Motor-Mobility Testing for the Enhancement of Web Application Accessibility

Philip B. Gallagher
Mercer University
gallagher_pb@mercer.edu

Michael K. Griffin
Mercer University
Michael.Kerr.Griffin@live.mercer.edu

Amro Khasawneh
Mercer University
khasawneh_an@mercer.edu

Abstract - This article outlines a research initiative aimed at enhancing the accessibility of digital platforms, with a particular focus on critical sectors like telemedicine. Collaborating with the Global Partnership for Telehealth (GPfT), the authors are developing motor-mobility testing methods to improve access to essential information, starting with GPfTs Pathways application. Grounded in the revised Americans with Disabilities Act (ADA) and Web Content Accessibility Guidelines (WCAG) 2.0, the study aims to support ADA compliance and disability justice. The research herein offers both testing methods and a means to enhance the delivery of global telehealth information and services as a result of their use. This article offers a comprehensive approach to motor-mobility accessibility testing of the Pathways app, aiming to bridge the gap between education and advancing web application accessibility, ultimately fostering inclusivity online.

Index Terms - Accessibility, ADA compliance, motor-mobility testing, web applications

Introduction & Fundamental Literature

Since 2022, Dr. Philip B. Gallagher and Dr. Amro Khasawneh have collaborated with the Global Partnership for Telehealth (GPfT) on their mission to make online telemedicine accessible to everyone [1]. With offices in the United States, South Africa, and coming to South America, GPfT and these researchers have labored studiously to study the Americans with Disabilities Act (ADA), Section 508, and the World Wide Web Consortium's (W3C) Web Content Access Guidelines (WCAG) for digital information accessibility and compliance [2, 3]. Together with research partners and students, we have evaluated GPfT's web-based telehealth application, Pathways, to improve the accessibility of the platform and the delivery of telehealth services and medical information around the world. Currently, there are six categories of telemedicine barriers and challenges: (1) infrastructure and access, (2) operational and systems, (3) logistics, (4) regulatory, (5) communication, and (6) legislative [4]. Our team is focusing on the communication barriers.

As part of this research project, Dr. Gallagher has been developing testing methods for assessing the motor-mobility accessibility of web applications for the field of Technical and Professional Communication (TPC). His methods herein, unlike those of MAST in healthcare [5], focus explicitly on mobility and fine motor skills as related to communication interaction based in the contemporary app development environment. The goal of these methods is to enhance the access and operability of web apps for 'everybody,' no matter the body's fine motor or motion capabilities [6].

Akin to the motivations of past TPC adjacent studies of older adults' use of healthcare apps [7, 8, 9], the authors of this work find motor-mobility accessibility of web content to be of paramount importance because being able to do things online—like going to the doctor or doing physical therapy—makes it possible for more people to be independent [10]. Our approach to creating straightforward means and methods for assessing interactive communication compliance, based on accessible design practices and federal regulations–steps some past studies offered little detail about–are intended to help ensure that any platform can be tested to better meet peoples' needs and move app design toward compliance with government and online information accessibility standards.

So, not only does this work support users with physical disabilities, the team is also working with the goal of information and disability justice in mind [11, 12]. Still more, we are working to help the GPfT avoid accessibility litigation. Litigation is commonplace within mass communications in the US per Youngblood et al. [13], so with our assistance GPfT can continue to provide life-changing medical care around the world.

To these ends, this study of the "operability and robustness" [3] of Pathways on Windows systems (the

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most prevalent user hardware according to GPfT developers) with adaptive accessories made by Microsoft, a current industry leader in Operating System (OS) integrated adaptive technology, aims to enhance the everyday use of Pathways. More than that, this work seeks to enhance the accessibility and quality of use of any web application by providing methods for evaluation that can be used for User Interface (UI) development and design based on the results.

Working together with Dr. Amro Khasawneh, Dr. Gallagher has curated simplified, in-person means for studying the accessibility of Pathways for end-users based on users' mobility and fine motor control [1]. These methods allow us to go beyond Universal Design (UD) theory for improving UI design [6] by integrating real user feedback into the design process. Also, our structured think-aloud protocol and observation-based methods extend the use of automatic tools used in past case studies [14, 15]. As part of developing our in-person methods, we conducted a study of the ways to employ user observation and think-aloud protocol focused on body position and movement, and the completion of a heuristic evaluation based on Section 508 and WCAG 2.0 web accessibility requirements for putting people first using POUR website design [16].

Hereafter, we provide the research questions behind our study. Then, the methodology describes the workflow for using our testing protocol. We outline the full process, presenting the pretest, test, and posttest procedures. Next, we offer detailed, dual-purpose guidance so others can use our in-person motor-mobility and fine motor focused testing. To close, we offer our own simulated use case demonstration of the methods and preliminary findings. We indicate the limits, recommendations, and objectives of our testing for readers' consideration, as well as a few key takeaways from our Pathways application research in conclusion.

To that end, we turn to the research questions we adopted, and the methods we developed for doing motor-mobility observations and measurements in this study.

Research Questions

To understand the motor-mobility context and requirements for using a web application, Dr. Gallagher and Mr. Griffin asked two primary research questions.

RQ 1

How do we capture the positions and movements required for a user to interact with a web app that we can test?

RQ 2

What environmental elements (virtual and physical) must be considered during platform usage and operation both with and without adaptive tools to enhance accessibility?

To answer these questions, we undertook the development of a study and workflow to capture the user experience and accessibility of the Pathways application through examination of the following:

1) Placement & size of and motion required for interactive elements,
2) Required body positioning and mobility during platform usage
3) Traditional keyboard and unmodified mouse navigation, and
4) Operability of the application with adaptive accessories

Working with four students, Michael Kerr Griffin, Sanaa Strickland, Jorden Davis, and Lindsey Riley, the authors of this article developed the following study and methodological timeline for conducting thorough review of the motor-mobility accessibility of GPfT's Pathways web app.

Methods

To begin, for the study we looked at the existing Pathways app with the aim to make it more accessible. Though the app had been studied previously for ADA compliance of the visual communications on the platform, it had not been evaluated for motor-mobility compliance of the interactive elements and environment to see how accessible it is for users with limited movement or fine motor skills. So, in accordance with Section 508 and WCAG 2.0 standards, we set to work developing a workflow to study the Pathways application.

The workflow for the study adhered to the eight phases illustrated in Figure 1.

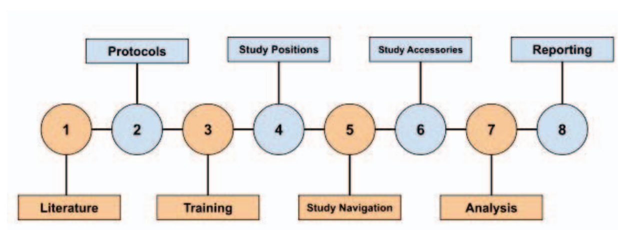

Fig. 1. Our workflow timeline.

1) Review of the literature
2) Establish protocols
3) Receive compliance training
4) Study element and body positions
5) Study keyboard & mouse navigation
6) Study adaptive accessory navigation
7) Complete Motor-Mobility Compliance Form
8) Report findings to stakeholders (in this use case, the GPfT Director of Information Technology)

These eight phases are detailed in the following paragraphs according to pretest, test, and posttest activity.

I. Pretest

PHASE 1. As part of the literature review, team members familiarized themselves with the updated Americans with Disabilities Act of 1973, the newest version of Section 508, and W3C's WCAG 2.0 guidelines [2, 3]. Afterward, each of us read a series of articles from Web AIM on motor-mobility disabilities and accessibility concerns of users with no or limited bodily motion [10, 15]. Last, we reviewed the most recent testing guidance provided by the US Access Board to establish the "ICT testing baseline for web accessibility," so that "the minimum requirements of [our] test process used to determine conformance of web content with [Section 508]" passes governmental muster [17].

PHASE 2. The team developed a task list for establishing protocols (the results of which may be found in the "Motor-Mobility Observation Guide" section below). As readers may observe, we created a systematic process for preparing, observing, and recording the body position and movement of participants, as well as the grasping and fine-motor skills necessary for interacting with the web application. With the literature and protocols, Dr. Gallagher provided training in ADA compliance review using the hardware, software, and evaluative tools comprising this study, and introduced students to the Pathway's UI.

PHASE 3. ADA compliance training for this study consisted of two 90-minute sessions. In the first session, student subject matter experts (SMEs) were trained in the practice, purpose, and importance of Accessibility and ADA compliance. Next, they learned about web apps, specifically the Pathways platform, and the tools they would use during testing. After, they received instruction on doing user testing that involves observations and Think-aloud Protocols for experiential data capture. Last, student SMEs learned how to use our motor-mobility rubric for assessing ADA compliance of online content and navigation, as well as heuristic evaluation methods they will deploy to complete a mobility quality assessment for the Pathways app. At the end of the first training session, students set up a time for hardware and software training during the second session.

The second session provided student SMEs the necessary skills to set up the study cameras, use the measuring devices, launch screen sharing and motion capture technologies, and to practice the moderator role (i.e., facilitate testing scenarios and tasks) prior to data gathering in the lab during testing.

By executing the above 3 phases, the authors of this work suggest that the proper conduct of motor-mobility compliance research for adherence to governmental regulations and online information access best practices can be achieved. The sum of these activities results in establishing the necessary knowledge and ability to collect motor-mobility data that may then be shared with application hosts, developers, and stakeholders to enhance their applications' accessibility. In the next section, we provide details about the in-person study phases of the testing workflow—phases 4, 5, & 6.

II. Test

The testing methods outlined in this section constitute the core laboratory activities required during the in-person study phases 4, 5, & 6 in our workflow for motor-mobility accessibility testing. In our use case, we conducted the following practices for the examination and evaluation of GPfT's Pathways application. However, it is important to note that any web app or online-hosted platform could be substituted for study.

PHASE 4. Working in pairs, reviewers examine all pages of the Pathways app for the positioning & size of interactive elements–links, buttons, menus, search bars, data entry locations, etc. Reviewers examine all pages from both the provider and presenter & patient roles. Special attention is given to required interactions, while optional interactions are noted as supplemental to the purpose of the application (i.e., the conduct and sharing of health information between providers and presenters & patients). During examination of interactive elements, reviewers interact with the application and record observations of the position of their body as a user. Also, reviewers annotate their activities with the required movement or motions they must take as a user. Data from this phase is later compared to best practices research on ADA compliant motor-mobility practices for navigating virtual spaces found in the literature.

PHASE 5. Working in pairs, reviewers use an unmodified mouse to navigate all pages of the Pathways app from one interactive element to the next. Reviewers use a mouse to navigate all pages as both the provider and presenter & patient. Special attention is given to mouse navigation to required elements, while optional elements are noted as supplemental. During navigation with a mouse, reviewers note observations about their body position and motions as a user. After navigating with an unmodified mouse, users complete all interactions again using the keyboard only. Reviewers note any difference of navigation experience between mouse and keyboard in terms of what is accessible & operable, and what is not. Data from this phase will be compared to what is accessible & operable using the adaptive accessories in phase 6.

PHASE 6. Working in pairs, reviewers use the Microsoft adaptive hub and their adaptive mouse, joystick, D-pad, and the Dual Button to navigate all pages of the Pathways app from one interactive element to the next. Reviewers use all the adaptive accessories to navigate all pages as both the provider and presenter & patient. Special attention is given to using the adaptive tools for navigation in lieu of an unmodified mouse to interact with all required elements, while optional elements are noted as supplemental. During navigation with adaptive accessories, reviewers will note observations about their body position and motions as a user.

After navigating with all adaptive accessories, users compare their assisted interactions with using the keyboard and unmodified mouse. Reviewers note any difference of navigation experience between the adaptive accessories and the mouse and keyboard in terms of what is accessible & operable. Data from this phase is later used to complete the Motor-Mobility Compliance form and as results for presentation to GPfT.

III. Posttest

Upon completion of phase 4 through 6, our workflow for motor-mobility accessibility testing proceeds into the reporting phases, 7 and 8.

Phase 7. To begin, student SMEs complete the Motor-Mobility Compliance Form. The compliance form is based on a rubric developed by combining the updated Americans with Disabilities Act of 1973, Section 508, and W3C's WCAG 2.0 guidelines using plain language [2, 3]. The form is structured following the POUR website design criteria [16]. Perception, operation, understanding, and robustness of the application are considered for the optimization of the digital interactive content. Based on heuristic evaluation results, SMEs complete their compliance review forms by indicating if a required POUR web design element (as defined by Section 508 and WCAG 2.0) was or was not present and/or provided by the application. Also, they assess, if elements are provided, and to what degree the elements made accessible interaction with the application possible or prohibited interactions for users.

Phase 8. A formal written report that follows general UX reporting conventions is developed in conjunction with a summative presentation for the stakeholders. According to a course instructor for the Interaction Design Foundation (IxDF), UX reports should use clear, plain language, organize content using simple, descriptive sections, maintain honesty and transparency—even when things did not go according to plan—and must be kept as short as possible, providing only the essential information necessary to enact recommendations [18].

Additionally, the use of efficient executive summary is required, and briefing on testing methods, protocols, and configurations is expected, but writers are encouraged to keep methodological details to a minimum. Instead, they are asked to focus on illustrating their findings, making effective recommendations, and providing support for enacting those recommendations. A basic organizational logic—summative introduction, a methodology and materials brief, reporting positive, negative, and severity of the negative findings, making data-driven recommendations, and closing with action plans—is not only used in the written reports, but also observed in presentations for stakeholders [19].

This phase concludes our motor-mobility testing methods and project workflow description. In what follows, we offer the specific testing guidance we can provide for body position and movement capture, as well as grasping and fine motor movement recording.

Guidance

In addition to the workflow outlined in the previous section, the authors offer readers two approaches for motor-mobility testing: (1) a general motor-mobility guide for ascertaining the physical accessibility of digital information on a web application where body position and movement is concerned, and (2) a guide to capturing grasping and fine-motor movements. This guidance section will address the setup, observation process, and consideration requirements for each approach hereafter.

I. User Body Position and Movement

The following protocols are for observation of body position and movement.

Preparation. Before conducting body observations, it is crucial to establish a well-equipped observation area furnished with essential tools, like video cameras and screen capture software, as well as tools for measuring range of motion. Range of motion measurement varies from simple rulers and measuring tapes, to goniometers and inclinometers, to full 3-D motion capture sensors and software like those from Neraxon [20]. Tools are necessary to facilitate the capture of user motions. To systematize observations, a detailed checklist of the various body positions and movements for observation is required. The checklist may include seated posture, hand movements, head positions, and any discernible signs of stress or strain.

For instance, the checklist can prompt observers to document if a user maintains an upright posture while using the application or if there are repetitive hand motions that might indicate potential pain points. Thoughtful preparation, coupled with a suitable observation space, makes a thorough examination of bodily motion dynamics possible and enhances the overall quality of the observational research process.

Observation Procedure. When observations begin, it is important to start by recording the user's initial body position. The posture of a user when they initiate their interaction with an application presents a baseline that can be used for comparison to later interactions with the application. Also, a synopsis of the user's motor abilities should be captured to illustrate their physical capabilities. This is similar to a first impression task, where a user may simply be asked to take a limited amount of time to navigate the user interface.

Then, researchers should aim to observe how the user adjusts their position throughout the session. They should take careful notes concerning any movements or changes in bodily position made to accommodate their motor abilities. Further, any body movements that indicate discomfort or challenges to the user should be recorded while they are using the interface. This includes strained or repetitive motions such as leaning forward, frequent readjustments, stretching or full extensions, and reaching the limit of a user's range of motion. All user motions must be noted.

Considerations. In addition to recording user position and motion during observations, researchers should take notice and caption any adjustments made to the user's environment by themselves or others. The introduction of specialized chairs, cushions, or adaptive accessories that affect body position or movement needs to be addressed. Further, any ergonomic considerations, like the height, angle, and modification of screen, keyboard, or mouse placement must be recorded. These are just a few of the most common considerations researchers should be mindful of during the observation procedure, however, this is not an exhaustive list. Researchers must pay attention to all modifications impacting the participant's body and movements.

II. Grasping and fine-motor skills

In addition to observations of body position and motion, researchers must capture and analyze grasping and fine-motor skills. The following protocols are for observation of user grasping and fine-motor control and movement.

Preparation. To ensure the devices and accessories are properly configured for the user, researchers must prepare adaptive accessories like specialized keyboards, mice, or other input devices for users. This is aided by having a checklist ready to note different fine-motor tasks the user will perform, such as clicking, typing, scrolling, or other specific actions within the application.

Observation Procedure. Researchers should note the user's approach to reaching for and interacting with the keyboard, mouse, or other adaptive accessories. They must record how the user manages fine-motor tasks, such as typing accuracy, mouse control, or device manipulation, or any challenges encountered during these interactions. Additionally, observing any techniques or adaptations the user employs to navigate the web application, especially if they are using adaptive accessories is pivotal information.

Considerations. Researchers should pay close attention to the speed, accuracy, and ease with which the user can perform tasks, including any hesitations, errors, or delays in their interactions. They must document any verbal or non-verbal cues that suggest frustration, strain, or satisfaction during these fine-motor tasks.

Collectively, these two protocol guides aim to support detailed user observations for the motor-mobility study of the GPfT Pathways web application, specifically focusing on body position, movement, and fine-motor skills. Collectively, these protocols support several critical testing objectives. In the next section, we provide a demonstration of our own use case and our findings which support the use of our testing methods, as well as the limitations of our approach, recommendations, and conclusions.

USE CASE DEMONSTRATION

In our IRB approved research study exploring user interaction with the Pathways Telemedicine platform, we conducted a simulated heuristic evaluation where 4 student participants, aged between 19 and 25, and 2 faculty participants, between 35 and 40, had the opportunity to compare traditional inputs with Microsoft's adaptive tools. All participants were trained in the above protocols and heuristic evaluative practices, and students participated in a 16-week Independent Study course working one-on-one with Dr. Gallagher during testing. Our team's focus was on understanding accessibility and usability dynamics across various features, including the login screen, provider and patient virtual offices, waiting rooms, navigating forms, file sharing, and chat features.

As the evaluation commenced, each participant was first equipped with traditional keyboards and mice and then Microsoft's adaptive tools. This setup allowed for direct comparisons between the two input methods as participants engaged with the website's diverse features.

I. Login screen

Participants encountered the login screen first, where they were required to enter their credentials. Those using traditional inputs demonstrated fluid movements but occasionally struggled with precision, especially when entering alphanumeric characters. In contrast, participants utilizing Microsoft software and adaptive tools found it easier to input their credentials, thanks to features like voice controls, predictive text, and simplified keyboard layouts.

II. Virtual offices and waiting rooms

Once logged in, participants navigated to their respective virtual offices and waiting rooms. Those using traditional inputs exhibited efficient but sometimes hesitant movements when clicking through various sections. Participants using adaptive tools encountered these same challenges, but with the adaptive tool's enlarged buttons and simplified navigation gestures, their movement exhibited smoother transitions between virtual spaces with less motion and effort.

III. Using forms and file sharing

Interacting with forms and file sharing functionalities presented additional challenges for participants using traditional inputs. Precise clicking and typing were required, leading to occasional errors and delays. Conversely, participants utilizing adaptive tools demonstrated improved accuracy and efficiency in completing forms and sharing files due to simplified input methods, intuitive interface adaptations, and a marked reduction in physical effort.

IV. Interactive chats

Engaging with chat features allowed participants to communicate as providers and presenters & patients. Those using traditional inputs demonstrated proficient typing skills but occasionally struggled while navigating chat windows and selecting specific messages. Also, some chat UI buttons were small and harder to click accurately resulting in miss-clicks. Participants using the adaptive tools found it easier to navigate the chat UI by comparison. The simplified movement facilitated by tool features like large, multidirectional controls streamlined the movement required and decreased the need for dexterity during communications.

By having participants use both traditional and adaptive inputs across Pathways app features, researchers gained valuable insights into the comparative effectiveness of each method. The adaptive tools emerged as offering enhanced accessibility and usability across various tasks, including navigating the login screen, virtual offices, forms, file sharing, and chat features. This underscores the importance of incorporating and supporting adaptive input options to ensure a more inclusive and user-friendly digital experience for individuals of all abilities However, in the spirit of transparency, there was a break-in period for users who had not used adaptive tools prior to the study, not observed with users who were familiar with them.

FINDINGS

I. RQ1: How do we capture the positions and movements required for a user to interact with a web app that we can test?

Position and movement capture for web app interaction involve observing and recording user adjustments, posture, and gestures. Traditional inputs exhibit fluid but sometimes imprecise movements, while adaptive tools streamline actions with less reliance on fine motor skills.

II. RQ2: What environmental elements (virtual and physical) must be considered during platform usage and operation both with and without adaptive tools to enhance accessibility?

Environmental considerations for platform usage include ergonomic adaptations for physical setups and interface adjustments for virtual spaces. With adaptive tools, enlarged buttons and simplified navigation improve accessibility, reducing reliance on precise movements and enhancing overall usability.

With insights from user research like this, we can optimize web app design by refining layouts, button sizes, and navigation to accommodate diverse user needs. We believe further user testing will support proposed changes, ensuring continuous improvement in accessibility. Training resources to educate stakeholders are pivotal to inclusive design practices, and comprehensive documentation is essential to outline accessibility standards. Collaboration with advocacy groups too promotes awareness and implementation of accessibility guidelines in the tech community. Together, these actions foster a more inclusive digital environment, enhancing the user experience for individuals of all abilities who encounter applications like Pathways.

LIMITATIONS

While these testing practices and our use case makes significant contributions to web accessibility and online information, most notably our development and motor-mobility testing methods, this article exhibits several limitations. First, given the topic and our goal is to share procedural methods with readers, the rigor of our use case is not sufficiently addressed and explored herein. Further, the limited generalizability of a single use case for our methods means that they may not suit other web apps or online platform research. Also, some sampling bias may be present given the pool of faculty and student SMEs as participants in our study. Inclusion of a more diverse group of individuals is necessary going forward. Last, though our interest is in improving the accessibility of digital environs for users with disabilities, these particular individuals only played an indirect role in the formulation or our methods via review of secondary literature. In the upcoming second phase of our GPfT motor-mobility research, we will be using these methods, testing our approaches and tools, with users with motor-mobility disabilities. The next phase will help us to affirm and refine our current findings.

RECOMMENDATIONS

Despite the limitations of this study, based on our practiced use of the workflow and protocols for motor-mobility testing of web apps, like Pathways, we have determined the following practitioner and researcher recommendations:

1) Maintain privacy and consent by ensuring the user is aware and has consented to the physical and virtual observation process. Respect their privacy throughout the study.
2) Record comprehensive physical observations by capturing detailed notes and recordings to accurately document the user's interactions and movements

3) Host post-observation reviews that include reviewing and analyzing the observations, looking for patterns, challenges, and successful strategies employed by the user, in addition to any pain points they experienced.

Conclusion

To conclude, our development of testing methods and their use for a case study seeks to provide:

- practicable protocols for testing the motor-mobility accessibility of websites & applications
- means for examining required and optional interactive elements in an application and their placement
- body positions and mobility information for the use of required and optional elements of the application
- experience and operability information for application interactions using traditional keyboard and mouse
- experience and operability information for using Microsoft's line of adaptive accessories for Windows systems (including the adaptive hub and the adaptive mouse, joystick, D-pad, and the Dual Button) with an application (as compared to standard input devices), and
- to examine the compliance status of an application following ADA Section 508 & WCAG 2.0 guidelines by means of our heuristic rubric [1].

Meeting these goals will not only help us to ensure that the Pathways app developers have the information needed to attain and sustain compliance with federal regulations and W3C guidelines, any one may use them to support their own product's ADA motor-mobility compliance. The methods covered herein are not limited to studying the Pathways application.

Further, the discoveries made using our methodology for analyzing web apps can be used for publications, presentations, and creating data-driven redesigns that improve information accessibility for users with motor-mobility impairments broadly. By leveraging discoveries such as those made possible by our procedural work with GPfT, readers may increase the accessibility of any online application and platform, including telemedicine, for users around the world.

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About the Authors

Dr. Philip B. Gallagher is an Assistant Professor of Technical Communication at Mercer University and an ADA testing and compliance consultant for the Global Partnership for Telehealth. His research focuses on accessibility and UX pedagogy, biometric user data capture, and technology in communication environments used to improve the access and utility of information. Read more about him at: philipbgallagher.com.

Michael K. Griffin is a student researcher in the Department of Biomedical Engineering and Department of Technical Communication at Mercer University. He is a member of Dr. Philip B. Gallagher’s Accessibility and UX Research Lab. He also works in the Biomedical Gait Lab and Mercer Prosthetics Center. His scholarly pursuits aim to advance the quality of healthcare through the integration of Technical Communication, UX, and accessibility principles alongside biomechanical and physiological knowledge derived from the field of Biomedical Engineering.

Dr. Amro Khasawneh is an Assistant Professor of Industrial Engineering and Industrial Management at Mercer University. His research focuses on using both qualitative and quantitative research methods to improve patient safety as well as patient engagement. His other research interests are modeling online behavior and decision-making, applying human factors design principles to teleoperated human-machine systems, and Virtual Reality (VR) training. Dr. Khasawneh has published more than 30 articles in several peer-reviewed journals and conferences such as JMIR, Human Factors, and Automation in Construction.