

© Copyright [2019]

[Kalyani Katariya]

User-Centered Design and Usability Study of Android-Based Vision Screening Tools:

The Quick Check Application

Kalyani Katariya

A thesis

submitted in partial fulfillment of the

requirements for the degree of

Master of Science in Computer Science & Software Engineering

University of Washington

2019

Committee:

William Erdly, Chair

Arnie Lund

Jason Yip

Program Authorized to Offer Degree:

Computing and Software Systems

University of Washington

**Abstract**

User-Centered Design and Usability Study of Android-Based Vision Screening Tools:

The Quick Check Application

Kalyani Katariya

Chair of the Supervisory Committee:

William Erdly

Computing and Software Systems

The availability of smartphones with increased computing capabilities has opened new doors for researchers and medical practitioners to reach out to patients. Usability remains the crucial factor in using mobile applications that support patient-health care provider interactions. The use of mHealth, a medical practice supported by mobile devices, is now being used to assess and monitor conditions such as autism, dementia, and Parkinson's disease.

A series of applications being developed by the EYE Center for Children's Vision Learning and Technology. This is a University of Washington Bothell non-profit organization dedicated to the research, development, and communication about

technologies to assess and treat functional vision problems that impact learning. A new vision screening Android-based mobile app, *QuickCheck* (used to screen for vision-related problems such as near and distance visual acuity, amblyopia, and convergence insufficiency) is being developed by the group and is the focus of this research. A usability framework, considerations and recommendations regarding the use of a mobile device as a clinical assessment tool, is provided.

Five users participated in the usability study and we used System and software quality models ISO/IEC 25010–1, 2011 and Usability Definitions and concepts, ISO 9241–11 Guidance on usability, 2018 standard to define objective measurement of *QuickCheck* app. MARS(Mobile App Rating Scale) questionnaire, interview and user observations have used to measure users overall satisfaction with the app. The results of the usability test for the *QuickCheck* app demonstrated that overall quality of the app meets the general acceptance criteria for the identified functional and non-functional requirement. However, several areas of concern and improvement are also noted such as task flow, improvements in CISS questions and time required to complete the CISS test. Qualitative findings include the need for feedback to users, help instructions format. Further recommendations for full-scale clinical testing are provided.

## Table of Contents

<b>Chapter 1. Introduction.....</b>	<b>12</b>
<b>1.1 EYE Center .....</b>	<b>12</b>
<b>1.2 Problem Description .....</b>	<b>13</b>
<b>1.3 Objectives .....</b>	<b>16</b>
<b>1.4 Organization of the Thesis .....</b>	<b>16</b>
<b>Chapter 2. Literature Review .....</b>	<b>17</b>
<b>2.1 Smartphones and Their Applications in Health.....</b>	<b>17</b>
<b>2.2 Smartphones and Their Applications in Ophthalmology .....</b>	<b>18</b>
<b>2.3 Smartphone Applications with Types of Vision Screening Tests They Offer .....</b>	<b>20</b>
<b>2.4 Understanding Usability.....</b>	<b>25</b>
<b>2.4.1 Definition of Usability .....</b>	<b>25</b>
<b>2.5 Usability Metric Framework for Mobile Applications .....</b>	<b>26</b>
<b>2.6 Usability metric for the mHealth app .....</b>	<b>28</b>
<b>2.7 Comparison for Usability Evaluation Models for Mobile Applications .....</b>	<b>30</b>
<b>2.8 Usability Evaluation Models for mHealth .....</b>	<b>33</b>
<b>Chapter 3. Design Methodology .....</b>	<b>34</b>
<b>3.1 Design Thinking Process for <i>QuickCheck</i> app .....</b>	<b>34</b>
<b>3.2 Screening Solutions Provided by EYE Center .....</b>	<b>35</b>
<b>3.2.1 Near Vision Toolbox.....</b>	<b>35</b>
<b>3.2.2 Limitations of the Near Vision Toolbox (an earlier version of QuickCheck) .....</b>	<b>37</b>
<b>3.3 Design for QuickCheck App .....</b>	<b>37</b>

- 3.3.1 Persona ..... 37
- 3.3.2 User Story..... 39
- 3.3.3 Scenario ..... 40
- 3.3.4 Vision *QuickCheck* App Flow Diagram ..... 42
- 3.3.5 Screen Design for Quick Check..... 43
- 3.3.6 Low Fidelity Mock-Up ..... 44
- 3.3.7 Logo Design..... 47
- 3.3.8 Screen Shots of the *QuickCheck* App (From Latest Release) ..... 49
- 3.4 Participatory Design: Designing with the UW Kid’s Team ..... 52
- Figure 24: The four roles that children may have in the design of new technologies ..... 53*
- 3.5 UW Kids Team Design Session for Quick Check..... 54
  - 3.5.1 Participants: ..... 54
  - 3.5.2 Research questions explored during the session:..... 54
  - 3.5.3 Method: Sticky Notes, Likes Dislikes Design Ideas ..... 54
  - 3.5.4 Session Details:..... 54
    - 3.5.4.1 During the circle time ..... 55
    - 3.5.4.2 During the screening..... 55
    - 3.5.4.3 Gather likes, dislikes and, design ideas from the kids ..... 55
  - 3.5.5 Likes, dislikes, and design ideas captured from the session: ..... 55
  - 3.5.6 Solutions discussed for the likes, dislikes, and design ideas: ..... 56
  - 3.5.7 Images of students’ likes, dislikes, design ideas ..... 57

<b>3.6</b>	<b>UW Kids Team Design Session for Red Flags (Add screen shot for Red Flag app)</b>	<b>57</b>
3.6.1	Participants: .....	58
3.6.2	Research Question explored: .....	58
3.6.3	Method.....	58
3.6.4	Session Details:.....	58
3.6.4.1	During the circle time .....	58
3.6.4.2	During the screening.....	58
3.6.4.3	Gather likes and dislikes from kids .....	58
3.6.5	Gather likes, dislikes and, design ideas from the kid .....	59
3.6.6	Likes, dislikes, and design ideas captured from the session .....	59
3.6.7	Solutions discussed for the likes, dislikes, and design ideas: .....	60
3.6.8	Images of students' likes, dislikes, design ideas .....	61
<b>Chapter 4. Measurement Framework for Vision Screening Usability.....</b>		<b>62</b>
<b>4.1</b>	<b>Usability metric for vision screening app: findings .....</b>	<b>62</b>
4.1.1	Efficiency for <i>QuickCheck</i> : .....	62
4.1.2	Effectiveness for <i>QuickCheck</i> : .....	63
4.1.3	Learnability for <i>QuickCheck</i> : .....	63
4.1.4	Operability for <i>QuickCheck</i> :.....	64
4.1.5	GQM Model for <i>QuickCheck</i> .....	64
<b>Chapter 5. Methods .....</b>		<b>66</b>
<b>5.1</b>	<b>Usability Test Plan for Vision <i>QuickCheck</i> app .....</b>	<b>66</b>

- 5.1.1 Overview and usability goals ..... 67**
- 5.1.2 Methodology..... 68**
- 5.1.3 Participants ..... 69**
- 5.1.4 Training..... 70**
- 5.1.5 Test Procedure ..... 70**
- 5.1.6 Roles involved ..... 73**
  - 5.1.6.1 Moderator role ..... 73**
  - 5.1.6.2 Test participants role ..... 73**
  - 5.1.6.3 Research group member role..... 73**
- 5.1.7 Test Environment Setup and Equipment..... 74**
  - 5.1.7.1 Instruments required..... 74**
  - 5.1.7.2 Room setup ..... 74**
  - 5.1.7.3 Mobile device setup..... 75**
- 5.1.8 Usability Metrics Association with Usability Tasks ..... 76**
  - 5.1.8.1 Effectiveness ..... 76**
  - 5.1.8.2 Efficiency..... 76**
  - 5.1.8.3 Learnability ..... 76**
  - 5.1.8.4 Operability..... 77**
- 5.1.9 Usability Test Tasks ..... 77**
- 5.1.10 Usability task measuring criteria..... 79**
  - 5.1.10.1 Completion Rate ..... 79**

5.1.10.2	Error-free rate.....	79
5.1.10.3	Time on Task (TOT).....	80
5.1.10.4	Subjective Measures .....	80
5.1.11	Reporting Results .....	80
Chapter 6.	Results and Discussion .....	81
6.1	Usability Test Result .....	81
6.1.1	Methodology.....	81
6.2	Results of the pre-test questionnaire (demographics) .....	82
6.2.1	Participants Profiles .....	82
6.3	Results of Tasks/Scenarios .....	84
6.3.1	Understanding Effectiveness and Satisfaction .....	84
6.3.1.1	Task Completion Success Rate .....	84
6.3.1.2	Task Ratings .....	85
6.3.1.3	Summary of Error Data .....	87
6.3.2	Understanding Efficiency .....	89
6.3.2.1	Time on Task .....	89
6.3.3	Understanding Learnability .....	92
6.3.4	Understanding Operability .....	93
6.4	Results of Interview .....	94
6.4.1	Theme 1: Motivation to use the app.....	95
6.4.2	Theme 2: Barriers in the app usage .....	95

6.4.3	Theme 3: Factors that might influence the app usage.....	96
6.5	Post- Test Questionnaire (MARS Test) Results for Overall Metrics .....	97
6.5.1	Overall Ratings .....	97
6.5.2	App Specific response.....	98
6.6	Observations from the Data Log .....	100
6.6.1	Test Specific challenges faced by users.....	100
6.6.2	General Observation Noted During the Usability Test by Moderator .....	101
Chapter 7. Limitations and Future Work .....		103
7.1	Limitation .....	103
7.1.1	Threats to construct validity.....	103
7.1.2	Internal validity .....	103
7.1.3	External validity .....	104
7.2	Recommendations for Future work: Redesign ideas.....	104
7.2.1	Redesign for Test specific feedback .....	105
7.2.2	Design ideas for suggestions from the interviews .....	107
7.2.3	General Suggestions from Participants .....	109
7.3	Suggestions for the future clinical test .....	110
Chapter 8. Conclusion .....		112
Appendix A.....		121
Usability Test Moderator Script for Quick Check .....		121
Appendix B.....		123

**Appendix C..... 124**

**Appendix D ..... 127**

**Appendix E..... 129**

**List of Figures**

*Figure 1:* The paper-based kit provided by Washington state for vision screening ..... 14

*Figure 2 :* Global mobile health (mHealth) market ..... 18

*Figure 3:* mHealth apps available on various platform and increase in availability of apps in 2017..... 19

*Figure 4:* Google play store showing the results for vision screening keyword ..... 20

*Figure 5:* Complete Eye Doctor application screen shot..... 21

*Figure 6:* Smart Optometry application screen shot..... 21

*Figure 7:* Eye Exam application screen shot ..... 22

*Figure 8:* Check your Eyes application screen shot ..... 22

*Figure 9:* iPhone screen shots..... 23

*Figure 10:* The EHB (Eye Handbook) application screen shot. .... 24

*Figure 11:* Process for Design Thinking (Source: <http://denovo.dwt.com/>) ..... 34

*Figure 12:* Earlier version of Near Vision Toolbox: Login and Home page screens toolbox ..... 35

*Figure 13:* Earlier version of Near Vision Toolbox: CISS test ..... 36

*Figure 14:* Earlier version of Near Vision Toolbox: Near Vision Acuity Test ..... 36

*Figure 15:* Earlier version of Near Vision Toolbox: Stereopsis ..... 36

*Figure 16:* QuickCheck app usage scenario ..... 41

*Figure 17:* User flow for QuickCheck app..... 42

*Figure 18:* Early stage Wireframes design on paper for the QuickCheck app (Screen1 - 4) ..... 44

*Figure 19:* High fidelity wireframes of the QuickCheck app..... 45

*Figure 20:* Logo design few for the QuickCheck app (few samples)..... 48

*Figure 21:* Logo design variation for the QuickCheck app ..... 48

*Figure 22:* Finalized logo design for the QuickCheck app..... 48

*Figure 23:* Screen Shots of the *QuickCheck* App (From Latest Release) ..... 51

*Figure 24:* The four roles that children may have in the design of new technologies ..... 53

*Figure 25:* *QuickCheck* app usability test procedure timeline..... 72

*Figure 26:* Environment Setup for Usability Test ..... 75

*Figure 27:* Default *QuickCheck* app settings ..... 75

*Figure 28:*Demographics of the participants ..... 82

*Figure 29:* Time variation for each test in “perform vision screening task’ ..... 91

*Figure 30:* Average time taken by participants to complete the vision screening three times ..... 92

*Figure 31:* Response to question in SECTION B (Functionality) of MARS test – user’s learning experience with the *QuickCheck* app ..... 93

*Figure 32:* Response to question in SECTION A (customization) of MARS test providing users' view on operability. .... 93

*Figure 33:* The response from the participants for the app specific questions ..... 99

*Figure 34:* Design ideas for Stereopsis..... 105

*Figure 35:* Design ideas for Distance vision tool ..... 106

*Figure 36:* Design ideas for CISS..... 107

*Figure 37:* Screne to show all the available tests..... 107

*Figure 38:* Feature to provide Technical Support..... 108

*Figure 39:* Simple animation screen to explain instructions to follow for each test. .... 108

*Figure 40:* Figure shows the modification in help screen to provide additional options for user ..... 109

**List of Tables**

Table 1 <i>Compares the Screening Devices Used by Washington State Schools with the App Developed by EYE Center Group.</i> .....	15
Table 2 <i>ISO standards related to usability measurement from (Rana, A. and Mridu, M., 2012)</i> 25	
Table 3 <i>Usability Attribute to be Considered for Mobile apps (Rana et.al 2012)</i> .....	27
Table 4 <i>Compilation of Usability Attributes on mHealth Applications</i> .....	29
Table 5 <i>Usability Models for Mobile Applications</i> .....	31
Table 6 <i>User Stories for school nurse</i> .....	39
Table 7 <i>Usability Test Tasks</i> .....	77
Table 8 <i>Personality Role Play Performed by Research Group Members for The Study</i> .....	83
Table 9 <i>Task Completion Rates</i> .....	85
Table 10 <i>Mean Task Ratings &amp; Percent Agree</i> .....	86
Table 11 <i>Summary of Completion, Errors, Time on Task, Mean Satisfaction</i> .....	88
Table 12 <i>Time Required to Complete the Various Tasks by All Participants</i> .....	89
Table 13 <i>Individual Test Time in the ‘Perform vision screening task’</i> .....	90

## ACKNOWLEDGEMENTS

I would like to offer my sincere thanks to my supervisor and committee chair Dr. William Erdly, for his guidance, encouragement, support, and persistence. Special thanks to Dr. Arnie Lund and Dr. Jason Yip for their guidance and agreeing to serve on my committee. I would also like to thank the faculty, my peers, Educating Young Eye (EYE) research group member, doctors, and nurses who participated in the study and staff at the University of Washington Bothell. Last but not least I would like to thank my family who supported me unconditionally through my master's endeavor. I also want to acknowledge and thank various services available at the University of Washington Bothell which helped me reach my goals.

## Chapter 1. Introduction

This chapter covers the work by EYE Center, Problem statement and objective of the research study. It also provides a short summary of all the chapters.

### 1.1 EYE Center

The Educating Young Eyes Center for Children's Vision Learning & Technology, (EYE), is a University of Washington, Bothell sponsored non-profit organization dedicated to the research, development, and education of technologies. It aims to increase awareness of the importance of functional vision in children's learning process and provide applications and tools accessible to all communities. A significant amount of work around children's vision issues had already been done by co-founders Dr. William Erdly and Dr. Alan Pearson and others long before its establishment, including but not limited to:

- Contributed to the passed Senate Bill 6245 in Washington, which amended the state law to require near vision screening in addition to distance vision screening in Washington State schools, effective April 1, 2016.
- Developed a set of apps and games concerning children near vision issues for both web and mobile platforms.
- Organized a symposium at University of Washington Bothell on November 8, 2014, and another symposium at the University of Washington Bothell in 2016, 2017 addressing topics such as vision related social justice, education, and technology
- The main goal of the EYE Center is to provide tools and services to detect vision problems in children across both web and mobile platforms. Optometrist Dr. Alan Pearson, the co-founder of the EYE Center, was being consulted at all point in order to be clinically accurate.

## 1.2 Problem Description

Vision plays a crucial role in children's physical, social and overall development. The report published by the National Center for Children's Vision and Eye Health provides national statistics related to eye health. It reports Amblyopia (sometimes called lazy eye) is found about 2% in 6-72-month-old children and it is the most common issue found in children. ( Multi-ethnic Pediatric Eye Disease Study Group, 2008) (McKean-Cowdin R, Cotter SA, Tarczy-Hornoch K, et a, 2013) (Friedman DS, Repka MX, Katz J, et al., 2009). Early detection of amblyopia is important, it's treatment is effective, when it is started before the age of 7 and less effective at old ages (Holmes JM, Lazar EL, Melia BM, et al., 2011). 2-4% children under the age of 6 have Strabismus (the misalignment of eye) at later stage which can lead to amblyopia ( Multi-ethnic Pediatric Eye Disease Study Group, 2008) (McKean-Cowdin R, Cotter SA, Tarczy-Hornoch K, et a, 2013) (Friedman DS, Repka MX, Katz J, et al., 2009). 4% of children of 6-72 months of age have nearsightedness (Borchert MS, Varma R, Cotter SA, et al., 2011) and 9% of children of the age group of 5-17-year-old (Kleinstei RN, Jones LA, Hullett S, et al, 2003) have Myopia sightedness. 21 % of age 6-72 month and 13% among age group 5-17 have Hyperopia i.e farsightedness (nearby objects appear blurry) (Kleinstei RN, Jones LA, Hullett S, et al, 2003)

To tackle these challenges at early age vision screening is essential for following reasons:

- Identifies children at high risk for eye disease or in need of a professional eye examination
- Helps to detect disorders at an early stage
- Results in a referral to an eye doctor, if screening show a need for further diagnosis.
- Provides information and education about eye health.

Approximately one million students are in school in Washington State (Office of Superintendent of Public, 2016). About 25% of these students have a vision issue that may impact their learning (Ferebee, 2004). At the policy level, early detection for vision problems is incorporated into US national goals and health standards. Washington state does not have a law for pre-school screening but has a mandate for vision screening for the age group of 5 and above (Ruderman, 2016) .

The current method of vision screening in Washington state uses the paper-based screening test and the vision screener devices. Common problems such as distance, near visual acuity, binocular instabilities (convergence insufficiency), and strabismus remain undiagnosed with the types of tests provided by the schools. Vision screening at schools is conducted by nurses, teachers and/or volunteers. They conduct the preliminary test using paper-based tools or, more recently, expensive “vision scanners.” Then if required, they further refer students to an optometrist for the comprehensive clinical test. Figure 1 shows the screening method used in Washington state schools for vision screening. This paper-based kit has a variety of limitations such as Stereopsis assessment (measuring the 3d depth perception), as well as requires maintenance of the parts.



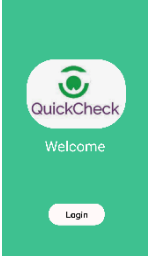


*Figure 1:* The paper-based kit provided by Washington state for vision screening.

There are a variety of means to conduct these tests. Overviews of these methods are provided in Table 1. Development of the Vision *QuickCheck* application would help to address vision issues at an early age, provide schools an effective alternative.

Table 1

*Compares the Screening Devices Used by Washington State Schools with the App Developed by EYE Center Group.*

Categories	Spot Vision Screener	Plus OptiX vision screener	Vision <i>QuickCheck</i> (Beta)
			
Cost	~\$7000	~\$3000	Free
Efficiency	Less than a minute (captures photo)	Less than a minute	~3-4 minutes for test completion
It tests for	Hyperopia, Myopia, Astigmatism, Refraction, eye alignment, Anisocoria	Refraction, Astigmatism, Hyperopia, Myopia, eye alignment, Anisocoria	Myopia, Hyperopia, Stereopsis(strabismus), convergence insufficiency
It does not test for	Convergence insufficiency, strabismus	Convergence insufficiency, strabismus	

### 1.3 Objectives

The Objectives of this thesis were to:

1. Implement a user centered design thinking approach and design the *QuickCheck* app
2. Develop relevant solution using participatory design with UW Kid's Team.
3. Propose usability considerations and recommendations for using the mobile device as a clinical assessment tool in ophthalmology.
4. Perform a usability study with actual users of the *QuickCheck* app.

### 1.4 Organization of the Thesis

Chapter 2 reviews the current state of the art for smartphones and their applications in health and Usability framework for mHealth. Chapter 3 Covers design thinking stages involved in the development of the *QuickCheck* app, user research and participatory design session with UW Kids' Team. Chapter 4 describes the usability metrics, framework and evaluation mode for the *QuickCheck* app. Chapter 5 provides a detailed description of the usability test methods used for *QuickCheck* app so that another individual or organization can use this information to reproduce the exact same study. Chapter 6 reports the data captured during the usability test of the *QuickCheck* app using the pre-test, post-test questionnaire, interview, and observation notes. Chapter 7 covers the limitations of the study and guidelines, recommendations for the future work and chapter 8 shares the conclusion.

## Chapter 2. Literature Review

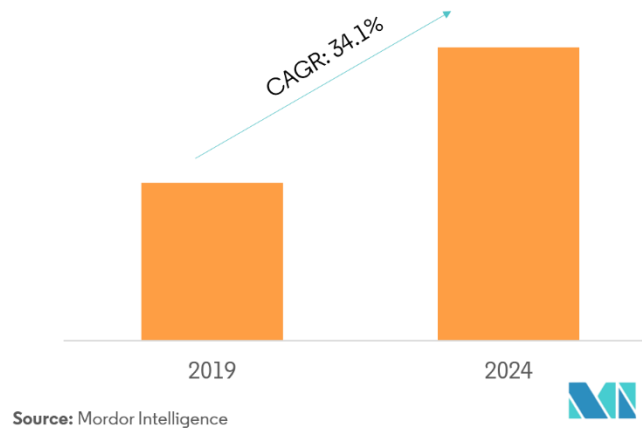
This chapter reviews the current state of the art for smartphones and their applications in health, particularly in the field of ophthalmology. It then describes the existing smartphone applications available in the market for vision screening. Then, it reviews the literature on usability in general, for mobile applications and specifically for mHealth applications. It also discusses as well as compares existing usability evaluation models for mobile applications and in mHealth. At the end of the chapter, the evaluation model used for the *QuickCheck* app is also shared.

### 2.1 Smartphones and Their Applications in Health

Various research studies during the early twenty-first century assessed the advantages of mobile devices to increase the physician-patient interaction, information accessibility and efficiency. There is a large amount of literature available on the use of mobile devices and PDA's (Personal Desktop Assistance) in medical practices. (Enders SJ, Enders JM, Holstad SG. , 2002) (Ford S, Ilich S, Smith L, et al., 2004) (Barrons, 2004) (Collins, 2004) (Baumgart, 2005) (Raybardhan S, Balen RM, Partovi N, et al., 2005) (Honeybourne C, Sutton S, Ward L., 2006) (Dallenbach, 2007) (Fox BI, Felkey BG, Berger BA, et al., 2007)

The availability of smartphones with increased computing capabilities has opened new doors for researchers and medical practitioners to reach out to the patients. They are now using mHealth, medical practice supported by mobile devices, to address conditions like autism, dementia and Parkinson's disease.

According to the Mobile Health Market Report 2019-2024, the global compound annual growth rate (CAGR) for mHealth applications is 34.1% as shown in Figure 2 (Mobile Health (Mhealth) Market - Growth, Trends, And Forecast (2019 - 2024), n.d.)



*Figure 2* : Global mobile health (mHealth) market

ophthalmology has also seen a growth in the use of mHealth. Smartphones are used in ophthalmology as a testing tool for eye exams. Existing literature mentions that the smartphone applications are going to play a crucial role in ophthalmology with continuously evolving and improving technology. ( Shah VA, Lord RK, Kaja S, 2010) (Chhablani, J., Kaja, S., & Shah, V., 2012).

## 2.2 Smartphones and Their Applications in Ophthalmology

There are various purposes for which the mobile apps are used in ophthalmology. Some of the identified categories are (Chhablani, J., Kaja, S., & Shah, V., 2012)

- Testing tools,
- Patient education tools,

- Physician reference tools,
- Physician education tools.

This thesis focuses on the testing tools category. These tools are extensively used for basic tests in ophthalmology. Based on the results, patients might need further eye exams from the eye clinic.

The next stage was to study the available Mobile apps in store. App stores have a category related to health applications. The Google Play store had 158,000 health applications in 2017 and is the leading market for mobile health (Research2guidance, 2017). Figure 3 shows the rise in mHealth applications for the year 2017 across various smartphone markets.

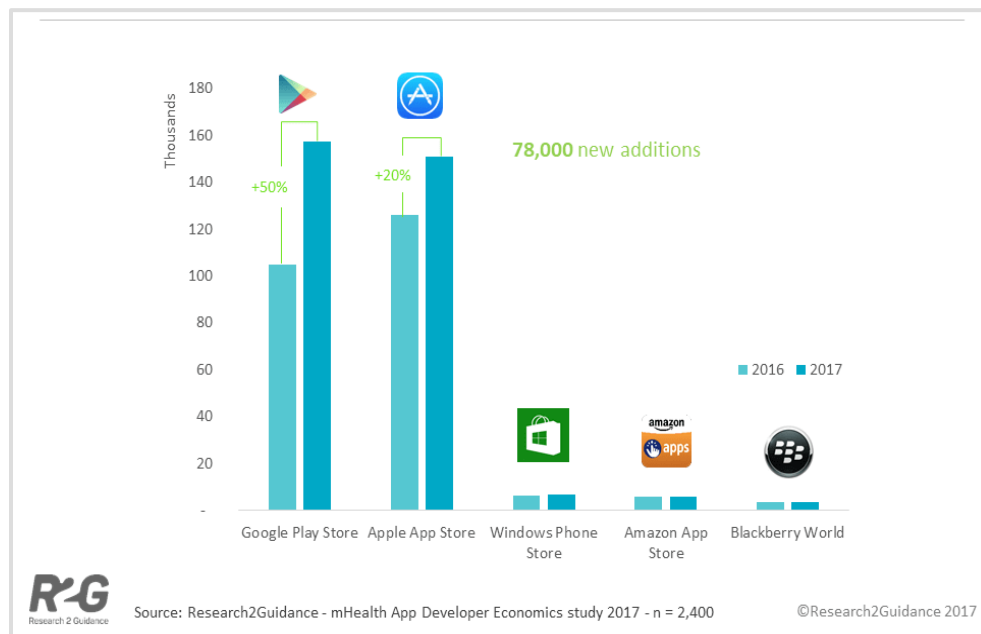


Figure 3: mHealth apps available on various platform and increase in the availability of apps in 2017.

To study existing mHealth ophthalmology applications, I used the search terminology ‘eye exam app’, ‘vision screening app’, and ‘eye test app’, while also selecting only the apps

with four stars or more. As shown in Figure 4 approximately 200 results populated with these keywords.

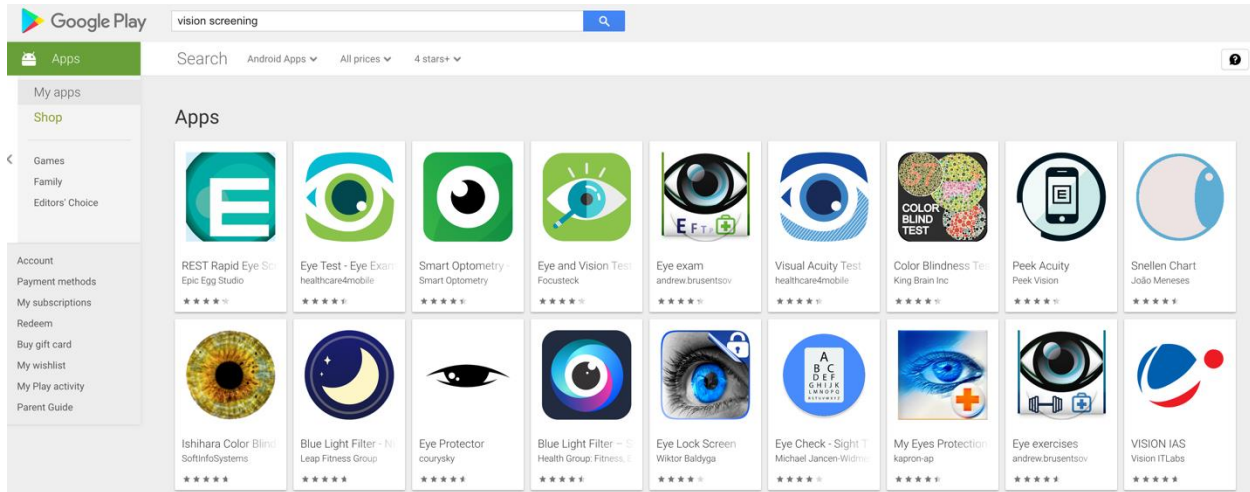


Figure 4: Google play store showing the results for vision screening keyword

Almost all of the apps were testing color vision and visual acuity. I selected a few apps for the discussion based on its use as a clinical assessment tool in ophthalmology. Hardly any of the available apps address the challenges faced by the school kids as discussed in Chapter 1 Introduction.

### 2.3 Smartphone Applications with Types of Vision Screening Tests They Offer

#### 1. Complete Eye Doctor:

Allows to test Visual acuity test, Astigmatism, Color Cube, Duochrome test, Amslergrid, Contrast Sensitivity, Color Blindness, OKN Strip Test, AMD, Landolt Test.

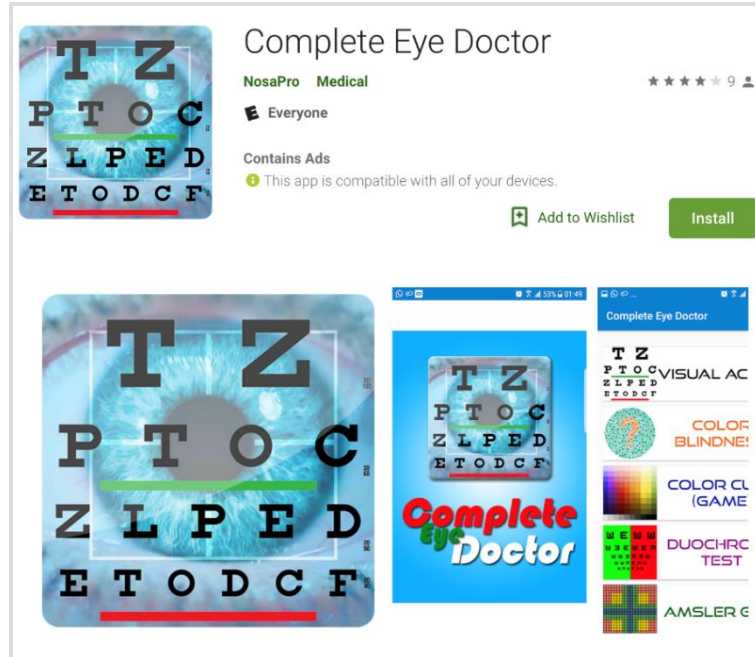


Figure 5: Complete Eye Doctor application screen shot

2. Smart Optometry:

Smart Optometry is used for near vision testing. It provides 16 eye exams in 11 languages such as Color Vision, Contrast, Visual Acuity, Worth Four Dot.

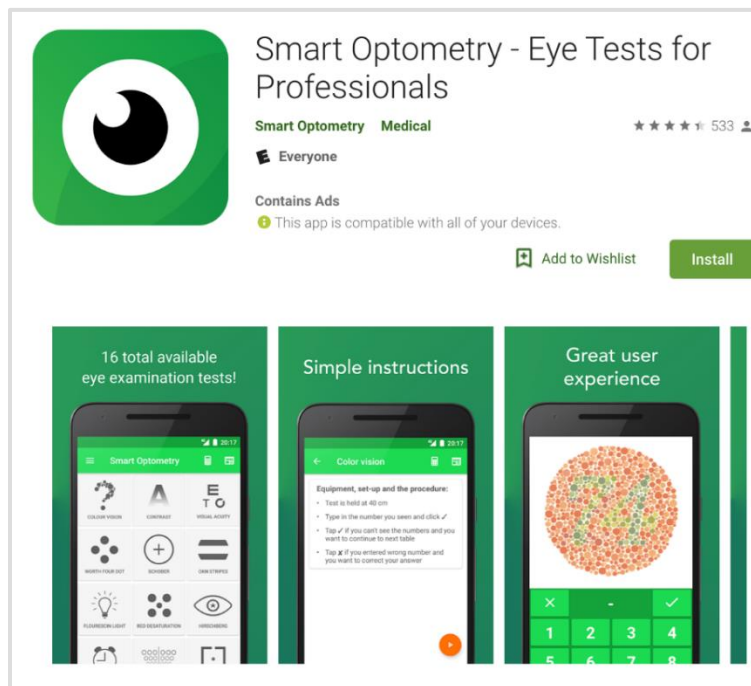


Figure 6: Smart Optometry application screen shot

- 3. Eye Exam: This app allows to check visual acuity.

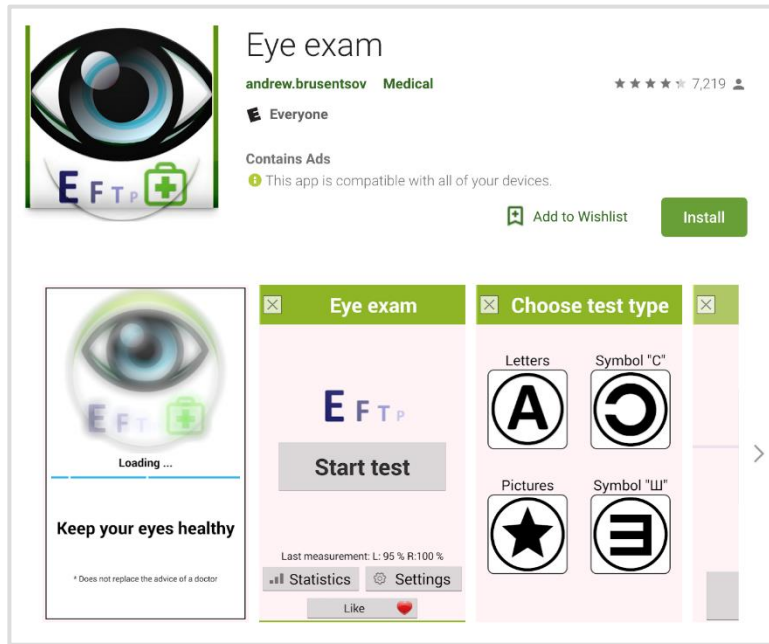


Figure 7: Eye Exam application screen shot

- 4. Check Your Eyes: This app allows to check visual acuity and color vision.

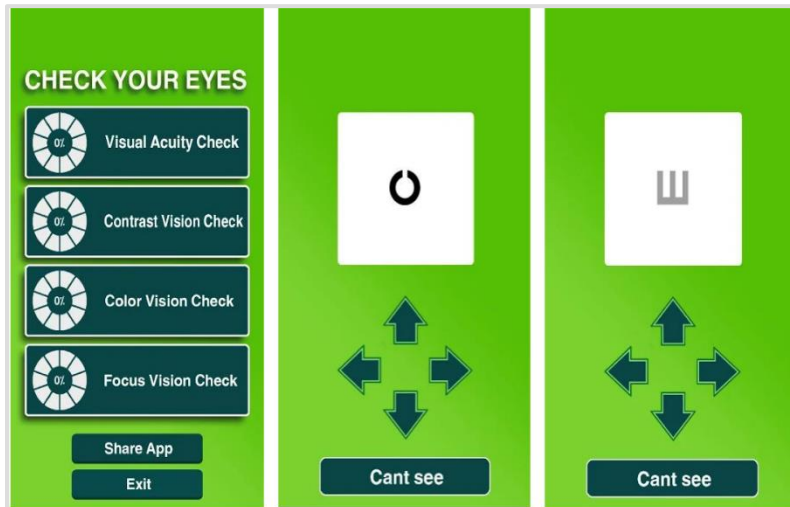


Figure 8: Check your Eyes application screen shot

## 5. Various testing tools available on the iPhone:

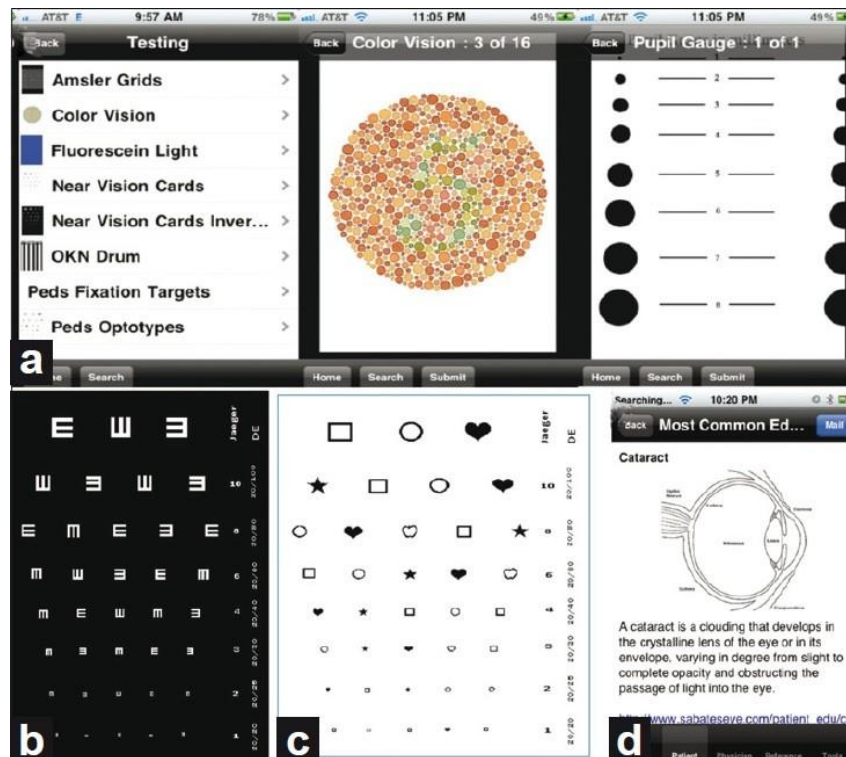


Figure 9: iPhone screen shots: (a) Various testing tools available on iPhone; (b) color vision tool; (c) pediatric optotypes; (d) disease description panel in patient education section. image source: (Chhablani, J., Kaja, S., & Shah, V., 2012)

## 6. The EHB (Eye Handbook):

This is the most inclusive iPhone application available on iTunes and Android stores. The Eye Handbook is a smartphone diagnostic and treatment reference tool. Below is a list of some of its common features:

Calculators, ICD coding, Audio, Video downloads, Directory, Eye Atlas, Eye Wiki, Forums, ophthalmology and Optometry Journals, Medication ,journals, Eye Diagrams, Patient Education tools, RSS Feeds, Acronym, Testing, Treatment Reference, Vision, Symptoms.

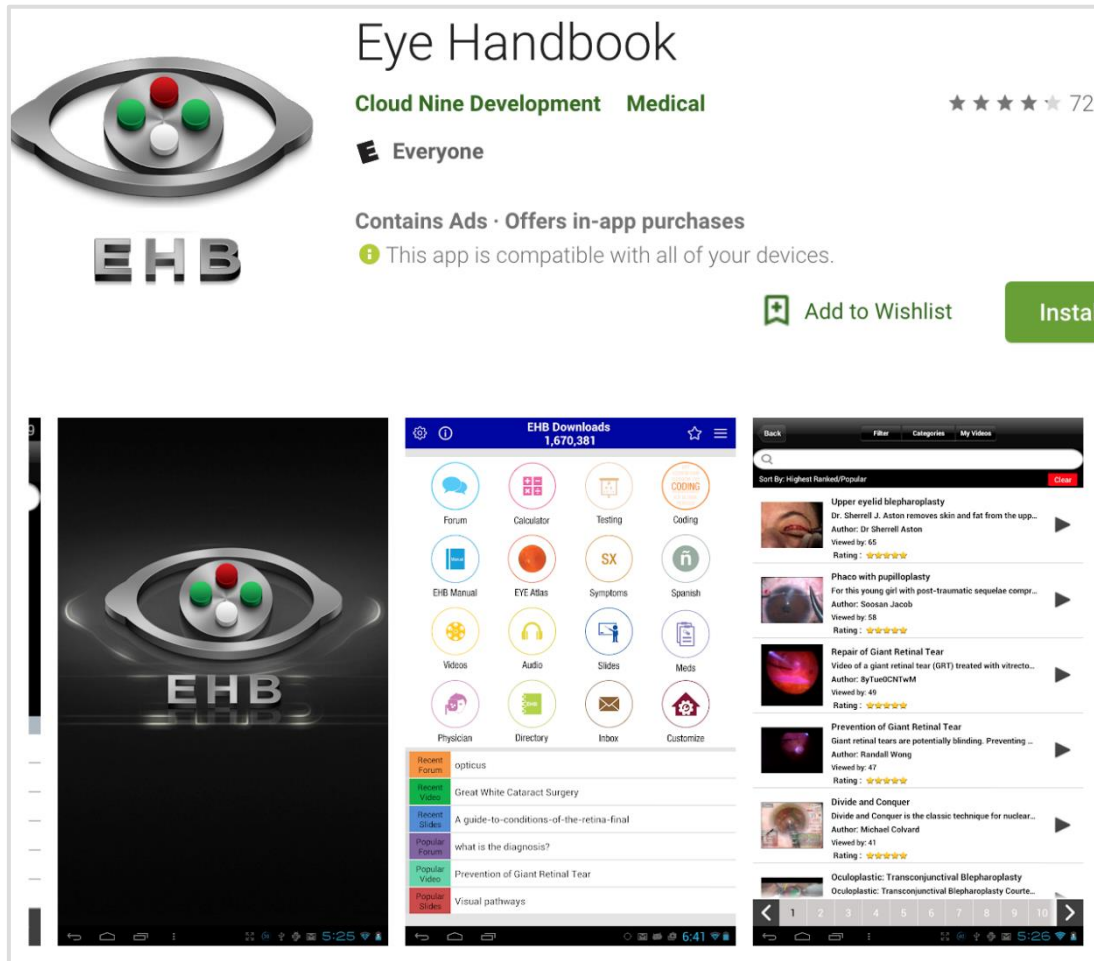


Figure 10: The EHB (Eye Handbook) application screen shot.

With such a vast number of mobile apps available in the market, it is crucial to evaluate the apps. The report published by American Society of Health-System Pharmacists on evaluation of mobile applications shares the concern that quality, efficacy, accuracy, privacy, compliance (HIPPA) and safety of mHealth apps must be evaluated critically (Hanrahan C, Aungst T, Sabrina C, 2014).

Also, usability remains the crucial factor in adopting smartphone applications for their designated purpose by various stakeholders such as medical practitioners and patients. It is challenging to present the vast amount of information in user friendly, easily accessible manner.

## 2.4 Understanding Usability

This section discusses the usability definitions and ISO standards associated with the different usability metrics.

### 2.4.1 Definition of Usability

According to the ISO/IEC 9126–1 revised in 2011 to ISO/IEC 25010 (International Organization for Standardization, Systems and software engineering -Systems and software Quality Requirements and Evaluation (SQuaRE)- System and software quality models ISO/IEC 25010–1 Quality model,, 2011) contains a software quality model that defines usability as the “degree to which a product can be used to attain stated goals with effectiveness, efficiency and satisfaction in a specified context of use”. Some authors have proposed their own model by including the “learnability” characteristic in the model proposed by ISO9241–11: (Dix et al., 2003), (Nielsen, J et al., 1993) and (Abran et al., 2003). Please see Table 2.

Table 2

*ISO standards related to usability measurement from (Rana, A. and Mridu, M., 2012)*

<b>ISO Standard for Usability</b>	<b>Usability Description</b>
(International Organization for Standardization, Ergonomics of human-system interaction Part 11: Usability: Definitions and concepts, ISO 9241–11 Guidance on usability, 2018)	Identifies efficiency, effectiveness, and satisfaction as major attributes of usability.
(International Organization for Standardization, Systems and software engineering -Systems and	Defines the standard as software quality attributes that can be decomposed into five

software Quality Requirements and Evaluation (SQuaRE)- System and software quality models ISO/IEC 25010–1 Quality model,, 2011)	different factors: understandability, learnability, operability, attractiveness, and usability compliance.
(International Organization for Standardization, Systems and software engineering -Systems and software quality requirements and evaluation (SQuaRE)-- Measurement of quality in use ISO/IEC 25022:2016, 2016)	Defines the related concept of quality in use as a kind of higher-order software quality attribute.
(International Organization for Standardization, Systems and software engineering -- Systems and software Quality Requirements and Evaluation (SQuaRE) -- Evaluation process ISO/IEC 25040:2011, 2011)	Develops a model for measuring quality in use from the perspective of internal software quality attributes.

## 2.5 Usability Metric Framework for Mobile Applications

It has been identified that usability is one of the crucial factors for mobile phones which determines their success rate and ease of use for the end user (Baharuddin et al., 2013), (Coursaris C and Kim d, 2011). The literature study employs effectiveness, efficiency and satisfaction as quality characteristics. Table 3 describes the most common usability guidelines for mobile application development obtained from a literature review by (Rana, A. and Mridu, M., 2012)

Table 3

*Usability Attribute to be Considered for Mobile apps (Rana et.al 2012)*

<b>Attributes of usability</b>	<b>Explanation for attribute</b>
Completeness	The extent of completion of the tasks performed by the users should be high
Accuracy	The accuracy with which users' complete tasks should be high.
Less or no error	The errors made by the users during the process of completing a task should be low.
Ease to input the data	The data input process should be simple.
Ease to use the output	The output should be very simple and accurate.
Ease to install	The application should be friendly to install.
Response time	The system must respond in an appropriate time.
Simple	The application should be straightforward.
Time	The duration of tasks or parts of the tasks should be appropriate.
Ease to learn	The user interface must be designed for the user to learn easily.
Application size	The space used by the application should be appropriate.

Battery power used	The battery power use by the application should be minimal.
Wireless connectivity	The application should be able to easily connect to the network.
Features available	Appropriate features should be available on the application.
Interface satisfaction	Measures satisfaction as the interface that the users prefer using.
Provide support/help	The help information given by the application should be useful.
Safety	The user should be safe and secured while using the application.

## 2.6 Usability metric for the mHealth app

While performing the background study, I came across another meta-analysis review performed on the usability of mobile health applications (Coursaris C and Kim d, 2011). This review, however, does not study mobile applications for vision related disorders. It identifies attractiveness, learnability, operability, and understandability as the key attributes for mHealth apps study. Based on this study, Table 4 shows the results obtained by the usability evaluation of mHealth applications by (Zapatah et al, 2015). Results from this study can be used as the guideline for new mHealth application development.

Table 4

*Compilation of Usability Attributes on mHealth Applications (Zapatah et al, 2015)*

<b>Metric</b>	<b>Features associated with metric</b>
Attractiveness	The color black is often found to be repulsive.
	The color of components should contrast with the background.
	Adults are not interested in gaming applications, unlike teens.
Learnability	Training is important to reduce the time needed by users to learn how to use the app.
	A monotonous user interface causes poor learnability.
	A tutorial at the start of the app is desired by users to guide them.
	Users learn how to use a touchscreen after a few tries.
Operability	It takes a young adult $\frac{1}{4}$ of the time required by an older adult to complete a task.
	Free text inputs should be avoided.
	Dropdown menus with pre-written options improve efficiency.
	Difficulty in scrolling despite the existence of visual hints
	Difficulty in performing swipe gestures
	Difficulty in holding the tablet and interacting at the same time
Understandability	Texts should be easily understood to avoid confusing terms or actions.
	Need for bigger font sizes, even on the keyboard

Buttons need to look like real buttons.
Too much information or commands on a single screen should be avoided.
There is a tendency to press icons but not the associated text.
Difficulty in managing navigation levels, relying on the back button as a safer option

## 2.7 Comparison for Usability Evaluation Models for Mobile Applications

In order to decide the usability evaluation model for the *QuickCheck* app, it was crucial to review the existing literature. This literature review provided a framework and list of considerations to assess the suitability of different models for the *QuickCheck* app. The Questionnaire for User Interaction Satisfaction (QUIS) (Norman K et al., 1988) QUIS was developed by the research group at the University of Maryland. It provides a wide-ranging list of usability dimensions with a solid evaluation framework. The model has been extensively used by the HCI community (citation count: 268) for commercial and research purposes. It has been more widely used for evaluating web-based applications than mobile applications. Also, its applicability for mHealth applications has not been tested.

The work by (Zahra, Fatima et al., 2017) provides a bird's eye view on the existing usability evaluation models. It helps to understand the advantages and limitations of these models. See Table 5

Table 5

*Usability Models for Mobile Applications (Zahra, Fatima et al., 2017)*

<b>Models available</b>	<b>Usability dimensions used for evaluation</b>	<b>Advantage</b>	<b>Limitation</b>	<b>Tested for</b>
Condos et al. (2002)	Navigation, Contents, Information architecture, Error prevention, Presentation, Input rate, Menu visualization	Covers a good range of usability metric	Does not provide enough guideline on how to apply proposed metric	e-commerce application
mGQM (2012)	Accuracy, Attractiveness, Features, Safety, Simplicity, Time taken	Built on the ISO 9241-11 usability model, specifically developed for mobile applications	Lacks the evaluation criteria for trust and security	m-banking application
Coursaris & Kim (2011)	Effectiveness, Efficiency, Satisfaction, Errors, Utility, Learnability, Attitude, Operability, Safety, Accuracy, Ease of use, Flexibility, Usefulness, Accessibility, Playfulness, Memorability	Developed for the researcher to examine which usability dimensions should be considered while evaluating mobile applications	Does not provide the supporting metrics for each dimension	Not evaluated to determine its applicability and accuracy.

Baharuddin, et al. (2013)	Effectiveness, Efficiency, Satisfaction, Usefulness, Aesthetics, Learnability, Simplicity, Intuitiveness, Understandability Attractiveness	Usability model based on HCI principles such as user, environment, technology, and task/activity	Lacks support on how to evaluate specific mobile application security and privacy	Not evaluated to determine its applicability and accuracy.
Tan, et al. (2013)	Efficiency, Effectiveness, Productivity, Satisfaction, Learnability, Safety, Accessibility, Generalizability, Understandability	Framework aimed at mobile companies to analyze collected data on the usability	Criteria are centered on user experience with the mobile app.	Case study in a small telecommunications company
Harrison et al (2013) Saleh et al (2015)	Effectiveness, Efficiency, Satisfaction, Learnability, Memorability, Errors, Cognitive load	Contribution of the study is the inclusion of cognitive load dimension and model was developed to extend the existing usability models.	Lacks guidelines and metrics related to chosen usability dimension	Requires evaluation to determine its applicability and accuracy

## 2.8 Usability Evaluation Models for mHealth

To evaluate the quality and usability of the mHealth apps various frameworks have been suggested. (Jake-Schoffman, Danielle E et al., 2017) summarizes the existing methods for evaluating the content, usability, and efficacy of commercially available mHealth apps, however, it does not provide a framework that can be applied to mHealth. (Nouri et al., 2018) identifies 7 main classes - Design, Information/Content, Usability, Functionality, Ethical Issues, Security and Privacy, and User-perceived value - with 37 sub-classes of criteria. This extensive list is helpful to decide the criteria based on which a specific mHealth app can be tested.

Mobile app rating scale (MARS) developed by (Stoyanov SR et al., 2015) provides five broad categories of criteria - Engagement, Functionality, Aesthetics, and Information Quality, and one subjective quality Scale. It has tested against sixty well-being mHealth applications. It has not yet been widely used but it provides a good framework for usability evaluation. The MARS is customizable. It satisfied the requirements for assessing the usability of the *QuickCheck* app i.e. Efficiency, Effectiveness, Learnability, and Operability. Thus, I decided to use the MARS evaluation model for *QuickCheck* app. To check more details of the test, check the APPENDIX section. I customized the test to assess the specific features related to vision screening, such as calibrations and operability of mobile device during the vision screening. These criteria are not covered in the existing MARS framework.

## Chapter 3. Design Methodology

This chapter provides user research, design and output produce at each design thinking stage involved in the development of the *QuickCheck* app.

### 3.1 Design Thinking Process for *QuickCheck* app

Design Thinking is a human centered approach to design solutions innovatively. According to (Razzouk et al., 2012), “Design thinking is generally defined as an analytic and creative process that engages a person in opportunities to experiment, create and prototype models, gather feedback, and redesign.” We followed this design thinking approach for the development of the *QuickCheck* app. Design thinking helps to understand the unmet needs of the end user. The approach helps to build a deep understanding of the people, their habits, concerns which can be incorporated into the design solution. Design thinking is an iterative approach which allows continuous improvement in the solution. i.e. the results of the first iteration confirm if assumptions made at the start of the project were correct or need to refine further and make the necessary changes in the next iteration. See Figure 11.

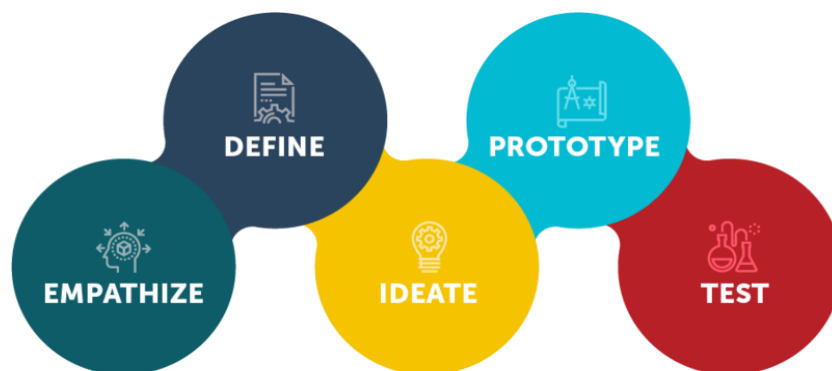


Figure 11: Process of Design Thinking

(Source: <http://denovo.dwt.com/>)

The first step was to understand the needs of the target audience i.e. school nurses, teachers, and doctors (Empathize). Based on the insights from the doctors, school nurse’s

persona, we built the idea by identifying user stories (Define and Ideate). Then we designed the wireframes, flow diagrams and mockups for the *QuickCheck* app (Prototype). In the end, we tested the app with actual users and gathered feedback (Test). The entire process, as illustrated in Figure 11, is iterative. The design thinking approach allowed me to gather insights and experiment with ideas at different stages of product development. This entire process helped EYE center research group to develop a more relevant and usable solution for the school nurses. I will discuss the existing EYE center solution and various design thinking stages along with their outcomes in the next sections.

### 3.2 Screening Solutions Provided by EYE Center

EYE center research group has previously developed vision screening applications as shown in Figure 1-4.

#### 3.2.1 Near Vision Toolbox

Near Vision Toolbox provided a platform for detecting vision problems of children and making vision therapy more efficient for children.

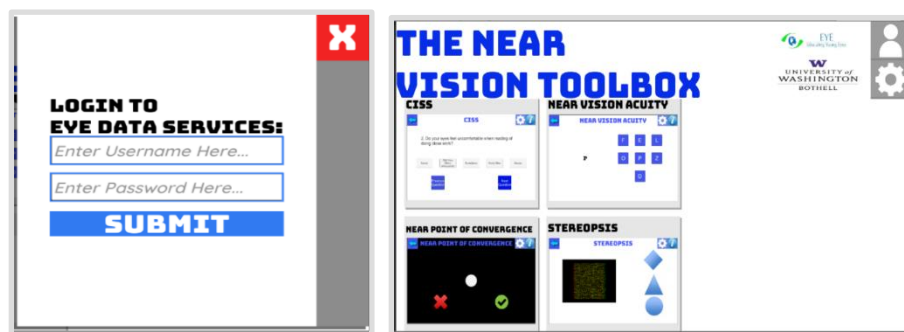


Figure 12: Earlier version of Near Vision Toolbox: Login and Home page screens toolbox

1. Convergence Insufficiency Symptom Survey (CISS): The CISS was designed to quantify the severity of symptoms associated with convergence insufficiency (CI).

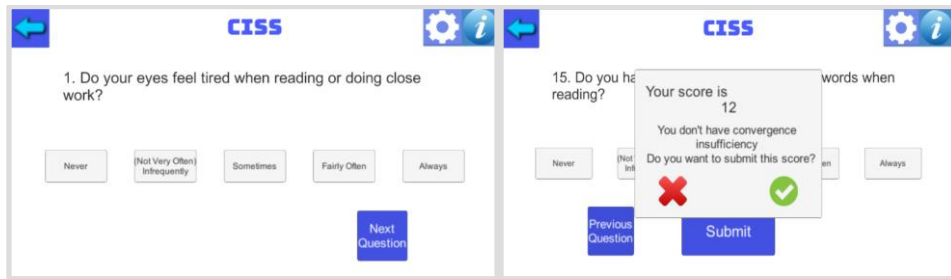


Figure 13: Earlier version of Near Vision Toolbox: CISS test

2. Near Vision Acuity: The purpose of testing near vision was to determine how people can cope with near tasks.



Figure 14: Earlier version of Near Vision Toolbox: Near Vision Acuity Test

3. Stereopsis: Stereopsis is a term that is most often used to refer to the perception of depth and 3-dimensional structure obtained based on the visual information deriving from both the eyes by individuals with normally developed binocular vision.

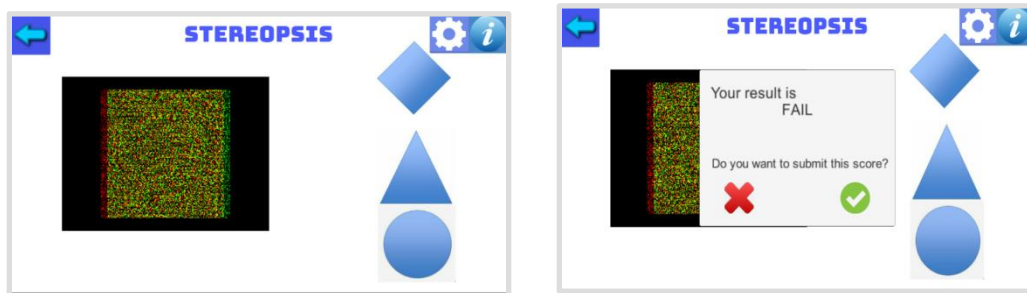


Figure 15: Earlier version of Near Vision Toolbox: Stereopsis

### **3.2.2 Limitations of the Near Vision Toolbox (an earlier version of QuickCheck)**

1. The earlier version was not capable of storing the student's record.
2. It was not generating a consolidated result for the students' performance in all the vision screening tasks.
3. There was a lot of scope for UI improvement.
4. It was developed as a web application and the current need was for a mobile based solution.
5. The intention to create it was more as an activity tool than a diagnostic tool.
6. Distance vision acuity test was not developed in this toolbox which is important for school kids.
7. The overall time required to finish all the tasks was 10 minutes.

## **3.3 Design for QuickCheck App**

With these lists of challenges, we started brainstorming about how we can take this solution to the next stage and make it more usable in the real world. We started doing user research to create a design which would be truly relevant to Ophthalmologists.


### **3.3.1 Persona**

There are four different perspectives regarding personas: goal-directed perspective, role-based perspective, the engaging perspective, and the fiction-based perspective. The personas developed using fiction-based perspective are called Ad hoc personas. The personas in the fiction-based perspective are often used to discover design and insights in the field (Floyd et al., 2008). Ad hoc personas do not include data as the source for describing persona, but it generates personas from the designers' insight, assumption (Norman, 2004) and discussing with the people who have interacted with actual persona. I learned that school nurses, teachers, volunteers

conduct vision screening in the schools. Also, one of the intended users of this app in the future is parents. They can use the tool at home to perform the screening of their kids. EYE Center research group wanted to address the challenge of schools by providing the more appropriate screening tools for kids. Hence, our important persona for *QuickCheck* is a school nurse who performs vision screening in schools. The screen shots show the Ad hoc persona created for *QuickCheck* app. Dr. Pearson and Dr. Erdly who have worked extensively with school nurses provided the data for the school nurse persona.

## Sophia Ochoa

School Health Professionals



Age  
33


Occupation  
School Nurse

Location  
Seattle


---

**Quote**


“*The knowledge and technology nurses use is very important since they dealing with peoples life.*”  
— [Carolyn Jarvis](#)

 **Goals**

- Fetch the student record
- Perform the vision screening such as near vision, distance vision, check the 3D vision.
- Get the results as referral required or no referral required.

 **Frustrations**

- As a school nurse, I have to perform the vision screening for almost 100 kids in one school. The current paper-based procedure is screening is time consuming.
- Using digital device, it takes few seconds to perform the vision screening. But it is not capable of detecting the near vision problems. Diagnosing the near vision is crucial for students learning process in school.
- The device is so bulky and requires investing around 1500 dollars.
- I manually prepare reports for the kid's vision screening, It will such time saver if report get directly send as an email to parents.

 **Values**

- Eye health for school kids is crucial.
- The methods, devices should have a greater accuracy and precision.
- Nurse must have a correct knowledge to perform the vision screening.

### 3.3.2 User Story

Based on the persona, we identified user stories that are important to address the needs and frustrations of the school nurse. See Table 6.

Table 6

#### *User Stories for school nurse*

<b>ID</b>	<b>As a /an</b>	<b>I want to</b>	<b>So that</b>
1	School Nurse	Be able to register to the Eye Center Vision screening app	I can login to the app
2		Be able to login to the app	I can conduct the student vision screening test
3		Be able to choose two levels Level 1: Kindergarten and grade one Level 2: Grades two and above	So that I can conduct a relevant screening test for students
4		Be able to see the options to the 5 screening tests suggested by the Washington state: 1. Distance visual acuity (eye chart) 2. Distance visual acuity with eye flippers (eye chart) 3. Near visual acuity (eye chart)	I can identify the student vision related issues

		4. Stereopsis test 5. Convergence insufficiency survey	
5		Be able to store the screening data for the student	Based on results, student can be given proper advice as 'refer to an eye doctor' or 'refer'.
6		Be able to print the results.	A parent can take the results and act on them (results should say if a referral is needed).
7		Be able to get help for conducting screen tests using mobile device (i.e. training instructions video/manual)	So that I would know how to conduct the test using the mobile app

### 3.3.3 Scenario

According to (Nielsen L. , 2002), "A scenario is a written story that describes the future use of a system or a website from a specific, and often fictitious, user's point-of-view". Scenarios help to focus design efforts on the user's requirements. The scenario would also help to clarify the user's goal, a process they might use and inputs to the system. Since we were redesigning the vision screening tool for a mobile device it was important to know how the user might use the app in a real situation. Optometrist Dr. Alan Pearson have experience of performing the vision screening and working with the school nurses/ teacher. He helped us to imagine the

scenario for *QuickCheck*. We choose the schoolteacher persona to describe the vision screening app scenario. Figure 16 shows the scenario used for the *QuickCheck* app.

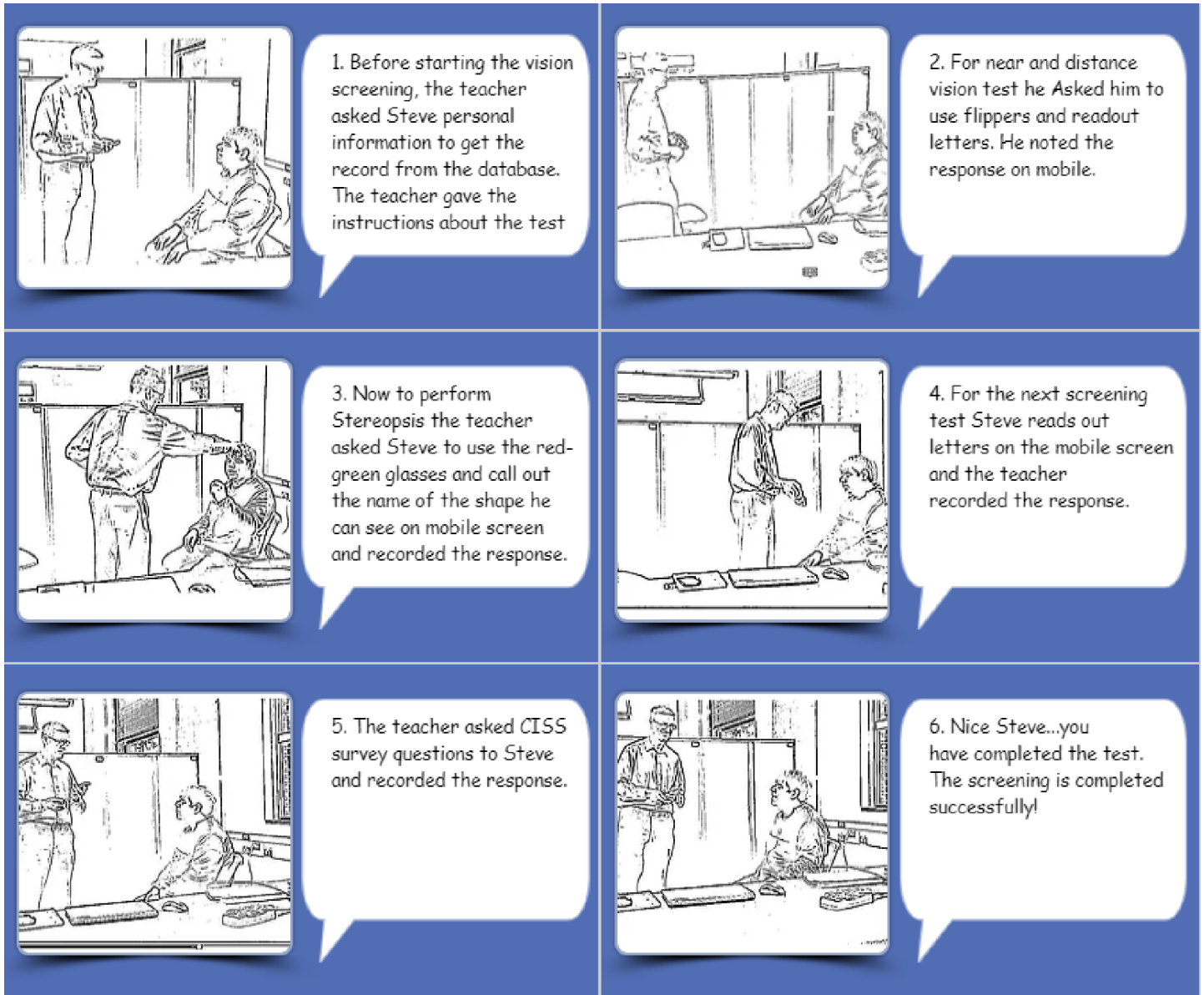


Figure 16: QuickCheck app usage scenario

### 3.3.4 Vision QuickCheck App Flow Diagram

Based on the scenario in Figure 16, I came up with a possible high-level flow of the QuickCheck application. See Figure 17. Flow helped to understand the user's interaction with the QuickCheck app at various stages to achieve the end goal i.e. to perform a complete vision screening.

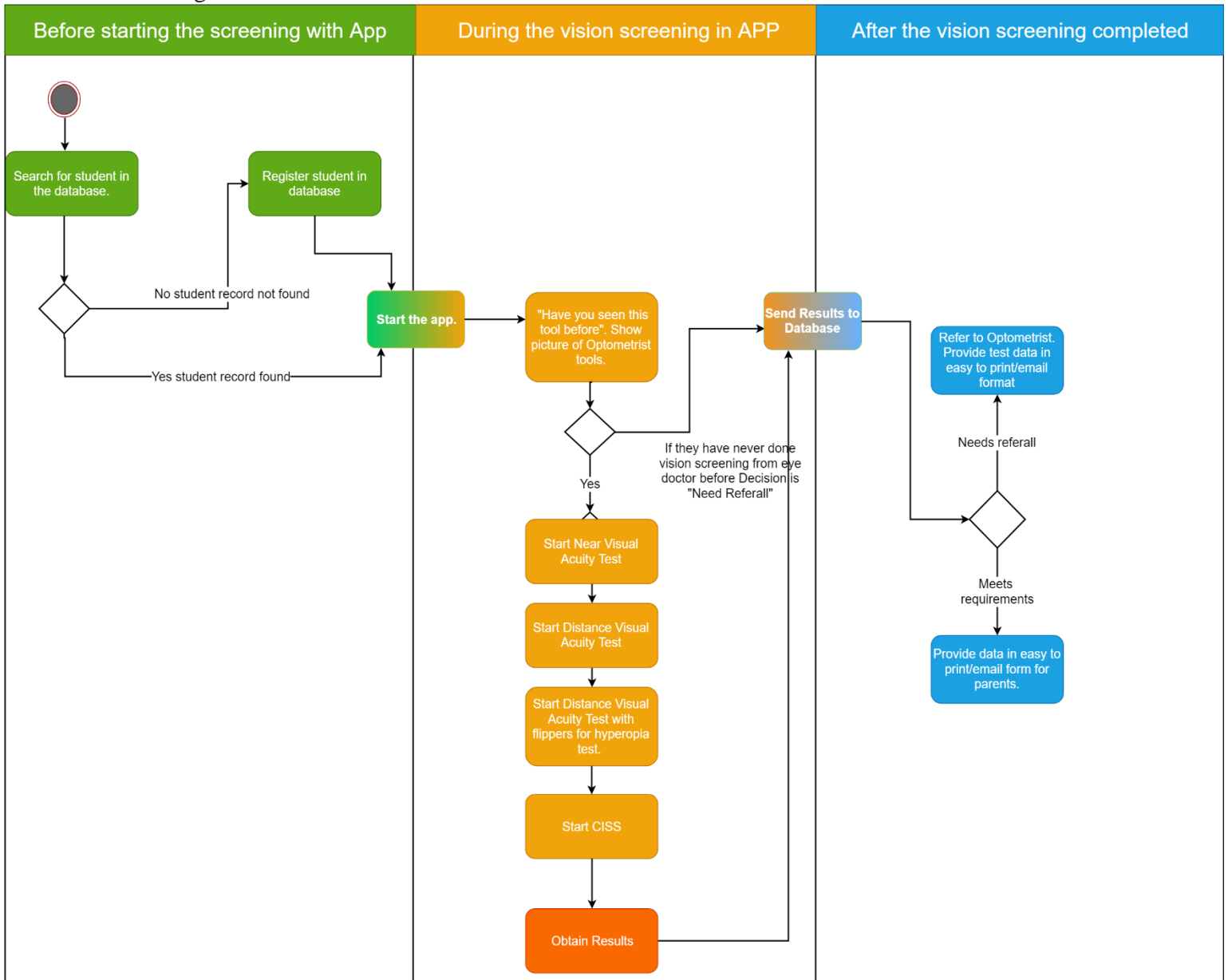
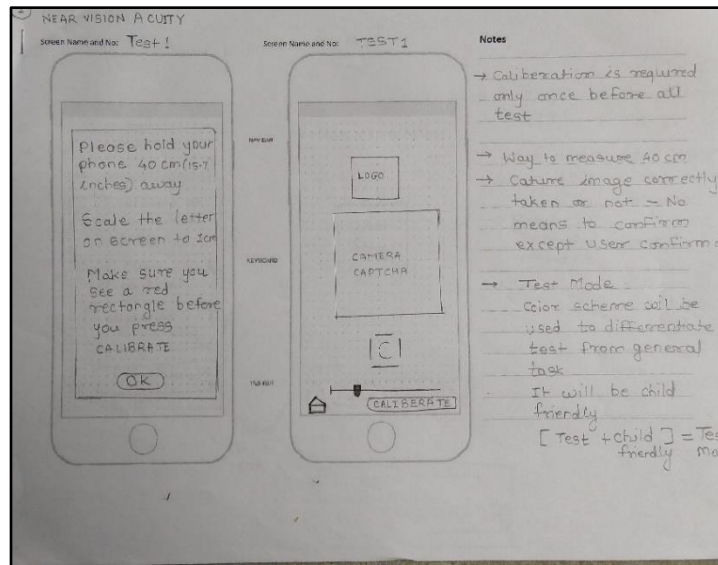


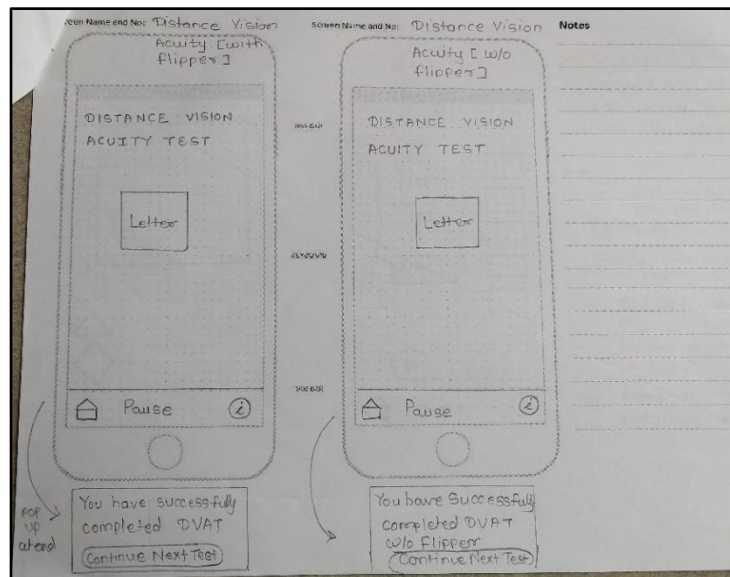
Figure 17: User flow for QuickCheck app

### 3.3.5 Screen Design for Quick Check

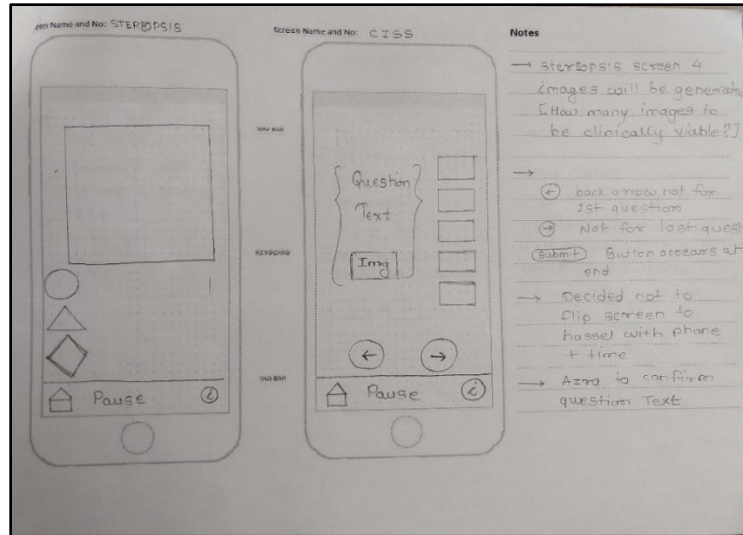
The next stage in the design was to create a low fidelity design. Wireframes are low fidelity representation of the product, i.e. not very detailed but detailed enough to understand the screen flow. Figure 18 shows the paper wireframes created for the *QuickChec* app.



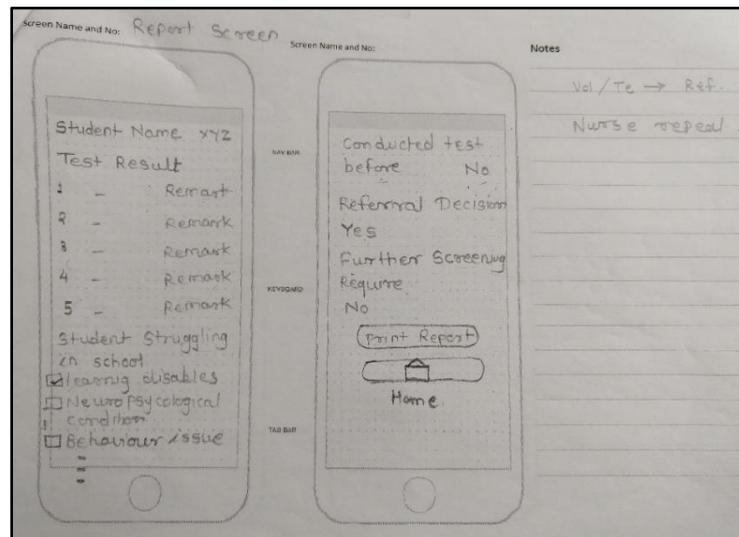
Screen1- Calibration



Screen 2-Near and Distance vision acuity tools



Screen 3-Stereopsis and CISS tools



Screen 4- Results page

Figure 18: Early stage Wireframes design on paper for the QuickCheck app (Screen1- 4)

### 3.3.6 Low Fidelity Mock-Up

To make further design decisions, I created mock-up using the Figma tool. Low fidelity mockup helped me to identify key flows of the system that will enhance the user flow such as allowing the user to retake the test, auto populates the student record from the data base, provide error messages and confirmation messages after each test. See Figure 19

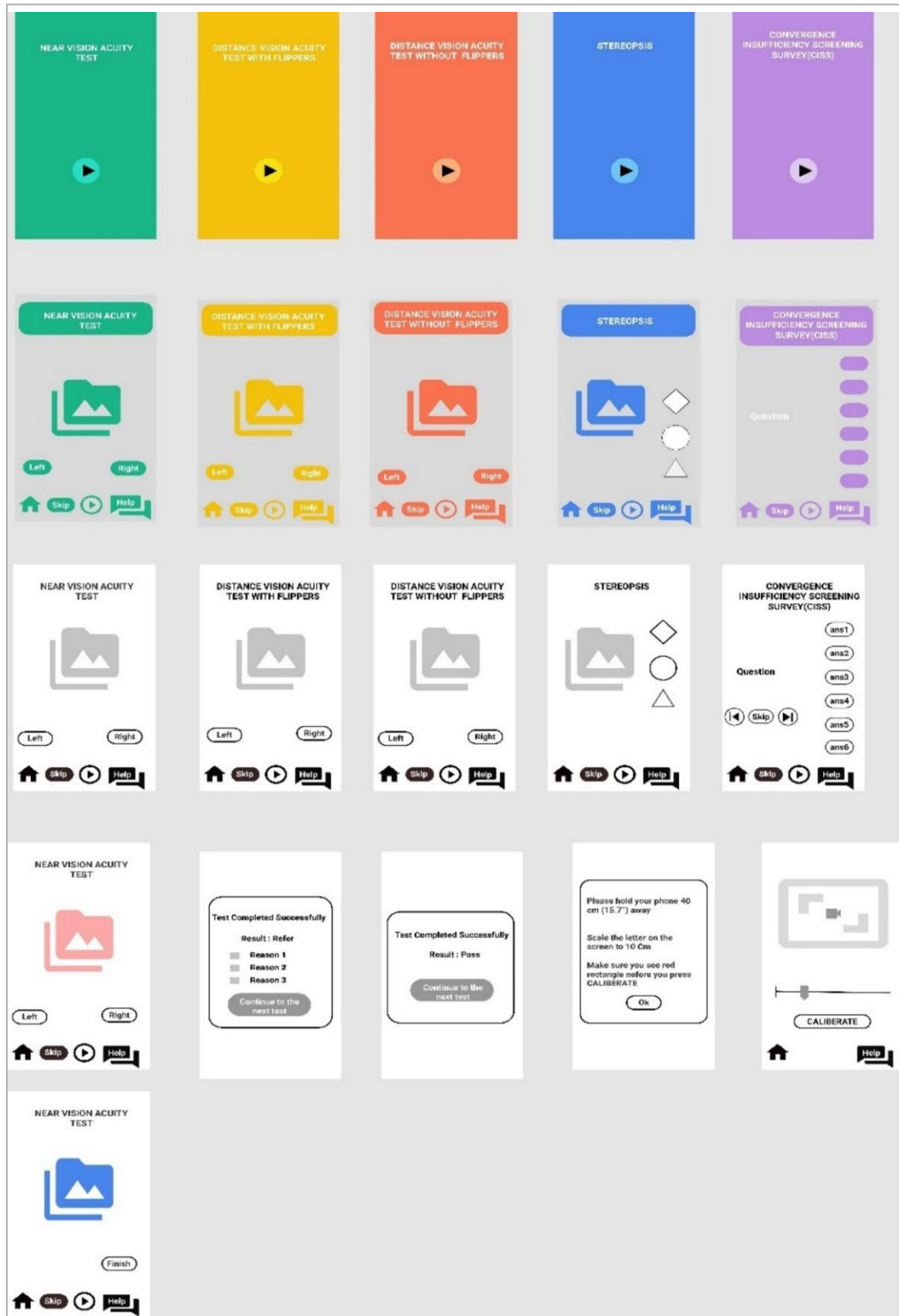



Figure 19: Low fidelity mockup of the QuickCheck app

At every stage of the design, I presented the outcome to research group members, gathered their feedback and made improvements. In the initial design phase, we identified some of the essential features for the *QuickCheck* app such as the following:

- Allow users to skip the test. Not all the tests are required for all students. Some students who have been already identified with disorders like ADHD (Attention-deficit/hyperactivity disorder) do not require CIS (Convergence insufficiency) survey. Children with ADHD struggle to read (Czamara, D et al., 2013) so they will surely fail CISS (Convergence insufficiency) test. So, nurses should be able to skip the test and save time.
- Help option to provide instruction on how to conduct the screening task. Using a mobile device for vision screening is going to be a new experience for most of the school nurses so instructions on how to conduct the screening task would enhance their learning experience.
- Use the big size buttons to support different thumb sizes. (Balakrishnan, 2008).
- Use of different colors for each test to indicate the transition between the tests.
- Allow user to record student's response using the buttons of each letter 'H', 'O', 'T', 'V' on the left-hand side of the screen. The nurses do not have to worry about whether the answer given by the student is right or wrong (app logic would take care of it.) This will help to reduce cognitive load (Whitenton, 2013) on the school nurse while conducting the vision screening for 100-500 students.
- Provide the option of less distraction mode while performing vision screening. (Nielsen and Molich, 1990) defined 10 user interface design principles, one of them is the minimalistic design which states "All unnecessary information competes for the

user's limited attentional resources, which could inhibit user's memory retrieval of relevant information.”. Sometimes kids may get distracted with more information on screen so having minimum content on screen would help to capture student's attention.

I also identified color, layout, and fonts for the app with the following considerations:

- Decided to use icons as buttons, instead of the classic label style buttons. Some common icons such as ‘home’  are easy to recognize and can be easily operated using fingers. Icons also save space on the screen. (Harley, 2014)
- Chose the green color for the app screens since green is restful for eyes and is also associated with healthy living. (Soegaard, 2019)
- Chose the ‘Roboto’ font which is the system font for android devices it also helps to achieve readability of the text. (Sharrock, 2018)
- Provide customization option in the app to suit the user's preferences based on habit. e.g. Based on users' habit of right-handedness or left-handedness they should be able to change the placement of student response recording button on the right or left of the screen.

### 3.3.7 Logo Design

After reviewing some existing literature, guidelines from the internet, and brainstorming on a couple of ideas, I identified some keywords and colors that would be relevant for the design of a logo for the *QuickCheck* app. I thought that the design should be associated with eye health, well-being, and quickness (since an important feature of the app is to be able to perform the vision screening quickly). I prepared various samples (see Figure 20) with name, logo and discussed them with the group.



Figure 20: Logo design for the QuickCheck app (a few samples)

When group members liked one design, I created multiple variations (see Figure 21) based on some suggestions and then finalized one of those designs (see Figure 22).



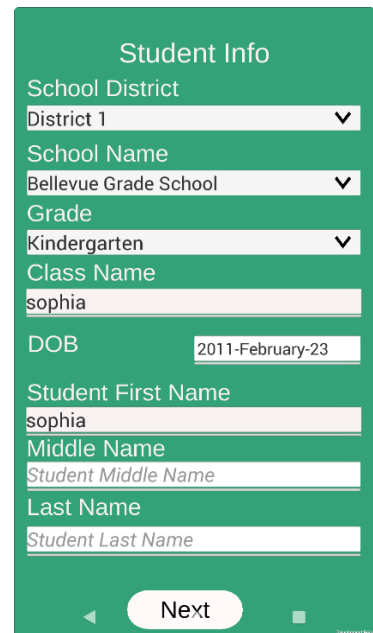
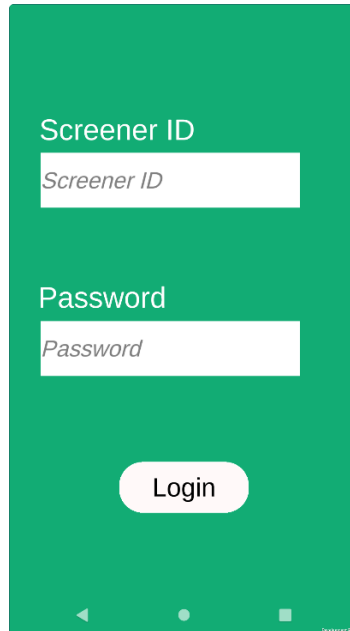
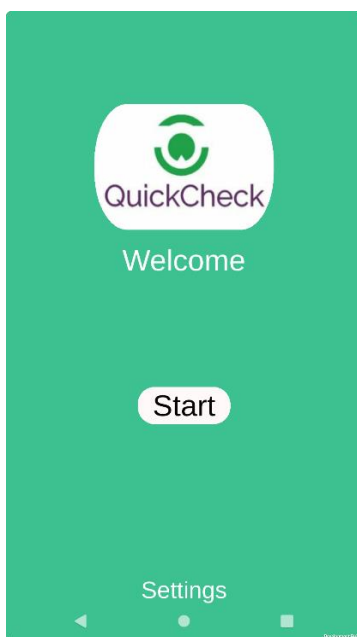
Figure 21: Logo design variation for the QuickCheck app



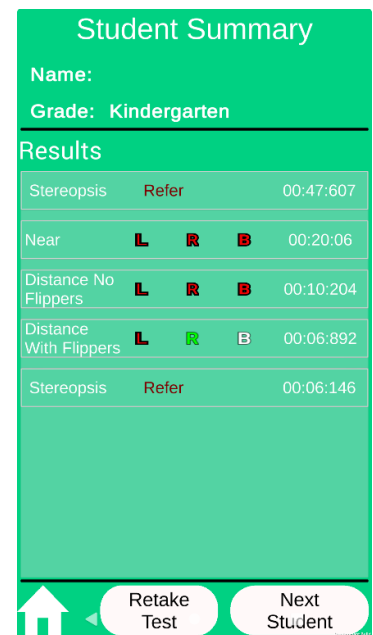
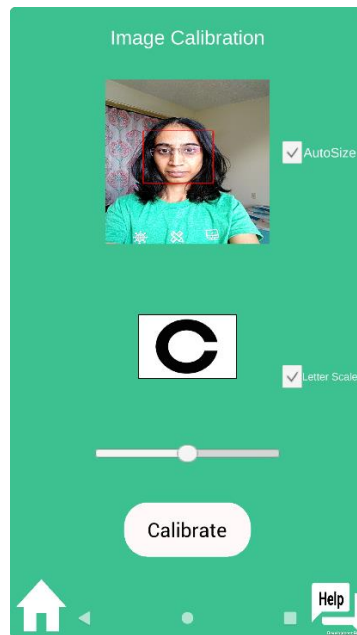
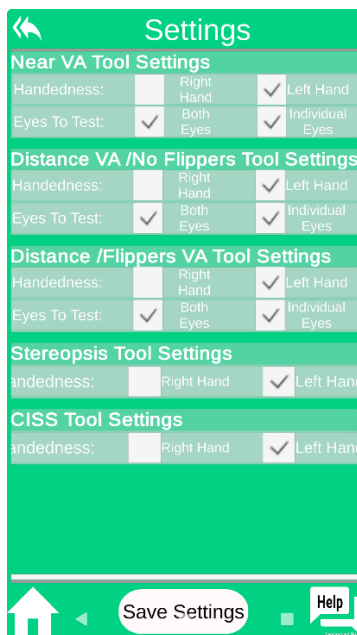
Figure 22: Finalized logo design for the QuickCheck app

### 3.3.8 Screen Shots of the QuickCheck App (From Latest Release)

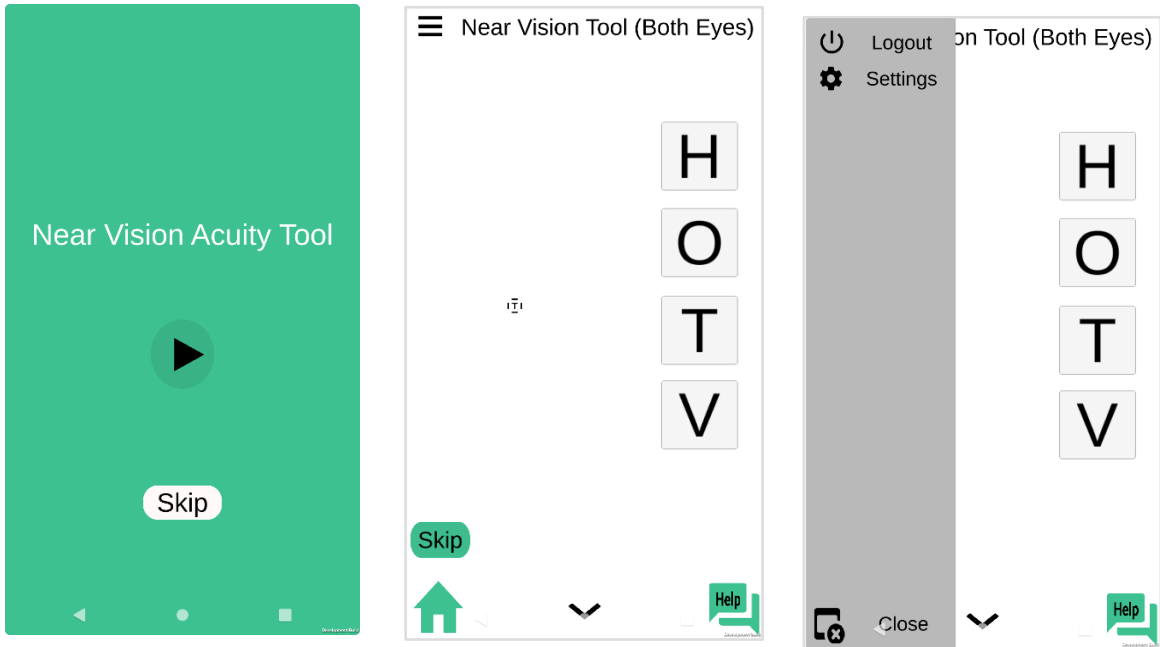
1. Login and auto populate the student record screens



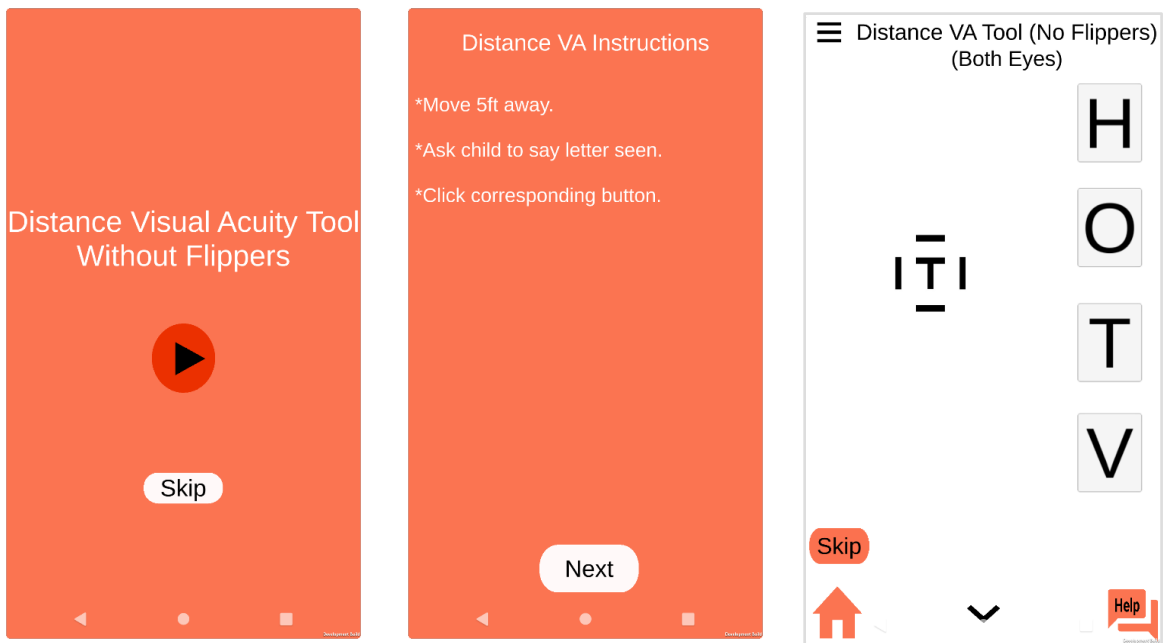
2. Settings, Calibrate the distance and results page



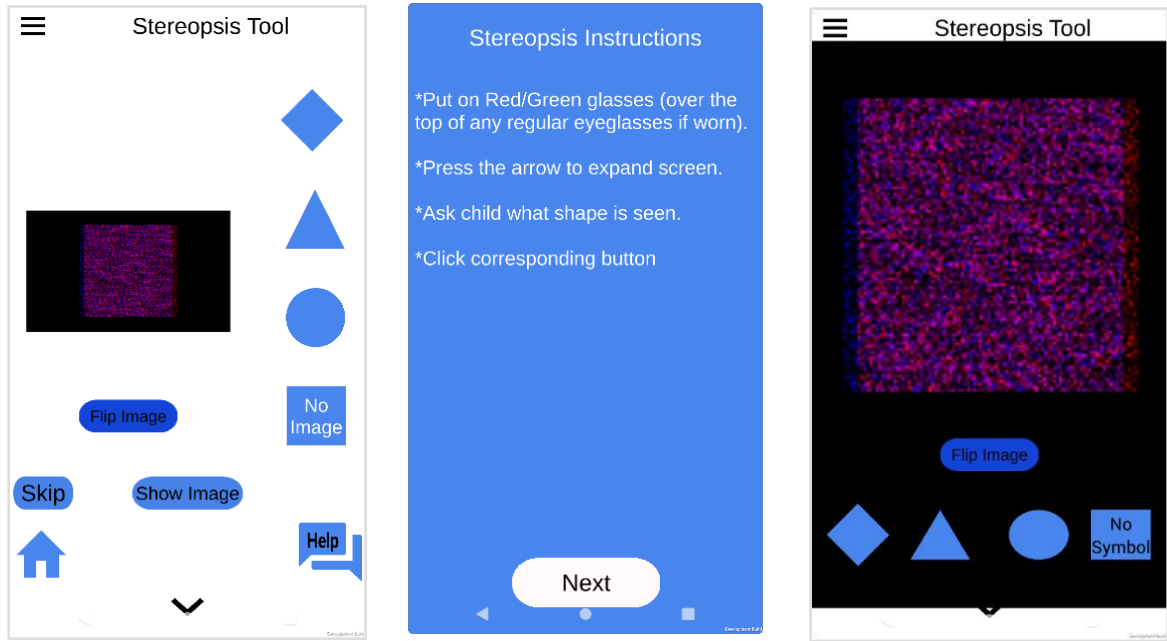
3. Near Vision acuity test and screen with menu options



4. Distance Vision Acuity Test



### 5. Stereopsis Test



### 6. Convergence Insufficiency Symptom (CIS) Survey

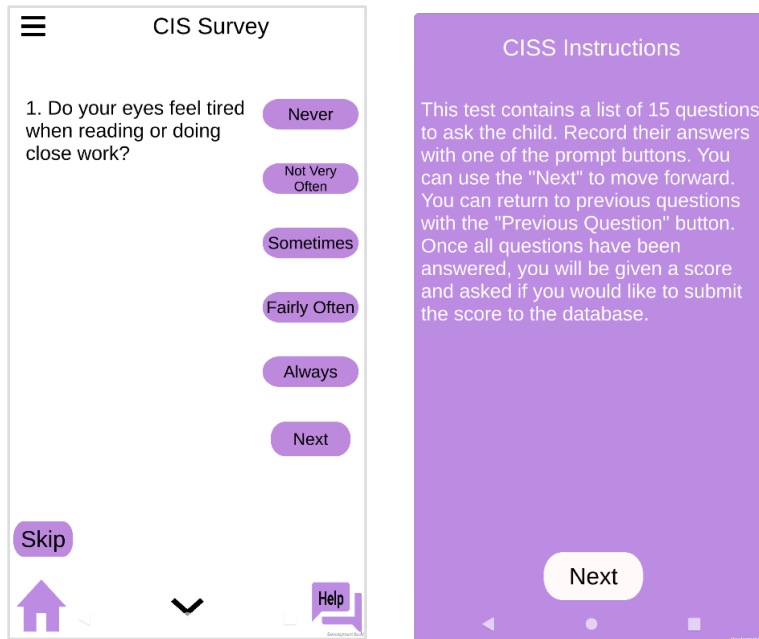


Figure 23: Screen Shots of the QuickCheck App (From Latest Release)

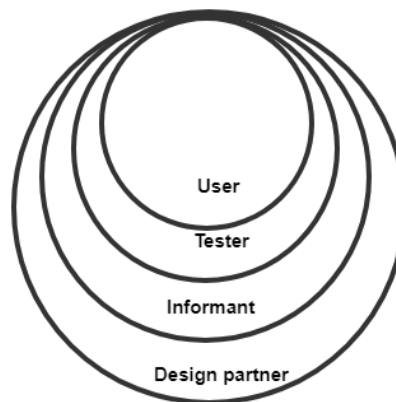
### 3.4 Participatory Design: Designing with the UW Kid's Team

In participatory design, end users of the system are involved in the ideation and design process in order to construct the ideal and more relevant design. It helps to identify the experience that matters the most to the user. Participatory design method in HCDE (Human Centered Design Engineering) suggests that the intended user of the system should be involved as a design partner at the various stages of the design for the developers to get to the relevant design idea and critical feedback. To design more usable and relevant solution for the various end users of the *QuickCheck* app, we decided to conduct the participatory design.

In Summer 2018, I joined the UW Kids team research group at the university of Washington. The research group includes kids ages 7 to 11, software designers and Ux researchers. Their work is to suggest and evaluate software design, share their experiences with various technologies, games, web applications, mobile applications using participatory design method. Dr. Jason Yip at the University of Washington, Seattle runs Kids Team for the last three years. The Kids' Team meet happens every Tuesday and Thursday. From my experience with the Kids Team, kids are full of creative design ideas which would sometimes escape as an adult and they are not afraid of sharing their feedback. While working on *QuickCheck* app I learned that kids are also one of the users of the app. Though they are not literally operating the app, they are experiencing the entire app while they are getting screened by the school nurse. So, it was also important to understand how kids experience vision screening using the *QuickCheck*. The proposed design of the *QuickCheck* app also intends to have a kid's friendly mode (i.e. make the screening more interactive and display minimalistic content on screen). Hence, I decided to conduct the codesign session with Kids Team for the *QuickCheck* app.

There are various methods such as ‘interview’, ‘sticky notes’, ‘design on a big sheet’, ‘the bag of stuff’ that the UW Kids Team uses for design session depending on the goal of the research study, the kind of research questions and at what stage the software development or design process is.

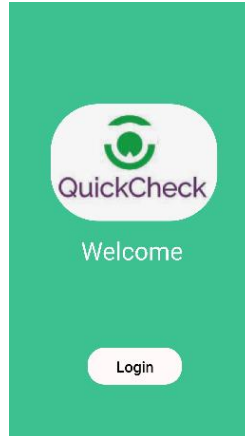
(Druin, Allison, 2009) suggests that there are four main roles that children can play in the design process: user, tester, informant, and design partner (see Figure 1). Each role is identified based upon what stage of the design children are involved in the design process of the product and what are the research goals.



*Figure 24:* The four roles that children may have in the design of new technologies

We were at the early stage of the *QuickCheck* app design. EYE research group was looking for some feedback as well as design ideas on early release of the app. Hence, during design session kids in the Kids Team played two roles as a design partner and an informant. I conducted two design sessions with the UW Kids Team for two-mobile apps developed by the EYE center UW Bothell: *QuickCheck* and Redflag. EYE center research group members also joined these sessions. The session details, research questions explored and findings from the design session with UW Kids Team are summarized in the below sections.

### 3.5 UW Kids Team Design Session for Quick Check



#### 3.5.1 Participants:

EYE Centre research group, UW Kid's team Research Group, Dr. Jason Yip, UW Kid's Team

#### 3.5.2 Research questions explored during the session:

1. How the design can be improved for Settings, Instructions, Results page
2. Kids' experience with the app and design ideas to improve the app

#### 3.5.3 Method: Sticky Notes, Likes Dislikes Design Ideas

There are various methods such as 'interview', 'sticky notes', 'design on a big sheet', 'the bag of stuff' that the UW kids team uses for design session depending on the goal of the research study, the kind of research questions and at what stage the software development or design process is. We used sticky notes for capturing the kids' likes, dislikes and design ideas since we were in the early release stage and were interested in design ideas.

#### 3.5.4 Session Details:

The session was organized as Circle time (Introduction), Design session and Feedback session (gather/present likes, dislikes from the kids).

### 3.5.4.1 During the circle time

At the start of the session, we discussed with the kids ‘what color do you like?’, ‘have you done eye test before?’. We showed them a demo video of the app to give an idea of what the app looks like.

### 3.5.4.2 During the screening

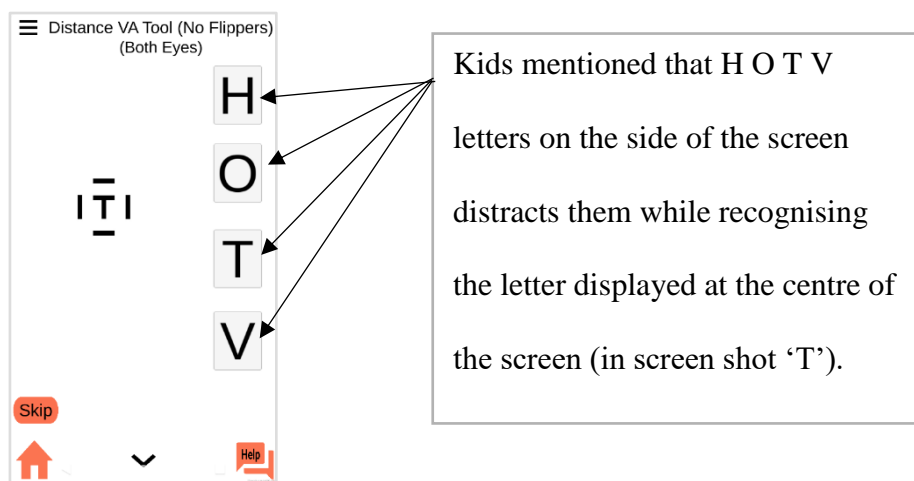
We performed the screening for 5 kids using flippers and red blue glasses. The aim was to give them the experience of the app.

### 3.5.4.3 Gather likes, dislikes and, design ideas from the kids

After they were screened, the UW Kid’s team research group members were paired with each kid to capture their likes, dislikes, and design ideas. At the end of the session, we gathered in a circle and discussed the students’ feedback. We tried to understand why they liked or disliked some things in the app. We also talked about the challenge for positioning the HOTV letters which students found distracting.

### 3.5.5 Likes, dislikes, and design ideas captured from the session:

1. At the end of the results page, candy or some fun pictures can be shown for the kids.
2. The HOTV letters on the screen are distracting.



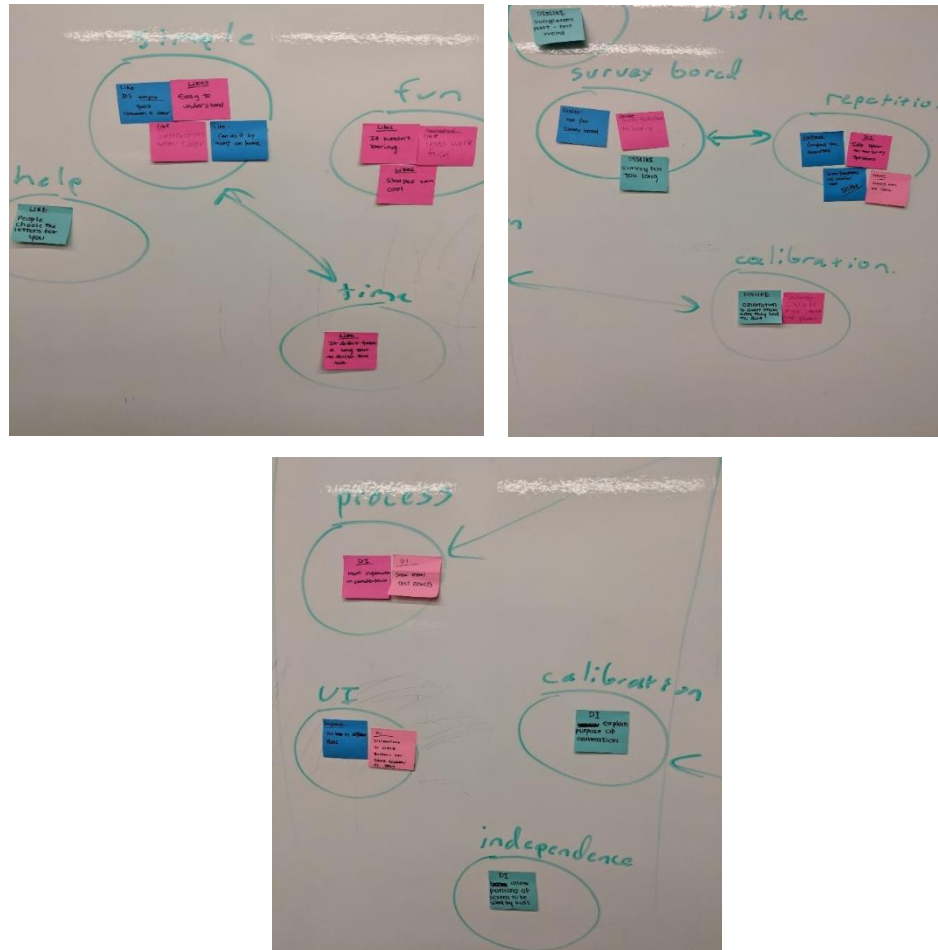
3. Calibration and its purpose were not clear to the kids.
4. Survey questions were too boring and repetitive which could result in a more false positive response because the student can just answer yes or no instead of using the multiple answer options in the survey.
5. Help instructions can be written on a separate line. A short video for the instructions can be useful.
6. Some interaction for the kids can be added if possible.
7. Use of music/sound during the survey questions instead of the chicken/click sound can be helpful.

#### **3.5.6 Solutions discussed for the likes, dislikes, and design ideas:**

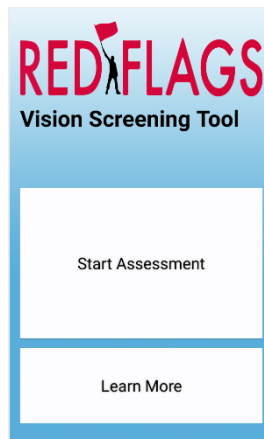
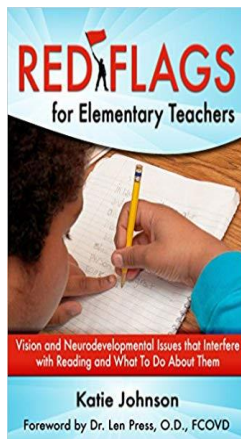
1. Suggestion for the use of music/sound during the survey questions: Use some neutral sound to keep the student engaged during CISS. The sound should not be conveying any positive or negative reaction for the answers.
2. Suggestion to speed up the test: If we can add an option in the settings menu to enable and disable 'test instruction', it can help to speed up the test.
3. Suggestion to keep track of screening tasks: Use animation to show how many screening tasks are completed.

### 3.5.7 Images of students' likes, dislikes, design ideas

likes, dislikes, design ideas with sticky notes



### 3.6 UW Kids Team Design Session for Red Flags (Add screen shot for Red Flag app)



### **3.6.1 Participants:**

UWB EYE Center Research group, UW Kids Team Research group, UW Kids Team.

### **3.6.2 Research Question explored:**

1. How can the design help administrators conduct the tests better?
2. How can we make the design more interactive?
3. Kids experience - would they be more engaged if they interact more with the application instead of just being given instructions?

### **3.6.3 Method**

Using a big paper sheet to share likes, dislikes, design idea.

### **3.6.4 Session Details:**

#### **3.6.4.1 During the circle time**

At the start of the session, we discussed with the kids ‘what do you like to do with your eyes?’.

#### **3.6.4.2 During the screening**

The EYE Center group members in each group performed the tests with the kids. The aim was to have the kids experience the app and the tests that are conducted. We performed the Red Flag app activity with 6 kids.

#### **3.6.4.3 Gather likes and dislikes from kids**

After each test, the UW Kids team research group members facilitated a discussion to capture the likes, dislikes and design ideas for the test.

### 3.6.5 Gather likes, dislikes and, design ideas from the kid

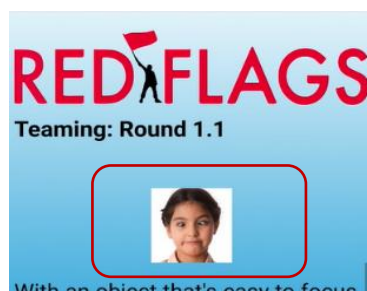
At the end of the session, we had the kids present their likes, dislikes and design ideas to the whole group.

### 3.6.6 Likes, dislikes, and design ideas captured from the session

1. Liked the tests where they can use their whole body, e.g. Tummy crawl.
2. They liked that it was quick, straightforward and not overwhelming.
3. Liked the timer used in the Red flag app.
4. They liked the Visual Discrimination test because it was like a puzzle.

What they would like to see:

1. They would like to get instant results back for the test that they have taken, instead of waiting until the end to find out if they passed the test or not. They were afraid of getting a red flag.
2. They felt that the tests where the pencil is moved closer to their face are scary. Also, one kid mentioned that it reminds them of the school so if we could use something else instead of pencil, maybe straw with some small picture on it.
3. They would like to keep track of the activities that are there and how many are remaining, like a progress bar indicating the activity progress.
4. The pictures at the top of the screen are creepy and did not make sense.



The highlighted picture in the app is creepy for kids

5. They wanted to have sounds in the app to indicate which button was selected by the test administrator.

### **3.6.7 Solutions discussed for the likes, dislikes, and design ideas:**

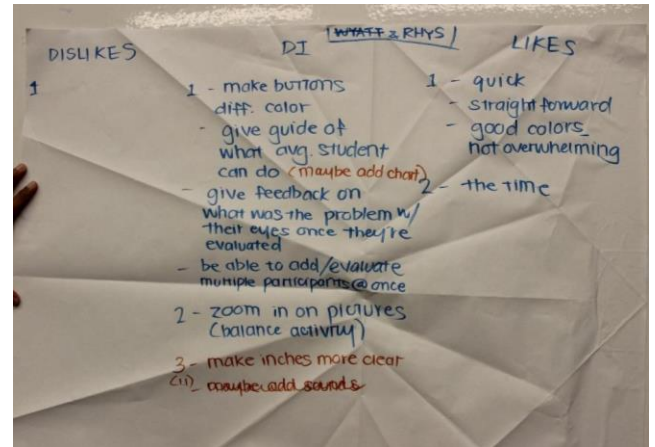
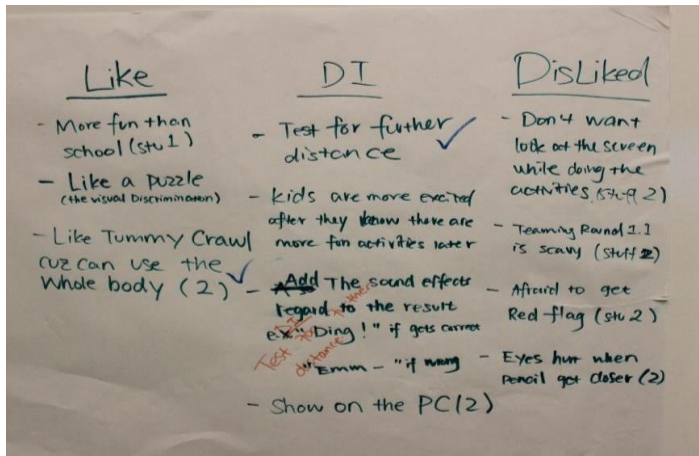
1. They would like to see some graphs and charts that give information about how the “average kid’s” results look like.
2. Allow multiple students to take the test at the same time. During the Red Flag design session, we had to go back and forth between the two students and only one student’s results get recorded as a result.
3. Add sounds to indicate when a result is displayed but it should not convey any positive or negative reaction for the answers. A sound or a message to indicate that the test is completed.
4. Would like to see some loading screen.
5. The buttons could be rounded and colorful.
6. To some groups Red flag name and the logo makes sense. But one kid shared that the Red Flag app name and logo was scary. The kid suggested if we can use a god’s eye symbol.



(A picture of one of many God’s Eye snapshot from the internet)

7. For the Discrimination test, use the screen vertically instead of the current horizontal layout.
8. Do not abbreviate things, instead just use the full word, e.g. at some places the app uses 'in' instead of inches. They thought that it was 'in' (like English preposition).

### 3.6.8 Images of students' likes, dislikes, design ideas



## Chapter 4. Measurement Framework for Vision Screening Usability

### 4.1 Usability metric for vision screening app: findings

Based on the literature review as described in Chapter 2, I will describe the metrics, framework and evaluation mode for the *QuickCheck* app. This study proposes usability dimensions that should be considered while designing and testing the app related to ophthalmology.

From literature and discussion with research group I identified Efficiency, Effectiveness, Learnability, Operability are the important metrics for the *QuickCheck* app. ISO standard (International Organization for Standardization, Ergonomics of human-system interaction Part 11: Usability: Definitions and concepts, ISO 9241–11 Guidance on usability, 2018) defines Effectiveness as “accuracy and completeness with which users achieve specified goals” and Efficiency as “a resource used in relation to the results achieved; typical resources include time, human effort, costs, and materials”.

#### 4.1.1 Efficiency for *QuickCheck*:

As a part of the current study, we focused on measuring the time required to perform a complete vision screening one time and for each individual screening task. Below are two crucial reasons to measure efficiency for the *QuickCheck* app:

- One of the goals of the *QuickCheck* design is that it should take minimum time (~3 minutes) to complete the one-time screening. Measuring the time required to complete the test will help to prove the efficiency of the app for school nurses who have to screen approximately 100-500 students, depending on the school population. It would also help the EYE center research group to perform a comparison with other

screening tools such as standard paper screening, go check eye and Pin point eye at a later stage.

- Accuracy with which nurses/doctors and teachers will be able to complete the screening test is very essential for any health-related application, as a person's life depends on such decisions.

For any mHealth app accuracy, compliance and privacy is the topmost concern and it is also applicable to the *QuickCheck* app.

#### **4.1.2 Effectiveness for *QuickCheck*:**

Effectiveness of the *QuickCheck* app can be defined as the number of errors, challenges faced by the users while using the various features and success rate for completing the screening task in the app. Also, the data in the app should be HIPAA compliant since these are medical records. This would ensure the student records are secured in the *QuickCheck* database.

#### **4.1.3 Learnability for *QuickCheck*:**

Learnability is an important aspect of the *QuickCheck* app as it involves a step-specific process to be learnt by the screener (one who conducts the vision screening i.e. nurses, teachers, etc.). This may require training or instruction at various stages on how to conduct vision screening. Learnability will help to understand the effectiveness of our help instructions provided for the user.

#### **4.1.4 Operability for *QuickCheck*:**

Use of the mobile as a pre-clinical assessment tool for vision screening is a new approach for school nurses and teachers. It requires proper mobile handling knowledge which implies that the concerns related to operability of the device should be considered in the design of the *QuickCheck* app. Usage of certain *QuickCheck* app features might be impacted by left- / right-handedness, since the options to record students' responses are on the left-hand side of the screen. Using the settings menu, these options on the screen can be displayed on the right-hand side. An existing study (Balakrishnan, 2008) also shows that users have varying thumb sizes which affect their experience of using mobile phone keypads and hence buttons, text box size, and search box design should cater to users with large thumbs.

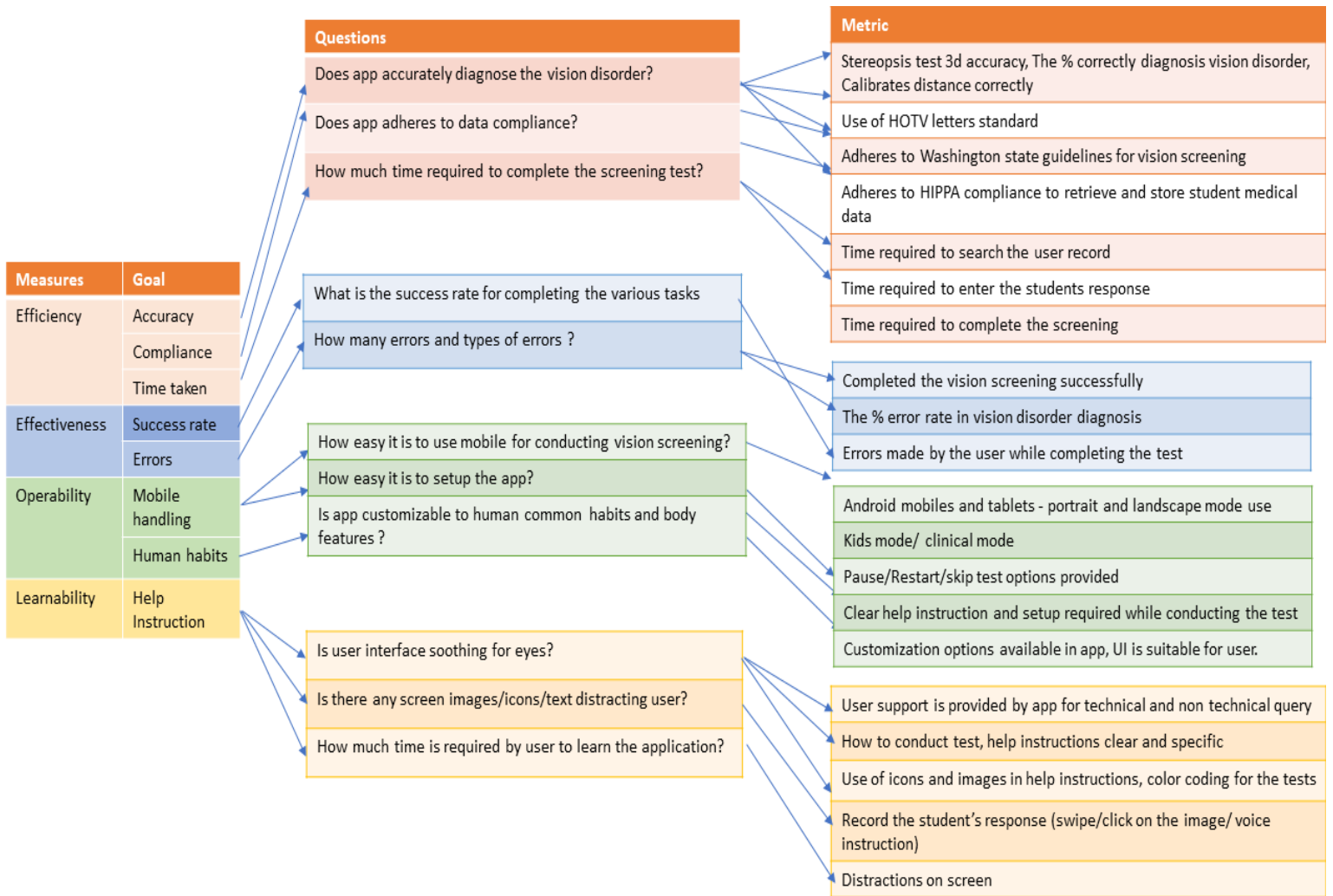
#### **4.1.5 GQM Model for *QuickCheck***

In order to understand the sub-metric of each of the above metrics (Efficiency, Effectiveness, Operability, Learnability), I used the GQM framework to further break down each of the usability dimensions.

Goal Question Metric (GQM) approach, originally proposed by (Basili et al., 1994), was used in the present study to develop a usability metric for the *QuickCheck* application. GQM application is very useful to define the measurement framework for a research study, in this case defining and measuring the usability metric. GQM model involves various activities such as identifying the goals, measuring the defined goals, collecting and validating the data, and performing data analysis. While applying the GQM model for this study, the first phase was identifying the goal. The goals created in the first phase were core metrics for the usability study. This was followed by questions to assess each goal. These questions then provided the basis for

quantitative and qualitative metrics. These detailed considerations for the metrics can now be used for the *QuickCheck* app usability study. The specific goal, metric and associated questions as captured using the Goal Question Metric (GQM) model are presented in Table 4.

Table 4: GQM model for the *QuickCheck* app



The usability metrics and framework proposed here can be used by any other mHealth ophthalmology applications, customized suitably to meet the needs of specific mobile app design.

## Chapter 5. Methods

This chapter provides a detailed description of the usability test methods used for *QuickCheck* app so that another individual or organization can use this information to reproduce the exact same study. Also, this can provide a guideline for EYE center research group at the University of Washington, Bothell to plan their usability study at a larger scale with Washington state schools in Fall 2019.

### 5.1 Usability Test Plan for Vision QuickCheck app

Usability testing is the method to find out usability deficiencies at an early stage of product development. It helps to address the design problems and provide considerations to enhance the user experience.

In usability testing, users are requested to perform certain tasks with the product. Users are observed while performing the tasks and any issues with the product are captured. The actual users of the system should be considered for usability testing. Also, usability testers must take another crucial decision on deciding the number of users participating for usability testing. Jacob Nielsen's model of usability testing mentions that we do not require more than 5 test users to find out the usability deficiencies (Nielsen J. , 2000). Most of the usability problems can be found out from 5 participants. The model says that when we start collecting data from a single tester, we have already learned a third of all there is to understand about the usability. As we add more number of users we learn less and less as the problems getting reported starts repeating. After the fifth user, it is almost a waste of time to identify the same problems and do not learn anything new. It mentions, to identify all the usability problems we need to test at least 15 users but model further recommends to test with 5 users because the design process is iterative so we have to keep doing usability tests after each iteration which would be costly (in terms of money and resources) required to conduct the usability tests.

Now next step was to plan the actual tests and decide the methods that will be used for a usability test. According to ‘Handbook of Usability Testing’ [ref] the procedure for conducting a usability test has the following stages:

1. Develop the Test Plan
2. Setup a Testing Environment
3. Find and Select Participants
4. Prepare Test Materials
5. Conduct the Test Sessions
6. Analyze Data and Observations
7. Report findings and Recommendations

This chapter details the stages 1 to 5 in the usability testing of the *QuickCheck* app. Stages 6 and 7 will be discussed in Chapter 6. To prepare the complete plan, I used the guidelines and references available on Usability.gov (Usability.gov)

### **5.1.1 Overview and usability goals**

The *QuickCheck* app provides efficient mobile based screening tool for doctors and school nurses to perform the vision screening. The app allows them to quickly assess if the child has one of the following eye conditions:

1. Near vision acuity difficulties,
2. Distance vision acuity difficulties,
3. Possible Hyperopia: Depth perception difficulties or possible strabismus,
4. Significant near point symptoms indicating convergence insufficiency.

If the child scores below a certain score, the child will be referred to a doctor for further analysis. The school nurse or doctors will be able to conduct vision screening using this mobile app to record the student's answers.

By observing users perform assigned tasks, we hope to gain a better understanding of user satisfaction, design concerns, and app strengths.

The goal of the study is to understand -

1. Effectiveness: Measure error occurred and the task completion success rates.
2. Efficiency: Measure the time required to complete the vision screening test.
3. Learnability: Assess the learnability of the app's functionality among first time users and whether it improves over multiple usages of the app.
4. Operability: Identify the operability challenges related to the handling of the mobile device during the vision screening.

### **5.1.2 Methodology**

The methods for usability test were decided based on literature review and rigorous discussion with Prof. Erdly (advisor) and Prof. Arnie Lund. The rationale of each method used in usability testing of *QuickCheck* app is discussed in the Chapter 4 Measurement Framework for Vision Screening Usability.

The methods used for *QuickCheck* app usability testing were as follows:

1. Usability-Lab Studies:

School nurses, doctors and EYE center research group members worked together in a lab environment. Participants were given a set of scenarios that lead to tasks.

## 2. Interviews:

A research group member and participants discussed the user's perspective on certain topics so as to understand the challenges faced by users while interacting with the app.

## 3. Thinking aloud:

Participants were asked to think aloud when they were interacting with the system. The interaction data was recorded in the form of written observation notes and audio record.

## 4. Record observations:

During the testing, the research group members noted errors, observations, and challenges faced by the participants while conducting various tasks using the app.

## 5. Questionnaire:

In order to understand demographics, challenges, and satisfaction, a detailed pre-test questionnaire (demographic study) and post-test questionnaire using MARS (Mobile App Rating Survey) were conducted.

### **5.1.3 Participants**

Actual users of the *QuickCheck* app will be school nurses and doctors. Hence, we decided to approach school nurses and doctors for this study. The selection criteria for nurses was that they must have knowledge and experience of conducting the vision screening according to Washington state standards and methods. We choose nurses based on voluntary willingness to participate in the usability study. Their responsibilities were to attempt to complete a set of tasks presented to them and to provide feedback regarding the usability and acceptability of the user

interface. The participants then partook in a post-session interview and a questionnaire. A research group member performed two roles; one as a moderator for the test and the other as a role play for a school kid getting screened by the school nurses and doctors.

#### **5.1.4 Training**

The participants received an overview of the usability test procedure, equipment, and vision *QuickCheck* app before the test. Research group members were provided detailed instruction on different personalities for the kid role play. Doctors and nurses were not informed about differences in the personalities of the kid role play. One week before the usability test, I conducted a practice session to understand the practical issues and concerns. Moderators (from research group members) were provided an overview of the different stages and tasks that they needed to perform at each step during the usability test. This ensured that all the research group members who were to play the role of participant and moderator got familiar with the procedure and their tasks for the test.

#### **5.1.5 Test Procedure**

Participants took part in the usability test at the University of Washington Bothell. The android devices loaded with *QuickCheck* app were provided to participants. The participant's interaction with the mobile application was monitored by the moderator in the same room. I briefed the participants on the *QuickCheck* application and instructed them that they were to evaluate the application, rather than the facilitator evaluating the participant. Participants signed an informed consent that acknowledged the following: the participation is voluntary, that participation can cease at any time, but their privacy of identification will be safeguarded. I asked the participants if they had any questions. Participants were requested to complete a pre-test demographic and background information questionnaire. They were explained that the

amount of time required to complete each test task was being measured. At the start of each task, the participant was expected to read aloud the task description from the printed copy and then begin the task. Time-on-task measurement began when the participant started the task. The moderator instructed the participant to ‘think aloud’ so that a verbal record could exist of their interaction with the mobile application. The moderator observed and prepared notes for user behavior in the data logging document for each participant. After each task, the participant elaborated on the task session with the moderator. After all the task scenarios were attempted, the participant completed the interview and the post-test satisfaction questionnaire.

Figure 25 shows the high-level task that moderator and participants performed for the usability test and the time required for each stage.



Figure 25: QuickCheck app usability test procedure timeline

### **5.1.6 Roles involved**

To perform a vision screening usability test we require nurses, and kids to be screened, moderators to record observation, conduct an interview. Each role was expected to perform various tasks. The roles involved in the usability test were as follows.

#### **5.1.6.1 Moderator role**

- Providing an overview of the study to the participants
- Defining usability and the purpose of usability testing to the participants
- Responding to participants' requests for assistance
- Recording the observations and data log

#### **5.1.6.2 Test participants role**

- Performing the assigned task for the usability test
- Asking questions or assistance if required to complete the task

#### **5.1.6.3 Research group member role**

During the research group discussion, we identified 5 personalities of school kids commonly observed. Research group members enacted them during the test. They were -

1. Shy personality: Someone who is not willing to speak much.
2. Distracted personality: Hard to keep attention, getting quickly distracted by the things in the surroundings.
3. English-as a second language personality: Difficulty to understand the instructions in English.

4. Un-cooperative personality: Does not cooperate during the screening test and gives wrong answers.
5. Regular personality: Listens carefully and answers all the questions as asked, can verbalize the answers well.

### **5.1.7 Test Environment Setup and Equipment**

Test sessions were conducted in a classroom at the University of Washington Bothell campus.

#### **5.1.7.1 Instruments required**

List of instruments required during the test: Chairs, small table, measuring tape, flippers, red blue glasses for stereopsis test, laptop to conduct questionnaire, data logger sheet to record observations, timer to measure the time, audio recorder in phone to audio record the test, task list handout for participant, usability test handout, mobile app user manual.

#### **5.1.7.2 Room setup**

We placed three chairs in one corner of the hall with a small table; one for the screener (doctor or school nurse) which was in front of the phone, other for the research group member who would be doing the role play for the school kid, and the third was for the moderator which was placed 45 degrees behind the screener. We prepared two more similar setups in the other two corners of the hall. In total three setups were arranged in the hall. Each setup was sufficiently distanced from each other so that a participant could not get disturbed by the other participant's voice during the think aloud session. Audio record app was used to record the audio. Task list document and other test related handouts were kept on the table. The test setup for one

corner was as shown in Figure 26. Three participants performed the usability test at the same time.

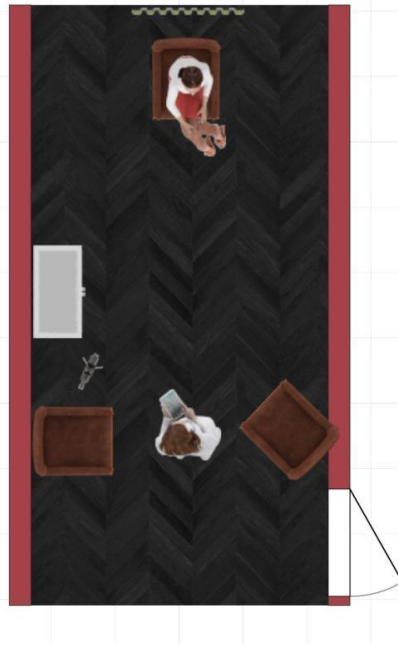


Figure 26: Environment Setup for Usability Test

### 5.1.7.3 Mobile device setup

*QuickCheck* app was preloaded on all mobile device with the latest version. The app was setup with default settings as shown in Figure 27

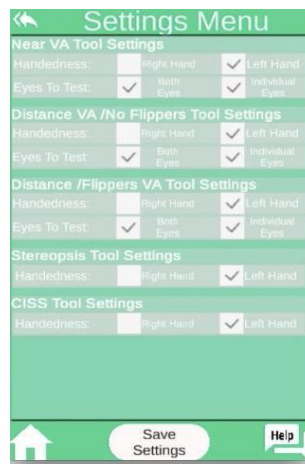


Figure 27: Default *QuickCheck* app settings

### **5.1.8 Usability Metrics Association with Usability Tasks**

This section discusses identified metrics with respect to the *QuickCheck* app in detail. The metrics were identified using the GQM method in Chapter 4 and GQM was tested during the usability test.

#### **5.1.8.1 Effectiveness**

To know the effectiveness of the *QuickCheck* app, usability test measures task completion success rate and a number of errors for task 1 through 4. Further analysis of this data from usability test will help to understand the effectiveness of the *QuickCheck* app.

#### **5.1.8.2 Efficiency**

Measuring the time required to complete the test will help to prove the efficiency of the app. At a later stage, the data can be compared with data of other screening tools available in the market such as standard paper screening, go check eye, pinpoint eye. Task number 3 and 4 in usability task Table 7 can measure the time taken by each user to perform the vision screening.

#### **5.1.8.3 Learnability**

Learnability is an important aspect of the *QuickCheck* app as it involves a specific process to be learned by the screener (one who conducts the vision screening i.e. nurses, teachers, etc.). This may require training or instruction at various stages on how to conduct vision screening. Learnability will help to understand the effectiveness of our training guide and instructions provided for the user. From the usability task Table 7, tasks 2, 3 and 4 can help to understand the users' learning experience with the app. Also, MARS (Mobile Application Rating Scale) Section B would provide additional feedback on users' learning experience with the app.

#### 5.1.8.4 Operability

Use of the mobile device for vision screening is a new approach for school nurses and teachers. It requires proper mobile handling knowledge which implies that the concerns related to operability of the device should be considered in the design of the *QuickCheck* app. From the usability task Table 7, tasks 3 and 4 can help to understand the users' operability experience with the app. Also, MARS (Mobile Application Rating Scale) test Section B (customizations) will provide more understanding about users' operability experience with the app.

#### 5.1.9 Usability Test Tasks

Writing good tasks for a usability study is an art. Nngroup mentions that writing the quality task scenarios impacts the usability study (McCloskey, 2014) (Schade, 2017). It is essential that the task should target the users' end goal rather than the task's end goal. The following Table 7 lists the tasks that were designed for the participants in the present study.

Table 7

*Usability Test Tasks*

Task No	Task Name	Scenario
1	Populate the student record	You are conducting a vision screening test for a kid in some school. Can you please pull the record for the following student?  School Name : Bellevue Grad School  District : District 1

		<p>Grade : Kindergarten</p> <p>Class name : David</p>
2	Calibrate the student	<p>Sometimes when you perform the vision screening and kids keep on moving ahead trying to look the letter by leaning ahead to give the answer. What if the app can automatically adjust the distance? Can you please calibrate the student sitting in front of you?</p>
3	Perform the vision screening	<p>Till the date, you used various tools to perform the vision screening. Can you use a mobile app to perform the screening? Can you perform the following tests for the student using the <i>QuickCheck</i> app?</p> <ol style="list-style-type: none"> <li>1. Near vision acuity: both eyes, left eye, right eye</li> <li>2. Distance vision acuity tool without flippers: right eye, left eye, both eyes.</li> <li>3. Distance vision acuity tool with flippers: right eye, left eye, both eyes.</li> <li>4. Stereopsis</li> <li>5. Convergence insufficiency symptom survey (CISS)</li> </ol>

4	Perform the vision screening 2 more times	To be able to conduct the vision screening with a mobile app sounds interesting, isn't it? Now, what if you want to conduct the vision screening for more students? Can you please do the screening for two more students? You can screen the following students using the app. (Two student records details were shared with participant.)
---	---	---

#### 5.1.10 Usability task measuring criteria

The next section describes the usability task goals for the *QuickCheck* app.

##### 5.1.10.1 Completion Rate

Completion rate is the percentage of test participants who successfully completed the task without errors. The incorrect or incomplete task was defined as an error. In other words, the completion rate represents the percentage of participants who, when they were finished with the specified task, had an "output" that was correct. Note: If a participant required assistance in order to achieve a correct output then the task was scored as an error and the overall completion rate for the task was affected. A completion rate of 100% completion rate is the goal for each task in this usability test.

##### 5.1.10.2 Error-free rate

Error-free rate is the percentage of the test participants who completed the task without any errors. An error-free rate of 80% error-free rate is the goal for each task in this usability test.

### **5.1.10.3 Time on Task (TOT)**

The time to complete a scenario is referred to as "time on task". It was measured from the time the person began the scenario to the time he/she signaled completion.

### **5.1.10.4 Subjective Measures**

Subjective opinions about specific tasks, features, and functionality were captured in the post-test questionnaire. At the end of the test, participants rated their satisfaction with the overall system.

## **5.1.11 Reporting Results**

Chapter 6 Results and Discussion provides the Usability Test findings. It consists of an evaluation of the usability metrics against the pre-approved goals, subjective evaluations, and specific usability problems and recommendations.

## Chapter 6. Results and Discussion

The present chapter reports the data captured during the usability test of the *QuickCheck* app using the pre-test, post-test questionnaire, interview, and observation notes. The captured data is further analyzed to get insights about the usability metrics identified as the goal for usability testing of *QuickCheck* app.

### 6.1 Usability Test Result

The EYE center research group members conducted an onsite usability test using the latest version of the *QuickCheck* mobile app. The test moderator, participants and research group members were present in the testing room. During the session, we collected data for each participant's task completion rates, error, the time required to complete the task, comments, interview, and overall satisfaction ratings. The detailed plan is shared in Chapter 5.

#### 6.1.1 Methodology

Each individual session lasted approximately one hour. Before the test, the consent and the background questionnaire were filled by the participants. Participants read the task scenarios and after all the tasks were completed, the test moderator conducted an interview followed by a post-test questionnaire using the Mobile App Rating Scale (MARS).

After each task, the moderator asked the participant to rate the interface on a 5-point Likert Scale with measures ranging from “Strongly Disagree” to “Strongly Agree”. Post-task scenario subjective measures included:

1. How easy it was to perform the task.
2. How easy it was to navigate through the task.
3. Overall satisfaction with the task's performance.

## 6.2 Results of the pre-test questionnaire (demographics)

### 6.2.1 Participants Profiles

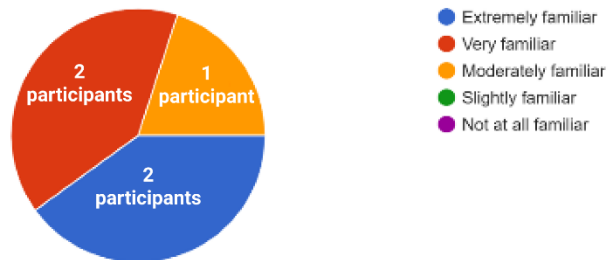
Participants were from a mixed background such as school nurses, doctor and a technical expert(student). Five participants were scheduled over the two testing dates. Four out of five participants completed the test on 11<sup>th</sup> May 2019 and one participant on 13<sup>th</sup> May 2019. None of the professionals used the mobile app as a clinical assessment tool before. The diverse pool of participants helped to understand the perspectives of how different people experience the *QuickCheck* app. Demographics of the participant were as follows –



Participants group was diverse, out of 5 participants 3 were nurses, 1 was a doctor and one was a technical expert. None of them have ever used a mobile device as a clinical assessment tool. Except for technical expert, all the other participants were familiar with the vision screening for kids in school. More specific demographic details are shown in Figure 28.

#### The comfort of using a mobile device in general

5 responses



Which of the below vision test you have conducted before (Check all that apply)

5 responses

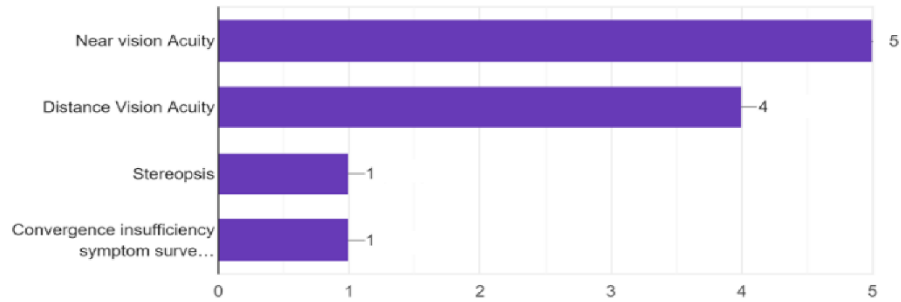


Figure 28: Demographics of the participants

Details about the personality role play performed by research group members for the study are as shown in

Table 8

Personality Role Play Performed by Research Group Members for The Study

Participants	Role play during the first screening	Role play during the second screening	Role play during the third screening
Student (technology expert)	1N	1N	1N
Nurse1	1N	1N	1N
Nurse2	2D	2D	2D
Nurse3	3E	3E	3E
Doctor	1N	2D	4S

Research group members role play personality type	1N-Normal behavior 2D-Distracted 3E-English as a second language 4S-Special kid (No reading writing ability, have vision problem)
---	--

### 6.3 Results of Tasks/Scenarios

Test participants attempted completion of the following tasks (see Table 7 for complete test scenarios/tasks).

Task 1: Auto populate the student record from the student database

Task 2: Calibrate the student

Task 3: Perform the vision screening

Task 4: Perform the vision screening two more times

#### 6.3.1 Understanding Effectiveness and Satisfaction

Effectiveness of the *QuickCheck* app includes measures such as task completion success rate and number of errors. Below section 6.3.1.1 and section 6.3.1.3 discusses the task completion rate and errors captured during the usability test.

##### 6.3.1.1 Task Completion Success Rate

Usability test moderator recorded the participant's ability to complete the tasks without prompting. The task success rate is calculated as -

$$\text{Success rate} = \text{number of successes} / \text{number of participants}$$

All participants successfully (S) completed Task 3 and Task 4 (Perform the vision screening and Perform the vision screening two more times). Four out of five completed Task 2 (Calibrate the student). Only two participants were able to complete Task 1 successfully (Auto populate the

student record from the student database). The partially completed or incomplete tasks were counted as a failure (F). Table 9 shows a summary of the task completion.

Table 9

*Task Completion Rates*

<b>Participant</b>	<b>Task 1</b>	<b>Task 2</b>	<b>Task 3</b>	<b>Task 4</b>
1	F	F	S	S
2	F	S	S	S
3	F	S	S	S
4	S	S	S	S
5	S	S	S	S
Success	2	4	5	5
Completion Rates	40%	80%	100%	100%

**6.3.1.2 Task Ratings**

After the completion of each task, participants rated the ease or difficulty of completing the task for three factors:

- It was easy to find my way to perform this task from the app start page.
- As I was as working on this task, I was able to navigate in the mobile app.
- I am satisfied with the task that I performed.

The 5-point rating scale ranged from 1 (Strongly disagree) to 5 (Strongly agree).

#### ***6.3.1.2.1 Ease of finding Information in the app***

All participants agreed that it was easy to find information in the app for performing the vision screening two more times (mean agreement rating = 5). It was easy to find information in the app for performing the vision screening for the first time with mean agreement rating = 4.8. Participants found it easy to find information in the app for auto populating the student record with mean agreement rating = 4.6 and rating to find information in the app for performing the calibration was given 3.8 which might need some improvement.

#### ***6.3.1.2.2 Ease of Navigating in the app***

Participants found it easy to navigate in the app while performing the vision screening for the first time and also performing it 2 more times with mean agreement rating = 4.8. Participants also found auto populating the student record and calibration easy to navigate with mean agreement rating = 4.5.

#### ***6.3.1.2.3 Satisfied with the task performed***

The rating for the task “Performing vision screening 2 more times” is 4.6 which indicates that participants were satisfied with the task. They were satisfied with the task “Performing vision screening for the first time” with mean agreement rating = 4.4 and with the task “Calibrate the student rating” = 4. Participants mean rating for the task “Auto populating the student record” is 3.6. Table 10 shows the mean task rating and percentage agreement rating for each criterion with the four assigned tasks on a scale of 1(1-Strongly disagree) to 5 (5-strongly agree).

Table 10

*Mean Task Ratings & Percent Agree*

<b>Task</b>	<b>Ease of finding Information in the app</b>	<b>Ease of Navigating in the app</b>	<b>Satisfied with the task performed</b>	<b>Overall</b>
	(mean rating on a scale of 1-5)			
1 Auto populate the student record	4.6	4.5	3.6	4.2
2 Calibrate the student	3.8	4.5	4	4.1
3 Perform the vision screening	4.8	4.8	4.4	4.7
4 Perform the vision screening two more times	5	4.8	4.6	4.8

**6.3.1.3 Summary of Error Data**

Test moderator captured the number of errors participants made while trying to complete the tasks. Below are the common errors that were reported during the usability test.

-

- Accidentally clicking on skip test
- Clicking the retake test instead of next student
- Mistyping username password
- Clicking on a heading, image that isn't clickable or isn't zoomable
- Calibrate self instead of the user
- Typing both first and last name in the first name field
- Entering today's date instead of the date of birth
- Record the correct answer instead of students answer

Table 11 displays a summary of the errors logged by moderators during the test. The data shows that maximum errors occurred while performing the calibration task. The maximum error data is highlighted in orange. Also, task 1 (auto populate the student record) has the lowest completion rate marked in blue. Errors and completion rate suggest that there is functionality or design issue with calibration and auto populating the records.

Table 11

*Summary of Completion, Errors, Time on Task, Mean Satisfaction*

<b>Task</b>	<b>No of participant completed task successfully</b>	<b>No of errors recorded</b>	<b>Time on Task</b>	<b>Satisfaction *1</b>
1 Auto populate record	2	4	100	4.2
2. Calibration	4	10	49.6	4.1
3. Vision screening	5	2	543	4.7
4. Vision screening performed two more times	5	9	808 *2	4.8

\*1 Satisfaction = Mean combined rating across three post-task measures: ease of finding the information, ability to navigate in the app, and satisfaction with the task performed.

\*Total time is calculated as the sum of the first test and second test average for the 'time on task' for the 4th task. This is since the errors were recorded for the overall task and not for the first test and second test.

### 6.3.2 Understanding Efficiency

Time on task is the metric used for measuring the efficiency of the *QuickCheck* app. This section shares the time taken by each participant to perform various tasks.

#### 6.3.2.1 Time on Task

Task moderators recorded the total time required to perform the tasks in seconds using the mobile timer. Table 12 provides the total time taken by the participant to perform the four assigned tasks. Some tasks were inherently more time consuming to complete than others and are reflected by the average time on task.

Table 12

*Time Required to Complete the Various Tasks by All Participants*

<b>Task list</b>	<b>P1</b>	<b>P2</b>	<b>P3</b>	<b>P4</b>	<b>P5</b>	<b>Mean. TOT*</b>
1. Auto populate the student record	60	162	150	59	69	100
2. Calibrate the student	43	34	70	45	56	49.6
3. Perform the vision screening (First screening)	600	390	808	551	366	543
4. Perform the vision screening two times						
(Second screening)	774	264	668	338	237	456.2
(Third screening)	660	209	344	318	228	351.8

\*All the times are in seconds

\*TOT-Time on task

Participants mentioned that they felt CISS is too lengthy and should be redesigned. To understand it more, further breakdown of time taken by each test in the ‘Perform vision screening’ and ‘Perform vision screening for two more times’ tasks was required. The individual

test timings are noted by listening to the audio record of the four participants. Since we asked each participant to think loud it was possible to note the test time. The audio record of one participant was lost due to the issues in the mobile in which it was recorded. Table 13 shows each test time for four participants.

Table 13

*Individual Test Time in the 'Perform vision screening task'*

<b>Participants</b>	<b>Time taken for Near vision test (in seconds)</b>	<b>Time taken for Distance vision test (in seconds)</b>	<b>Time taken for Stereopsis (in seconds)</b>	<b>Time taken for CISS (in seconds)</b>
P1(1 <sup>st</sup> screening)	357	242	95	220
(2 <sup>nd</sup> screening)	110	188	102	170
(3 <sup>rd</sup> screening)	75	104	58	115
P2(1 <sup>st</sup> screening)	126	220	128	120
(2 <sup>nd</sup> screening)	132	145	34	108
(3 <sup>rd</sup> screening)	95	102	29	80
P3(1 <sup>st</sup> screening)	80	112	38	134
(2 <sup>nd</sup> screening)	74	56	20	91
(3 <sup>rd</sup> screening)	58	58	18	94
P4(1 <sup>st</sup> screening)	70	192	140	128
(2 <sup>nd</sup> screening)	60	109	47	98
(3 <sup>rd</sup> screening)	72	85	50	94
<b>The average time taken by each test</b>	<b>109.1</b>	<b>134.4</b>	<b>63.3</b>	<b>121.0</b>

For all the tests, the minimum time is recorded during the third attempt of the vision screening test and the maximum time is recorded during the first attempt. These

values provide the min and max time range for each of the test. Figure 29 shows that for Near Vision, Distance Vision and Stereopsis the range varies significantly from max to min showing the larger improvement of time as they perform it for the 3<sup>rd</sup> time. For CISS there is no significant variation as compared to the other three tests which shows less improvement of time as participant performed it for the third time. This observation supports the participants' comment that CISS is lengthy.

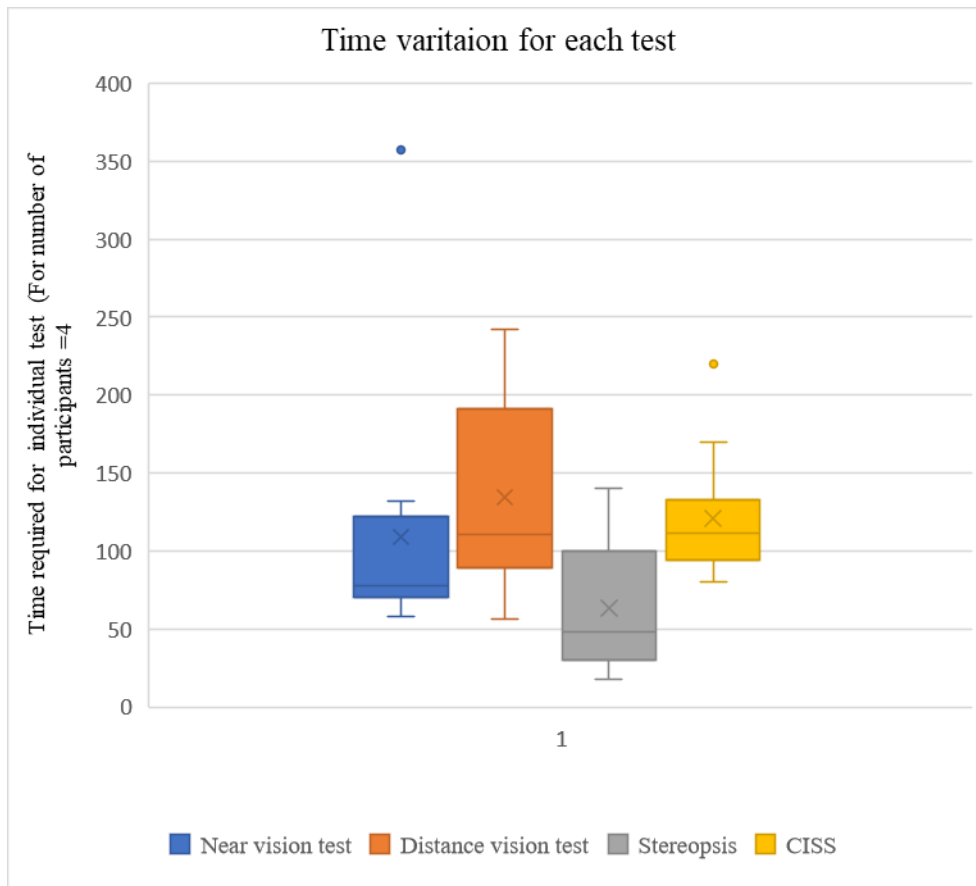


Figure 29: Time variation for each test in “perform vision screening task”

This data is useful to provide some insights about the learnability of the app discussed in the next section.

### 6.3.3 Understanding Learnability

Learnability of the app is the comfort and speed with which the participants get acquainted with the use of the *QuickCheck* app over the multiple uses. To understand the learnability of the *QuickCheck* app, we plotted the graph of mean timing calculated in Table 13

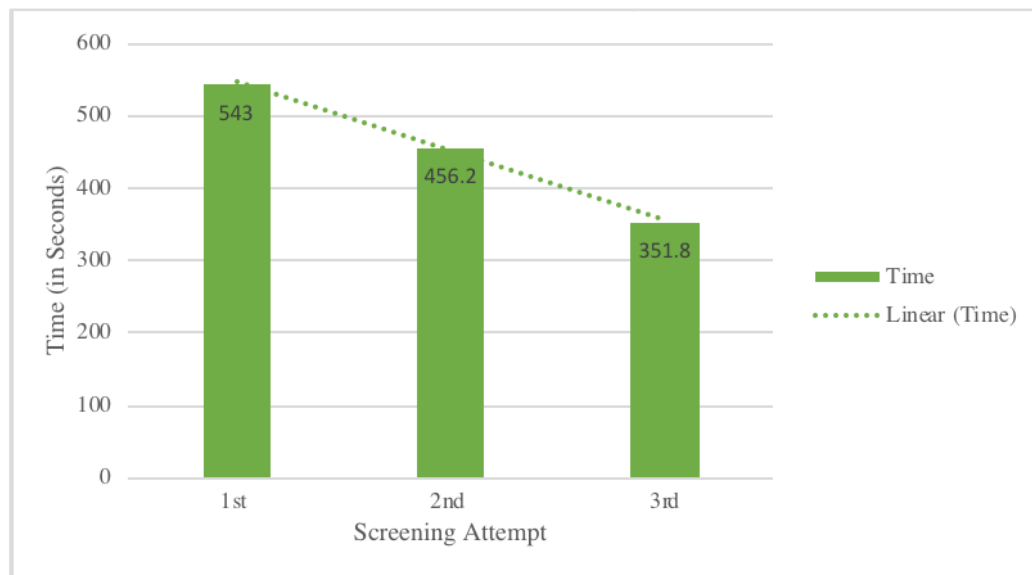


Figure 30: Average time taken by participants to complete the vision screening three times.

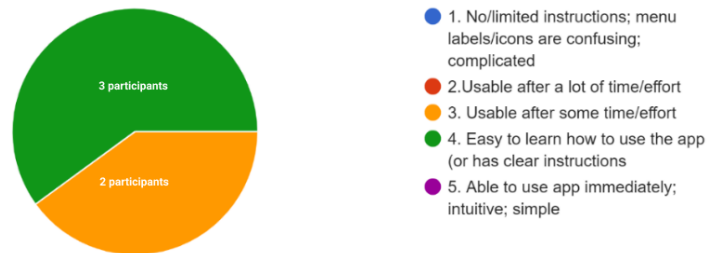
Second and third vision screening attempt as shown in Figure 30. The graph shows that the participants learning improved over time i.e. less time required to conduct the test as they use the app for the 3<sup>rd</sup> time.

Though this is an obvious behavior, we need to do the repeated measures and clinical trials with school nurses to gather a large statistic. The study with more number of school nurses and kids will give a more accurate measure of the minimum time required to reach the floor value and after how many attempts it is achieved.

The questions asked in the post-test questionnaire Figure 31 also helps to understand users' learning experience with the app. Almost 3 out of 5 participants feel that the app is easy to learn, and 2 participants think that it is usable but still requires some time or effort to learn.

5. Ease of use: How easy is it to learn how to use the app; how clear are the menu labels/icons and instructions?

5 responses



*Figure 31:* Response to question in SECTION B (Functionality) of MARS test – user's learning experience with the *QuickCheck* app

#### 6.3.4 Understanding Operability

Another usability metric that we gather more understanding about was the operability i.e. the ease of the mobile handling during the vision screening test and customization options in the app to suit the user's habits such as left-handedness or right-handedness. Figure 32 shows the responses that we received from the test participant on mobile handling and customization capability of the app.

2. Customization: Does it provide/retain all necessary settings/preferences for apps feature...ws to choose mobile handling habits)?

5 responses

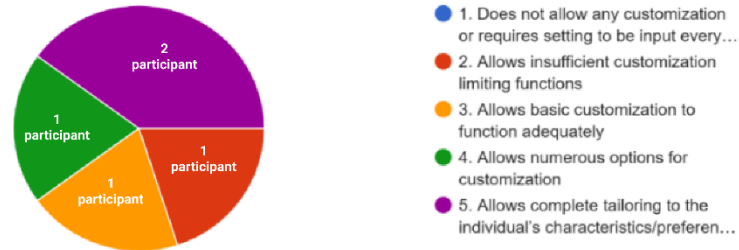


Figure 32: Response to question in SECTION A (customization) of the MARS test providing users' view on operability.

#### 6.4 Results of Interview

After the participants finished the task, a short interview was conducted to get more insights about the users' experience with the app. Participants provided feedback for what they liked the most, the least, and suggestion for improving the app. Interviews also helped to confirm the observations logged during the actual usability test.

The five interviews were analyzed for the themes across participants to identify opportunities, needs and goals for the end user. Three themes seem to be immersed:

1. Motivation to use the app
2. Barriers in the app usage
3. Factors that might influence the app usage.

Further detail studies will be required to identify other factors that influence vision screening apps and perform a detailed analysis of the captured data.

#### **6.4.1 Theme 1: Motivation to use the app**

The following comments were captured during the interview about what the participants liked the most:

“Overall flow of the app was good, auto populate was helpful too”

“App is simple quick and precise”

“To be able to have it on the phone is very helpful.”

Our prediction was, if the user’s productivity is increased by the usage of the app it will motivate them to use the app. The quotes from different participant suggest that ‘quick to use’, ‘simplicity’, the ‘overall flow of the app’ and tool being accessible on mobile is something they like about the app. ‘Quick to use’ and ‘preciseness’ keywords indicate that app usage may help to increase productivity. Yet, more data is required to support this prediction. The comments made by two participants also suggest that one reason that could motivate users to use the app is features that are not supported by existing vision screening methods.

“Liked near vision and liked the app because electronic screeners don't test for near vision”

“Feels very thorough, Flippers made the results more accurate”

#### **6.4.2 Theme 2: Barriers in the app usage**

The following comments were captured during the interview about what the participants liked the least.

“It takes a lot of time to complete.”

“I was not confident in calibration throughout the whole test.”

“Did not like, when the app did not help to differentiate the with and w/o flipper test.”

“CISS color scheme is not very good. About the CISS questions, students who have learning difficulties like ADHD or other will get refer after CISS test. Such students have been already identified by the school.”

The keywords like ‘takes a lot of time’, ‘was not confident’, ‘did not help’ suggest that these are the barrier in app usage. For example, while performing the calibration task many nurses calibrated themselves instead of kids (since the app uses the front camera). None of the nurses have used calibration before and were confused about how to calibrate correctly. They tried to refer the instructions, but it did not help much. As they were not able to calibrate correctly, they were worried about the accuracy of the screening results. One participant tried to calibrate again, after an unsuccessful attempt, but the app did not allow the recalibration. So overall experience with calibration task was impacted. The comment “I was not confident in calibration throughout the whole test.” supports it clearly. In order to improve the user experience, the feedback associated with the tasks (‘calibration’, ‘CISS’, ‘Near vision test instructions’) should be carefully examined to address the concerns highlighted by participants.

#### **6.4.3 Theme 3: Factors that might influence the app usage**

The following comments were captured during the interview about the participant’s suggestions. The participants comments highlights that user expected a support(help) at various stage while using the app. According to the Kano model (Kano, 1984), Satisfiers are the “features that users want as opposed to expecting.” If these features are available satisfaction is improved, preventing them from feeling dissatisfied. End users are happier when they get more. So below comments point out the ‘satisfiers’ as suggested in Kano model

“Instructions were fine, but it would be nice if there was like a support service for when an error occurs for tech problems for e.g. student not existing or a test not working properly”.

“It will be helpful to have a short video of how to conduct the test using the *QuickCheck App*”

“Stereopsis help instruction should mention the distance at which the phone should be held during the test”

The comments below are associated with specific features of the app such as auto populate student record and showing a full screen image for stereopsis test.

“Showing the duplicate records for auto populate should not happen,

“Instead of 'show image' allow to tap on the image for stereopsis.”

“CISS test takes a lot of time. CISS should be performed only if they fail near point convergence test.”

## **6.5 Post- Test Questionnaire (MARS Test) Results for Overall Metrics**

### **6.5.1 Overall Ratings**

After task completion, a post-test questionnaire was given to participants to rate the app for overall four measures. These measures include:

- Section A- (Engagement - the app is interesting, customizable, interactive well-targeted to the audience)
- Section B (Functionality – app functioning, easy to learn, navigation, flow logic, and gestural design of the app)

- Section C (Aesthetics – graphic design, overall visual appeal, color scheme, and stylistic consistency)
- Section D (Information – Contains high quality information (e.g. text, feedback, measures, references) from a credible source. Select N/A if the app component is irrelevant.)
- Section E App subjective quality
- Section F (App Specific)

App quality scores for each section are as follows.

A: Engagement mean score = 4

B: Functionality mean score = 4

C: Aesthetics mean score = 3.7

D: Information mean score = 3.6

E: App subjective quality score = 4.1

Overall App quality mean score = 3.8

The mean rating demonstrates the quality and desirability on various aspects such as engagement, functionality related to the app. It gives the insight into which areas of the app can be focused during the next design iteration. Mean rating suggests that most ratings hovered around three, four or five stars. This indicates the overall quality of the app is good with a scope to further improvements.

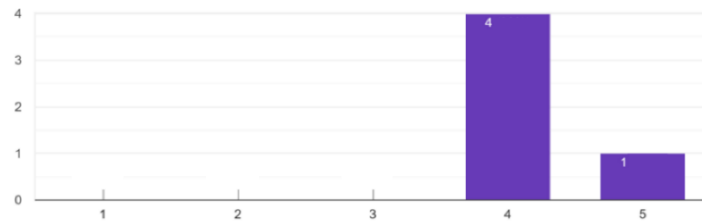
### **6.5.2 App Specific response**

Screen shots in Figure 33 show the response from the participants for the app specific questions. Four out of five participants think that app is likely to increase the awareness of the importance of addressing the vision disorders and will also encourage parents to get the eye

exam done for their kids. Three out of five think that the usage of the app is likely to increase the understanding of vision related disorders and increase the detection of vision disorders.

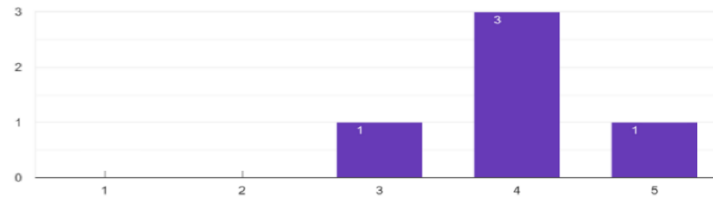
1. Awareness: This app is likely to increase awareness of the importance of addressing various types of vision disorders which usually remain undiagnosed?

5 responses



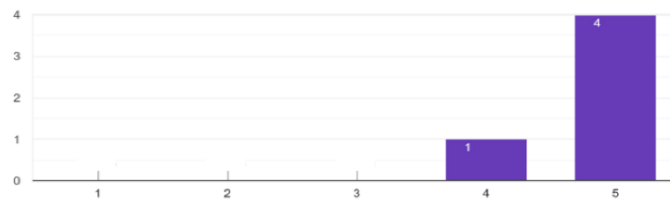
2. Knowledge: This app is likely to increase knowledge/understanding of vision-related disorders

5 responses



3. Help-seeking: Use of this app is likely to encourage further help-seeking for vision exam with an eye doctor (if it's required)

5 responses



4. Behavior change: Use of this app is likely to increase/decrease the detection of vision disorders?

5 responses

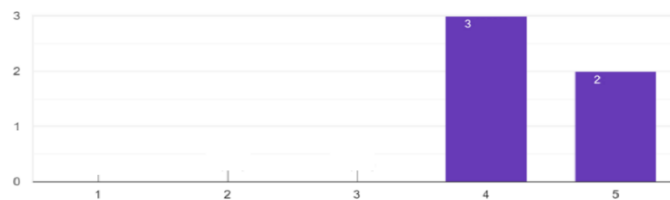


Figure 33: The response from the participants for the app specific questions (screenshots 1-4)

## 6.6 Observations from the Data Log

During the usability test, moderators noted the user behavior observation and user's comments. Observation notes and comments are listed below. Observations noted have given an important insight about the users experience and challenges that users faced with the app. The observations are categorized as general observations and test specific observations. General observations are related to calibration, skip, settings, result, and retake test. While the test specific observations are related to specific tests like Distance vision acuity and CISS.

### 6.6.1 Test Specific challenges faced by users

The challenges listed in this section point out the functional errors identified while users performing the different task with the app. That reveals that the interaction with the app does not always happen necessarily as we expect. During the CISS test user expected more feedback and for Stereopsis and 'Distance without flippers' expected better instruction to follow.

1. Stereopsis test does not have information about how to use the red blue glasses.
2. It will be good to have a reminder in the Stereopsis test about which side to have the image color.
3. 'Distance with No flippers' test says no flippers, but 'Near VA' test says cover eye, this is confusing as to whether to use flippers in 'Distance No Flippers' test or not.
4. CISS questions say, "close work" but question 4 says "classwork".
5. During the CISS test, the next question was getting loaded before clicking on the next button, so user accidentally skipped the question.
6. During the CISS survey, there was no feedback if the test taker has attempted all the questions. It only provides the details of the questions which were missed.

### 6.6.2 General Observation Noted During the Usability Test by Moderator

Similar to test specific observations, general observations point out users interaction with various features in the app happen differently than the intended way. Such as during calibration task participants calibrated themselves instead of students to be vision screened or during the test many nurses sat next to the student and allowed students to enter the response in the app.

Whereas during the user scenario we imagine that they will stand at a distance and record students response by themselves. Below is the list of general observations noted by moderators during the usability test.

1. Before the start of the test, the following general instruction should be mentioned:  
“No need to remove the glasses or contact lenses while completing the vision screening.”
2. Somewhere on the app, it should allow to note if the student is wearing corrective lenses, either contacts or glasses.
3. Participant sat next to student during CISS test so that they could see options instead of reading them out.
4. Although nurse managed to calibrate, they calibrated themselves rather than the student. Calibration instructions weren't clear.
5. Participants wanted to use settings menu to change the ‘left-handedness’ or ‘right-handedness’ option but could not locate the settings menu.
6. In the results screen, confusion about what the white color B on Distance with flippers test mean.
7. Retake test flow was not clear. The participant could not understand if the app is maintaining the session for the current student or not. Whether they take the entire

- test, the same test or if it starts from the beginning. The actual flow for the Retake functionality is complex. The user could figure out this flow on their own. There has to be some help related to a general instruction on "What if you skipped the test?"
8. When user accidentally clicked on the skip, no message was asked to the user such as "Are you sure you want to skip the test?" and they skipped the test without the intention of skipping the test and did not realize it.
  9. The participant sat to the side instead of in front of the student.
  10. CISS questions were ambiguous. Instead of multiple conditions can't we just provide a list such as "Do you experience following"?

## Chapter 7. Limitations and Future Work

This chapter discusses the limitations of the present study and the guidelines and recommendations for future work. It also provides a redesign of some of the existing features which were identified as a usability challenge for the user along with some new design ideas.

### 7.1 Limitation

#### 7.1.1 Threats to construct validity

“The construct validity is a matter of judging if the treatment reflects the cause construct and the outcome provides a true picture of the effect.” (Dumas JS, Redish JC, 1999) (Nielsen J, 1993) The objective measures were collected in the present study through the interview, observation data log during the test and subjective feedback through a questionnaire. The objective data was also verified using audio records performed during the test so the data gathered mirrors the reality and provides a true picture.

#### 7.1.2 Internal validity

Internal validity is the validity of the study within the used setting and the reliability of the outcomes obtained.

1. None of the research group members had a prior experience of conducting a usability test and hence recording the observations, data log and error was a challenge. Although I conducted the practice session for all group members, during the actual test, I realized that they were still confused about what to record and what not to record. This might have had an impact on the data collection.
2. We lost the audio record data for one participant due to an unforeseen error in a mobile device in which we audio recorded the respective session data.

3. Thinking a loud slows down the overall action. So, during the usability test while users were 'Thinking loud' it might have affected the time required to complete the task leading to an error in time measurement for each task.

### 7.1.3 External validity

External validity is related to the generalization of the findings. The sample of the participants in the usability test was small (5 participants) which constitutes a clear threat to the external validity of the study. In order to get more quantitative data and generalizable result, the study should be conducted with a larger sample set.

## 7.2 Recommendations for Future work: Redesign ideas

This section provides the redesign of some of the existing features which were identified as a usability challenge for the user along with some new design ideas. This project was to identify the methodology that can be used for the larger clinical study for the QuickCheck app. Before implementing the below features it should be prioritized based on the Kano model (Kano, 1984). Kano model categorizes the user's reaction in three categories as:

**Delighters:** Users do not expect to have Delighters. If these features are not there, they will not be unhappy but if they are implemented it highly increases the user's satisfaction level. They are usually users unsaid expectations. Delighters should be focused only after 'basic needs' and 'satisfiers' of the system are addressed.

**Satisfiers** are those Features that users want to see in the application. If these features are available satisfaction is improved, preventing them from feeling dissatisfied. End users are happier when they get more.

**Basic Needs:** These are featuring that users expect to see in the application. It can directly impact the user's satisfaction. Basic needs can be captured in the user's feedback during the usability test or prior to the user research.

Based on these models EYE Center research group members need to further analyze priorities of the redesign features shared in next section 7.2.1.

## 7.2.1 Redesign for Test specific feedback

### 1. Design ideas for Stereopsis Tool

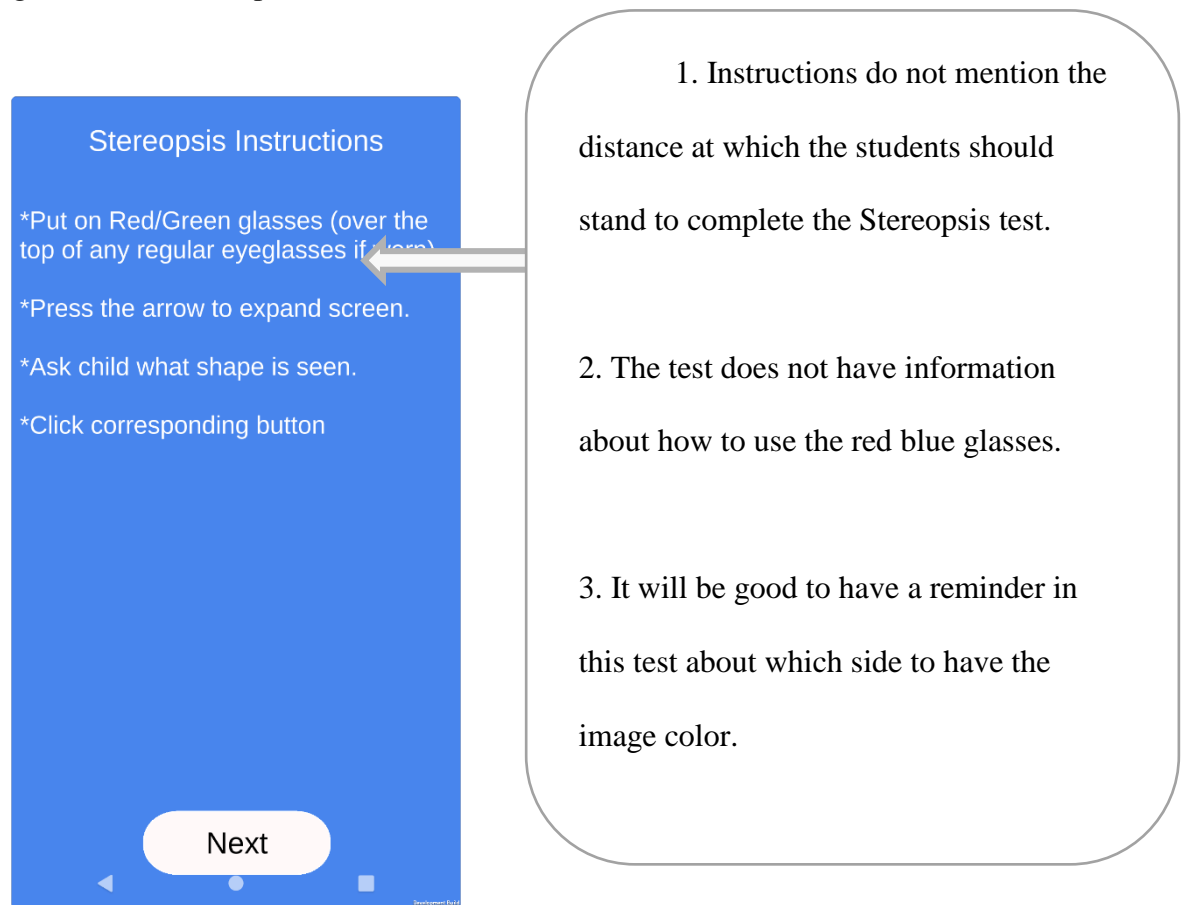


Figure 34: Design ideas for Stereopsis

### 2. Design ideas for Distance with No flippers

This test says no flippers, but 'Near VA instructions' says, "cover eye". This is

confusing for the users as to whether to use flippers in this test or not. Just saying the ‘Distance Visual Acuity Tool’ instead of ‘Distance Visual Acuity Tool Without Flippers’ will be less confusing.

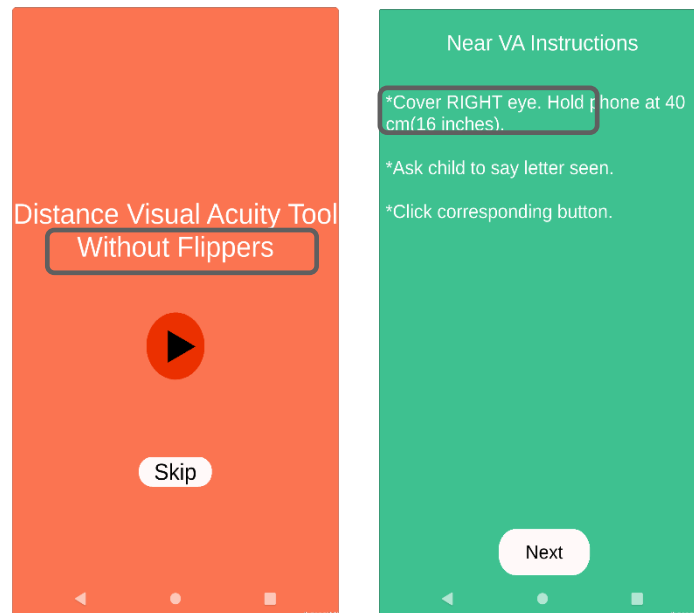


Figure 35: Design ideas for Distance vision tool

### 3. Design ideas for CISS (Convergence Insufficiency Symptoms Survey)

- CISS questions 1,2,3,5 all say, “close work” but question 4 says “class work”.
- During this test, the next question gets loaded automatically before clicking on the next button and hence during the test, users accidentally skipped some questions.
- At the end of the CISS test, user expects a confirmation message if they have successfully attempted all questions or not. Currently, it only prompts if the user has missed any questions during the survey.

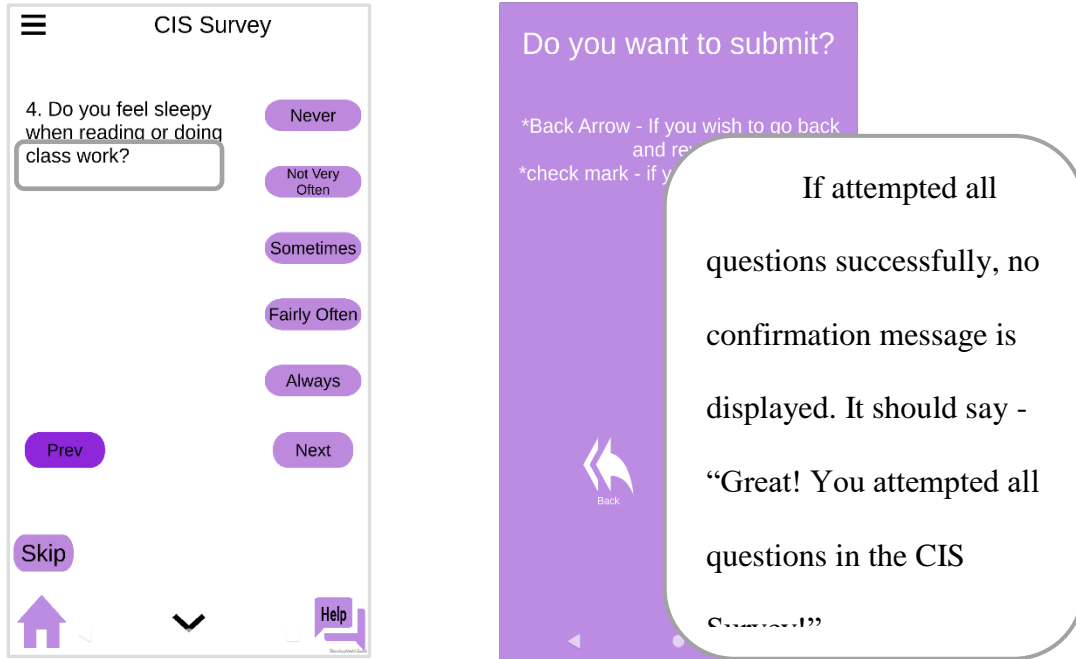


Figure 36: Design ideas for CISS

### 7.2.2 Design ideas for suggestions from the interviews

1. There should be a screen at the start listing all the tests, something as shown in Figure

37

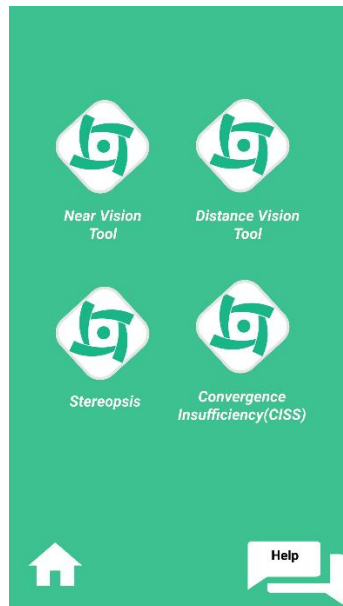


Figure 37: Screen to show all the available tests

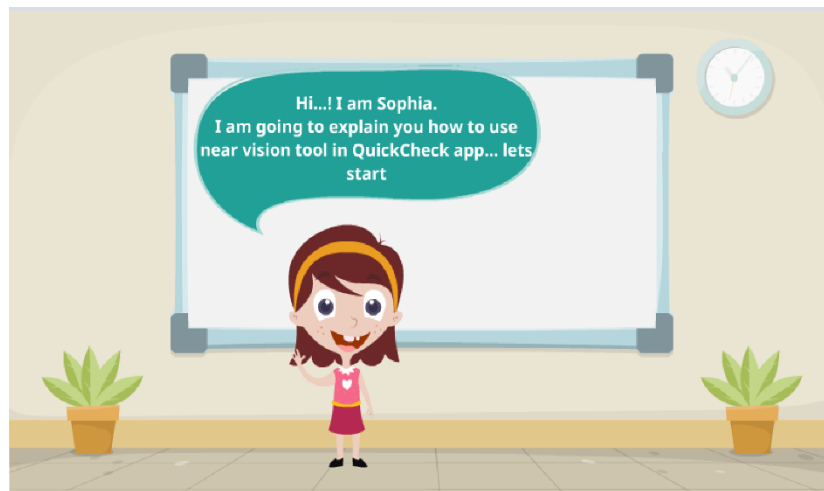
2. If students are allowed to click on the H, O, T, V letter buttons, they can be more focused during the test. It helps to keep them engaged if we allow interaction with the app.

It would be nice to have a tech support service when an error occurs for tech problems like a student not existing or a test not working properly. A chatbot feature with frequently asked questions”



*Figure 38:* Feature to provide Technical Support

If there is a short optional video of the instructions, that might be helpful, especially for users with more visual learning style.

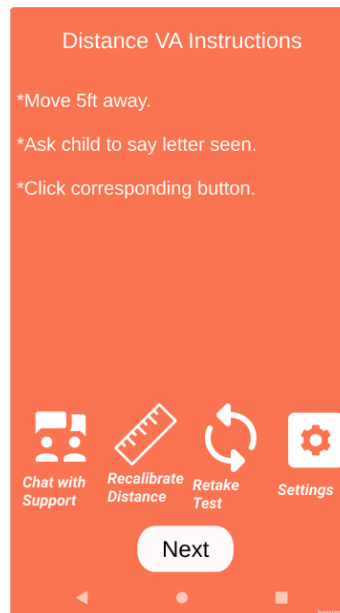


*Figure 39:* Simple animation screen to explain instructions to follow for each test.

### 7.2.3 General Suggestions from Participants

1. Before the start of the test, the following general instruction should be mentioned:  
“No need to remove your glasses or contact lenses while completing the vision screening.”
2. Somewhere in the app, it should allow noting if the student is wearing corrective lenses, either contact lenses or glasses.
3. The user was not able to calibrate during the start of the test and the app does not give an opportunity to recalibrate later. The user was confused about which process to follow to go to calibrate again. In the help menu, Options for recalibrating, Settings retake should be provided, instead of the menu screen.
4. Although some nurses managed to calibrate, they calibrated themselves rather than the student. Calibration instructions weren't very clear.
5. Participants wanted to use the settings menu to change the ‘left-handedness’ or ‘right-handedness’ option but could not locate the settings menu.
6. The app should have a tour to introduce its features to new users at the start of the app.

Figure 40 shows a collective redesign idea for a retake, recalibrate, support feature (chatbot) and settings menu which was problematic flow for users during the usability test.



*Figure 40:* Figure shows the modification in help screen to provide additional options for the user

### 7.3 Suggestions for the future clinical test

1. Before planning a larger clinical assignment, new release of the *QuickCheck* app should implement the recommendations from this usability study as well as the feedback from the UW Kid's team design session.
2. Measuring the accuracy of the screening test should be an essential aspect of the larger clinical study.
3. Also, in the future participatory design should also be conducted with adult users (nurses and teachers, parents)
4. There should be shorter cycles of usability test (may be every 3 months) to test the usability of the newly developed features.
5. The tasks designed for the current usability test were lengthy. They should have been divided among sub-tasks for each screening test.

6. Data should not be stored on personal devices since we lost the data from one of the group member's personal device. There should be some arrangement for dedicated android devices for the research group.
7. The next test should also measure how kids get screened with the fully charged mobile device. The battery power use by the application should be minimal. Since school nurse has to conduct vision screening for 100-500 student it is one of the important criteria.

## Chapter 8. Conclusion

Early detection of vision problems is crucial for their effective and timely eye health treatment. A mobile application is quite helpful in this regard, due to its portability, computing capability, ease to use and low-cost aspects. The present thesis provides a usability evaluation of the proposed framework, considerations, and recommendations regarding the use of a mobile device as a clinical assessment tool.

ISO/IEC 25010–1, 2011 quality models and ISO 9241–11 guidance on usability, 2018 standard was used to define the objective measurement of the *QuickCheck* app. Five users (doctor, nurses and technical expert) participated in the usability study of the *QuickCheck* app to test its beta version which provides four vision screening tools (Near vision acuity, Distance vision acuity, Stereopsis, Convergence insufficiency).

In conclusion, we can say that a highly usable solution using human-centered design thinking approach and participatory design method was implemented for the *QuickCheck* app. One of the strengths of this application is the operability design considerations such as placement of the letters, users' habits (left-handedness, right-handedness) which are especially important since we are using a mobile device as a clinical assessment tool. Another important feature is the ability to store the student's record so that the schools can share the screening results with parents easily. Also, in the future, this can help to get the student's overall eye health report.

Users' overall rating for the app is good (3.8). However, several areas of concern and improvement are also noted such as task flow, improvements in CISS questions and time required to complete the CISS test. Qualitative findings include the need for proper feedback to users at different stages and improvements in overall user interaction with the app features.

The major limitation of this usability study is that it does not allow the results to be generalized to a larger population since the test was conducted with a small group. A clinical study with a large sample of users must be conducted to address this issue. However, prior to this future clinical study, the proposed recommendations from this study must be implemented for the detection of new usability issues of the app. Further research works related to usability should also focus on measuring the accuracy of the *QuickCheck* app related to vision screening.

## References

- Abran et al. (2003). Consolidating the ISO Usability Models. *Submitt. 11th Int. Softw. Qual. Manag. Conf. 8th Annu. INSPIRE Conf.,.*
- Adlin, T. (2010). *The Power of Ad Hoc Personas: Truly Practical Methods to Get Your Organization On the Same Page* . Retrieved from aycl.uie.com:  
[https://aycl.uie.com/virtual\\_seminars/the\\_power\\_of\\_ad\\_hoc\\_personas](https://aycl.uie.com/virtual_seminars/the_power_of_ad_hoc_personas)
- Baharuddin et al. (2013). Usability dimensions for mobile applications—A review. *Res. J. Appl. Sci. Eng. Technol*, 5: 2225–2231.
- Balakrishnan, V. a. (2008). A Study of the Effect of Thumb Sizes on Mobile Phone Texting Satisfaction. *J. Usability Studies*, 118-128.
- Barrons. (2004). Evaluation of personal digital assistant software for drug interactions. *Am J Health-Syst Pharm.*, 61(4):380-5.
- Basili et al. (1994). Basili et al. In V. R. Rombach, *Encyclopedia of Software Engineering* (p. The Goal Question Metric Approach). Wiley.
- Baumgart. (2005). Personal digital assistants in health care: experienced clinicians in the palm of your hand? *Lancet*, 366(9492):1210-22.
- Borchert MS, Varma R, Cotter SA, et al. (2011). Risk Factors For Hyperopia And Myopia In Preschool Children. *Ophthalmology.*, 118(10):1966-1973. .
- Chhablani, J., Kaja, S., & Shah, V. (2012). Smartphones in ophthalmology. *Indian journal of ophthalmology*, 60(2), 127–131. doi:10.4103/0301-4738.94054.
- Collins. (2004). Measuring performance indicators in clinical pharmacy services with a personal digital assistant. . *Am J Health-Syst Pharm*, 61(5):498-501.

- Coursaris C and Kim d. (2011). A Meta-Analytical Review of Empirical Mobile Usability Studies. *Journal of Usability Studies*, vol. 6, no. 3, pp. 117-171,.
- Czamara, D et al. (2013). Children with ADHD symptoms have a higher risk for reading, spelling and math difficulties in the GINIplus and LISApplus cohort studies. *PloS one*, 8(5), e63859. doi:10.1371/journal.pone.0063859.
- Dallenbach, B. D. (2007). Detecting drug interactions using personal digital assistants in an out-patient clinic. *QJM*, 100(11):691-7.
- Dix et al. (2003). *Human Computer Interaction, 3rd edition*. Pearson.
- Druin, Allison. (2009). *Mobile Technology for Children: Designing for Interaction and Learning*. San Francisco, CA, USA: Morgan Kaufmann Publishers Inc.
- Dumas JS, Redish JC. (1999). *A practical guide to usability testing*. Intellect Book. Portland.
- Enders SJ, Enders JM, Holstad SG. . (2002). Drug-information software for Palm operating system personal digital assistants: breadth,. *Pharmacotherapy*, 22(8):1036-40.
- Ferebee, A. (2004, November). *PUBLIC CHALLENGES & OPPORTUNITIES - Health in Schools*. Retrieved from <http://www.healthinschools.org: www.healthinschools.org/wp-content/uploads/2016/10/visionfinal.pdf>
- Floyd et al. (2008). Resolving Incommensurable Debates: a Preliminary Identification of Persona Kinds, Attributes, and Characteristics. *In Artifact*,, pp. 2 (1) pp. 12-26. Retrieved from Periodicity.
- Ford S, Illich S, Smith L, et al. (2004). Measuring performance indicators in clinical pharmacy services with a personal digital assistant. *Am J Health-Syst*, 46(5):589-93.

- Fox BI, Felkey BG, Berger BA, et al. (2007). Use of personal digital assistants for documentation of pharmacists' interventions: a literature review. *Am J Health-Syst Pharm*, 64(14):1516-25.
- Friedman DS, Repka MX, Katz J, et al. (2009). Prevalence of Amblyopia and Strabismus in White and African American Children Aged 6 Through 71 Months: The Baltimore Pediatric Eye Disease Study. *Ophthalmology*, 116(11):2128-2134.
- Hanrahan C, Aungst T, Sabrina C. (2014). *Evaluating Mobile Medical Applications*. Retrieved from <https://www.ashp.org/>: <https://www.ashp.org/-/media/store%20files/mobile-medical-apps.pdf>
- Harley, A. (2014, July). *Icon Usability*. Retrieved from Nielsen Norman Group: <https://www.nngroup.com/articles/icon-usability/>
- Holmes JM, Lazar EL, Melia BM, et al. (2011). Effect Of Age On Response To Amblyopia Treatment In Children. *Archives of Ophthalmology*, 2011;129(11):1451-1457. 21.
- Honeybourne C, Sutton S, Ward L. (2006). Knowledge in the Palm of your hands: PDAs in the clinical setting. *Health Info Libr J.*, 23(1):51-9.
- International Organization for Standardization. (2011, March). *Systems and software engineering -- Systems and software Quality Requirements and Evaluation (SQuaRE) -- Evaluation process ISO/IEC 25040:2011*. Retrieved from [iso.org](http://iso.org): <https://www.iso.org/standard/35765.html>
- International Organization for Standardization. (2011, June). *Systems and software engineering - Systems and software Quality Requirements and Evaluation (SQuaRE)- System and software quality models ISO/IEC 25010-1 Quality model*,. Retrieved from [www.iso.org](http://www.iso.org): <https://www.iso.org/standard/35733.html>

- International Organization for Standardization. (2016, June). *Systems and software engineering - Systems and software quality requirements and evaluation (SQuaRE)-- Measurement of quality in use ISO/IEC 25022:2016*. Retrieved from iso.org:  
<https://www.iso.org/standard/35746.html>
- International Organization for Standardization. (2018, March). *Ergonomics of human-system interaction Part 11: Usability: Definitions and concepts, ISO 9241–11 Guidance on usability*. Retrieved from www.iso.org: <https://www.iso.org/standard/63500.html>
- Jake-Schoffman, Danielle E et al. (2017). Methods for Evaluating the Content, Usability, and Efficacy of Commercial Mobile Health Apps. *JMIR Mhealth Uhealth*, 5(12): e190.doi: 10.2196/mhealth.8758.
- Kano, N. (1984). Attractive quality and must-be quality. *The Journal of the Japanese Society for Quality Control*, 14(2): 39–48.
- Kleinstei RN, Jones LA, Hullett S, et al. (2003). Refractive Error And Ethnicity In Children. *Archives of Ophthalmology*,, 121(8):1141- 1147.
- McCloskey, M. (2014, January). *Turn User Goals into Task Scenarios for Usability Testing*. Retrieved from Nielsen Norman Group: .[ <https://www.nngroup.com/articles/better-usability-tasks/>
- McKean-Cowdin R, Cotter SA, Tarczy-Hornoch K, et a. (2013). Prevalence of Amblyopia or Strabismus in Asian and Non-Hispanic White Preschool Children: Multi-Ethnic Pediatric Eye Disease study. *Ophthalmology*, 120(10):2117-2124.
- Mobile Health (Mhealth) Market - Growth, Trends, And Forecast (2019 - 2024)*. (n.d.). Retrieved from mordorintelligence.com: <https://www.mordorintelligence.com/industry-reports/mobile-health-market>

- Multi-ethnic Pediatric Eye Disease Study Group. (2008). Prevalence of amblyopia and strabismus in African American and Hispanic children ages 6 to 72 months. *Ophthalmology*, 115(7), 1229–1236.e1. doi: 10.1016/j.optha.2007.08.001.
- Nielsen and Molich. (1990). *LITERATURE ON DESIGN GUIDELINES*. Retrieved from interaction-design.org: <https://www.interaction-design.org/literature/topics/design-guidelines>
- Nielsen J, L. T. (1993). A mathematical model of the finding of usability problems. *Proceedings of the INTERCHI '93 conference on human factors in computing systems* (pp. 206-213,doi>10.1145/169059.169166). Amsterdam: IOS Press: Amsterdam.
- Nielsen, J et al. (1993). *Usability engineering*. San Francisco: Morgan Kaufmann Publishers Inc.
- Nielsen, J. (2000, March). *Why You Only Need to Test with 5 Users*. Retrieved from nngroup.com: <https://www.nngroup.com/articles/why-you-only-need-to-test-with-5-users/>
- Nielsen, L. (2002). From user to character: an investigation into user-descriptions in scenarios. *Proceedings of the 4th Conference on Designing Interactive Systems: Processes, Practices, Methods, and Techniques* (pp. 99-104). London: ACM.
- Norman K et al. (1988). Development of an instrument measuring user satisfaction of the human-computer interface. *Proceedings of the SIGCHI Conference on Human Factors in Computing System* (pp. P 213-218 10.1145/57167.57203). Washington, D.C., USA: ACM.
- Norman, D. A. (2004, January ). *Ad-Hoc personas & Empathic Focus*. Retrieved from JND.org: <http://www.jnd.org/dn.mss/personas/empath.html>

- Nouri et al. (2018). Criteria for assessing the quality of mHealth apps: A systematic review. *Journal of the American Medical Informatics Association*, 25. 10.1093/jamia/ocy050.
- Office of Superintendent of Public. (2016). *Office of Superintendent of Public Instruction*. Retrieved from <http://reportcard.ospi.k12.wa.us>:  
<http://reportcard.ospi.k12.wa.us/summary.aspx?groupLevel=District&schoolId=1&reportLevel=State&yrs=2014-%202015&year=2014-15>
- Rana, A. and Mridu, M. (2012). Analytical Comparison of usability Measurement Methods. *Int. J. Comput. Appl*, 39:11–18.
- Raybardhan S, Balen RM, Partovi N, et al. (2005). Documenting drug-related problems with personal digital assistants in a multisite. *Am J Health-Syst Pharm*, 62(17):1782-7.
- Razzouk et al. (2012). What Is Design Thinking and Why Is It Important? *Review of Educational Research*, 82. 330-348. 10.3102/0034654312457429.
- Research2guidance. (2017, November). *mHealth App Economics 2017/2018 Current Status and Future Trends in Mobile Health*. Retrieved from [research2guidance.com](http://research2guidance.com):  
[<https://research2guidance.com/325000-mobile-health-apps-available-in-2017/>]
- Ruderman, M. (2016). *Children's Vision and Eye Health: A Snapshot of Current National Issues (1st ed.)*. Chicago, IL:: National Center for Children's Vision and Eye Health at Prevent Blindness.
- Schade, A. (2017, April). *Write Better Qualitative Usability Tasks: Top 10 Mistakes to Avoid*. Retrieved from Nielsen Norman Group: <https://www.nngroup.com/articles/better-usability-tasks/>

- Shah VA, Lord RK, Kaja S. (2010). *Association for Research in Vision and Ophthalmology Annual Meeting*. Fort Lauderdale, FL: Smartphones in Ophthalmology (Workshop) Program #487.
- Sharrock, G. (2018, May). *Custom vs native fonts in apps*. Retrieved from medium.com: <https://medium.com/default-to-open/custom-vs-native-fonts-in-apps-9cd7d872491c>
- Soegaard, M. (2019, March). *Recalling Color Theory Keywords: a way to refresh your memories!* Retrieved from interaction-design.org: <https://www.interaction-design.org/literature/topics/color-theory>
- Stoyanov SR et al. (2015). Mobile App Rating Scale: A New Tool for Assessing the Quality of Health Mobile Apps. *JMIR Mhealth Uhealth* , 3(1):e27 DOI: 10.2196/mhealth.3422 PMID: 25760773 PMCID: 4376132.
- Usability.gov. (n.d.). *Usability Test Plan Template*. Retrieved from <https://www.usability.gov/https://www.usability.gov/how-to-and-tools/resources/templates/usability-test-plan-template.html>
- Whitenton, K. (2013, December). *Minimize Cognitive Load to Maximize Usability*. Retrieved from Nielsen Norman Group: <https://www.nngroup.com/articles/minimize-cognitive-load/>
- Zahra, Fatima et al. (2017). Usability evaluation of mobile applications; where do we stand? *AIP Conference Proceedings*, (p. 1891. 020056. 10.1063/1.5005389).
- Zapatah et al. (2015). Empirical studies on usability of mHealth apps: a systematic literature review. *J. Med. Syst.*, pp. 1-19.

## Appendix

### Appendix A

#### Usability Test Moderator Script for Quick Check

Thank you for coming along and for agreeing to take part in our research. The purpose of today is to get your feedback on a new mobile app aimed at doctors and school nurses. The *QuickCheck* app provides quick and efficient mobile based screening tool to doctors and school nurses to perform the vision screening. The quick Check allows doctors and nurses to quickly assess if the child has one of the following eye conditions:

1. Near vision problems,
2. Distance vision problems,
3. Stereopsis,
4. Convergence insufficiency.

If the child scores below a certain score, the child will be referred to a doctor for further analysis. The school nurse/doctors will be able to conduct the vision screening using a mobile app to record the student's answers. We are interested to hear from you today as you are the target audience for the mobile app and we're keen to hear your opinions and suggestions on what has been developed so far in the app. During the session, I will request you to fill out some questionnaire, perform certain activities and have a short interview to understand your experience with the app.

The session is very informal, and I encourage you to be as open and honest as you can. We're interested to hear about your challenges, your opinions and suggestions so please feel relaxed to share these.

We will be recording audio today, but your input is confidential. The report that we will produce will include what was said, but all feedback will remain anonymous, we will not be including your name etc.

It's all very informal, it is not a test and there are no right or wrong answers. We are interested to hear your feedback so please don't feel under pressure to complete tasks correctly or feel intimidated by any of the questions we ask today.

Do you have any questions before we begin?

## Appendix B

### Consent Form *QuickCheck* Usability Study

I agree to participate in the study conducted by the University of Washington Bothell Eye Center. I understand that participation in this usability study is voluntary and I agree to immediately raise any concerns or areas of discomfort during the session with the study administrator.

In this usability test:

- You will be asked to perform certain tasks on a computer.
- We will also conduct an interview with you regarding the tasks you performed.

All information will remain strictly confidential. The descriptions and findings will be used to help improve the *QuickCheck* Mobile application. However, at no time will your name or any other identification be used.

Please sign below to indicate that you have read and you understand the information on this form and that any questions you might have about the session have been answered.

Date: \_\_\_\_\_

Please sign your name:

\_\_\_\_\_

Thank you!

We appreciate your participation.

## Appendix C

### Pre-test Demographic Questionnaire

\* Required

1. **First Name \***

\_\_\_\_\_

2. **Your email id \***

\_\_\_\_\_

3. **Age \***

\_\_\_\_\_

4. **Gender \***

*Mark only one oval.*

Female

Male

Prefer not to say

Other: \_\_\_\_\_

5. **How comfortable you are using a mobile device in general? \***

*Mark only one oval.*

Extremely familiar

Very familiar

Moderately familiar

Slightly familiar

Not at all familiar

6. **Your profession \***

*Mark only one oval.*

School Nurse

Doctor

Other Health Professional related to Vision

Other: \_\_\_\_\_

7. **Have you used a mobile app before for any other form of clinical assessments? \***

*Mark only one oval.*

Yes

No

**8. How familiar are you with vision screening for kids in school? \***

Mark only one oval.

- Extremely familiar
- Very familiar
- Moderately familiar
- Slightly familiar
- Not at all familiar

**9. The age group of kids you have work with (all that apply) \***

Mark only one oval.

- Children (under 12)
- Adolescent (13-17)
- Young Adults (18-25)
- All age groups
- Have not worked with kids

**10. Which of the below vision test you have conducted before (Check all that apply) \***

Check all that apply.

- Near vision Acuity
- Distance Vision Acuity
- Stereopsis
- Convergence insufficiency symptom survey (CISS)
- Other: \_\_\_\_\_

**11. How would you mark your familiarity for conducting vision screening \***

Mark only one oval.

- Extremely familiar
- Very familiar
- Moderately familiar
- Slightly familiar
- Not at all familiar

**12. Have you performed school-based vision screening? \***

Mark only one oval.

- Yes. I perform the vision screening yearly
- Yes. I perform the vision screening in past
- No I have not perform the vision screening before

13. Have you used a photo screening devices (for eg. PlusOptix or SPOT device) for vision screening? \*

Mark only one oval.

- Yes
- No
- Maybe
- Other: \_\_\_\_\_

## Appendix D

### Interview Questions QuickCheck

1. Did you notice the setting option at the start of the app?

*Mark only one oval.*

- Yes
- No
- Maybe

2. Help instructions were helpful?

---

3. What other information would you like to see in the help section?

---

---

---

---

---

4. What do you like least/most about our QuickCheck App? (get the comment for least and most from participant)

---

---

---

---

---

5. Which feature of QuickCheck was most important to you? (at least 2 features)

---

---

---

---

---

6. Do you have any suggestions on how we can improve this app?

---

---

---

---

---

7. What other products/devices do you use to accomplish similar tasks and why?

---

---

---

---

---

8. Questions from observation notes: what was thought process while you were performing x task? What was blocking?

---

---

---

---

---

## Appendix E

### User Satisfaction Survey using Mobile App Rating Scale (MARS)

#### SECTION A- (app is interesting, customizable, interactive well-targeted to audience)

---

1. **1. Interest: Is the app interesting to use? Does it use any strategies to increase engagement by presenting its content in an interesting way?**

*Mark only one oval.*

- 1. Not interesting at all
- 2. Mostly uninteresting
- 3. OK, neither interesting nor uninteresting; would engage user for a brief time (< 5 minutes)
- 4. Moderately interesting; would engage user for some time (5-10 minutes total)
- 5. Very interesting, would engage user in repeat use

2. **2. Customization: Does it provide/retain all necessary settings/preferences for apps features (e.g. settings for conducting the various test, allows to choose mobile handling habits)?**

*Mark only one oval.*

- 1. Does not allow any customization or requires setting to be input every time
- 2. Allows insufficient customization limiting functions
- 3. Allows basic customization to function adequately
- 4. Allows numerous options for customization
- 5. Allows complete tailoring to the individual's characteristics/preferences, retains all settings

3. **3. Target group: Is the app content (visual information, language, design) appropriate for your target audience?**

*Mark only one oval.*

- 1. Completely inappropriate/unclear/confusing
- 2. Mostly inappropriate/unclear/confusing
- 3. Acceptable but not targeted. May be inappropriate/unclear/confusing
- 4. Well-targeted, with negligible issues
- 5. Perfectly targeted, no issues found

4. Do you have a specific comment/suggestion for how the app could be made more interesting?

---

---

---

---

---

## **SECTION B (Functionality – app functioning, easy to learn, navigation, flow logic, and gestural design of app)**

---

5. 4. Performance: How accurately/fast do the app features (functions) and components (buttons/menus) work?

*Mark only one oval.*

1. App is broken; no/insufficient/inaccurate response (e.g. crashes/bugs/broken features, etc.)
2. Some functions work, but lagging or contains major technical problems
3. App works overall. Some technical problems need fixing/Slow at times
4. Mostly functional with minor/negligible problems
5. Perfect/timely response; no technical bugs found/contains a 'loading time left' indicator

6. 5. Ease of use: How easy is it to learn how to use the app; how clear are the menu labels/icons and instructions?

*Mark only one oval.*

1. No/limited instructions; menu labels/icons are confusing; complicated
2. Usable after a lot of time/effort
3. Usable after some time/effort
4. Easy to learn how to use the app (or has clear instructions)
5. Able to use app immediately; intuitive; simple

7. 6. Navigation: Is moving between screens logical/accurate/appropriate/uninterrupted; are all necessary screen links present?

*Mark only one oval.*

1. Different sections within the app seem logically disconnected and random/confusing/navigation is difficult
2. Usable after a lot of time/effort
3. Usable after some time/effort
4. Easy to use or missing a negligible link
5. Perfectly logical, easy, clear and intuitive screen flow throughout, or offers shortcuts

**8. 7. Gestural design: Are interactions (taps/swipes/pinches/scrolls) consistent and intuitive across all screens?**

Mark only one oval.

- 1. Completely inconsistent/confusing
- 2. Often inconsistent/confusing
- 3. OK with some inconsistencies/confusing elements
- 4. Mostly consistent/intuitive with negligible problems
- 5. Perfectly consistent and intuitive

**9. 8. Do you get feedback/message on the completion of sequence of task?**

Mark only one oval.

- 1. No/limited instructions; instructions are confusing; complicated
- 2. Usable after a lot of time/effort spend on instruction
- 3. Usable after some time/effort spend on instruction
- 4. Easy to learn how to use app (or has clear instructions)
- 5. Able to use app immediately; intuitive; simple, clear instructions

**10. Do you have specific comment/suggestion for how learning the app could be made easy?**

---

---

---

---

---

**Section C (Aesthetics – graphic design, overall visual appeal, color scheme, and stylistic consistency)**

---

**11. 9. Layout: Is the arrangement and size of buttons/icons/menus/content on the screen appropriate?**

Mark only one oval.

- 1. Very bad design, cluttered, some options impossible to select/locate/see/read device display not optimized
- 2. Bad design, random, unclear, some options difficult to select/locate/see/read
- 3. Satisfactory, few problems with selecting/locating/seeing/reading items or with minor screen-size problems
- 4. Mostly clear, able to select/locate/see/read items
- 5. Professional, simple, clear, orderly, logically organized, device display optimized. Every design component has a purpose

**12. 10. Graphics: How high is the quality/resolution of graphics used for buttons/icons/menus/content?**

*Mark only one oval.*

- 1. Graphics appear amateur, very poor visual design - disproportionate, completely stylistically inconsistent
- 2. Low quality/low resolution graphics; low quality visual design – disproportionate, stylistically inconsistent
- 3. Moderate quality graphics and visual design (generally consistent in style)
- 4. High quality/resolution graphics and visual design – mostly proportionate, stylistically consistent
- 5. Very high quality/resolution graphics and visual design - proportionate, stylistically consistent throughout

**13. 11. Visual appeal: How good does the app look?**

*Mark only one oval.*

- 1. No visual appeal, unpleasant to look at, poorly designed, clashing/mismatched colors
- 2. Little visual appeal – poorly designed, bad use of color, visually boring
- 3. Some visual appeal – average, neither pleasant, nor unpleasant
- 4. High level of visual appeal – seamless graphics – consistent and professionally designed
- 5. As above + very attractive, memorable, stands out; use of color enhances app features/menus

**14. 12. The different colors used for the different vision test is useful? Does that indicate the transition between the tests?**

*Mark only one oval.*

- 1. Not at all useful and does not indicate the transition between tests
- 2. Little useful but does not indicate the transition between tests
- 3. Useful and may indicate the transition between tests
- 4. Very useful , helps to indicate the transition
- 5. Extremely useful and very well indicates the transition between tests

**15. Do you have a specific comment/suggestion for layout, the color scheme of the app**

---

---

---

---

---

**Section D (Information – Contains high quality information (e.g. text, feedback, measures, references))**

**from a credible source. Select N/A if the app component is irrelevant.)**

---

16. **13. Accuracy of app description (in the app store): Does app contain what is described?**

*Mark only one oval.*

- 1. Misleading. App does not contain the described components/functions. Or has no description
- 2. Inaccurate. App contains very few of the described components/functions
- 3. OK. App contains some of the described components/functions
- 4. Accurate. App contains most of the described components/functions
- 5. Highly accurate description of the app components/functions

17. **14. Quality of information: Is app content correct, well written, and relevant to the goal/topic of the app?**

*Mark only one oval.*

- 1. Irrelevant/inappropriate/incoherent/incorrect
- 2. Poor. Barely relevant/appropriate/coherent/may be incorrect
- 3. Moderately relevant/appropriate/coherent/and appears correct
- 4. Relevant/appropriate/coherent/correct
- 5. Highly relevant, appropriate, coherent, and correct

18. **15. Error messages clarify the problem you faced.**

*Mark only one oval.*

- 1. Misleading. App contains the irrelevant error message
- 2. Inaccurate. App contains very few error messages
- 3. OK. App contains somewhat relevant error messages
- 4. Accurate. App contains most accurate message for the encountered error
- 5. Highly accurate. App contains highly accurate message for the encountered error

19. **Do you have a specific comment/suggestion for information contains on the app**

---

---

---

---

---

**SECTION E App subjective quality**

---

20. **16. Would you recommend this app to people who might benefit from it?**

*Mark only one oval.*

- 1. Not at all. I would not recommend this app to anyone
- 2. There are very few people I would recommend this app to
- 3. May be. There are several people whom I would recommend it to
- 4. There are many people I would recommend this app to
- 5. Definitely. I would recommend this app to everyone

21. **17. How many times do you think you would use this app in the next 12 months if it was relevant to you?**

*Mark only one oval.*

- None
- 1-2
- 3-10
- 10-50
- >50

22. **18. Would you/your organization pay for this app?**

*Mark only one oval.*

- No
- Maybe
- Yes

23. **19. What is your overall star rating of the app?**

*Mark only one oval.*

- \*\* One of the worst app I have used
- \*\*\*\*
- \*\*\*\*\* Average
- \*\*\*\*\*
- \*\*\*\*\* One of the best app I have used

## Section F (App Specific)

---

24. **1. Awareness: This app is likely to increase awareness of the importance of addressing various types of vision disorders which usually remain undiagnosed?**

*Mark only one oval.*

- |                   |                       |                       |                       |                       |                       |                |
|-------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|----------------|
|                   | 1                     | 2                     | 3                     | 4                     | 5                     |                |
| Strongly disagree | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | Strongly agree |

25. **2. Knowledge: This app is likely to increase knowledge/understanding of vision related disorders**

*Mark only one oval.*

1      2      3      4      5

---

Strongly disagree                  Strongly agree

---

26. **3. Help-seeking: Use of this app is likely to encourage further help-seeking for vision exam with an eye doctor (if it's required)**

*Mark only one oval.*

1      2      3      4      5

---

Strongly disagree                  Strongly agree

---

27. **4. Behavior change: Use of this app is likely to increase/decrease the detection of vision disorders?**

*Mark only one oval.*

1      2      3      4      5

---

Strongly disagree                  Strongly agree

---