Developer and End-User Perspectives on Addressing Human Aspects in Mobile eHealth Apps

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Abstract

Context: eHealth apps are mobile apps that help in self-management of critical illnesses, provide home-based disease management, and help with personalized care. Users of eHealth apps are naturally very diverse in terms of their *human aspects*, e.g., their age, gender, emotional reactions to the apps, cognitive style, physical and mental challenges. Unfortunately, many eHealth apps do not take these user differences sufficiently into account, making them ineffective or even unusable.

Objective: This paper reports a study from eHealth app stakeholders' – developers and end-users – perspectives on critical challenges and benefits of better incorporating *human aspects* into eHealth app development and usage. We also investigate how different *human aspects* are being addressed by developers, which ones are the most important for different user groups, and which ones are currently missing/poorly handled.

Method: A mixed-method approach that integrates qualitative and quantitative research was used for this study. We gathered and analyzed data from 240 online survey responses and 25 detailed interviews within the same study and validated the results.

Results: We report key issues encountered in eHealth app design, difficulty in addressing different *human aspects*, areas requiring further research and practical assistance, and recommend our findings to best address these challenges. We found addressing *human aspects* throughout the app development life-cycle is beneficial for more effective eHealth apps. Our findings also suggest the need for improved standards and guidelines, better developer-user collaborative culture, and better *human aspects* education to produce more effective eHealth apps.

Conclusion: This paper investigates current approaches used in the eHealth app domain that take into account the *human aspects* of app users. The paper guides eHealth app stakeholders, future researchers, academia and industry partners be aware of *human aspects* related challenges and improve produce apps.

Keywords: eHealth App, Human Aspect, User Study, Development, Improved Support.

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References

List of Tools and Techniques

This document contains a summarized list of the tools and techniques reported in our user studies. We have organized this list according to (i) the stages of the app development work process where these tools and techniques are typically used, and (ii) the manner in which they were reported in the studies. To provide a focused, concise presentation, we avoid duplicate mentions in this list. For instance, Zoho Analytics appears multiple times in the context of Business Intelligence development, while Zoho Sprints is mentioned thrice for Project Tracking. However, in this document, we have elected to include only a single reference to Zoho, directing readers to its main software hub at https://www.zoho.com.

Secondly, we have incorporated insights from both the literature and our own experience when categorizing reported tools and techniques. This holds true even when these specific groupings or naming conventions were not explicitly mentioned by our study participants. For example, participants have indicated that, within focus groups, they prioritize development decisions based on various criteria. These include collective rankings of user needs, aggregated counts of users who have identified specific issues, a compiled amount of feedback for a given issue, and the total number of user-reported bugs discussed in a workshop setting. All these four criteria align well with the methods used in the 'Nominal Group Technique,' and so we categorize them under this name.

Finally, we have chosen to exclude all in-house tools reported in the study. This decision is due to both the ethical restrictions of this research and the unavailability of public references or links for those tools.

1. Cross-platform Development

- **Apache Cordova:** Apache Software Foundation. Apache Cordova - Mobile apps with HTML, CSS & JS. Available: https://cordova.apache.org/
- **NativeScript:** Progress Software Corporation. NativeScript - Open Source framework for building truly native mobile apps. Available: https://www.nativescript.org/
- **Flutter:** Google, Inc.. Flutter - UI toolkit for building natively compiled applications. Available: https://flutter.dev/
- **React Native:** Facebook, Inc. React Native - A framework for building native apps using React. Available: https://reactnative.dev/
- **Resharper:** JetBrains s.r.o. ReSharper - A developer productivity extension for Microsoft Visual Studio, focusing primarily on code quality, navigation, and refactoring. Available: https://www.jetbrains.com/resharper/
- **Visual Studio:** Microsoft Corporation. Visual Studio - An integrated development environment from Microsoft, widely used for Android, iOS, and cross-platform mobile app development. Available: https://visualstudio.microsoft.com/
- **Xamarin:** Reference: Microsoft, Inc. Xamarin - Build native apps for iOS, Android, and macOS using .NET. Available: https://dotnet.microsoft.com/apps/xamarin

2. **Visual Modeling**

- **Adobe Photoshop:** Adobe Systems. A graphic design and image editing software. Available: https://www.adobe.com/products/photoshop.html
- **Anima:** Anima App Ltd. A tool to create responsive and interactive design. Available: https://www.animaapp.com/
- **Axure RP:** Axure Software Solutions. A comprehensive wireframing and prototyping tool. Available: https://www.axure.com/
- **Balsamiq:** Balsamiq Studios, LLC. A rapid wireframing tool. Available: https://balsamiq.com/
- **Figma:** Figma, Inc. A cloud-based design tool. Available: https://www.figma.com/
- **Fluid UI:** Fluid Software. A browser-based wireframing and prototyping tool. Available: https://www.fluidui.com/
- **InVision:** InVisionApp Inc. A prototyping tool for design collaboration. Available: https://www.invisionapp.com/
- **Justinmind:** Justinmind. A prototyping platform for web and mobile apps. Available: https://www.justinmind.com/
- **Marvel:** Marvel Prototyping Ltd. A design, wireframe, and prototyping tool. Available: https://marvelapp.com/
- **Proto.io:** Labs Division of SNQ Digital. A web-based prototyping tool. Available: https://proto.io/
- **RAPPT:** Bootstrapping Mobile App Development. Available: https://ieeexplore.ieee.org/document/7203036
- **Sketch:** Bohemian Coding. A vector-based design tool for macOS. Available: https://www.sketch.com/
- **Zeplin:** Zeplin, Inc. A collaboration tool for designers and developers. Available: https://zeplin.io/

3. **Business Intelligence**

- **Cognos Analytics:** IBM Corporation. Data analytics and business intelligence. Available: https://www.ibm.com/products/cognos-analytics
- **Data Studio:** Google, Inc. Dashboard and reporting tool. Available: https://datastudio.google.com/
- **DOMO:** Domo, Inc. Business intelligence tools and data visualization with low code and pro-code. Available: https://www.domo.com/
- **GoodData:** GoodData Corporation. Business intelligence and embedded analytics. Available: https://www.gooddata.com/

- **Jaspersoft:** TIBCO Software Inc. Reporting and analytics software. Available: https://www.jaspersoft.com/
- **Logi Analytics:** Logi Analytics, Inc. Embedded analytics for software teams. Available: https://www.logianalytics.com/
- **Microsoft Power BI:** Microsoft Corporation. Data visualization and business intelligence platform. Available: https://powerbi.microsoft.com/
- **SAP Business Objects:** SAP SE. Business intelligence solutions for enterprises. Available: https://www.sap.com/products/technology-platform/bi-platform.html
- **Tableau:** Tableau Software, LLC. Advanced data visualization and business intelligence software. Available: https://www.tableau.com/
- **Zoho:** Zoho Corporation Pvt. Ltd. Self-service BI, data analytics software & project management. Available: https://www.zoho.com

4. **Project Tracking Software**

- **ActiveCollab:** A44 Ltd. Agile project management and time tracking. Available: https://www.activecollab.com/
- **Backlog:** Nulab, Inc. Project management and bug tracking. Available: https://backlog.com/
- **ClickUp:** ClickUp. Productivity platform for tasks, docs, and goals. Available: https://clickup.com/
- **Clubhouse:** Clubhouse Software, Inc. Project management tailored for software development. Available: https://clubhouse.io/
- **GitLab:** GitLab Inc. DevOps lifecycle tool with project tracking. Available: https://about.gitlab.com/
- **Jira:** Atlassian. Agile project management tool for software development. Available: https://www.atlassian.com/software/jira
- **MeisterTask:** MeisterLabs. Agile project management. Available: https://www.meistertask.com/
- **Notion:** Notion Labs Inc. All-in-one workspace. Available: https://www.notion.so/
- **Pivotal Tracker:** Pivotal Software, Inc. Agile project management tool. Available: https://www.pivotaltracker.com/
- **Redmine:** Open-source community. Flexible project management web application. Available: https://www.redmine.org/
- **Targetprocess:** Targetprocess. Agile project management software. Available: https://www.targetprocess.com/
- **Trello:** Atlassian. Kanban-style project management. Available: https://trello.com/

- **Wrike:** Wrike, Inc. Collaborative work management platform. Available: https://www.wrike.com/

5. **Web-based Project Management**

- **Basecamp:** Basecamp, LLC. Project management and team collaboration. Available: https://basecamp.com/
- **Celoxis:** Celoxis Technologies. Comprehensive project management tool. Available: https://www.celoxis.com/
- **Freedcamp:** Freedcamp. Task lists, boards, and project planning. Available: https://freedcamp.com/
- **KanbanFlow:** CodeKick AB. Lean project management. Available: https://kanbanflow.com/
- **Kanbanize:** Businessmap Ltd. Kanban software for lean management. Available: https://kanbanize.com/
- **LiquidPlanner:** LiquidPlanner, Inc. Dynamic project management. Available: https://www.liquidplanner.com/
- **Monday.com:** Monday.com Ltd. Work operating system for project tracking. Available: https://monday.com/
- **Podio:** Podio ApS. Customizable low-code work management. Available: https://podio.com/
- **ProofHub:** ProofHub, LLC. Project management and collaboration software. Available: https://www.proofhub.com/
- **Scoro:** Scoro Software. End-to-end work management solution. Available: https://www.scoro.com/
- **Smartsheet:** Smartsheet Inc. Work management and automation platform. Available: https://www.smartsheet.com/
- **TeamGantt:** TeamGantt. Easy Gantt chart software. Available: https://www.teamgantt.com/
- **Teamwork:** Teamwork.com. Project management and team collaboration. Available: https://www.teamwork.com/

6. **Usability Tools and Guidelines**

- **Android Reference Guidelines:** Guidelines specific to Android platform. Available: https://developer.android.com/design/index.html
- **Apptimize:** Apptimize, Inc. A/B testing for Android and iOS apps. Available: https://apptimize.com/

- **Branch:** Branch Metrics, Inc. Deep linking for mobile apps. Available: https://branch.io/
- **Design+Code:** Guidelines and best practices for mobile app design. Available: https://designcode.io/
- **Firebase Analytics:** Google, Inc. Mobile app analytics. Available: https://firebase.google.com/products/analytics/
- **Flinto:** Flinto, LLC. Prototyping tool for creating interactive and animated apps. Available: https://www.flinto.com/
- **Google Material Design:** Google, Inc. Design guidelines and components. Available: https://material.io/
- **iOS Human Interface Guidelines:** Apple, Inc. Design principles and guidelines for iOS. Available: https://developer.apple.com/design/human-interface-guidelines/ios/overview/themes/
- **ISO Usability Standards:** ISO 9241-11: Ergonomics of human-system interaction (Part 11: Usability: Definitions and concepts). Available: https://www.iso.org/obp/ui/#iso:std:iso:9241:-11:ed-2:v1:en
- **mHIMSS Usability Guidelines:** Guidelines and evaluation methods for mobile health. Available: http://www.himss.org/
- **Optimal Workshop:** Optimal Workshop Ltd. User research platform for usability testing. Available: https://www.optimalworkshop.com/
- **Optimizely:** Optimizely, Inc. Experimentation and A/B testing. Available: https://www.optimizely.com/
- **UsabilityHub:** UsabilityHub Pty Ltd. Remote user testing and usability surveys. Available: https://usabilityhub.com/
- **UserTesting:** UserTesting, Inc. On-demand human insights for user experience testing. Available: https://www.usertesting.com/

7. **Repository-based**

- **AWS CodeCommit:** Amazon Web Services, Inc. Fully-managed source control service. Available: https://aws.amazon.com/codecommit/
- **Bitbucket:** Atlassian. Git repository management for professional teams. Available: https://bitbucket.org/
- **Cloud Source Repositories:** Google, Inc. Private Git repositories on Google Cloud. Available: https://cloud.google.com/source-repositories
- **Gerrit:** Google, Inc. Code review and project management for Git-based projects. Available: https://www.gerritcodereview.com/
- **GitHub:** Probably the most well-known Git repository hosting service. Available: https://github.com/

- **Helix Core:** Perforce Software Inc. Version control for accelerated development. Available: https://www.perforce.com/products/helix-core
- **Nexus Repository:** Sonatype, Inc. Universal binary repository manager. Available: https://www.sonatype.com/nexus-repository-sonatype
- **SourceForge:** Slashdot Media. Web-based service that offers software developers a centralized online location to control and manage free and open-source software projects. Available: https://sourceforge.net/
- **Subversion:** Apache Software Foundation. Centralized version control system. Available: https://subversion.apache.org/
- **Team Foundation Version Control:** Microsoft Corporation. Version control tool integrated with Visual Studio. Available: https://learn.microsoft.com/en-us/azure/devops/repos/tfvc/what-is-tfvc?view=azure-devops
- **Tuleap:** Enalean. Open source software for Agile development and more. Available: https://www.tuleap.org/
- **Vault:** SourceGear, LLC. Version control tool for Windows developers. Available: https://sourcegear.com/vault/

8. **Third-Party APIs**

- **Algolia:** Algolia, Inc. Search and discovery API. Available: https://www.algolia.com/
- **Amazon S3:** Amazon Web Services, Inc. Scalable storage service. Available: https://aws.amazon.com/s3/
- **Auth0:** Auth0, Inc. Authentication and authorization platform. Available: https://auth0.com/
- **HERE Location Services:** HERE Technologies. Geolocation and mapping services. Available: https://developer.here.com/
- **Mapbox:** Mapbox, Inc. Custom maps and location services. Available: https://www.mapbox.com/
- **OneSignal:** OneSignal, Inc. Push notification service. Available: https://onesignal.com/
- **OpenWeather:** OpenWeather Ltd. Weather data APIs. Available: https://openweathermap.org/api
- **PayPal:** PayPal, Inc. Payment gateway services. Available: https://developer.paypal.com/
- **Plivo:** Plivo, Inc. Voice and SMS API. Available: https://www.plivo.com/
- **SendGrid:** Twilio Inc. Email API service. Available: https://sendgrid.com/
- **Square:** Square, Inc. Payment processing solutions. Available: https://squareup.com/us/en/developers

- **Stripe:** Stripe, Inc. Payment gateway and financial services. Available: https://stripe.com/
- **Twilio:** Twilio Inc. Cloud communications platform. Available: https://www.twilio.com/
- **Vimeo OTT:** Vimeo, Inc. Video API for streaming services. Available: https://vimeo.com/ott
- **Weatherstack:** apilayer Ltd. Real-time weather data API. Available: https://weatherstack.com/
- **Zoom:** Zoom Video Communications, Inc. Video conferencing API. Available: https://marketplace.zoom.us/docs/api-reference/introduction

9. Testing on Real-World

- **A/B Testing:** Testing two versions of an app feature to see which performs better. Available: https://www.optimizely.com/optimization-glossary/ab-testing/
- **Beta Testing:** Releasing the app to a select group of users for real-world testing before launch. Available: https://developer.apple.com/testflight/
- **Testbirds:** Utilizing a crowd of testers to test the app in various conditions. Available: https://www.testbirds.com/
- **Long-Term Monitoring:** Continuous analysis of app performance over an extended period. Available: https://www.newrelic.com/mobile-monitoring
- **Real Device Testing:** Testing on actual hardware rather than emulators. Available: https://www.browserstack.com/app-live
- **Session Recording:** Capturing user interactions within the app for analysis. Available: https://www.smartlook.com/session-recordings/
- **User Testing:** Testing with actual users to evaluate the app's usability. Available: https://www.usertesting.com/

10. Industry-Academia Best Practices

- **Agile-Scrum:** Adapting Agile and Scrum frameworks for rapid and iterative mobile app development. Available: https://www.scrumalliance.org/about-scrum
- **Code Reviews:** Peer code review process to improve code quality and maintainability. Available: https://www.atlassian.com/agile/software-development/code-reviews
- **Jenkins:** Incorporating Jenkins for continuous integration and deployment. Available: https://www.jenkins.io/
- **Human-Centered Design:** Applying user-centered design principles from the ideation phase through development. Available: https://www.interaction-design.org/literature

- **Microservices Architecture:** Adopting a microservices architecture for modular and scalable mobile app backend. Available: https://microservices.io/
- **Pair Programming:** Two developers working at one workstation to improve code quality. Available: https://dev.to/documatic/pair-programming-best-practices-and-tools-154j
- **Quality Metrics:** Using static and dynamic analysis tools to measure code quality metrics. Available: https://www.sonarqube.org/
- **Test-Driven Development:** Writing tests before code to ensure software meets requirements. Available: https://www.agilealliance.org/glossary/tdd/

11. Iterative Development Approach

- **Behavior-Driven Development:** Encourages collaboration between developers, QA and non-technical or business participants. Available: https://cucumber.io/docs/bdd/
- **Continuous Feedback:** Regular feedback loops with stakeholders and users to steer development. Available: https://www.atlassian.com/agile
- **Feature Flags:** Conditional feature rollout for easy toggling of features in a live environment. Available: https://launchdarkly.com/
- **Incremental Builds:** Gradually integrating new features into existing codebase to ensure stability. Available: https://en.wikipedia.org/wiki/Incremental_build_model
- **MVP (Minimum Viable Product):** Development of a product with just enough features to satisfy early adopters. Available: https://en.wikipedia.org/wiki/Minimum_viable_product
- **Retrospectives:** Regular meetings to discuss what went well and what needs improvement. Available: https://www.atlassian.com/team-playbook/plays/retrospective
- **Sprints:** Fixed-length iterations for development cycles, commonly two to four weeks long. Available: https://www.scrum.org/resources/what-is-a-sprint-in-scrum
- **User Stories:** Descriptions of software features from an end-user perspective. Available: https://www.mountaingoatsoftware.com/agile/user-stories

12. Guidelines and Checklist

- **WCAG Guidelines:** Ensuring the app meets accessibility guidelines with a thorough checklist. Available: https://www.w3.org/WAI/standards-guidelines/mobile/
- **Code Quality Checklist:** Employing a checklist to maintain code quality during development. Available: https://github.com/codepath/android_guides/wiki/Code-Path's-Android-Cliffnotes
- **Compliance Guidelines:** Ensuring that the app complies with legal and policy requirements. Available: https://developer.apple.com/app-store/review/guidelines/

- **Cross-Platform Checklist:** Guidelines for ensuring app compatibility across different platforms. Available: https://flutter.dev/
- **Data Security Guidelines:** Employing best practices to secure user data. Available: https://www.owasp.org/index.php/OWASP_Mobile_Security_Project
- **GDPR Compliance:** Ensuring the app meets the General Data Protection Regulation. Available: https://gdpr.eu/
- **Google Design Guidelines:** Following UI/UX design principles for mobile apps. Available: https://material.io/design
- **Internationalization Guidelines:** Adhering to best practices for globalizing the app. Available: https://developer.apple.com/internationalization/
- **Performance Optimization Guidelines:** Following best practices to improve app speed and responsiveness. Available: https://developer.android.com/guide/topics/performance
- **Testing Checklist:** A list of essential tests to conduct before deployment. Available: https://developer.android.com/training/testing/fundamentals
- **Version Control Guidelines:** Best practices for versioning the app. Available: https://semver.org/

13. End-User Inclusion in Requirement and Design Process

- **Affinity Diagramming:** A method to understand user preferences and needs. Available: https://www.usertesting.com/blog/affinity-mapping
- **Contextual Inquiry:** Gathering detailed information by observing people in their daily environment. Available: https://www.nngroup.com/articles/contextual-inquiry/
- **Crowdsourcing User Needs:** Utilizing the crowd to collect insights on user requirements. Available: https://doi.org/10.1007/978-3-030-44429-7_11
- **Empathy Mapping:** Creating empathy maps to understand the users' perspectives. Available: https://doi.org/10.1080/14606925.2017.1352966
- **Feedback Surveys:** Using questionnaires to collect user opinions and suggestions. Available: https://doi.org/10.1109/ICDMW.2011.63
- **Participatory Design:** Involving users in the design process for feedback and insights. Available: https://repositories.lib.utexas.edu/bitstream/handle/2152/28277/SpinuzziTheMethodologyOfParticipatoryDesign.pdf
- **Persona Development:** Creating detailed user profiles to guide design decisions. Available: https://doi.org/10.1016/j.sbspro.2012.08.227

14. Collecting User Feedback

- **App Store Reviews:** Analyzing user reviews and ratings on app stores to gather feedback. Available: https://doi.org/10.1016/j.jss.2016.11.027
- **In-App Surveys:** Deploying short surveys within the app to collect user opinions. Available: https://doi.org/10.7717/peerj.3785
- **Net Promoter Score (NPS):** Measuring customer loyalty and willingness to recommend the app. Available: https://www.qualtrics.com/experience-management/customer/net-promoter-score/
- **Social Media Monitoring:** Monitoring social media channels for public opinions and discussions about the app. Available: https://www.hootsuite.com/platform

15. Human-centric Requirements Engineering

- **Card Sorting:** Allowing users to categorize features or content into predefined groups. Available: https://www.nngroup.com/articles/card-sorting-definition/
- **Customer Journey Mapping:** Charting the steps a user takes in engaging with the app. Available: https://www.smashingmagazine.com/2015/01/all-about-customer-journey-mapping/
- **Ethnographic Study:** Long-term observation of user behavior and practices. Available: https://doi.org/10.2196/13817
- **Kano Model:** Prioritizing features based on their impact on customer satisfaction. Available: https://foldingburritos.com/kano-model/
- **MoSCoW Method:** Prioritizing requirements into Must-haves, Should-haves, Could-haves, and Won't-haves. Available: https://doi.org/10.1109/ICICICT1.2017.8342602
- **Prototype Testing:** Using a simplified model of the app to test features and gather user feedback. Available: https://doi.org/10.1016/j.jbi.2016.02.002
- **Requirement Workshops:** Collaborative sessions with stakeholders to gather requirements. Available: https://doi.org/10.1109/ICADIWT.2008.4664355
- **SWOT Analysis:** Identifying Strengths, Weaknesses, Opportunities, and Threats in a project. Available: https://doi.org/10.1002/9780470592663.ch24
- **Task Analysis:** Studying how users complete specific tasks to identify requirements. Available: https://doi.org/10.1002/9781118131350
- **Use Cases:** Defining interactions between a user and a system to achieve goals. Available: https://www.usability.gov/how-to-and-tools/methods/use-cases.html

16. Focus Groups Discussion

- **Delphi Method:** Utilizing a panel of experts to reach a consensus through a series of questionnaires and controlled opinions. Available: https://scholarworks.umass.edu/pare/vol12/iss1/4/
- **Fishbowl Discussion:** A small group discusses an issue while a larger group observes, later switching roles to gather various perspectives. Available: https://doi.org/10.1111/eje.12414
- **Nominal Group Technique:** Facilitates group decision-making by ranking user needs and features in a moderated setting. Available: https://asq.org/quality-resources/nominal-group-technique
- **World Café:** A structured conversational process that facilitates open discussions in informal settings to share collective knowledge. Available: https://www.theworldcafe.com/key-concepts-resources/world-cafe-method/

17. User-Evaluated Usability and Accessibility

- **Accessibility Audits:** Evaluation of the app for accessibility compliance and guidelines. Available: https://doi.org/10.1145/355460.355480
- **Click Tracking:** Analyzing where users click within the app to improve layout and design. Available: https://doi.org/10.1111/j.1937-5956.2012.01386.x
- **Eye Tracking:** Utilizing eye-tracking technology to evaluate how users interact with visual elements. Available: https://doi.org/10.1109/ICISIM.2017.8122153
- **Heatmaps:** Visualizing areas of the app where users spend the most time. Available: https://www.heap.io/topics/mobile-app-heatmaps
- **Remote Usability Testing:** Users testing the app remotely, usually from their own devices. Available: https://doi.org/10.1145/182966.182969
- **Screen Reader Testing:** Evaluating app compatibility with screen readers. Available: https://developer.android.com/guide/topics/ui/accessibility/testing
- **Voice Command Testing:** Assessing how well the app integrates with voice-activated controls. Available: https://doi.org/10.2196%2F18431

18. User Centric and Human Centric Design

- **Heuristic Evaluation:** Experts evaluating the interface against usability principles. Available: https://doi.org/10.1145/142750.142834
- **Clickstream Analysis:** Analyzing the navigation path or the clicks that users follow on a mobile app. Available: https://www.google.com/analytics
- **Cognitive Walkthrough:** Evaluating the ease with which new users can accomplish tasks. Available: https://doi.org/10.1080/10447311003781409

- **Retrospective Testing:** Asking users to evaluate their experience after they have completed their tasks. Available: https://www.usability.gov/how-to-and-tools/methods/running-usability-tests.html
- **Think-Aloud:** Users articulate their thought process while interacting with the mobile app. Available: https://www.usability.gov/how-to-and-tools/methods/running-usability-tests.html

19. Other Vendor Frameworks and Regulations

- **Adobe Creative Cloud:** Utilizing Adobe's Creative Suite. Available: https://www.adobe.com/creativecloud.html
- **Code Signing:** Ensuring app integrity through cryptographic methods. Available: https://developer.apple.com/support/code-signing/
- **HTML5:** Using HTML5 for building web-views and some native app functionalities. Available: https://developer.mozilla.org/en-US/docs/Web/Guide/HTML/HTML5
- **Microsoft's ASP.NET MVC Framework:** Utilizing Microsoft's framework for web and mobile app development. Available: https://dotnet.microsoft.com/apps/aspnet/mvc
- **MS SQL Server:** Using Microsoft SQL Server for backend database services. Available: https://www.microsoft.com/en-us/sql-server/sql-server-2019
- **SwiftUI:** Using SwiftUI for iOS app development. Available: https://developer.apple.com/xcode/swiftui/
- **Test-Driven Development (TDD):** Following TDD practices for robust code. Available: https://doi.org/10.1007/3-540-44870-5_84
- **UML:** Using Unified Modeling Language for app development. Available: https://www.uml.org/

20. UI Testing

- **Accessibility Testing:** Ensuring the app's user interface is accessible to people with disabilities. Available: https://developer.apple.com/accessibility/
- **Automated Scripted Tests:** Running scripted UI tests automatically. Available: https://developer.android.com/studio/test
- **Color Contrast Testing:** Ensuring sufficient color contrast for readability. Available: https://www.w3.org/WAI/test-evaluate/preliminary/#contrast
- **Exploratory Testing:** Manual testing to explore the UI and discover issues. Available: http://www.satisfice.com/articles/et-article.pdf
- **Fuzz Testing:** Sending random data to UI elements to test stability. Available: https://owasp.org/www-community/Fuzzing

- **Gesture Testing:** Testing multi-touch and other gestures in the UI. Available: https://developer.android.com/training/gestures
- **Localization Testing:** Testing the app's UI in different languages and regions. Available: https://developer.apple.com/internationalization/
- **Load Testing:** Testing UI performance under heavy load conditions. Available: https://doi.org/10.1016/j.infsof.2017.11.016
- **Regression Testing:** Re-testing the UI after updates to ensure no new bugs are introduced. Available: https://doi.org/10.1007/978-3-319-49421-0_10
- **White-Box Testing:** Testing internal structures of the UI, often used for unit tests. Available: https://en.wikipedia.org/wiki/White-box_testing