Evaluating and Improving the Usability of MIT App Inventor

by

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Abstract

MIT App Inventor is a blocks-based programming language for Android apps designed to teach programming skills to middle school and high school students. We aim to make app development accessible for all.

Anyone learning to program must learn computational thinking methods; App Inventor users must also learn how to use the service. Our target users, teenagers and people without programming experience, often conflate the two learning processes: they think App Inventor is hard because learning to program is hard. As such, App Inventor needs a user interface that matches the conventions of commercially-available software our users already know how to use. Such an interface will allow them to focus on learning how to program and to transfer their knowledge and skills to other programming languages and environments.

I designed several tasks and conducted a usability study on the existing, publicly-available App Inventor service. Users encountered 75 unique issues and a total of 157 issues. This is an average of 5 unique issues and 10.5 total issues per user. I made changes to the App Inventor source code that addressed 34 of the most common issues encountered. My intent was to make App Inventor both more usable to novice programmers and more similar to the programming environments that experienced programmers use. Finally, I conducted a usability study with the same tasks on the modified version of App Inventor. Users encountered 65 unique issues, including 19 issues encountered in the first study, and 107 total issues. Based on user comments and behavior, I conclude that my solutions resolved 21 of the original issues, partially mitigated 9 issues, and did not improved the usability of 4 issues.

Thesis Supervisor: Harold Abelson
Title: Class of 1922 Professor of Computer Science and Engineering

Acknowledgments

First, I would like to thank my advisor, Hal Abelson, for allowing me to follow my passion for user interfaces and human-computer interaction. He gave me the latitude and resources to explore the usability of App Inventor and has provided valuable feedback throughout this process.

I could not have completed this project without Andrew McKinney's support. He was always excited about the work that I was doing. He helped me formalize my idea for this thesis, he collaborated with me to prioritize the issues to address after the first study, and he was willing to help when I was stuck.

I appreciate the generosity of Christopher LaRoche and Katherine Wahl, the MIT IS&T Usability Team. They helped me refine my usability study tasks, they fit my project to their busy testing schedule, and they conducted all of the sessions.

Special thanks to my sister, Quinn Colter: in addition to being a usability study pilot tester while on vacation, she edited my thesis for content and clarity. Her corrections have significantly improved the usability of this document.

I would not have a thesis without the participation of five pilot testers and twenty-seven testers. I learned so much about usability tests and human-computer interaction by observing them. I thank each of the participants for their time.

My friend, Candice Murray, kindly formatted all of my references for LaTeX. My fellow researcher, Benjamin Xie, helped me troubleshoot issues as I was typesetting my thesis in LaTeX.

Finally, a big thanks to the members of the App Inventor developer team who answered my questions, reviewed my code, collaborated with me on projects that stemmed from this experiment, and edited parts of this thesis.

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Chapter 1

Introduction

MIT App Inventor is a web service designed with the overarching goal of democratizing Android application development [1]. Through freely available curriculum and tutorials, App Inventor also aims to teach middle school and high school students the fundamentals of programming. The service employs Blockly, a open-source blocks-based programming framework [7]. As a project within the MIT Center for Mobile Learning, we aim to make programming more accessible to young people and people who do not have a programming background. MIT App Inventor mitigates a lot of the difficulty intrinsic in programming for Android, which helps our inventors have a better experience when designing and developing Android apps. Furthermore, App Inventor tries to make it easier to learn how to program by replacing traditional lines of code with a more graphical and tactile method of creating code.

1.1 Motivation

App Inventor users must learn how to use the service in addition to learning good programming practices and techniques. Because App Inventor's target user groups are teenagers and people without programming knowledge, App Inventor needs a high-quality user interface that engages users in an intuitive, pleasant programming experience.

I have always been interested in human-computer interaction and user interfaces.

As a child, I liked teaching myself how to use computer programs, such as PowerPoint and Adobe Premiere. When I was teenager, my grandmother used to bring her computer to family gatherings so that I could teach her how to use it. From these experiences, I gained an appreciation for user interfaces that were intuitive and enjoyable for people to use.

Through my own experience learning to use App Inventor, I have found that it is not always intuitive. As a master's student at MIT, I have had the opportunity as a TA and a Technovation Mentor[1] to watch people use App Inventor for the first time, and I have seen their occasional frustration with it. Because the interface does not always match their expectations, they underestimate App Inventor's power and capability.

Because of these experiences, I wanted to first quantify the issues that users encounter with App Inventor. Second, I wanted to try to solve those problems. And third, I wanted to collect data to see if and how much my fixes improved the usability of the system. If my fixes proved to be beneficial, meaning they reduced the frequency with which an error was encountered, I could use the data to justify that the changes should be included in the public App Inventor service.

1.2 Contributions

My thesis is a three-phase experiment based on MIT App Inventor. First, I designed a usability study and observed volunteers as they completed the tasks. My participants were divided into two groups by their prior experience with programming. Second, based on the individual and collective responses to the tasks in the study, I attempted to fix 34 of the most common issues in App Inventor. My goal was twofold: 1) to make App Inventor more usable to novice programmers; and 2) to make it match other programming environments that experienced developers use. Finally, I observed participants completing the same usability study tasks in my new version of App

[1]Technovation is a global competition for young women in middle school and high school. They must create a business plan and develop an app that fulfills a need in their community. Teams are mentored by industry professionals [27].

Inventor. The results from the second usability study show that my changes were an overall improvement, eliminating 21 and partially mitigating 9 of the originally discovered 75 unique issues in the public App Inventor service. However, 4 of the original issues that I addressed were not mitigated by the solution and remain open problems.

The following chapters explain in more detail each of the steps in my thesis. In chapter 2, I outline related work, although there was only one paper about the results from a usability study being applied in code and retested, and one paper about building a usable programming language for children. Chapter 3 contains a brief introduction to App Inventor, its screens, and a sample app. In chapter 4, I describe the design and execution of the first usability study and its results. Chapter 5 is a report of my changes to App Inventor, including before and after screenshots. Chapter 6 contains the results of the second usability study, which are compared to the first study's results. I conclude in chapter 7 with a section about future work that directly stems from this project, and final thoughts in chapter 8 about what I learned through this experiment.

Chapter 2

Related Work

With increased use of personal computers and mobile devices, web-services and software companies are spending more resources on design and usability. The usability field is rapidly expanding to improve the overall user experience and to increase the marketability of companies' products.

In my research, I found only one paper that used the results of a usability study to inform their decisions to redesign the interface, which was then retested. In early 2014, Darejeh et al. published a paper investigating the Ribbon interface in Microsoft Office products and its learnability for users with low computer literacy [6]. After an initial usability test of the Ribbon, the authors used their findings to redesign the Ribbon interface and retested it. Through their data analysis, they showed that their redesigned Ribbon:

- Enabled participants to complete tasks that they could not complete in the original version;
- Increased participants' speed in completing the given tasks;
- Decreased the number of steps that participants took while performing the tasks.

In 2002, as a result of the work he did for his doctoral thesis, John Pane published a paper about HANDS, a programming language he developed for children in 5th grade or older [22]. HANDS is an event-driven programming language, like App Inventor. His goal was to reduce the difficulty of programming by improving the

usability of a development environment's user interface. They conducted a usability study with HANDS focusing on queries, aggregate operations, and the high visibility of data. They concluded that the users, all of whom were non-programmers, who used HANDS performed significantly better than the users who used a version of HANDS that had the three studied features disabled.

In 2015, biomedical researchers tested the usability of Printed Educational Materials (PEMs), packets of information that are a distributed to clinics in an attempt to change primary care [9]. The researchers note that the information in PEMs rarely had an impact on physician behavior. Their usability study was structured similarly to mine, though they used paper materials, and I used a web-based software product. They employed a graphic designer to redesign a publicly-available PEM based on physician feedback, then asked physicians to choose their preferred design, the original or the redesigned version. They also asked the physicians to rate the PEM on the System Usability Scale (SUS) [1]. They found that their redesigned Therapeutic Letters were easier to read, which could impact physician behavior. Furthermore, they concluded that even a single usability test can provide valuable feedback.

In late 2014, Geng et al. discussed the impact of fixing the usability problems of the Furniture Giveaway website [8]. They analyzed the usability of the 2009 and 2010 versions of the website by comparing the number of steps and amount of time required to complete specified tasks. They found that site structure, convenience of functionality, and graphic design improved the users' online experience .

In 2016 Sheng-yi Hsu et al. wrote a paper about users' behavior and efficacy using App Inventor, specifically the Blocks editor [11]. They stated that the benefit of blocks is that they lower the barrier for learning to program, but unfortunately the App Inventor Blocks editor does not improve understanding. They defined understanding as reading, searching, and maintaining code, crucial actions that most developers spend 35 percent of their time doing. They introduced a "shelf" structure to the App Inventor Blocks Editor. Users could organize blocks in different "shelves" in the

[1]The SUS is a form used to assess the subjective usability of a system. I describe more about the SUS and how I used it in my experiements in section 4.4.1

workspace and switch between viewing different block shelves for better readability of large volumes of blocks. They used A/B testing to determine whether their structure was beneficial to students who knew the basics of programming. They concluded that the shelves improved the students' understanding of the code blocks.

In 2005, Yu-chen Hsu published a paper about an experiment using metaphors to teach beginners and experts about Internet Protocol (IP) [12]. The author gave participants a pretest, then split the beginners and the experts into four groups; one group of beginners and one group of experts were taught the metaphor, and the other two groups were not taught the metaphor. After learning about IP, the researcher administered a post-test with two different types of questions. This paper shows that other researchers have divided a population of users into two groups based on their familiarity with computers, as I did.

In 2015, Andreas Sonderegger et al. performed a usability study in which they divided their users into two groups: older people (mean age 58.1 years) and younger people (mean age 23 years) [26]. They claimed that usability improvements intended to help older users also benefited younger users. They concluded that their results did not show an age-related effect for effectiveness or accuracy in task completion, but younger adults performed better on speed-related tasks.

In addition to academic literature about usability studies, there is a wealth of information about performing usability studies. Jakob Nielsen is known in the field as the expert of usability studies. He published a paper in 1994 that concluded four to five participants are sufficient for a usability study [20].

In 2000, Steve Krug published a book about improving the usability of business websites [14]. In addition to giving suggestions for how businesses can improve the overall design of their websites, he emphasized usability testing, and included a section on how businesses can do it themselves without hiring a professional. He insisted that testing always works, even with the wrong user; any test can show areas in a site that need improvement. Though his book focused on websites that are used primarily for finding information and making purchases, many of the principles can be applied to web-based software like App Inventor.

Finally, the United States government maintains a website about usability and improving user experience [4]. They include guidelines, methods, and templates for performing usability studies and reporting results.

Chapter 3

Introduction to App Inventor

3.1 Overview

Development of MIT App Inventor began in 2009 as a collaboration between Google's Mark Friedman and MIT professor Hal Abelson, who was on sabbatical at Google [1]. Because it was developed at Google, App Inventor was designed to build Android apps. In January 2012, Google open-sourced App Inventor, and the MIT Center for Mobile Learning assumed responsibility for maintaining and developing the service.

App Inventor is a free, open-source, world-wide service with over 4.7 million registered users and an average of 175,000 active weekly users from 195 countries. To date, users have built more than 14.9 million apps and have published about 30,000 apps on the Google Play Store.

App Inventor makes programming Android apps much easier than programming in Java using Android Studio or another IDE. Following the tutorials, users are able to create simple, fully-functioning apps in under an hour.

App Inventor consists of two main screens: the Designer view and the Blocks view. In the Designer view (see Figure 3-2), users drag and drop components into their app. If the component is a visible component, such as a Button or Image, the component is displayed on a mock phone screen within the Designer view. If the component is a non-visible component, such as the GPS sensor or a database, it is displayed in a list below the mock phone screen. The components' special properties (e.g. text that is

displayed on the component or a source image) can be customized in a pane in the Designer view. The components also have unique code blocks associated with their specific capabilities and properties. Users can access these code blocks by toggling from the Designer to the Blocks view.

In the Blocks view (see Figure 3-3), rather than traditional lines of text, App Inventor uses Blockly, an open-source framework for building visual programming languages [7]. The code is displayed as blocks that link together. Users drag and drop blocks corresponding to the components they have added to their apps to build the logic of their apps. The blocks are very readable, meaning users can easily determine what a segment of code does by reading through the blocks in hierarchical order. For example, as shown in Figure 3-1, when Button1 is clicked, Sound1 will play.

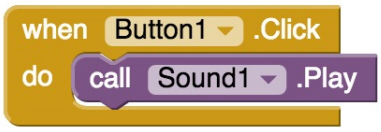


Figure 3-1: Example of the Blocks used in App Inventor

As illustrated by Figure 3-1, there are different types of blocks available in the Blocks view depending on the components used in the Designer. App Inventor is an event-driven language. The yellow `when Button1.Click` block responds to the event that the component called Button1 is clicked; the purple `call Sound1.Play` block is a procedure unique to Sound components that plays the file set as the component's source. Different block types are different colors, allowing the user to easily see how blocks are related. More block types and their corresponding colors can be seen in Figure 3-3.

Another feature unique to App Inventor is the Companion App, which allows live-testing an app during development. The user downloads the Companion App onto their Android device and uses it to connect their device to App Inventor. Once connected, the app the user is building is displayed in the Companion (over WiFi or through a USB connection), and the user can interact with the app as if it were installed on their device. As the user makes changes to the app in App Inventor,

those changes are reflected in the version running through the Companion on their device.

3.2 Sample App Built with App Inventor

The app shown in Figures 3-2 and 3-3 prompts the user to enter a favorite artist's name and then plays a snippet of one of the artist's songs when the user clicks "Listen!"

1. When the Listen! button (Button1) is clicked, the app makes a call to the iTunes API via the Web component (Web1).
2. When Web1 receives the JSON result from the iTunes API:
   (a) The app parses out the song's preview URL, title, and artist's name,
   (b) A Label (Label1) is set to display the song's title and artist's name,
   (c) The Player (Player1) component plays the song snippet from the URL.

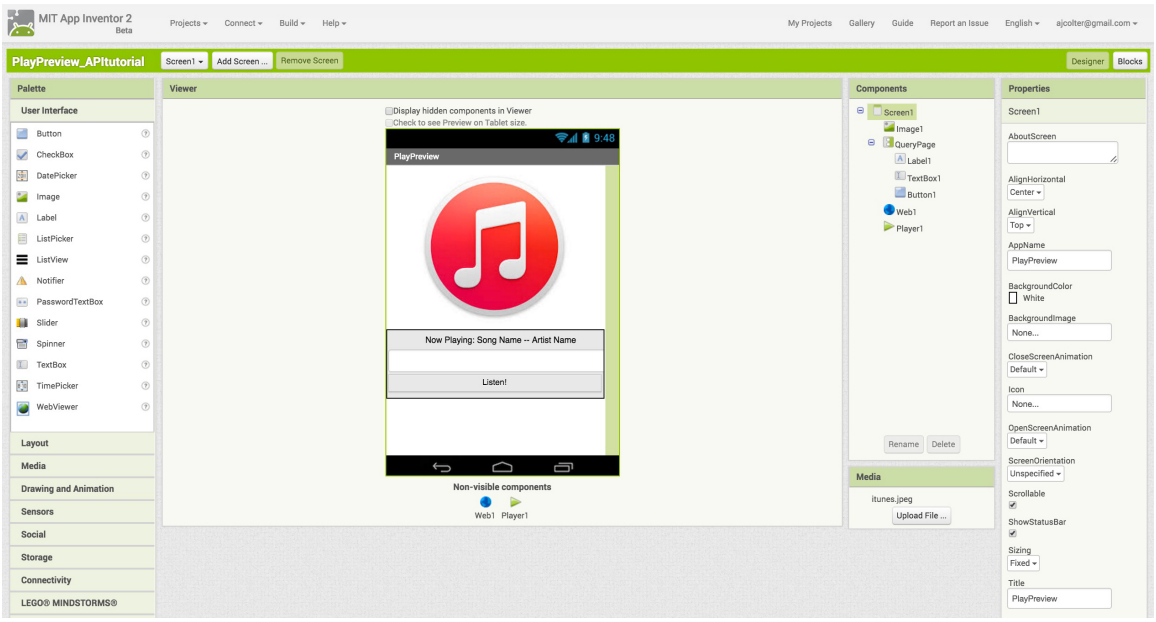


Figure 3-2: Designer View

3.3 Target User Groups

Our target audience is middle school and high school students. By giving students an easier alternative to traditional text-based programming, we hope to introduce them

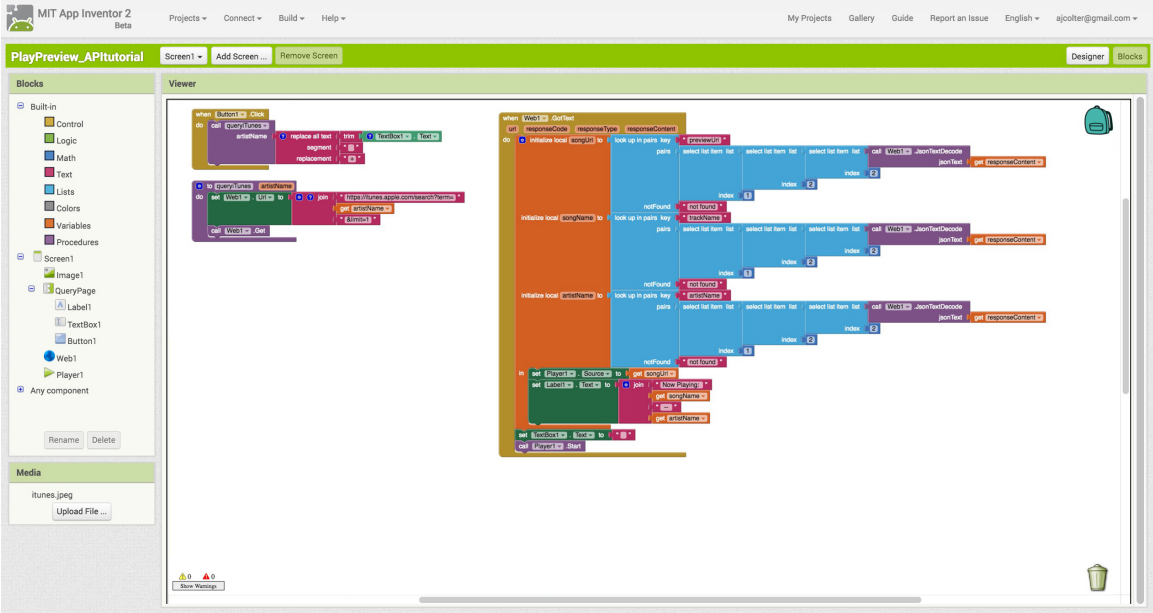


Figure 3-3: Blocks View

to programming at a younger age. We hope that students using our platform will learn good programming practices, which they can transfer to other programming languages. Regardless of their future career choices, we think that programming will be a necessary skill. Programming teaches students to think logically and empowers them to experiment with technology.

In addition to teenagers and college students, a significant portion of App Inventor users are end-user programmers. In a survey open from October 2013 through April 2016, 69.6% of 221,771 self-selected users said they used App Inventor at home. Some of these users are professional developers who use App Inventor to quickly prototype app ideas, or to teach others how to program. Other users are teaching themselves to program by using App Inventor. We intended to meet the needs of each of these groups.

3.4 Community Outreach

App Inventor has a vibrant online and offline community. Many people participate in the online user forums, with experienced users answering questions from less expe-

rienced users, usually helping them debug their apps.

The Master Trainers community is a global group of K-16 educators and other professionals who have been trained to teach App Inventor in their communities [17]. They teach students and teachers in workshops, classes, and afterschool programs about programming concepts and give them the tools they need to become app developers.

App Inventor also has an active open-source community with programmers from around the world contributing to the service [2]. This community includes students at MIT who work with the full-time App Inventor developers to hone their programming skills. They gain real-world experience working on a large codebase, which they can apply in industry and personal projects.

3.5 Curricula Developed for App Inventor

Many individuals and schools have developed programming curricula using App Inventor. The App Inventor team has published many free tutorials on our website. People outside of the core App Inventor team have also written books and maintain websites with App Inventor tutorials. Notably, David Wolber at UCSF has written two books and maintains an App Inventor curriculum on appinventor.org [30]. Additionally, in middle schools and high schools, teachers have developed their own curricula for introductory computer science classes.

Several competitions for middle school and high school students use App Inventor as a way of introducing teenagers to programming. The Technovation Challenge is a global competition for young women to develop a business plan around an original app that addresses a need in their communities [27]. The Verizon Innovative App Challenge invites teenagers to create apps and then compete at the regional, state, and national level [29]. Both of these competitions utilize mentors from industry to teach the students how to program and think innovatively.

Working with the Hong Kong Jockey Club Charities Trust and the Hong Kong Education Bureau, we are are developing a computer science curriculum for 4th through

6th grade students [15]. Fourth grade students will learn Scratch [25], and 5th and 6th grade students will learn App Inventor. In the first year, a pilot program will run in 32 primary schools. We plan to expand to the approximately 250 primary schools in Hong Kong over the course of four years.

Chapter 4

First Usability Study and Analysis

4.1 User Groups

App Inventor has three main user groups: teenage and college-age students, who are generally using the service for class assignments; people with little to no prior programming experience who want to learn how to program; and hobbyist programmers who want to create or prototype Android apps more quickly than by programming in Java.

Due to the limited timeframe of my Master's thesis, I chose not to include teenage participants in my usability study. Working with minors requires additional permissions and precautions, and teenagers are generally less reliable than adults.

Instead, I invited adult novice and hobbyist programmers with no prior exposure to App Inventor to participate in my usability study. I recruited participants by emailing MIT mailing lists and by posting a general request in various technical and non-technical Facebook groups. A brief Google survey established their programming background and determined their eligibility. In total, eight novice and seven hobbyist programmers participated in the first study [20]. They ranged in age from 18 to 54 years old. Seven of the study participants were affiliated with MIT.

The novice participants all identified as having one year or less of programming experience. One participant had prior experience with Scratch. One of the participants had less than 1 year of experience programming for iOS. Only two of the eight

participants had access to an Android phone or tablet.

Three of the hobbyist participants had between 1 and 5 years of programming experience; two had 5 to 10 years of programming experience; and two participants had more than 10 years of experience. Five of the hobbyist participants had prior experience working with a blocks-based language, and one participant had over 5 years of experience programming for iOS. Five of the seven participants had access to an Android phone or tablet.

I chose to divide my users into "beginner" and "technical" groups so that I could learn what non-programmers and programmers expect in a development environment. Novice programmers, based on their experience with common consumer software such as Microsoft Word and the Adobe Creative Suite, have different expectations than programmers, who have experience with IDEs. I want App Inventor to conform to common conventions of consumer software, so that it is easy for new programmers to learn how to use App Inventor, and so that they do not get frustrated and give up. I also want App Inventor to match other IDEs so that as novice users become more competent, the skills and conventions they learn can easily transfer to other programming environments.

4.2 Design

Before designing the study tasks, I compiled a list of common App Inventor usability issues. I spoke with two proficient App Inventor users, both of whom have taught programming with App Inventor to others [24], [28]. As a TA, I helped several MIT students who were learning App Inventor, both in person and by answering questions on the class forum [23]. Finally, I informally observed common questions asked on App Inventor forums [3]. I used this list as a basis for designing two sets of tasks: one for novice programmers (Beginner Tasks) and one for experienced programmers (Technical Tasks). (See Appendices A, B for the lists of tasks.)

With direction from Christopher LaRoche and Katherine Wahl, the MIT Information Service and Technology (IS&T) Accessibility and Usability Group, I refined

the sets of tasks to give the study participants an experience that would simulate the experience of a first-time App Inventor user in 30 minutes or less [16]. Two novice and three hobbyist programmers were asked to pilot test the tasks that were subsequently refined and used for the 15 study participants. Each task set had 8 tasks, but the participants were asked to stop if they did not complete all of the tasks in 30 minutes.

The Beginner Tasks focused on the Designer view. The Technical Tasks focused on the Blocks view. The decision to have beginner users primarily interact with the Designer view and technical users primarily interact with the Blocks view was due to the limited amount of time we had with each user; I wanted to make sure that we could test as many of the features of App Inventor as possible. The Designer view is similar to consumer software products, and the Blocks view is similar to development environments. This division proved to be logical in my pilot tests, where I noticed that the experienced programmers were less likely to return to the Designer view once they found the Blocks view. Furthermore, because code is less intimidating to them, I wanted to see how they would interact with many blocks.

The Beginner Tasks were inspired by the Hello Purr tutorial on the App Inventor website [10]. The tasks guided the participant through each of the steps required to build an App Inventor user's typical first app. By the end, they had a functioning app that they were asked to test on an Android phone (either their own, one provided by our lab, or the App Inventor emulator).

The Technical Tasks guided the participants to open a provided, pre-built app based on the MoleMash tutorial, an app similar to the whack-a-mole carnival game [19]. The tasks guided the participants to refactor parts of the provided code and add an additional feature to the basic app's scoring methodology.

4.3 Implementation

Chris and Katherine professionally conducted the usability tests as third-party moderators. Approximately half of the participants completed the study in-person at the MIT IS&T Usability Lab; the other participants completed the study remotely via

WebEx. Participants were encouraged to think aloud as they completed the tasks. All sessions were recorded (screen and audio) for analysis after the study. I was a silent observer in the Usability Lab for many of the sessions, and I took detailed notes based on what the participants were saying and doing as they completed the tasks.

Participants were directed to the public App Inventor service. The users who were participating in the lab were given this web address in the task introductions, but they started their session on the empty My Projects page. Chris signed in to App Inventor using his own Google account to reduce the amount of time necessary to start the study. Remote users were sent a detailed set up email that informed them they would need to log in to the service with a Google account and included a screenshot of the My Projects page to show them where they needed to start the study.

4.4 Results and Analysis

4.4.1 Numerical Analysis

After completing the study, users filled out a System Usability Scale (SUS) form (see Appendix D). The SUS is a simple, ten-item questionnaire for subjectively assessing the usability of a system [13]. This form is platform-agnostic and asks participants to rate their experience using the software on a 5-point Likert scale. A SUS score, which can range from 0 to 100, represents the overall usability of the system, with higher numbers representing a more usable experience.

Unfortunately, for the first study, we did not label the completed forms, which would have allowed us to separate them into beginner and technical groups. Thus, we cannot determine if the two groups gave different ratings to App Inventor's usability. Figure 4-1 shows SUS scores from each of the participants and Table 4.1 shows an analysis of the scores across all users.

Although I watched many participants struggle through the tasks, they generally reported on the SUS that App Inventor was easy to use, they would not need a lot of

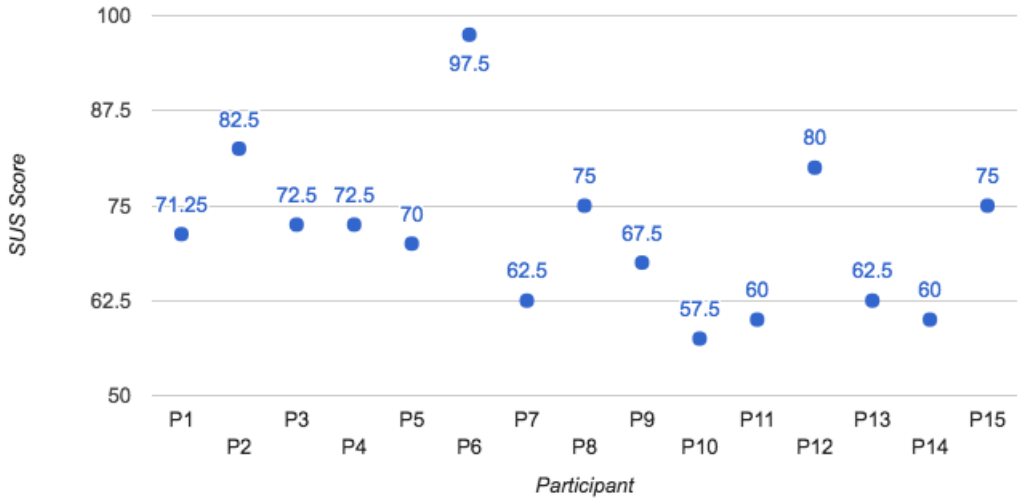


Figure 4-1: Plot of SUS Scores by Study Participant

	Mean	Median	Standard Deviation	Minimum	Maximum
All Users	71.08	71.25	10.47	57.5	97.5

Table 4.1: Table of SUS Scores Across All Users in First Usability Study

training to use it, they thought the functionality was well integrated, and that most people would be able to easily learn how to use App Inventor. Furthermore, most participants were able to complete all of the tasks, which probably made them feel successful. This is a valuable insight suggesting that if people feel successful, they are more likely to rate the product as easy to use. Thus, if we can help our App Inventor users, especially the teenage users, feel like they are successfully building apps, they will be more likely to think that App Inventor is easy to use, and they will continue programming.

4.4.2 Most Common Issues

Despite the results from the SUS indicating that App Inventor is fairly usable, across the fifteen users I tabulated 75 unique issues and a total of 157 issues. This is an average of 5 unique issues and 10.5 total issues per user. I used these issues to decide which parts of App Inventor I would redesign.

The most common issue was that event handler blocks were the same color as control blocks, which are easier to find. Ten out of the fifteen participants went to the Control drawer to find a handler for a button being clicked or a canvas being touched. Although it makes sense from a teaching perspective that the two categories of blocks are the same color because they both handle the control flow of the app, it was confusing and frustrating to the users.

In the second most common issue, eight participants had a difficult time finding the button to toggle to the Blocks view from the Designer view. Ultimately, all of the users were able to find the button and progress with their tasks; however, it took them a long time to find it and may have prevented some of the users from completing all of the tasks in the study. This issue was experienced by both beginner and technical participants.

The issues that I addressed and their solutions are detailed in Chapter 5.

4.4.3 Observations about User Behavior and Success

The two technical users with more than 10 years of programming experience had the least amount of difficulty using App Inventor. I propose a few explanations for this occurrence. First, App Inventor was designed by developers, so it should match these users' mental models for design and development environments. Second, these users are probably the most experienced at learning new programming languages. Although they had little experience with blocks-based programming languages, I think they were the least intimidated and it was easy for them to learn the basics of programming with App Inventor. Finally, they have the most experience being persistent in working with computers and programming languages, and they assumed that it would work. One remote participant did not finish the tasks in the time allotted, but after the session, he sent the remaining answers to the tasks to Katherine. This kind of tenacity is something that we want to teach to people learning to program, but it probably comes from years of experience, not from using inherently difficult software. Young students are unlikely to persevere with a program that is too hard to use.

We had one participant who works on the Scratch development team at MIT.

Through watching her, I realized that App Inventor is very similar to Scratch and matches the Scratch paradigms fairly well. She was more comfortable with the blocks than any of the other participants. The other technical participants worked on tasks one at a time, but did not build the full functionality in the allotted time. The Scratch-proficient participant easily completed the full functionality of the MoleMash app without guidance from the tasks. She said that she felt like she did not need to test it because she thought it was easy to do. This suggests that she was confident in her ability to write correct code, a confidence we hope to instill in young users.

4.5 Quotes from Participants about Common Issues

- The most common issue was looking for event handler blocks in the **Control** section of the blocks palette. One user said, "Now I just need to find a When Do. Where's a when? Can I do an If? There's a While. You'd think When would be the first thing." Another user said, "I thought it would be in Control because it's yellow like the other ones! But I don't see anything here." A third user said, "I expected the canvas block to be in control, but I guess it makes sense." I discuss my solution to this issue in section 5.2.1.
- Eight users had difficulty finding the button to switch to the Blocks view. Many users asked, "Where is the Blocks view?" One user said, "When I'm switching between things, my thought is to go to the upper left. I don't know why I have that instinct. That's where I was looking first." After they found the button, most users concluded, "I guess it makes sense now, but it was hard to find." See section 5.2.2 for my solution.
- Five users had trouble connecting to the Companion App. One user tried the *Hard Reset* option, and then she tried *AI Companion*. She said "I only picked *AI Companion* because the other 2 options didn't make sense." Another user who completed the study remotely commented, "Connect [the menu option] might not make sense, but I know about it because I was told to download the app." These comments motivated the changes in section 5.3.

- The technical tasks asked the users to abstract blocks into a function (see Appendix B, Task 3). One user commented, "I don't know how to write functions in this app." Another, after pulling the blocks into a procedure, asked, "How do I do my call? How do I get it in there?" The confusion about procedures and functions was an error in the usability tasks, which is discussed in section 5.2.4.
- A few users saw the Backpack, but no one knew what it would do. One user said, "I assume the Backpack is 'save for later,' but it isn't obvious to me what it is." Another user found the Backpack with code in it from the previous participant's session. He said, "I don't know what it does, but it's there." I attempted to make the functionality of the Backpack more discoverable with my changes described in section 5.2.5.
- Four users wanted instructions when they first opened App Inventor. One said, "A popup or tooltip would have been helpful for the completely uneducated." I created an onboarding sequence with small dialog boxes to guide users around App Inventor before they start their first project (see section 5.5 and Appendix C).
- Two users commented on the overall usability of the system. One said, "It's pretty straightforward. Not intuitive, but easy to see what is happening," and another said, "There seems to be a little bit of a learning curve. But it does seem intuitive once you're comfortable with it."
- Several users commented on ease of using the blocks. One participant liked the design of the blocks: "I like how they are shaped. Having the shapes that coordinate is very nice because it shows me where things go, how they fit, and what I'm looking for." Another thought, "The commands for making things happen to execute various functions is perfect. It's color coordinated, and I love that. It's very easy to conceptualize." One user said, "I like how the options are all right there. Having to remember everything that I need to do in programming is hard. Here I can just fill in the box." Another user said, "I noticed there's a sound effect when a connection is made. It's good to know it

happened."

- Most users had small delight moments when using App Inventor. One of the participants with more than 10 years of programming experience said, "This is visual programming! This is kind of fun!" One of the users finished his app, exclaiming, "It works! Hey, that's exciting!"

Chapter 5

Code Implementation and Rationale

Of the 75 unique issues identified in the first usability study, I implemented solutions for 34 issues. Working with our lead software developer, I prioritized the issues I would address. We chose the issues that were seen the most often, and the issues that would be the easiest to fix given the current codebase and my 1-year Master's thesis timeline. However, all of the issues have been documented and other MIT students in our group have chosen some of the issues as their own projects.

Most of the solutions involved very small changes, but in aggregate, they amounted to considerable changes in App Inventor[1]. In several cases, one solution addressed more than one issue. I have included before and after screenshots of App Inventor to illustrate my solutions. I tried to follow usability practices that I learned from MIT's user interface design class [18] and my own usability research [21].

5.1 Wording of Menus and Error Messages

Of the unique issues users faced, 17 were due to outdated wording, long messages in dialog boxes, or messages that were not as precise or descriptive as they need to be. These comprise the bulk of the issues I addressed, though they often required the least amount of time. I documented all of the strings that I changed so that they can

[1]I implemented all of my solutions on a personal branch of the App Inventor source code. I did not merge them into the public service's codebase as I completed them because I did not know if the solutions would be effective.

be translated.

5.1.1 Top Menu Bar and Submenus

Many users indicated that they did not understand the menu wording, which constitute 8 of the unique issues. They had questions like:

- What is a *checkpoint*?
- What is the **Gallery**?
- What is a *keystore*?
- What is *AI Companion*?

One participant thought the **Build** menu would be where to find blocks, while another thought it would be where she started a new project. The **Guide** heading was confusing to a user because it linked to the Documentation page instead of a tutorial.

I worked with another student to wireframe a new menu. We reorganized menu item placement and reworded submenu items. After receiving feedback from the team, she and I implemented the new menu and added it to my branch (see Figures 5-1 and 5-2).

We first changed the top-level menu bar:

- We removed *Beta* from our logo because we are no longer in beta mode. We removed the *2* from the logo because it originally differentiated App Inventor 2 from App Inventor Classic. Classic was retired in July 2015, so we no longer need to differentiate between the two services.
- **Connect** became **Test** (Figures 5-3 and 5-4). We considered renaming it Run, but ultimately decided we wanted to highlight the live-testing feature unique to App Inventor.
- **Build** became **Package** so that it would not be confused with building an app or building with blocks. We think it is intuitive because packaging an app is like packaging a gift when it is ready to be given.
- **Gallery** became **App Gallery** to give the users a hint that apps are in the Gallery. We kept the word Gallery to match Scratch's convention.
- We removed the **Guide** button and renamed the **Help** submenu item *Library*

to *Documentation*. Both options originally linked to the same page on the App Inventor website.

- We removed **Report an Issue** from the top bar and created a new **About** menu (see Figure 5-6).
- We added a **Teach** item (not shown) that will be placed between **About** and **English** to give educators using App Inventor quick access to the Educators forum and website once it is finished.

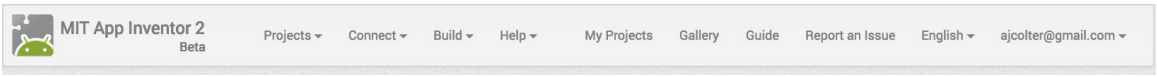


Figure 5-1: Original Top Menu Bar

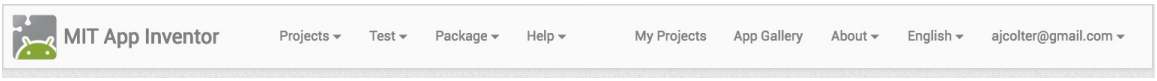


Figure 5-2: New Top Menu Bar

We also reworded submenu items:

- We changed *Checkpoint* to *Save a checkpoint*.
- We changed *Import Keystore* to *Import app signing keystore* to indicate that a keystore is used to sign an app for the Google Play Store.
- Under **Test**, we changed *AI Companion* to *Companion App over WiFi*; similarly, we changed *USB* to *Companion App over USB*. These options now indicate to users that they should connect the Companion App on their device to App Inventor via WiFi or USB, respectively (Figure 5-4).
- Under **Test**, we changed *Reset Connection* to *Stop live testing on Companion App* to be more informative of the action while still using few, simple words.
- Under **Test**, we moved *Hard Reset* to **About**, and we changed its text to *Update Companion on Emulator*, which is consistent with our documentation (see Figure 5-6).

We removed duplicate items from the top bar and submenus. **Report an Issue** was available in the top bar as well as under **Help**, and it linked to the same page as the *Forum*, also under **Help**. We combined *Forum* and *Report an Issue* under **Help**. We assume that most users will not need to report an issue because we are

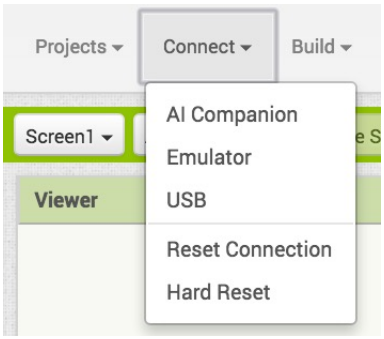


Figure 5-3: Original Connect Menu

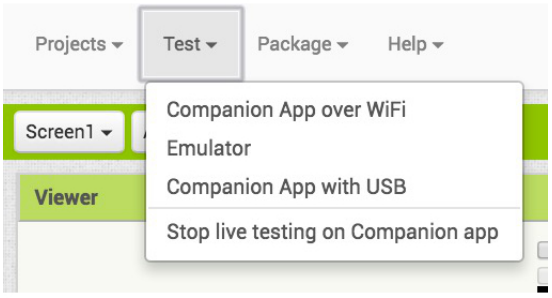


Figure 5-4: New Test Menu

no longer in beta mode. We reorganized some of the menu items to group related functionality. We moved and renamed several of the menu items under **Help** to a new **About** menu, as shown in Figures 5-5 and 5-6). *About* became *App Inventor Version*, *Companion Information* became *Current Companion Version*, and *Show Splash Screen* became *Show Welcome Splash Screen*. In the **Help** menu, we renamed *Library* to *Documentation* and added a link to the *Walkthroughs*, which includes the onboarding sequence (see section 5.5).

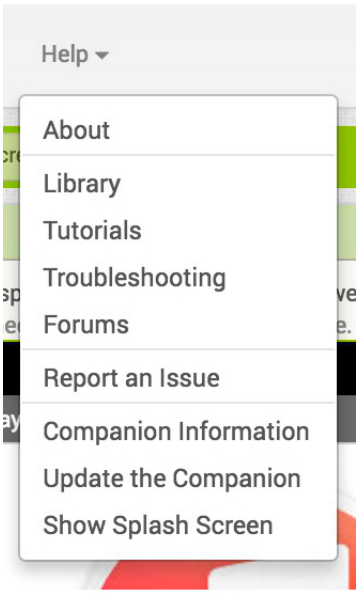


Figure 5-5: Original Help Menu

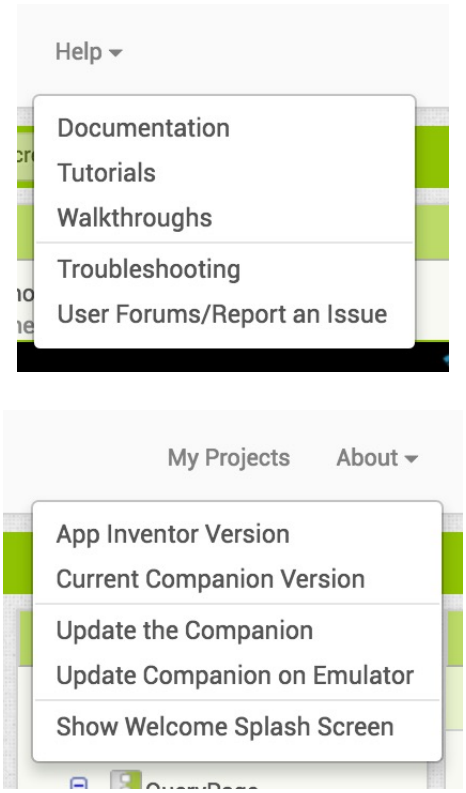


Figure 5-6: New Help and About Menus

5.1.2 Dialog Box Messages

I reviewed all of the messages shown to users and edited them for style and content. As much as possible, I tried to reduce the number of words in the messages and make any button text more descriptive of what the click would do.

The *Welcome to App Inventor* message that greets users the first time they log in to App Inventor had too many words that were too small (Figure 5-7). The opening screen has a lot of empty space, and the dialog box was very small on the screen. I redesigned the dialog with feedback from the team. I reduced the number of words and added action buttons to help users get started quickly. I also made the welcome dialog larger and removed the green outline to make the box feel lighter visually (Figure 5-8).

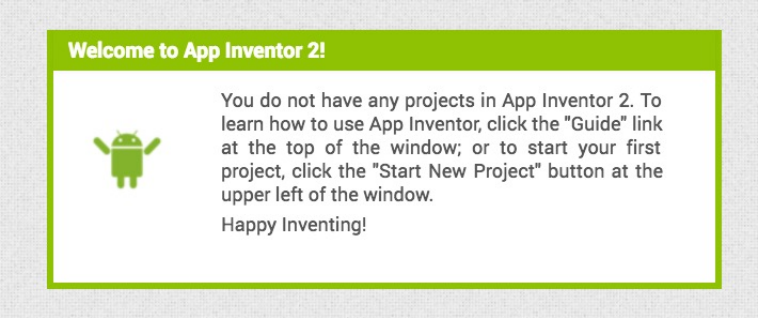


Figure 5-7: Original Welcome Dialog

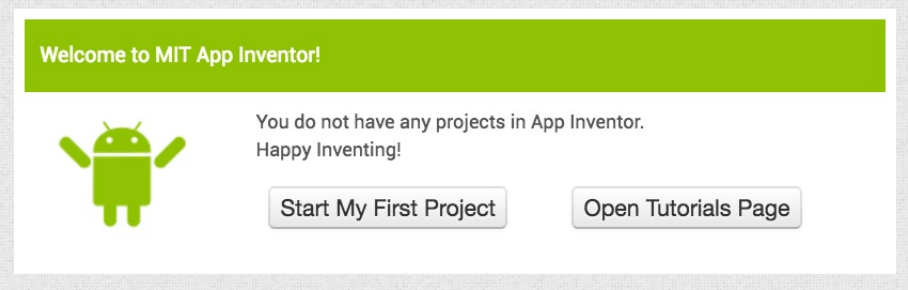


Figure 5-8: New Welcome Dialog

5.1.3 Strings in Designer View

Users made a few comments about strings in the Designer that confused them. One user was confused that the Palette drawer containing components such as Button,

Image, and TextBox, was called *User Interface* because he thought that he was designing the user interface of his app throughout the tasks. I changed the name of this drawer to *Basic*.

Another user was browsing the properties of the Sound component and commented that he did not know what MinimumInterval was because there were no units. It was easy to add '(ms)' to the property description for the components with a time interval. By doing this, users will not need to go to the documentation on a different page to understand the MinimumInterval property.

Finally, one user did not know what the string 'Display Hidden Components in Viewer' in the Viewer box meant. I changed it to 'Display Invisible Components' because components have a Visible property.

5.2 Blocks Issues

5.2.1 Event Handler and Control Blocks

Ten of the fifteen users were frustrated trying to find event handler blocks because they were the same color as control blocks. Control blocks are much more discoverable due to the small yellow square next to **Control** in the Built-in blocks palette. I made the event blocks a darker shade of yellow and the control blocks a lighter tint of the same yellow (Figures 5-9 and 5-10).

5.2.2 Blocks View Toggle Button

Eight of the fifteen users had difficulty finding the Blocks view toggle button in the top right corner the first time they were asked to switch to the Blocks view. To mitigate this problem, I added a box in my onboarding sequence[2] that showed users the button in the top right corner of the screen. The box required the user to click the Blocks toggle button before the script would let them continue to the next box (Figure 5-11).

[2]See description of the onboarding sequence on page 49.

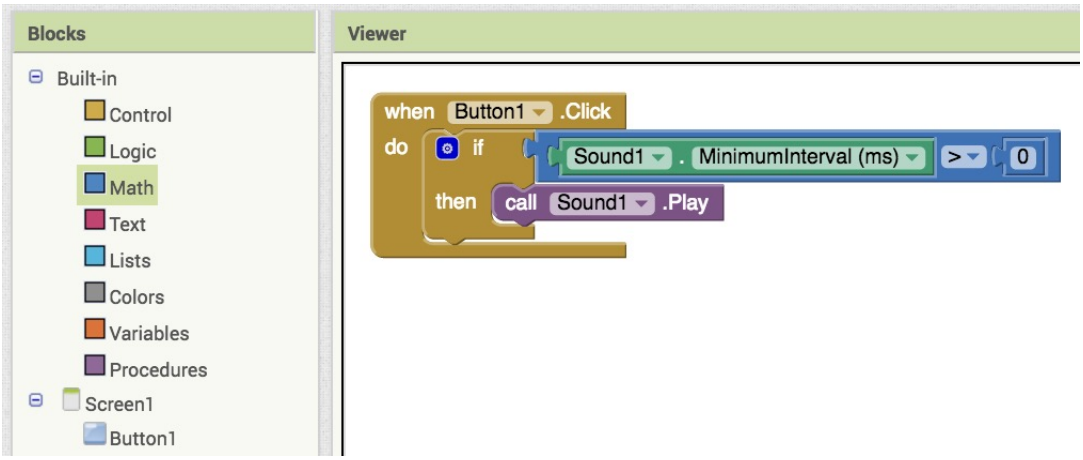


Figure 5-9: Original Event Handler and Control Blocks

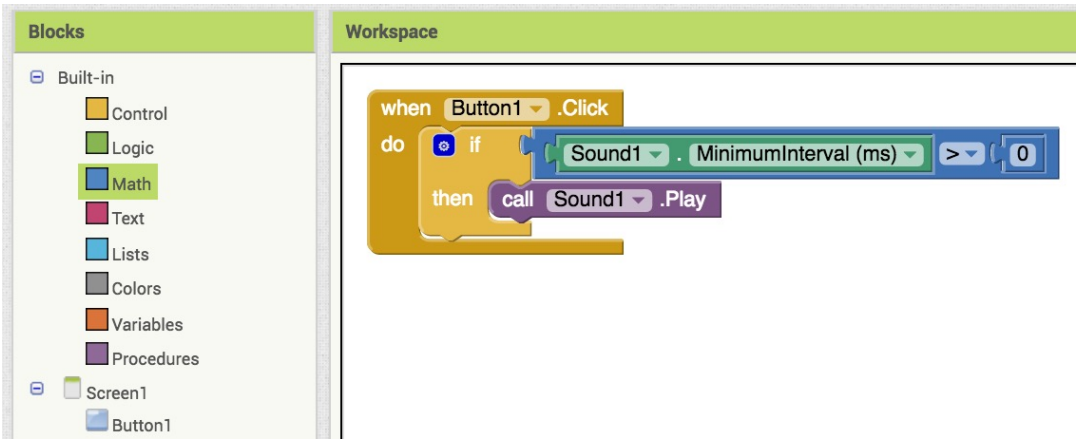


Figure 5-10: New Event Handler and Control Blocks

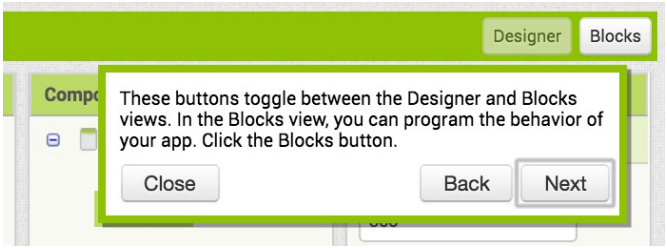


Figure 5-11: Onboarding Box Indicating the Blocks Toggle Button

5.2.3 App Component and Any Component Blocks

Four users found the **Any Component** expandable section of the blocks palette before they found the blocks for components they had in their app. I added three onboarding boxes to explain the different sections of the Blocks palette (Figure 5-12).

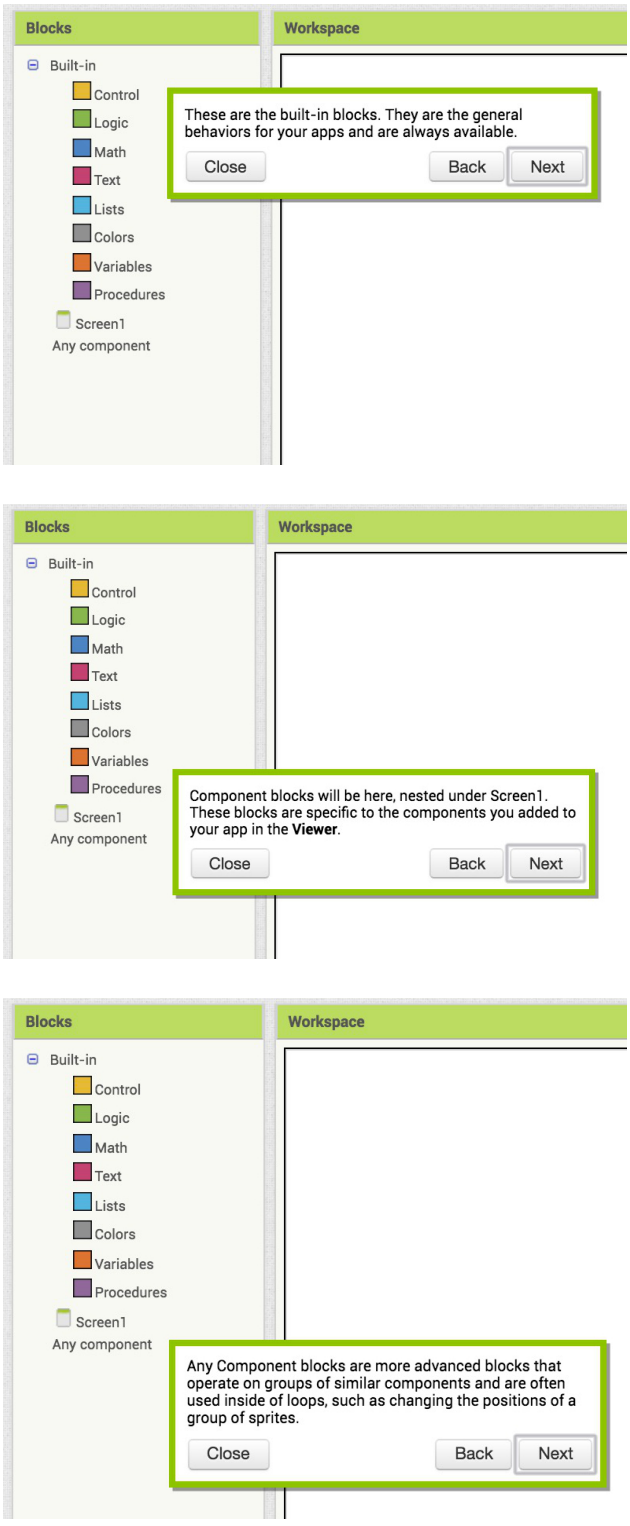


Figure 5-12: Onboarding Sequence Boxes for the Blocks Palette

5.2.4 Procedures vs. Functions

Two technical users had difficulty finding the *Procedures* built-in blocks. The task asked them to abstract some blocks into a Function, so they looked for a Function drawer in the Blocks palette. This was a mistake in the tasks. The task should have used the word Procedure, which is consistent with the AP Computer Science Principles curriculum [5, p. 16]. I fixed this mistake in the second usability study tasks.

5.2.5 Backpack

The Backpack provides a way for users to copy and paste code blocks from one project or screen to another. Two users specifically stated they did not know what the Backpack would do. An App Inventor student developer added new Backpack icons that better indicate the Empty, Hover, and Nonempty states of the Backpack, shown in Figure 5-14. Now when the Backpack is nonempty, the user sees blocks spilling out instead of the backpack being almost imperceptibly bigger, as shown in Figure 5-13.

Figure 5-13: Original Backpack in Empty and Nonempty States

Figure 5-14: New Backpack in Empty, Hover, and Nonempty States

I also added a box in the onboarding sequence about the Backpack, which included a link to documentation about it on the App Inventor site (see Figure 5-15).

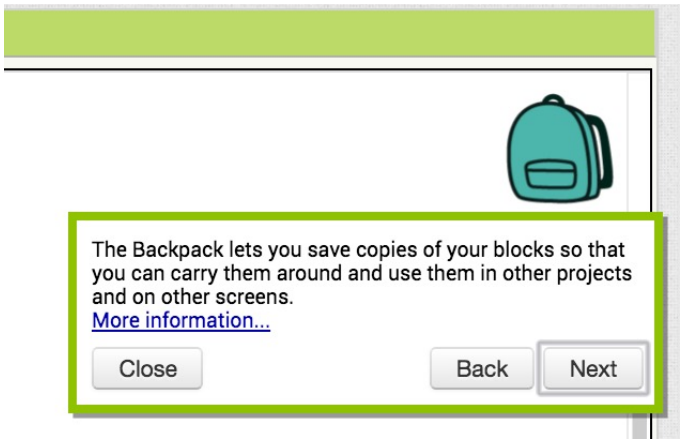


Figure 5-15: Onboarding Box that Introduces the Backpack

5.3 Trouble Connecting with the Companion

Two users tried to scan the *AI Companion* QR code with their devices' normal QR code reader app. By changing the menu item text to *Companion App over WiFi*, we hint to users that they should scan the QR code with the Companion App. Once they open the Companion App, it is easy to scan the code.

Because most of the study participants used Windows, they often encountered an error when starting the Emulator because the necessary (on Windows) aiStarter program was not already running. I changed the wording on the error to make it more clear that the program was not running.

5.4 Clicking did not Match Expectations

A few users tried to right-click on a component in the Designer to delete it. Working with another student, we added a right-click context menu for components. The menu in the Components pane has options to delete and rename the component (Figure 5-16). The menu for components in the Viewer pane has an option to delete the selected component (Figure 5-17).

Due to a bug with the Welcome message dialog (Figure 5-7), users had to click the Start New Project button in the top corner of the My Projects page twice because the first click dismissed the dialog. This bug confused users because they thought that

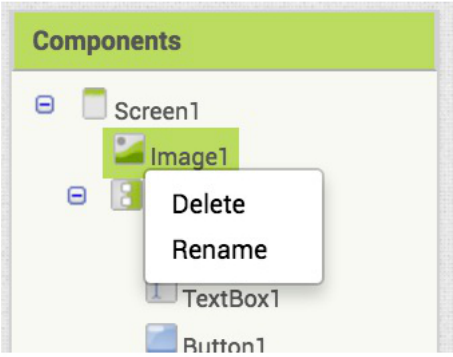


Figure 5-16: Right-click Menu in Components Pane

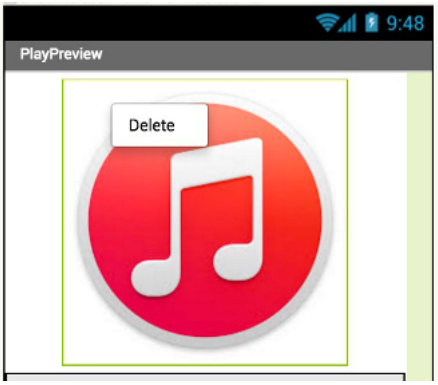


Figure 5-17: Right-click Menu in Viewer Pane

the Start New Project button was not responding to their click. I fixed this bug so that one click dismisses the welcome dialog and propagates to the Start New Project button.

5.5 Onboarding

Four users asked for quick instructions, onboarding, or an orientation to App Inventor when they started their tasks. I created an onboarding sequence using a Javascript "hooks" framework that was written by two App Inventor students but never integrated into the main service. My tour of App Inventor opens when the user clicks Start My First Project from the new Welcome dialog box (see Figure 5-8), and it is visible after the user enters a project name, making the onboarding very discoverable (Figure 5-18). The tour uses small dialog boxes that move around the screen to point out different features in App Inventor; see Appendix C for the full script of text in the boxes. The first box also gives the user the option to see annotated screenshots of the Designer and Blocks views on the main App Inventor site.

By adding the Javascript hooks, I added the capability to guide users through tutorials directly inside App Inventor. These boxes can validate whether the current step has been completed, making them more effective than a printed or video tutorial. Another student has been improving the usability of these boxes, by adding a progress indicator, a skip button to override the validation, and more tutorials. These

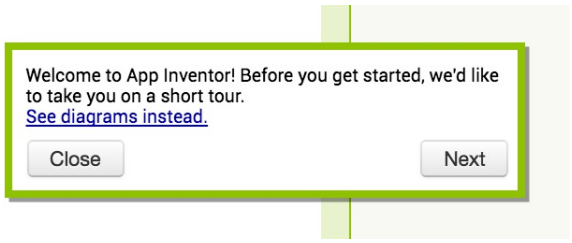


Figure 5-18: First Box in the Onboarding Sequence

improvements were not complete before the second usability study, so they will be tested separately.

5.6 Other UI Changes

5.6.1 Basic Component Palette Drawer

I reordered the components in the *User Interface/Basic* Palette drawer to group similar components (Figure 5-19). I also moved the *Label* component closer to the top so that it would be more visible to users and they would choose it instead of a TextBox when they wanted to create a caption (see Appendix A, Task 4). The TextBox component lets the app user enter text, which is not a proper caption component.

5.6.2 Color in App Inventor

One user, a designer, commented on the limited color choices. Though I did not add more colors, I changed the default colors to basic colors in the same tone, and I arranged them in rainbow order in the Designer view, instead of alphabetical order (Figure 5-20).

Finally, I gave App Inventor a fresh coat of green paint, which makes the colors pop and overall looks nicer (Figure 5-21).

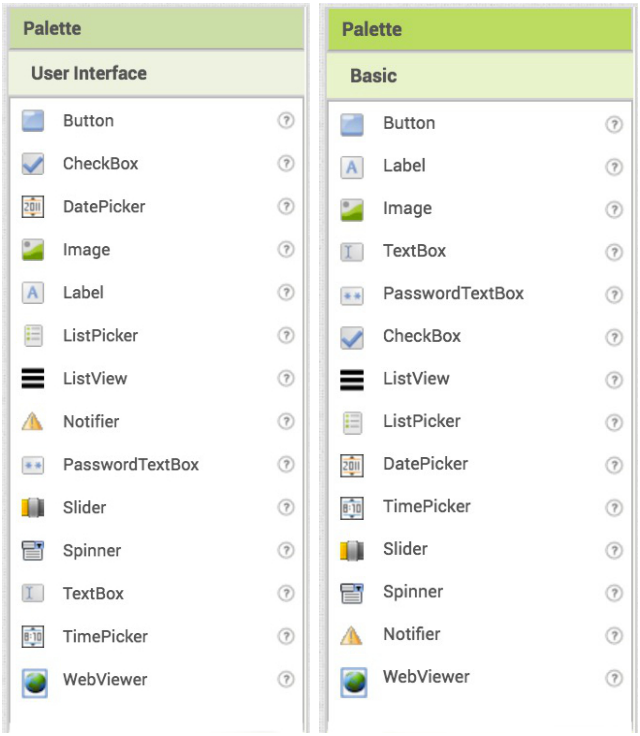


Figure 5-19: Original User Interface and New Basic Palette Drawer

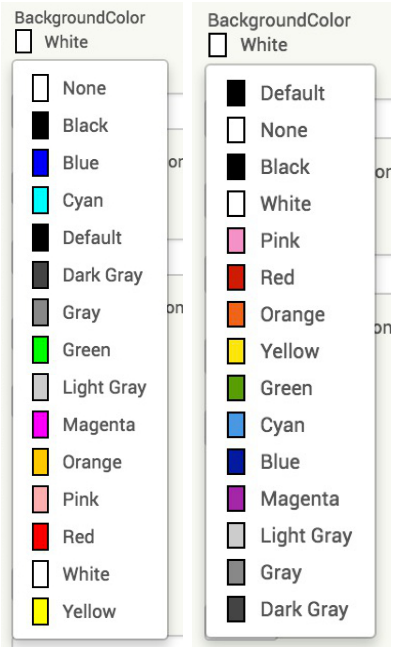


Figure 5-20: Original and New Color Palette

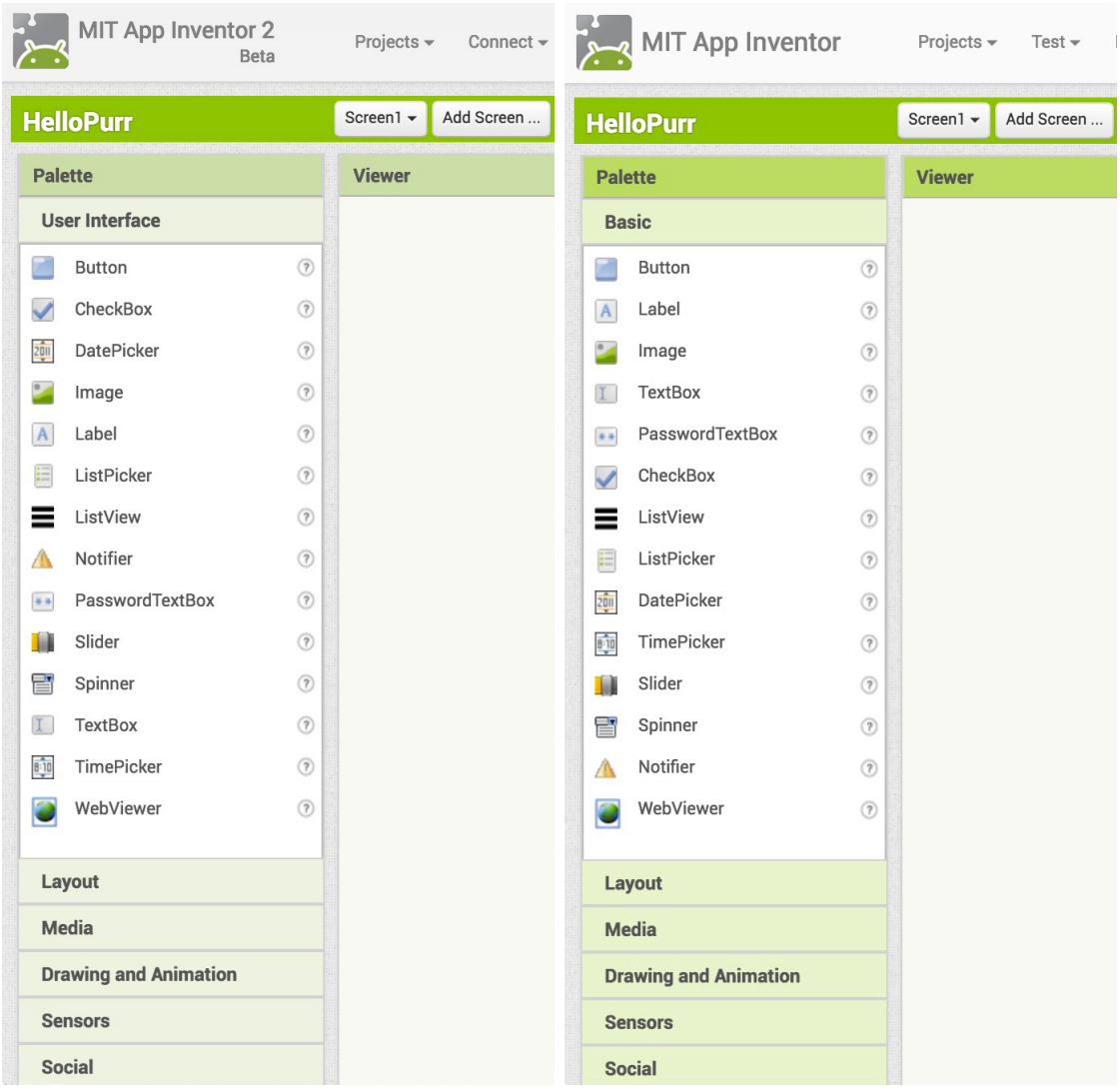


Figure 5-21: Original and New Designer View Comparing Green Color Schemes

Chapter 6

Second Usability Study and Analysis

6.1 User Groups

For the second usability study, I recruited participants primarily at MIT because in-lab sessions were easier for the session moderator, Chris LaRoche, and participants were less likely to experience technical difficulties. I found participants through Facebook groups associated with MIT students and once again asked them to apply through the brief Google survey. I also contacted applicants for the first usability study who had not participated.

Once again, I divided the 12 participants into two groups based on their prior programming experience. Five users completed the Beginner Tasks, and seven users completed the Technical Tasks. Due to an error on my part, one novice participant attempted the Technical Tasks. Though the experience was more frustrating for him than we intended, he had valuable insights and found areas of documentation that did not match my new version of App Inventor. Thus, we decided to include his session in the study data.

Ten of the users who participated in this usability study had personal access to Android phones or tablets, meaning they were familiar with the operating system. Though not a requirement for eligibility, I think that Android users are more representative of App Inventor users because they have experience with the Android OS. Also, they would have felt more comfortable navigating the short tasks involving the

phone. However, iPhone and non-smartphone users were still able to navigate the phone section of the tasks because the App Inventor Companion App was on the home screen of the device.

All of the second study users were between the ages of 18 and 30. The beginner users all stated they had less than one year of programming experience. Three of the technical users had between 1 and 5 years of programming experience; the other three had between 5 and 10 years of experience. None of the users were professional developers.

6.2 Design

We used the same tasks that I designed for the first study. We made a few minor changes, such as new screenshots, to reflect the changes in my new version of App Inventor.

6.3 Implementation

All of my code changes are on a branch in my personal Github repository of the App Inventor source code. We created a separate public instance of App Inventor using my branch and directed users to http://uiux.appinventor.mit.edu/. Chris prepared for and conducted the sessions the same way as the first study (see section 4.3).

6.4 Results and Analysis

6.4.1 Numerical Analysis between Both Studies

After the usability study, users completed the SUS form (see Appendix D). This time, we numbered the SUS forms with the order in which they were completed, so we were able to associate the forms with the users (see Table 6.1 and Figure 6-1). This means that in addition to aggregate data, we can break down the scores by user group. The

SUS is a score out of 100 with a higher score indicating a technology that is more usable.

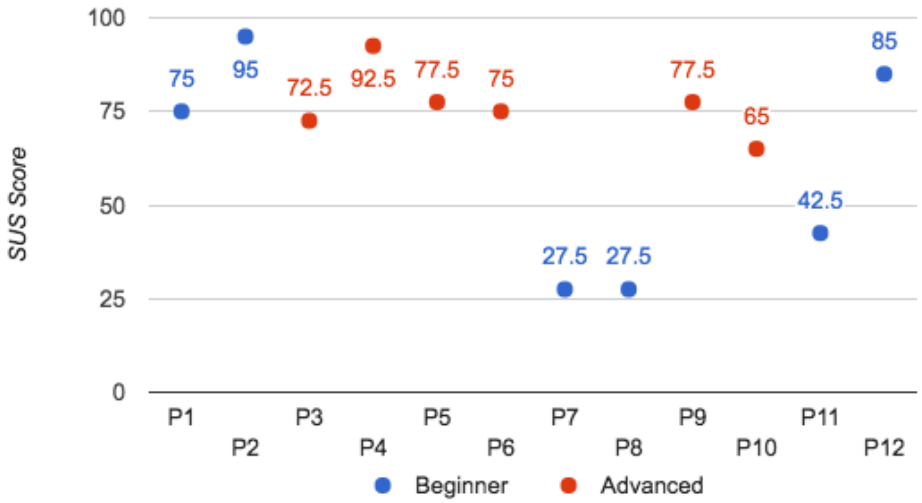


Figure 6-1: Scatter Plot of SUS Scores by Study Participant

	Mean	Median	Standard Deviation	Minimum	Maximum
Beginner Users	58.75	58.75	29.95	27.5	95
Technical Users	76.67	76.25	9.03	65	92.5
All Users	67.71	75	23.1	27.5	95

Table 6.1: Table of SUS Scores Across All Users in Second Usability Study

I chose not to do an inferential statistical analysis of these scores and the scores from the first usability study because the sample sizes are so small. Instead, I simply compared the scores.

When comparing the SUS scores of the users in the first study to all of the users in the second study, the averages are quite close: 71.08 and 67.71, respectively. However, the standard deviations are quite different: 10.47 and 23.1, respectively. There were two beginner users in the second study who reported very low SUS scores of 27.5; this score is approximately 2 standard deviations below the mean of the SUS for All Users in the second study. As previously explained, one of these users was a novice who completed the Technical Tasks; it is understandable that due to his experience with App Inventor, he did not perceive the technology to be very usable. However,

it is unclear why the other user gave App Inventor such a low SUS score. He said he had Googled App Inventor before using it (to learn what it does), and it seems that his expectations were not met. The overall theme of his session was that he seemed to think that App Inventor should do more of the work for him than it is designed to do.

6.4.2 Issue Analysis between Both Studies

I attempted to address 34 of the 75 unique issues from the first study. Of the 75 original unique issues, 56 issues were not encountered in the second study, including 21 issues that I addressed. Based on my solutions and user comments and behavior, I conclude that my solutions resolved those 21 original issues (Figure 6-2). The remaining 35 unseen issues can be explained by unique users; we cannot control for users' inherent variability in expectations, nor for their familiarity with computers and programming.

Across the twelve users in the second study, I tabulated 65 unique issues and 107 total issues. This is an average of 5.4 unique issues and 8.9 total issues per user. On average, these users found 0.4 more unique issues and 1.6 fewer total issues each than the first usability study participants. Of the 65 unique issues, only 19 were issues also seen in the first study (Figure 6-3). Of these 19 duplicate issues, I did not address nine and six were mitigated by my solution. Four of the solutions neither improved nor worsened the usability of the issue.

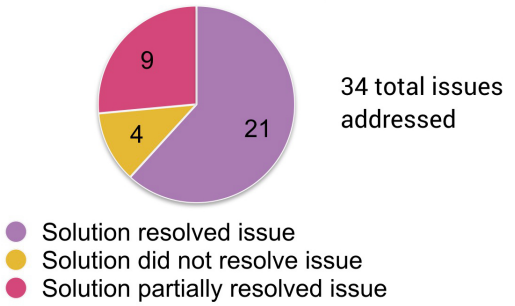


Figure 6-2: Success of Solutions to Unique Issues from First Usability Study

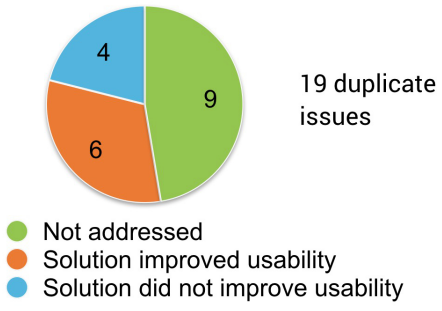


Figure 6-3: Duplicate Issues between Studies

6.4.3 Resolved Issues

My solutions, described in Chapter 5, resolved 21 of the original issues, meaning users did not encounter the issues in the second study. In the following list, I briefly explain the issue from the first study and describe the solution or reference a longer description from Chapter 5. Because these issues were resolved, I will merge the solutions into the App Inventor codebase.

1. Four users were confused by the error messages when the Companion App disconnected from or could not connect to App Inventor. See section 5.1.
2. A user did not understand the Session is Out of Date warning dialog. See section 5.1.
3. One user tried to scan the app's APK download QR code with the Companion App. See section 5.1.1.
4. Though users usually did not comment on it, observing their interactions showed that there were too many words on dialog boxes. See section 5.1.2.
5. The splash screen with release information shown when a user signs on to App Inventor was distracting for new users. We stopped showing the splash screen by default.
6. Three users were confused by the instructions from the splash screen to set up the Emulator or an Android device to work with App Inventor. Because the splash screen was not shown, users did not encounter this issue. The usability of the setup instructions should be evaluated separately.
7. Clicking the Start New Project button did not work if the Welcome dialog box was open; three users encountered this bug. See section 5.1.2.
8. Two users were hindered by the discrepancy of using the term *procedure* in App Inventor and the term *function* in the study tasks. See section 5.2.4.
9. Five users said the call block for a procedure was hard for to find without an example. See section 5.2.4.
10. A user thought the **Build** menu was where to find blocks; another user thought it was where she could start a new project. See section 5.1.1.

11. A user expected the **Guide** menu item to link to a tutorial, not App Inventor documentation. See section 5.1.1.
12. A user asked, "What is a checkpoint?" See section 5.1.1.
13. A user asked, "What is the gallery?" See section 5.1.1.
14. A user asked, "What is 'Display Hidden Components in Viewer'?" See section 5.1.3.
15. Three users did not understand the *AI Companion* menu item. See section 5.1.1.
16. Three users asked for a quick orientation. See section 5.5.
17. A user requested a popup or tooltip in the blocks view. See section 5.2.3.
18. A user tried to right-click to delete a TextBox component. See section 5.4.
19. A user did not know what a Sound component's MinimumInterval property was because it did not have units. See section 5.1.3.
20. Users were confused by the palette drawer named *User Interface*. See section 5.6.1.
21. One participant complained that the available colors were limiting. See section 5.6.2.

6.4.4 Partially Resolved Issues

Because my solutions improved the usability of the following 9 issues, I will merge my solutions into the App Inventor codebase. However, they remain open problems that should be further investigated and eventually resolved.

Blocks view toggle button is hard to find

The onboarding sequence showed users where to find the Blocks view toggle button. Six of the study participants, including the five beginner users, stepped through the onboarding. The onboarding was not easily discoverable for the technical users. Three of the technical users who did not see the onboarding had a hard time finding the button. However, this outcome is better than the first usability study, where eight

out of fifteen users could not find the toggle. One beginner user said, "The toggles [between Designer and Blocks] feel far away. I haven't used anything over here yet. It's good that I had to click on the blocks button earlier [in the tour]. That's how I remembered how to switch."

Using a TextBox instead of a Label as a caption

Several of the beginner users still chose the TextBox component to add a caption to their app, when I was expecting them to choose a Label component. Even though I reordered the components in the Basic palette, people still chose TextBox without seeing Label. I think they were predisposed to choose TextBox because of text boxes in Microsoft Word. When you add a text box in Word, you are adding a caption that can hover in your document. I think changing the component name to TextEntryBox or TextField would suggest to users that a TextBox in App Inventor is a component in which the app user can enter text.

Connecting with the Companion App

I hoped to resolve the issues with connecting the Companion App by changing the **Connect**/**Test** menu wording to be more descriptive (see 5.3); I also mentioned the top menus in the onboarding sequence. However, a few users still had trouble finding the 6-digit code to connect to the Companion App. One user thought that the code must have been emailed to her, while another thought that because he hadn't finished his app, he wouldn't have a code. They did not see the **Test** menu.

However, once users found the **Test** menu, they were much less confused by the submenu options, one user commenting, "Ooo Companion App Over Wifi. That sounds good." These users generally had the Companion App open and saw that it was asking for a code. We should add more descriptive instructions for connecting to App Inventor on the home screen of the Companion App.

A few other users tried to scan the Companion App QR code with the normal QR code reader on the phone. I think this problem will not be encountered if the users set up App Inventor for themselves and download the Companion App on their own

devices.

No trash can in Designer view

In both studies, a user did not see the Delete button for components in the Designer view because they "looked for a little trash can in the corner [of the Designer] because that's what it was in the other one [the Blocks view]," but there is no trash can. Because App Inventor is a heavily drag-and-drop interface, they were not looking for buttons. I think it makes sense to add a trash can in the corner of the Viewer so that users can drag and drop components in the Designer view, like they can in the Blocks view.

Right-click menu

Working with another student, I added a right-click menu that has a Delete option and a Rename option. A few users in both tests tried to right-click or double-click the text in a button or label to change it. Because nothing changed when they double-clicked, they easily understood that was the wrong thing to do. I think it was helpful to have a right-click context menu in the second study. This menu makes the Designer view more consistent with the Blocks view interactions. Hopefully we can add more options to the right-click menu in the Designer view, like changing the text on the component or linking an image source file.

Keystore menu option is unclear

Overall, three people asked about the Keystore menu options. These options are a rarely-used feature that allows apps created by different App Inventor accounts to be signed with the same developer key. This feature is only necessary if an App Inventor user with multiple accounts wants to list their apps as being created by the same developer in the Google Play Store. I initially thought about hiding it in a submenu, but that proved too difficult with the current GWT setup of the drop-down menus. Instead, I changed the menu wording to include a few more words relating to signing the app (see section 5.1.1). It did not make things worse, nor did it draw more

attention to the menu items, but the users were still confused. I think hiding it in an "Advanced Options" submenu is the best idea.

Saving the empty screen

App Inventor asks the user to confirm an autosave when the user is in the Blocks view but has not dragged any blocks into the Workspace. I clarified the wording of the message and the action buttons, but one user in each study still encountered the dialog box and was confused by it.

I think this dialog box is will appear more often if users go through the onboarding sequence. They will be spending more time in the Blocks view, reading the popups and navigating, without adding any blocks to the Workspace. I think App Inventor should automatically save the empty screen because the user has given the project a name. By doing this, the Save the Empty Screen dialog would be eliminated, which would reduce user confusion.

6.4.5 Unresolved Issues

Because my solutions did not improved the usability of the following 4 issues, I will not merge my solutions into the App Inventor codebase. These issues will require more experimentation to develop a usable solution.

Event handler blocks are the same color as control blocks, which are easier to find

I changed the color of the event handler blocks to be a darker shade of yellow and the basic control blocks to be a lighter tint of yellow. The colors were distinguishable when the blocks were placed near each other, as one user noticed toward the end of her session. However, they were not distinguishable enough to help users understand that they should not look for an event handler block in the **Control** drawer. Eight out of twelve users went to the **Control** drawer because it has a yellow square icon next to it.

Additionally, I tried to alleviate this issue by adding boxes in the onboarding sequence to teach users about the three different areas of the Blocks palette (see Figure 5-12). However, these boxes came at the end of the very long onboarding sequence; based on user behavior, I assume that most users were no longer thoroughly reading. It is also possible that the users did not have enough knowledge of components at the time of the onboarding to understand that different blocks would later be available.

When the users could not find the 'when' event handler block, many instead chose the 'if' control block and attempted to change the 'if' to a 'when.' Eventually, most users were able to find the 'when' in the appropriate component drawer. In some cases, the test moderator had the user move on to the next task without finding the block. One user summarized, "I thought the built-in blocks were pretty confusing when I was trying to find something for the button, not knowing that everything listed over here was a drawer. I thought they [the components listed] were objects, like they are in the Designer view. Objects that I could move and drop."

Once users found the components in the Blocks palette, they did not need help finding component blocks (like event handlers) again. I think creating new icons for the components that stand out visually would help the users not overlook the components in the Blocks palette.

Finding the Any Component Blocks before the App Component Blocks

Three users, when looking for event blocks, navigated from the Built-in blocks to the **Any Component** expander in the Blocks palette, skipping right over the app component blocks.

I added a box in the onboarding sequence about the use of Any blocks (see the last box in Figure 5-12). The box said Any blocks are advanced feature to be used with similar components, like Sprites. Most users saw Sprites and commented, "I don't know what Sprites are." One user optimistically stated, "That's okay. I'll figure it out." The users typically did not pull out Any blocks. If they had, they might have noticed that there are event blocks inside the Any blocks drawers, and the users would have been able to find the right block.

As suggested above, I think that creating new icons for components would help. I also think I should condense the three onboarding boxes about the Blocks palette into one box and add arrows to highlight the three different regions. Any blocks are an advanced feature and are not needed by beginner App Inventor users; they can be learned later. The onboarding sequence should not mention anything about sprites because users were unnecessarily confused by them. There was no mention of sprites in the first study, and no users expressed concerns about them.

Users did not understand the Backpack

Although the Backpack icon changed before the second usability study, people still did not know its purpose or how they should use it. I think the new icons better illustrate when blocks have been put in the Backpack. However, users still made comments like, "What's this Backpack it's talking about? I have no idea about the Backpack. I'm going to add things to it and see what happens," and, "It makes me think of carrying things somewhere or packing things. Does it have to do with compiling code? I'm not really sure." Finally, one user said, "It doesn't look like I can remove things from the Backpack, either," indicating she did not know how it worked, and it did not match her intuition about what it should do.

My solution was to add a box in the onboarding sequence about the Backpack (see section 5.2.5). One beginner user clicked the link for More Information, which took her to a page on the main App Inventor site that explains the Backpack. On seeing the page, she said, "Whoa, okay, I'm going to come back to that," and immediately closed the window to go back to App Inventor. She found too much information and was overwhelmed by it because she did not need to use the Backpack for her tasks.

I suggest removing the box from the onboarding sequence because beginner users do not need to use the Backpack. I want to add more discoverable documentation about the Backpack when the user starts to use it so that they can learn what it is and what it does when they are ready and curious. We can also make our documentation more user-friendly by reducing the number of words on the Backpack page.

AI Starter error

The aiStarter program is necessary for Windows users who would like to use the Emulator. AI stands for App Inventor; however, most users do not make that connection. Before the studies, we chose to set up App Inventor for our users because it is an involved process, and it should be a one-time occurrence, which would be a waste of time in a 30 minute usability study. Because our users did not go through the App Inventor setup process themselves, they did not know what the aiStarter or the error were. I think users might not have encountered this issue if they had set up App Inventor themselves.

For the second study, I clarified the words in the error box. However, the three users who subsequently encountered this error immediately clicked it away without reading the message. Then, when the Emulator did not start, they would try a different **Test** option. Six users across both studies thought that the Emulator would be the best way to test their app.

Approximately 85% of our user base uses Windows, so this error is a very relevant issue, especially in classroom settings where the teacher or IT professional set up the computers, but the students encounter the error. If users continue to encounter the error, it should encourage them to try an Android device with the Companion App instead of the Emulator. However, this solution may not be possible in school settings due to lack of hardware.

6.5 Quotes from Participants

- Most of my attempts to rephrase long messages on dialog boxes were futile. Through doing these studies, I learned that people do not like to read. One user expressed it perfectly when encountering the Save Empty Screen message, saying, "I don't know what this is. I'm just going to click it."
- One user said, "The designer reminds me of Illustrator a little bit [with the] narrow columns." I loved this quote because it shows what we are trying to do with App Inventor: match the software that users already know how to use,

to minimize the amount of time and effort it takes to learn how to use App Inventor.

- Three users in my second usability study were very concerned about the placement of blocks in the Blocks view, a comment only one user made in the first study. One user stated, "I don't know if these blocks flow linearly, and my suspicion is they don't." I thought this was a curious trend that must depend on personality and familiarity with programming. Some languages do flow linearly, and if that is what the participant was accustomed to using, they would expect something similar in App Inventor.
- One user who was not familiar with smartphones had an interesting exchange trying to connect to the Companion App. He clicked the menu option to get the QR code and said, "Oh, clever!" But he had difficulty trying to scan the code due to strange brightness and contrast issues on the screen. He then said, "I'm going to give up, like an impatient millennial," and proceeded to type in the code and said, "I'm glad there's another way to do it." After he got the phone to connect over WiFi, he said, "I don't have high expectations of consumer technologies of being able to do fancy things like these."
- About the Palette and all of the available components, one user said, "I like being able to see the lists of tools that I'm not using. That gives me more ideas of things that I could make, without already having the idea ... like an idea generator."
- Several users commented on the blocks and their ease of use. One said, "I really like the blocks because not everyone knows code. It was interactive and fun. Fun as code can be." And another said, "I think compared to a normal coding language, it's much easier to use than writing out the actual code. A lot of where you mess up is in the formatting. This makes the formatting easy." A third user commented, "It's definitely a lot easier than I thought it would be." Finally, one user said, "I think if I were a first-time Android app developer, I'd be interested in using this over the Android SDK." These users appreciated what App Inventor was designed to do, and seemed to have fun while building

the apps.

- Observing the usability tests was most fun when the participants had a delight moment with the apps they were building. One beginner user was particularly excited about App Inventor. After reading the onboarding out loud, he responded to the final box's "Have fun inventing!" with, "I will." As he progressed through the tasks and was able to format the design of the app screen to his liking, he said, "This is going well. I like my app so far." After building in the blocks, he said, "Maybe we get to test it... Yay!... ooh this is fun!... I have a friend who would love this app." At the conclusion of his study, he clicked the button and heard the cat meow, then excitedly said, "It's working!"

Chapter 7

Future Work

In addition to the proposed solutions in Sections 6.4.4 and 6.4.5 for issues not fully resolved by my work described in Chapter 5, there are several other areas that future versions of App Inventor could improve.

7.1 Onboarding

The onboarding sequence (see Appendix C) needs to be refined. It would benefit from its own usability study, in which users are asked to step through it and give their feedback about whether too much information is included at certain steps or if necessary information has been omitted from the script. For example, after watching users, it became clear that there were too many boxes in the sequence, especially because there was no indication of the length of the onboarding or the user's current position.

Users suggested adding arrows or some other visual cue, such as highlighting, to emphasize a feature or section of interest, in addition to the box moving to different locations on the screen. One person suggested animating the box around the screen, instead of having new boxes created each time, which would help guide their eyes around the screen and be a little less visually jolting.

Finally, one user wanted to end the onboarding early, but he did not realize that he could click the Close button to do so. Instead, he kept clicking Next until he

reached the end. It might be beneficial to add an X in the top corner of the dialog boxes and remove the Close button, so that the boxes match the convention of closing windows in the top corner.

7.2 Tutorials and Walkthroughs

We need to differentiate between *Tutorials* (static guides on the App Inventor website that teach how to build apps) and *Walkthroughs* (dynamic guides within the Designer and Blocks views that validate a user's progress as they build an app). We need to use more distinctive names for these two guides that appear next to each other in the **Help** menu. We also need to expand the *Walkthrough* selection; it currently has just three walkthroughs for building "Easy" apps.

7.3 More Design Control

Several users in both studies wanted more control over the look and feel of the app they were building. Participants requested more control over the alignment of their components. Several people expected to be able to drag components to a specific location on the Viewer's mock phone screen. We should make the Viewer behave more like Android Studio or XCode for component arrangement on a screen.

As I observed study participants, many of whom were coders or engineers, it was clear to me that they expected to be able to do simple design things that currently are not possible in App Inventor. For example, they became frustrated with App Inventor when it did not allow them to position a button at the bottom of the screen. If users could position components and adjust properties, like they can do in Android Studio, App Inventor apps would be more visually appealing and could compete with professional quality apps developed in Java. At the end of her session, one participant said, "You don't need to be a coder to do this. I could take a designer and get them to build an app. You could take a coder and get them to design something that's probably prettier than what they'd do on their own."

We should add a discoverable option for using more colors in the Designer view. Currently, a component's color property in the Designer view is limited to showing the default colors (see Figure 5-20). We could add a color picker button in the color property dropdown, giving users more control over the colors displayed in the Viewer. In the Blocks view, we could add a way for the user to create custom color blocks. We could replace the current 70-tone color picker with a wheel to allow users to choose more colors. In the Blocks view, it would be good to show a thumbnail on the RGB block of the color created with that block.

We should add more default fonts (App Inventor currently only has 3 fonts available for use), or we should create a way for people to upload their own font files use in their apps. We could extend the media upload functionality to include font files and let the user set the font source of a component to use an uploaded font. We should add more font formatting options so that the users can do what is currently available in Android Studio.

7.4 Outstanding Issues

7.4.1 Simulator in the Designer View

In total, four participants expected to be able to interact with their app on the mock phone screen in the Viewer. It would be nice to build a Simulator in the Viewer so that the user could interact with their app in the same screen in which they are building it. This would also eliminate the need for the Emulator, which runs slowly and requires extra software to use on Windows (see section 6.4.5).

7.4.2 Scrolling in the Blocks Workspace

Several people complained that the Blocks view Workspace scrolling behavior was inconsistent with the rest of App Inventor and their expectations. Blockly has implemented zoom scrolling, like what exists in Google Maps. Before we integrate this new Blockly functionality into App Inventor, we should perform a small usability test

to see if zoom scrolling is behavior that is familiar and useful.

7.4.3 Viewer Screen Sizes

Because Android phone and tablet screens come in a variety of sizes, it would be useful to have an option to see different screen sizes in the Viewer. This way, the user can design their apps for a variety of different screens, even if they do not own the physical devices.

7.4.4 Hidden and Non-visible Components

I changed the string 'Display Hidden Components in Viewer' in the Viewer to 'Display Invisible Components' because components have a 'Visible' property. However, my advisor later pointed out that this could be confusing because App Inventor also has Non-Visible Components. It would be better to keep the string 'Display Hidden Components in Viewer' and instead change the property on the component from 'Visible' to 'Hidden.' This property would not be selected by default. This change would make 'Display Hidden Components in Viewer' consistent and avoid confusion with non-visible components.

7.5 Other Thoughts

Many users commented that they would like a version of App Inventor that could build apps for iOS. This suggestion would be a large undertaking that was only recently made possible when Swift became open-source. In the US, more consumers have iPhones, but outside of the US, more consumers have Android devices. In the future, it would be nice to have an App Inventor feature that allowed users to export to Android and/or iPhone. However, due to the the different design patterns and capabilities of Android OS and iOS, it may not be possible for a user to design and program an app in App Inventor that can then be exported and easily used on both Android and iOS devices.

As more features of App Inventor are added and refined, it is important that we continue performing small usability tests. Our future usability tests do not need to be as extensive nor as time and resource intensive as my thesis experiment. They can be as simple as asking a few friends who are less familiar with App Inventor to go through a set of informal tasks to verify that what we have changed makes sense to them. We could also put new features in front of users at our outreach events and observe their behavior to get a better understand whether or not the new feature is intuitive to less-experienced users.

My usability studies uncovered over 120 usability-related issues in App Inventor. These issues will be properly documented so that they can become small projects for MIT undergraduate students and App Inventor open-source community members who are passionate about user interfaces, giving more people the ability to contribute to our project.

Chapter 8

Conclusion

App Inventor was created to teach people how to program. I used App Inventor to create my first mobile app almost 5 years ago. More recently, through this project, App Inventor taught me how to program with GWT and how to work with a large codebase. Additionally, I learned a lot about how people interact with App Inventor and can generalize my findings to better understand human-computer interaction.

Many users did not try certain actions they thought should work, and incidentally do work, in App Inventor. I think that because App Inventor had previously failed to match their expectations, they no longer wanted to experiment with features that were not readily apparent. For example, one user did not try to copy multiple blocks at one time, instead selecting each block individually and copying and pasting it, then putting all of the blocks back together. In App Inventor, it is possible to copy multiple blocks that are connected by selecting and copying the parent block. As another example, three users stated that they wished they could type to get a block they wanted; if they had tried that in the Workspace, they would have discovered that the feature exists.

I also learned that people do not like to read. One user stated, "When I see a bunch of text, I tend to zone out and don't read it, just rush through it instead." Steve Krug insists that users will not read instructions until they have failed to 'muddle through'—and then they will only skim the instructions and likely not find the information they need [14, p. 47]. I saw this repeatedly as I observed users

'muddle through' using App Inventor.

The lessons I have learned about users, usable design, and usability testing will be beneficial to me as I pursue a career in software development with a focus on user interfaces and human-computer interaction. Learning about how users think by observing them has taught me to be more mindful of design decisions that I make. I have learned the value of usability testing and how to perform it, a skill I can continue to hone as I conduct tests on future software that I develop.

By making App Inventor more usable, we make the world of programming more accessible to more people. I have accomplished my goal of making App Inventor easier to use so that our novice programmers will be less frustrated. I hope that more young people will be exposed to programming through App Inventor and eventually be able to use their skills in whatever career they choose.

Appendix A

Beginner Usability Study Tasks

Originally, each of the tasks appeared on its own page; to conserve space, they have been condensed in this reproduction.

Welcome to the App Inventor Usability Study!

Imagine you have an awesome idea for a new app that everybody needs: *The Cat's Meow*. Your app will have a picture of a cat that meows when the user pets it. It's sure to take the Internet by storm!

You do some research, and a friend recommends MIT App Inventor. You want to try designing your awesome cat app for your Android phone.

Task 1:

What do you think you should do to start your project?

Task 2:

After creating your new project, you start by designing what the app's screen will look like. You must add all of the components to the screen before you can add functionality to your app. First, you will need to add a button. How do you proceed?

Task 3:

Next, you'll need to add a picture of the cat to the button (source file is "cat.jpg" on your desktop).

Task 4:

You decide to add a text caption under the button, telling the user to pet the cat. How would you proceed?

Task 5:
Finally, you need to add the cat's meow sound (source file is "meow.mp3" on your desktop) to the app. How would you do this?

Task 6:
To make your app work, you'll need to add blocks, which are the code of the program. You want your meow sound to play when you click the button. You can make that happen by adding these blocks:

Task 7:
You want to test what your app does on your phone. You've already downloaded the MIT App Inventor Companion app. How would you proceed?

Task 8:
You decide that you don't need a caption. How would you remove it?

Thank you for your participation today!

Appendix B

Technical Usability Study Tasks

Originally, each of the tasks appeared on its own page; to conserve space, they have been condensed in this reproduction. These are the tasks from the second usability study; they are only minorly changed from the first study.

Welcome to the App Inventor Usability Study!

You already know how to program (at least the basics), but you've never programmed for smart phones. Imagine you want to learn how to program for Android, but you don't have a lot of time to invest.

You do some research, and a friend recommends MIT App Inventor. You decide to try it out. You think it could help you quickly prototype apps.

Task 1:

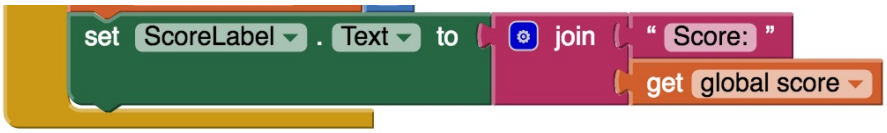
To help you get started, your friend sent you one of their App Inventor projects. You've saved it onto your desktop as "MoleMash.aia". How would you go about opening it up from the App Inventor website?

Task 2:

You've got your friend's app open in App Inventor. You want to see what the app does on your phone. How would you proceed?

Feel free to test Mole Mash by using the Companion app throughout the rest of these tasks.

Task 3:
You open up the blocks view and notice your friend's app has these code blocks that update the ScoreLabel text. These blocks are used in two separate places, but do the same thing.



You want to use good programming practice and abstract these blocks into a procedure.
How would you continue?

Task 4:
Now replace those set ScoreLabel.Text blocks with calls to your procedure in both places they are currently used.

Task 5:
You notice your friend's app is unfinished. You want to complete the app by adding functionality for a miss counter. The miss counter will count the number of times a player hits the canvas but does not touch the mole.
How would you go about adding a miss variable block, like the score variable block?

Task 6:
How would you set the miss variable to 0 when the player resets the game?

Task 7:
How would you go about creating a procedure to set the MissLabel text the way ScoreLabel is set?

Task 8:
You will need to add an event handler for when the Canvas is touched. How would you go about adding this block?

Thank you for your participation today!

Appendix C

Onboarding Script

These messages were displayed in popups around the Designer and Blocks views to quickly teach the user how to use App Inventor.

1. Welcome to App Inventor! Before you get started, we'd like to take you on a short tour.
2. This view is called the Designer. This is where you will design the look and feel of your app.
3. This is the Palette. It stores all of the components you can use in your apps in these labeled drawers.
4. This is the Viewer. It shows what the app will look like on a phone screen. Drag and drop components from the Palette here to add them to your app.
5. This is the list of Components. All of the components in the viewer will appear in a nested list here. You can select, rename and delete components from this column.
6. This is a list of the properties specific to the selected component in the app. You can change the component's size, text, color, etc.
7. These buttons toggle between the Designer and Blocks views. In the Blocks view, you can program the behavior of your app. Click the Blocks button.
8. This is the Workspace. You drag and drop blocks from the drawers on the left to this workspace and snap them together to program your app's behavior.
9. These are the built-in blocks. They are always available. You can find general

behaviors for your app, such as math, if/else statements, loops, variables, and procedures.

10. Component blocks will be here, nested under Screen1. These blocks are specific to the components you added to your app in the Viewer.
11. Any Component blocks operate on groups of similar components and are often used inside of loops, such as changing the positions of a group of sprites.
12. Up here at the top, you can find options to live-test your app, generate an installable APK for your app, get help, etc.
13. Have fun inventing!

Appendix D

System Usability Scale (SUS) Form

SUS
Please answer the following questions with regard to how strongly you agree or disagree with each statement.

1. I think that I would like to use this tool frequently.

Strongly disagree				Strongly agree
1	2	3	4	5

2. I found the tool unnecessarily complex.

Strongly disagree				Strongly agree
1	2	3	4	5

3. I thought the tool was easy to use.

Strongly disagree				Strongly agree
1	2	3	4	5

4. I think that I would need some training or additional support to be able to use this tool.

Strongly disagree				Strongly agree
1	2	3	4	5

5. I found the various functions in this tool were well integrated.

Strongly disagree				Strongly agree
1	2	3	4	5

6. I thought there was too much inconsistency in this tool.

Strongly disagree				Strongly agree
1	2	3	4	5

7. I would imagine that most people would learn to use this tool very quickly.

Strongly disagree				Strongly agree
1	2	3	4	5

8. I found the tool very cumbersome to use.

Strongly disagree				Strongly agree
1	2	3	4	5

9. I felt very confident using the tool.

Strongly disagree				Strongly agree
1	2	3	4	5

10. I needed to learn a lot of things before I could get going with this tool.

Strongly disagree				Strongly agree
1	2	3	4	5

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