence was that visual aspects of the project needed to be described, including discussion of navigation and selection of items.

Prototypes were required for the project, and they took the form of both horizontal and vertical, throwaway prototypes. While developing screen mock-ups was critical, the students needed to describe them to the stakeholder who was blind. The students adapted to the need to communicate in a purely textual form, though they did spend more time than the BPC Project team in gathering feedback on their prototypes from the stakeholders. Part of the reason for the regular feedback sessions was the complexity of the use of an audio interface for what would ordinarily be a highly graphical system.

7.4 (Accessibility) Requirements can be Complex

Accessibility permeated the TYD Project. As such, the project teams learned quickly that the accessibility of the system could not be described in a sentence or two. As the project progressed, the requirements and prototypes became more detailed and meaningful. Attention was paid to how the system would work with common assistive technology such as screen readers and Braille displays.

The BPC Project was an online project, and so the teams primarily relied on the W3C accessibility standards [9] and the motivation of Section 508 [3]. The use of the standards was in their view, fulfillment of the requirement. After feedback was received from the TYD Project teams and the instructor, the BPC Project teams acknowledged the need for rework but that "the accessibility would be addressed later."

7.5 Not all (Disabled) Users are the Same

The concept of user classes was discussed early in the course. As a result, many of the students will simply list "Disabled Users" or "Visually Impaired Users" as a single class of users, if at all. The TYD Project teams experienced first-hand that not all visually impaired users are the same as one stakeholder was blind and one was partially sighted. Further elaboration was provided in the user analysis portion of the documentation, that provided as great a level of detail as the other user classes (including those from the other project teams).

In terms of the prototype, the user interface developed by both teams accommodated users at various points of the visual spectrum, from sighted to partially sighted to completely blind. Throughout the

specification documents and the prototypes, the teams presented how these different users were accommodated as well.

8. Final Assessment

In addition to the events noted in Section 7, the research questions were assessed based on a relevant subset off questions on the final exam. The relevant questions referred to a scenario describing an electronic voting kiosk system, where the need for accessibility was explicitly stated. The questions were:

1. The Representatives from the Board of Elections in several NY counties were interviewed to gather the requirements. Do you feel that this is sufficient? Defend your position.
2. Your team provided a low-fidelity vertical prototype for the voter perspective when eliciting requirements from the representatives from the NY Board of Elections. Critique this choice of prototype for the project.

In grading each question, the mention of accessibility in the response was recorded. The discussion of accessibility was not THE answer to the question (though it was part of the answer), so the mention of accessibility was recorded rather than the points scored on the question. In counting the inclusion of accessibility, the concept must have been used correctly and in context of the scenario. One student's response set was omitted as an outlier due to his not completing the exam. The accessibility responses for all project teams are presented in Table 2.

Table 2. Student Exam Responses

Question		BPC Project Group Responses (9 Students)	TYD Project Group Responses (8 Students)
1	# of Students	5	6
	% of Group	55.6%	75%
2	# of Students	2	2
	% of Group	22.2%	25%

The student responses for the combined Spring 2006 group compared to the Spring 2005 group are presented in Table 3. The main difference between the students in the Spring 2005 class is that the students did not have any external stakeholders. The projects from the Spring 2005 course were self-selected, though accessibility was required. Accessibility was covered in the course to the same extent.

Table 3. Comparative Spring 2006 and 2005 Student Exam Responses

Question		Combined Spring 2006 Group Responses (17 Students)	Spring 2005 Group Responses (17 Students)
1	# of Students	11	7
	% of Group	64.7%	42.2%
2	# of Students	4	3
	% of Group	23.5%	17.6%

The exam questions were also used as part of the Spring 2005 final exam. Both questions 1 and 2 utilized the same scenario, thus addressing any differences in interpretation. Both questions were at the same point in the exam.

Approximately 65% of the Spring 2006 class identified the need to include users with disabilities in Question 1, compared to 42.2% of the Spring 2005 class. The difference between the two Spring 2006 project groups is also notable, as shown in Table 2, as the TYD Project teams had a greater instance of including stakeholders with disabilities than the BPC teams. The inclusion of disabled stakeholders was significantly greater in Question 1 for the TYD Project teams, who had direct interaction with the external stakeholder who was blind. Passive learning was apparent with the BPC Project teams as their response rate is greater than the Spring 2005 students, with 55.6% and 42.2% respectively. This difference can be explained as a positive effect resulting from the ongoing discussion on project accessibility issues between the TYD and BPC teams.

The difference was less notable between the BPC and TYD teams in Question 2, with 25% and 22.2% respectively. A larger difference exists between the Spring 2006 class and the Spring 2005 class, is noted with 23.5% and 17.6% respectively. These results show that the students in the Spring 2006 class all benefited from the inclusion of accessibility and the stakeholder elicitation in the project demonstration and discussion throughout the quarter. While neither response rate was as prominent as those for Question 1, an improvement in the identification of the need to include disabled stakeholders and accessibility in system prototypes is noted as a move in the right direction. A more direct question, may have yielded a better result, but the desire for students to include

users with disabilities in mainstream software development is an overall objective for accessibility.

9. Summary

The inclusion of an external stakeholder to support the project accessibility requirements was beneficial to the student experience. The final exam data showed that the project itself did not need to be in the area of assistive technology in order to show that learning and appreciation of the issues transpired. The personification of accessibility had an impact on the students, whether the interaction was direct or indirect. The greatest impact was on direct contact, based on the exam assessment and as demonstrated through the project itself.

Recruiting external stakeholders is no simple task. The task of recruitment takes time, and time may need to be extended when the stakeholders are required to have specific attributes. Be prepared to use all of your resources to locate the best candidates. Utilizing multiple stakeholders is preferred, as people are busy with their careers and interaction with multiple teams can become overwhelming.

The end result was a positive experience for the students, and an added benefit should be noted. When students interact with stakeholders who are disabled, who are professionals, students' stereotypes and misconceptions are challenged. Several of the students who communicated with the blind software developer mentioned how they respected him for his abilities – rather than pity for his disability. Such lessons can help bridge the gap that can occur between the stakeholders and the developers, whether that gap is perceived or actual.

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