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Empathy-Driven Student Transformations: Bridging the Gap in Software Development for Inclusive User Experiences

Jami Cotler
Siena College
Loudonville, NY USA

Eszter Kiss
James Cook University
Brisband, Australia

Dmitry Burshteyn
Siena College
Loudonville, NY USA

Megan Hale
Brockport College
Brockport, NY USA

Amani Walker
Siena College
Loudonville, NY USA

John Slyer
SkyHigh Adventures
Avrill Park, New York USA

Abstract

Developing empathy skills is crucial for software developers to create user-centric solutions and design exceptional user experiences addressing the diverse needs of customers. This paper presents the findings of a quasi-experimental study that aimed to enhance empathy among computer science students through the exposure of two interventions teaching about accessibility design. The study included 43 participants from two computer science courses from the same university. Quantitative data analysis using the Perth Empathy Scale revealed a significant increase in an aspect of positive-affective empathy among male participants. Qualitative data analysis of participants' reflections highlighted the transformative impact of the interventions, as participants expressed changes in their views towards people with impairments and reported the development of technical and soft skills, as well as enhanced empathy. The interventions also motivated participants to make changes to their team website designs, prioritize accessibility, and apply their learnings in their professional lives. A third measure was an expert website review which provided valuable feedback for improvement and yielded a high average score for screen reader accessibility. By equipping future computer scientists with these skills, we can ensure that technology meets the diverse needs of all users, promoting inclusivity and enhancing user experiences.

Keywords: Accessibility, Empathy, Career Readiness, Software Development, Inclusive Design, UX Design

1. Introduction

Developing empathy can arguably be one of the most important skills a computer scientist can develop (Gunatilake et al., 2023; Karimi & Pina, 2021). Empathy offers a gateway to self-awareness and navigating interpersonal relationships and is essential for software developers to create more relevant products. To be successful as a software developer a professional must be able to interact with a diverse group of colleagues, clients, stakeholders and leaders. Due to the complexities of software development, teams of professionals must work closely together, putting a premium on teamwork, problem solving and communication skills (Singh et al., 2012).

Brené Brown (2018) defines empathy as a proactive, judgment-free approach to use perspective-taking to understand and resolve problems. Empathy enables developers to build better software that truly meets the needs and expectations of its users. Having empathy skills is essential for software developers because it enables them to understand and connect with the end users of their products. By empathizing with users, developers can gain valuable insights into their needs, challenges, and preferences, which in turn allows them to design and develop software that truly addresses those requirements. Empathy also plays a central role in effective communication within development teams and with stakeholders, fostering collaboration and building trust (Rivas, Husein, 2022). Furthermore, empathy is a key component of user experience (UX) design, helping developers create intuitive interfaces and workflows that enhance user satisfaction. Finally, empathy promotes continuous improvement, as developers who empathize with users seek feedback and make iterative enhancements to their software. Overall, empathy skills empower software developers to create user-centered solutions, communicate effectively, design exceptional user experiences, and collaborate successfully with others (Blanco, López-Forniés, and Zarazaga-Soria, 2017; Lariza Laura de Oliveira., 2020).

There are many definitions of empathy available to the scientific community. Most of the definitions characterize empathy as a multidimensional variable encompassing two major factors: cognitive empathy and affective empathy (Cuff et al., 2016). Cognitive empathy is defined as the ability to deduce and recognize the emotions of others, while affective empathy indicates one's ability to experience other individuals' emotions by observing their behaviors (Riess, 2017). It implies that people with higher levels of empathy can not only recognize the emotions of others but also experience these emotions.

According to the World Health Organization (WHO, 2023), 16% of the population or 1.3 billion people have some sort of a disability. This includes visual, auditory, physical, speech, cognitive, language, learning, and neurological disabilities. It is important for computer science students who will be developing our next generation of technology to understand and even experience what it is like to use the technology they are developing as a person with a disability (Lay-Flurrie, 2021; Walther et al., 2017; Wolberger, 2023). Such technology will often require the implementation of special products such as screen magnification software, screen readers, speech recognition software, special keyboards for communication, and more. Moreover, these skills are rarely taught as part of computer science education (El-Glaly et al., 2020; Ferati & Vogel, 2020).

Empathy plays a pivotal role in the design of accessible software, ensuring it delivers robust solutions for its users (Paananen, Visuri, van Berkel & Hosio, 2023). When software developers empathize with individuals who have different abilities, they gain a profound understanding of the challenges and obstacles they face when using technology. This empathetic approach empowers designers to proactively identify and address accessibility issues, creating inclusive software that can effectively cater to a wide range of individuals, including those with disabilities. By incorporating accessible features, intuitive navigation, clear interfaces, and alternative input methods, empathetic designers enable users with disabilities to access and engage with software effectively. Furthermore, empathy fosters an inclusive mindset that goes beyond mere compliance with accessibility standards, aiming to provide a meaningful and enjoyable experience for all users. By embracing empathy, software designers become catalysts for breaking down barriers and promoting universal access to technology, ultimately enhancing the lives of individuals with disabilities and fostering a more inclusive digital landscape.

The Empathy Lab experience used in this study has been designed to allow students to have an immersive experience using a variety of assistive

technologies from the perspective of a person with a disability and consisted of two interventions. Students start this work by developing a website for a young elite triathlete. In the first intervention, students learn that their client is blind. They learn firsthand about her lived experiences and how she did every-day things familiar to them such as taking notes in class, buying clothes at the bookstore and reading textbooks. After gaining insights about their client, they are offered the chance to use a screen reader while blindfolded, as per their client's suggestion. The second intervention focuses on five hands-on activities including writing appropriate alt tags, understanding WCAG compliance requirements, hearing and physical impairment simulations and developing accessible code.

Students learn that when they design technology from an empathic perspective for a variety of potential users, the end-product may ultimately be more enjoyable and easier to use by everyone and not just by those whom it was initially designed for. When we design something that can be used by those with disabilities, we often make it better for everyone (Steere, 2008; Norman, 2013).

2. Literature Review

Empathy is a fundamental aspect of human interaction, and its relevance extends to the field of computer science. This literature review explores the pivotal role of empathy in computer science education, software development, and various domains of software design. To address the issue of inaccessible software and the lack of accessible educational materials, a team from RIT developed five Accessibility Learning Labs (ALL) with an experiential learning approach used to educate participants on creating accessible software. The team demonstrate the importance of accessibility across various topics, such as colorblindness, hearing, blindness, and dexterity. All instructional materials can be access using just a web browser (Shi, Malachowsky, El-Glaly, Yu & Krutz, 2020; Moses, Thazin, Nalachowsky & Krutz, 20023). Blanco, López-Forniés, and Zarazaga-Soria (2017) advocate for empathy as a foundational skill for informatics students, emphasizing its importance in fostering teamwork competences. Levy (2018) reinforces this by highlighting the integration of empathy into software engineering courses, emphasizing its potential to deepen students' understanding of user needs. In the realm of software development, Levy and Hadar (2018) stress the critical role of empathy in privacy requirements analysis, emphasizing its significance in designing systems that respect user privacy concerns. Lundström, Åberg, and Blomkvist (2015) shed light on empathy's role in fostering effective collaboration between developers and designers, emphasizing mutual understanding. Moving to mobile applications, Papoutsi and Drigas (2017) demonstrate how empathy enhances user-centric app design, while Kletenik and Adler (2022) creatively use games to instill empathy and promote accessibility awareness. Baker, El-Glaly, and Shinohara (2020) advocate for accessibility education in computing, highlighting the importance of empathy for users with disabilities. Virtual reality's potential in strengthening empathy and mastery learning is explored by Abadia, Calvert, and Dasika (2019), with Zhongxiang's (2023) meta-analysis supporting the notion that virtual reality can effectively enhance empathy. In industry, Drouet, Sleeswijk Visser, and Lallemand (2023) showcase real-world applications of empathy-centric design, while Gonzalez, George, Miteva, and Singh (2023) illustrate how gamification can foster empathy, especially for individuals with invisible disabilities. Lariza Laura de Oliveira (2020) examines the student perspective on empathy in the computer science classroom, offering valuable insights, and Fabrícia de Jesus Santos, Antonio Lucas de Almeida, Breno Santana Santos, Caio César Alves de Souza, and Marcos Neto Santos (2018) provide a systematic mapping of empathic computer science, summarizing the state of the field.

Overall, this literature review highlights the growing recognition of empathy's significance in computer science education, software development, and various domains of software design, underscoring its role in fostering effective collaboration, user-centric design, and a more inclusive digital world.

3. METHODOLOGY

Our study included participants who had voluntarily registered for two computer science courses offered in the Spring of 2023 semester. The participants were divided into two conditions based on their self-selected course registration. The experimental group consisted of 18 participants from the software engineering II class, while the corresponding control group had 25 participants from a web app development class. The selection of participants for each group was based on the experimenter's availability to administer the appropriate treatment to each condition. Institutional review board approval was received for this study.

This study used mixed methods approach along with an accessibility expert review. The quantitative analyses focused on the respondents' empathy with the help of the self-report Perth Empathy Scale (PES) (Brett et al., 2022). This instrument was administered to each student in the study at the beginning and end of the study. This self-report scale consisted of 20 items and is validated to assess both the cognitive and affective empathy, including their valence-specific aspects. This multidimensional empathy construct was selected due to its reliably and validity measures (Brett et al., 2022).

The qualitative research was based on the reflections collected after each of the two interventions: the reveal of the client's condition (female=20%, the rest were males) and the immersive Empathy Lab workshop (female=21%, the rest were males) in the software engineering II class. Reflective questions are listed in Appendix A. All students were seniors; the assignments were a required and graded part of the class, however students had to opt into the study for the authors to use their reflections. Not all students who gave permission completed the assignment for the first reflection. Both reflections included the same six questions about the students' view on people with impairments, skills developed, potential modifications on their project deliverables, students' view on future design and development of technology as well as the application of key learning, and finally, some feedback on the workshops. The researchers received permission to use 15 reflections. The reflections were typed and managed anonymously. Qualitative data interpretation was organized in four stages: 1. the researchers developed a codebook (appendix B & C), 2. researchers coded the data and 3. validity was established through interrater reliability and 4. data was analyzed and interpreted. The code book was developed using three methods. The first method was traditional coding, the next through AI-assisted coding, and the last through NVivo. NVivo, helped organize, analyze and find insights in our non-numerical or unstructured data. During the process of manual coding the researchers used inductive reasoning. Major themes were identified along with the codes to each response, and they were organized in a database. In the process of AI-assisted coding, prompts were fed to ChatGPT for refinement of the extraction. ChatGPT produced a list of key findings along with the corresponding quotes. The manual coding provided the frequency of codes along with deeper interpretations (appendix D). The AI-generated content was then integrated into the output produced by the manual coding and summaries were created. Finally, the responses were fed to NVivo for further refinement.

A final measurement was an expert analysis by the blind elite triathlete of the websites the student teams designed. The sites were reviewed twice during the semester with feedback for improvement. A final grade out of ten was assigned based on the "readability" of each of the sites. The user accessibility rating was part of the assignment grade.

4. RESULTS

4.1 Quantitative Results

The Perth Empathy Scale was used to assess pre- and post-differences in our participants. Our item analysis yielded statistically significant pre-post differences only in our male participants on the following item: "When I see or hear someone who is calm it makes me calm too.", indicating an increase in their Positive-Affective Empathy, $F(1,19)=4.789$, $p<.041$. An Analysis of Variance (ANOVA) yielded no statistically significant difference in these repeated measures design between experimental and control groups for the following subscales of the measure: Negative-Cognitive Empathy, Positive-Cognitive Empathy, Negative-Affective Empathy, Positive-Affective Empathy, and corresponding composite measures including General Cognitive Empathy, General Affective Empathy, and the composite Empathy Measure.

4.2 Qualitative Results (for all participants)

Intervention #1: Client Reveal

Question 1:

To the question inquiring as to whether the participants' view about people with impairments changed after revealing the client's condition, 71% claimed it changed, 7% reported an unchanged view and 21% remained neutral. Respondents whose view changed after the intervention noted the respect for people with impairments when it comes to navigating the website, spending time on making technology work for them, and running screen readers and narrators. Some respondents expressed how seemingly frustrating it could be for people with visual impairment to run "something you work with daily". Respondents also expressed their empathy for spending "some time in their shoes for a couple of minutes was really frustrating, had to really try to use other senses to operate".

Question 2:

Participants were asked if they developed any

new skills during the workshop. All fourteen participants were positive about developing certain skills. And these skills were linked to navigating websites with the help of a screen reader (71%) and using a keyboard (7%). Of respondents, 22% claimed they developed their empathy skills: "I think my empathy skills developed some more. Getting to work with it and understanding the difficulty helps me see things from the point of view of others who may need this technology". Some respondents started to think how the experience might impact their future: "From now on I'll be more conscious of these things and try exercises to put myself in the place of other people" and "I will take my time in everything I do from a perspective of an impaired person." They found that incorporating and testing accessibility might be a key learning from this experience: "I learned how important it is to incorporate accessibility into our websites."

Question 3:
All fourteen respondents agreed to make changes to their existing website to "appeal to the clients" and to include "the basic accessibility features". They envisaged to do these with the help of divs (7%), better headers (14%), more efficient use of screen readers (21%), and more descriptive alt tags (50%). It seemed to be an enlightening exercise as the respondents overwhelmingly stated they need to make various changes: "will make many changes to our website after going through this workshop" to make the website "easier to navigate", "less cluttered", and to "include assurances that our images will be able to be read out in descriptive fashions".

Question 4:
The next question considered changes to designing and developing technology in the future. Of the respondents, 71% were positive about taking steps towards more accessible technology in the future while 28% found they would make changes if they are relevant depending on "the projects" and on the "company's expectation". Fifty-eight percent expressed their plans to help accommodate diverse needs and make everything they produce more accessible. These sentiments were captured in the following quote:

> "I will improve on what I know and create all my future technologies to be accessible to people with impairments and for them to easily navigate them and to have the ability to reach their goals at the same time as someone who does not have impairments."

Question 5:
The next question enquired about how participants could apply the key learnings of the workshop in their professional life. Of the participants, 93% had a clear view on how to apply their key learnings, while the remaining 7% was unsure. Twenty-eight percent noted that the employers' expectations might play a role in how they utilize their newly acquired skills. They also found that possessing the skills and mindset of inclusivity might aid them when looking for jobs: "Some companies really care about this, so if I am applying for a job at that company, this will help me have some background knowledge about or research of need".

These might be useful when already working for an organization: "The best companies and government websites put a large emphasis on things like accessibility so (…) having empathy for others will be a good thing to have and show to my employers". Likewise, when it comes to changing business practices, these skills might prove useful: "I will make it an effort (…) to always include accessibility settings to help people with impairments easily navigate through the product. This will also aid the company to change the ways they implement their products". The efforts to "make pages simpler and easy and short" and to create a good layout with "attention (…) to the way a site will be read from someone using a screen reader" were also considered by the participants. Fifty percent found that generally thinking of inclusive application would be a key requirement of developing any piece of technology. Of participants, 21% wished to be "informing others about using techniques that help with accessibility". One of their peers shared their sentiments through this quote:

> "I plan on being a greater advocate for making sure that any project I work on is visually impaired compatible. In that regard, just being aware of the many different needs that your users/customers may have is very important for maintaining user satisfaction."

Question 6:
As far as the content and delivery of the workshop went, participants were asked to provide their feedback and 93% found the workshop useful. Participants especially appreciated the demonstration of the "many problems with trying to use the screen reader", the "format of the workshop", "the contrast between navigating through the website with the navigator when not blindfolded", and the overall "understanding how the [client] uses technology". Participants expressed their wishes to familiarize themselves with the screen reader deeper and to demonstrate "using the screen reader with other aspects of the computer such as desktop

applications". They would have also wished to see real-life presentation from the client: "Something that would be helpful would be to see how [the client] uses a website herself in depth, so we get an even better understanding". However, the practical nature was highlighted as a great way to understand challenges faced by blind people using technology: "with learning anything it is better to do it with practice and that is what this workshop has done so it was very helpful in helping us get a better understanding of the concept".

Intervention #2: Empathy Lab
The second intervention was the Empathy Lab after which students reflected on the same set of questions as the one after the first intervention.

Question 1:
To the question on the view about people with impairments 93% of the participants noted that their view has changed after the intervention while 7% remained neutral out of the total of 15 responses. Participants referred to empathy (64%) as the main factor that has changed after the intervention. Some views expressed milder sentiments: "Getting into their shoes, and actually feeling what they might makes me feel even more empathy for them". Others have shared stronger sentiments on the topic: "To pass judgment onto someone just because they're different from you is fairly obdurate and quite frankly inhuman".

Participants agreed that understanding the challenges faced by individuals with specific impairments is imperative in their personal and professional life. Hence, they acknowledged the importance of accessibility and inclusive design: "Putting myself in their situation with the exercises has shown me how important it is to be able to make it easier for them and more accessible for them so they can navigate through it easily". And this might contribute to changes in the way they complete tasks in the future: "The lab showed me how to create a more engaging software that will be able for people of all kinds of disabilities to use without any hitches".

Question 2:
The second question was enquiring about any new skills that students have developed as part of the exercises. Of the responses, 71% included mentions to different applications such as those related to images: "I improved my skill of being able to better explain a picture without (…) making the description too complex." Similarly, "I had to find creative and descriptive ways to explain a picture.", the use of alt tags: "I developed the ability to create more meaningful alt tags to make images more accessible", or more effective color selection: "One new skill I learned is finding more accessible colors.". These participants claimed that designing with accessibility was the main finding for them: "I feel I've gained the ability to better design things to fit people from all walks of life, not just for people like me". However, the findings were not only referring to technical skills but those of soft skills. As one participant claimed he "also learned how to apply teamwork to help with getting through a challenge caused by an impairment". Of the responses, 50% of the responses indicated the development of these soft skills as a result of the intervention: "Experiences like these are important to refining one's sense of empathy, especially for those that one may never consciously think of".

Question 3:
To the question of whether students were going to make changes on their teamwork website, all responses indicated unanimous agreement for the need for practical considerations inspired by the content of the workshops. Participants were looking at ways of redefining alt tags: "revising the alt tags for images to be better tailored to blind people.", color selection: "Our color scheme is lacking contrast between the text and different background colors.", and turning the content more concise: "In terms of length, it should be short and concise, with a lot of detail on colors". One participant even considered "testing every feature to make sure it works correctly and for everyone no matter the disability".

Question 4:
The next question looked at potential change participants could make to their way of designing technology in the future. All the 15 responses expressed the wish to do so; people-specific changes surfaced in 43% of the responses, while 64% of responses mentioned tech-specific ideas. Awareness and education were considered to be useful when planning for accessibility in the future with one participant referring to advocacy ("will apply to my professional life because I can advocate for more awareness for people with disabilities and impairments.") and another to education ("probably educate people on practical programming and design with these thoughts already in mind."). User experience was another highlight in future-proofing design ideas: "I also want to make sure that any technology I work on is not only usable, but enjoyable for all people to use". And as another participant found it keeping the notion of accessibility in mind could help all users:

> "I will definitely adjust how I develop tech as a result of this workshop. (…) By developing for an audience of everyone in mind, applications will be better for everyone as the simpler and more logical way they're designed and made to be used for, the easier it is for the average user to figure out."

Participants highlighted several technical considerations, such as easy navigability (21%), testing screen readers (14%), efficient use of alt tags (21%), clearer application of colors (28%), and overall design ideas (14%). It was apparent from the responses that students were not only thinking of what to change but also of how to change them:

> "I have made it a goal to study accessibility features and how to implement them in the best way possible to make the audience's experience appealing. That includes alt texts, organizing the sections to make it easier for the navigation system, and making the color, font, and style much more visible and easy to look at."

Question 5:

The next question sought students' ideas on how they might apply the key learnings from the project in their professional life. Of the responses, 93% indicated firm ideas about future application of the learnings on accessibility and inclusion. One participant thought of testing their product: "Going forward I would make changes to my designs from and be sure to have them thoroughly tested for usability". Others were thinking of what to do with the newly acquired skills: "I'm going to take the skills that I learned from this project and make sure to apply them daily whether I am a developer or have another job". And considerations of career prospects were introduced, too: "I want to be in the front-end developing career path which means I will need to pay attention to this". Some participants looked at the employers' perspectives: "change the ways they implement their products to meet the needs of impaired individuals". And someone already thought of what values to look for when applying for jobs:

> "There's a few values I want to see in companies when I apply for positions, the most important to me being diversity and inclusion in the workplace, but I will definitely advocate for accessibility development when I have a job."

This tied in with another response highlighting empathy as the key take-away from this project:

> "I can apply this workshop by showing stronger levels of empathy with the impaired, whether it's a client or teammate. I can also propose these problems to teams in the future to make sure these issues are accounted for. I can also make sure the way I carry myself is more in line with peoples' disabilities so for situations where I'm with someone in person, I'm more empathetic."

Question 6:

The last question was asking for feedback on the delivery of the Empathy Lab workshop. Most participants found it useful (78%), only 7% was indifferent as they already claimed to have enough awareness on accessibility features. The rest did not address the issue of usefulness. Of the responses, 43% indicated that students would have loved to spend more time on the activities. Participants fully enjoyed the workshop but also expressed a wish of "the only thing that I would think would be useful in the future is more time at each station". Some participants would have loved to gain more knowledge on the resources, for instance "Something that can be addressed is the tools for those who can't type or touch the screen and would have to talk to make a command". Upon providing valuable suggestions, participants completed the Empathy Lab at a high note:

> "It was good to highlight the different disabilities that exist in a safe, learning environment. It was good to separate these as not all disabilities are the same and most require completely different ways to ensure proper accessibility. Furthermore, it was good to simulate some of these as it allowed us to properly gain insight into what people experience so that we may be more considerate when designing our future applications."

The Expert Website Review:

The client provided feedback throughout the lab after her blind condition was revealed. She remarked on her "readability" of the web sites and offered direct feedback for improvements. Some comments addressed screen reader "readability", poorly labeled images and links, and the heading structure. At the end of the semester, she provided a final rating from 1-10 on a screen reader accessibility: 1 being unusable and 10 being excellent. The four teams were rated between 5-10, with an average score of 7.6.

5. DISCUSSION

Our quantitative findings indicated that the interventions had a positive effect on male students, enabling them to enhance their understanding and sharing of the positive emotions experienced by others. Importantly, this increase in emotional capacity signified an

improvement in their ability to genuinely connect with others and experience happiness for their successes and accomplishments. Moreover, this heightened emotional dimension suggested the potential for stronger emotional connections, leading to more profound and meaningful professional relationships as well as improved intimate relationships. Consequently, these improvements had the potential to enhance the quality of personal relationships across various contexts, ranging from everyday social interactions to workplace success.

The qualitative reflections generated rich discussions on the topics in question. The responses of the reflection exercise indicated the overall success of both interventions - especially the Empathy Lab. The notion of respect shone through all the responses. Participants claimed that the workshops increased the level of respect they feel towards people with impairments. The interventions helped them with understanding the challenges and frustrations of working with technology, especially when accessibility is not a priority in design. Furthermore, participants reported that they developed technical skills and soft skills and -most importantly- empathy skills for employment. They claimed that these skills may help them in applying for jobs and they reported a general sense of direction in their career. Participants presented a high level of adaptability when it came to making changes to the original website design. Finally, the reflections on the interventions were positive, reporting that the workshops were meaningful and life-changing.

6. LIMITATIONS & FUTURE WORK

Despite the fact that our sample is representative and generalizable to other computer science classes within similar university systems, further research is needed to assess the generalizability beyond this specific academic context. Follow-up studies should involve larger sample sizes and include participants from a variety of universities and professional settings, both within the United States and internationally.

Future research should also explore adding new dimensions, such as programming assignments focused on mobile devices and other technology. Additionally, issues related to various types of accessibility impairments need to be examined. These could include speech, language, and hearing, as well as physical limitations like impaired motor skills, dexterity, and mobility.

Our quantitative findings suggest that males might benefit more from the training than females. This observation aligns with research indicating that females generally excel in recognizing emotions and demonstrate higher levels of empathy (Rueckert & Naybar, 2008). To confirm these preliminary findings, more rigorously controlled studies should be conducted. These should address potential ceiling effects and examine the effect sizes specifically for female participants Additional controlled experiments are essential for empirical validation to provide more conclusive evidence for our initial observations.

Overall, while this study demonstrated strengths such as the use of a validated measurement instrument, its quasi-experimental design introduced limitations primarily related to internal validity, specifically the absence of random assignment and the unequal group sizes.

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APPENDIX A

Reflection questions after both interventions

1. Did your view about people with impairments change? If it did, how did it change?
2. Did you develop any new skills during this workshop? If so, what are they?
3. Will you make any changes to your team's website design as a result of this workshop?
4. Will you make any changes to the way you design and develop technology now and in the future as a result of this workshop?
5. How can you apply what you learnt from this project in your professional life?
6. Is there anything that could be changed in the delivery of this workshop to provide a better learning experience? For example, what did you find the most useful and what else could be addressed in this workshop?

APPENDIX B

Themes, codes and comments – Intervention 1 (Client Reveal)

Q	Themes	Codes	Comments
1	challenges	difficulty to navigate time consuming	changed view: in 10 responses; neutral: in 1; slightly changed: in 1 response
	tools	screen reader narrator alt tags	
2	developed skills	keyboard narrator navigating web page screen reader	all 14 responses were positive in developing certain skills
	developed empathy	developing empathy	
3	accessibility in general functionalities	general accessibility appeal divs headers screen reader alt tags	all 14 responses were positive on making changes
4	making changes	making change for diverse needs making change if relevant testing	10 responses were positive in making changes; 4 responses were tentative
5	employment	accessibility as per employers' expectations accessibility as per students' own discretion	13 had a view on how to apply the key learnings; 1 was not sure
	research	gather more information	
	advocacy	informing others of accessibility issues	
	being inclusive	Inclusive application	
	design	simplicity layout	
6	workshop	order of tasks more explanation understanding and empathizing	5 responses on usefulness without suggestions; 1 response did not find the workshop useful but made suggestion; 8 responses found it useful and made suggestions
	tools	application of screen readers more on accessibility features	

APPENDIX C

Themes, codes and comments – Intervention 2 (Empathy Lab)

Q	Themes	Codes	Comments
1	empathy application	application hard application soft application	13 changed their view; 1 neutral; 1 not changed
2	empathy application	empathy skills soft skills images software	11x responses were positive in getting new skills; 3x were neutral
3	inspiration practical consideration	ideas for accessibility alt tags colors	all 14 responses were positive on changes
4	people specific tech-specific	awareness and education legality and fairness user experience easy navigability screen reader alt tags color design	all 15 responses were positive on making changes in the future
5	take-away thought	think for inclusion think for usability empathize	all 14 responses had hints about accessibility
6	time spent on activities tools and resources skills	more time needed less time needed more tools and resources are required more skills required	11 responses found it useful (7 provided suggestions); 1 did not find it useful (provided suggestions); 2 did not address usefulness (1 provided suggestion).

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APPENDIX D

Frequencies in qualitative analysis

Codes	Frequencies Intervention 1	Frequencies Intervention 2
alt tags	50%	67%
color	21%	53%
keyboard	7%	0
layout	14%	20%
screen reader	64%	33%
testing	14%	27%
advocacy	14%	67%
developing empathy and respect	50%	60%
do research	14%	13%
employment-related considerations	36%	40%
inclusion	71%	47%
adding specific examples to workshop	7%	7%
application of screen reader in workshop	29%	0
application of worksheet in workshop	0	7%
comprehensive workshop	7%	27%
duration of workshop	0	47%
teamwork skills	0	13%