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THE ITERATIVE DESIGN OF A MOBILE LEARNING APPLICATION TO SUPPORT SCIENTIFIC INQUIRY

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Abstract

The ubiquity of mobile devices makes them well suited for field-based learning experiences that require students to gather data as part of the process of developing scientific inquiry practices. The usefulness of these devices, however, is strongly influenced by the nature of the applications students use to collect data in the field. To increase student success and satisfaction with these experiences, mobile learning applications must be intuitive and functional for students, and support a systematic approach to the complex process of collecting data during a scientific inquiry. This article examines how developers can take an iterative, user-centred design approach to developing mobile learning applications that scaffold the process of data collection by documenting the evolution of an iPad application called Habitat Tracker. This application was created as part of an integrated curriculum that includes online and mobile computing technologies and was designed to help students learn about the nature of science and scientific inquiry on field trips to a natural science museum. The results of this research include principles that developers can use to guide the design of future applications used to support scientific inquiry during field-based learning experiences.

Keywords

elementary education; primary education; mobile learning applications; scientific inquiry; instructional design; design principles.

Introduction

Mobile devices such as smart phones and tablets have rapidly become an integral part of daily life, and, in conjunction with well-designed applications, have been found to support learning when teachers use them to bolster student-centred approaches to instruction (Rogers & Price, 2009). Despite the potential of mobile technologies to enhance teaching and learning, many schools have yet to adopt these technologies, and research indicates that the time required for teachers and students to learn how to use new technologies can often act as a barrier to student learning (Sharples, 2002; Spector, 2012). Research demonstrating the ability of mobile learning applications to enhance students' exposure to the natural world and transpose traditional classroom practices into field-based experiences could help system developers and instructional designers document the value of mobile computing in education.

Science education is an area in which mobile computing devices have shown particular promise. Mobile applications designed for science education have the potential to support the types of learning practices described in recent science reform documents, and to help students achieve the goals outlined in United States national and state science standards (American Association for the Advancement of Science, 1993, 2000; Collins, 1998). As a result, many researchers have called for schools to adopt a science pedagogy model that integrates the use of technological tools into the curriculum and enables students to conduct their own investigations (Abrams, Southerland, & Evans, 2008; Linn, Davis, & Bell, 2004; Reiser, et al. 2001).

Science teachers can use mobile technologies to promote inquiry-based instruction and foster the development of students' scientific inquiry skills (Seol, Sharp, & Kim, 2012). Mobile devices are particularly effective for encouraging elementary students to engage in scientific learning and data collection on field trips (Parr, Jones, & Songer, 2004). Students can use mobile technologies to gather, analyse, and interpret data during field-based investigations (Centre for Science, Mathematics, & Engineering Education, 2000). The portability and connectivity of mobile technologies allow students to carry handheld devices out of the classroom, collect data, and submit records to databases for analysis in real time (Spain, Phipps, Rogers, & Chaparro, 2001). Research also suggests that the use of well-designed mobile learning applications to support field-based scientific inquiry can have a positive effect on student learning and engagement (Hung, Hwang, Lin, Wu, & Su, 2013; Vahey & Crawford, 2002).

A poorly designed mobile application, on the other hand, may place extraneous cognitive loads on students, preventing them from accomplishing their goals, improving their skills, or enjoying the learning experience (Ching, Shuler, Lewis, & Levine, 2009). If an application does not meet the needs of the user, it can be an impediment to education and may prevent students from achieving specific learning outcomes (Cole & Stanton, 2003). These adverse effects can undermine the potential of mobile technologies in the classroom and make it more difficult to meet student needs while engaging in scientific inquiry. To avoid these problems, mobile applications need to be designed with a user-centred approach, which places an emphasis on the needs of the user and stresses the importance of making products that are usable, applicable, and functional for a wide range of individuals (Baek, Cagiltay, Boling, & Frick, 2008; cf. Norman, 1988).

An examination of how a user-centred design approach influences the evolution of mobile learning applications could help foster improved field-based learning experiences for students. Science educators, system developers, and instructional designers could all benefit from a better understanding of how mobile applications can help reduce extraneous cognitive loads by scaffolding field-based data collection for students. In particular, identifying design principles that make mobile learning applications more intuitive and functional for elementary students while increasing germane cognitive loads (e.g., learning about the practice of science) can help guide the future development of new applications focused on science education. There is a clear need, therefore, for research documenting the value of an iterative, user-centred design approach and identifying effective design principles that incorporate systematic approaches to complex tasks leading to more effective field-based mobile learning applications.

Background

The *Habitat Tracker* project (http://tracker.cci.fsu.edu/) uses online and mobile learning technologies to engage fourth and fifth grade students with their own science education, integrating a United States standards-based curriculum focused on the nature of science and scientific inquiry with field trips to a local wildlife centre (Alemanne, et al. 2012; Marty, et al. 2012). Using a custom-designed mobile learning (iPad) application and website, students gather, share, and analyse scientific data about north Florida wildlife and natural habitats at the Tallahassee Museum, a 52-acre, outdoor natural science museum (http://tallahasseemuseum.org/). The museum exhibits a wide range of animals in large, open, natural habitats, and is a common field-trip destination for more than 35,000 students each year.

The Habitat Tracker curriculum is divided into three parts that take approximately three weeks to complete. The first part takes place in the classroom, where teachers introduce students to the process of scientific inquiry. Students engage in hands-on activities that demonstrate aspects of the nature of science such as asking scientific questions, making observations and inferences, and using tools to collect scientific data. Teachers prepare students for their field observation experience at the museum by directing the students to the Habitat Tracker website (Figure 1), where they can access multimedia content about the wildlife habitats they will visit, use their digital journals to record what they are learning about different animals, and collaborate with students in other classrooms and other schools on discussion boards. Students are encouraged to develop initial research questions that they can answer during their field trips, and record these questions in their journals.

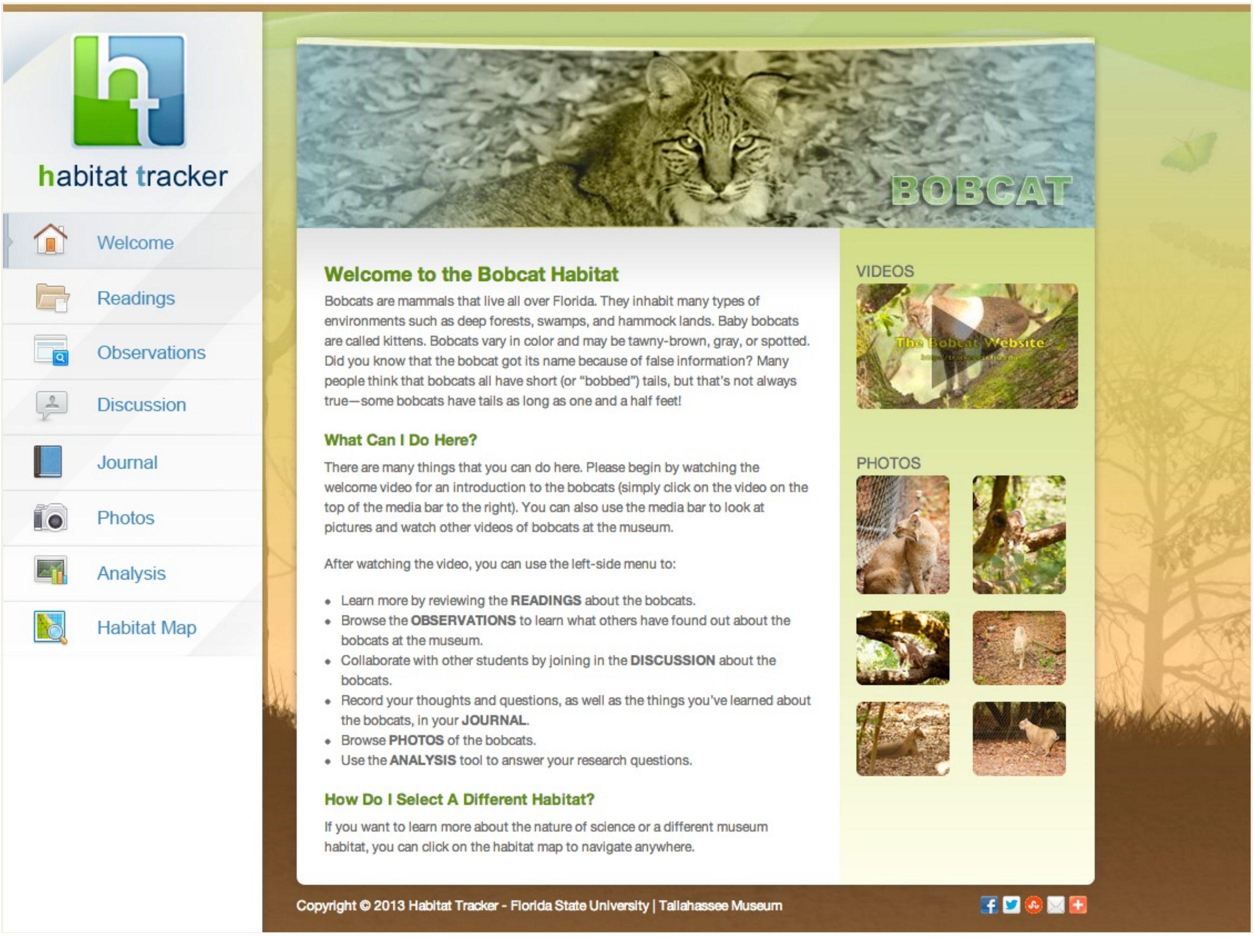

Figure 1. Bobcat habitat on Habitat Tracker website

The second part of the curriculum takes place at the Tallahassee Museum, where students collect scientific data that can help them answer their research questions. During their visit, students work in small groups and use the Habitat Tracker iPad application to write in their online journals and record observations about each of the museum's wildlife habitats, contributing those observations to a shared database that can be accessed by other students online. Interactive worksheets (Figure 2) scaffold the complex tasks of collecting multiple types of observational data—habitat observations (i.e., number of animals and other objects observed in the habitat), animal observations (i.e., location of the animals and their activities), and weather observations (i.e., current temperatures and cloud cover).

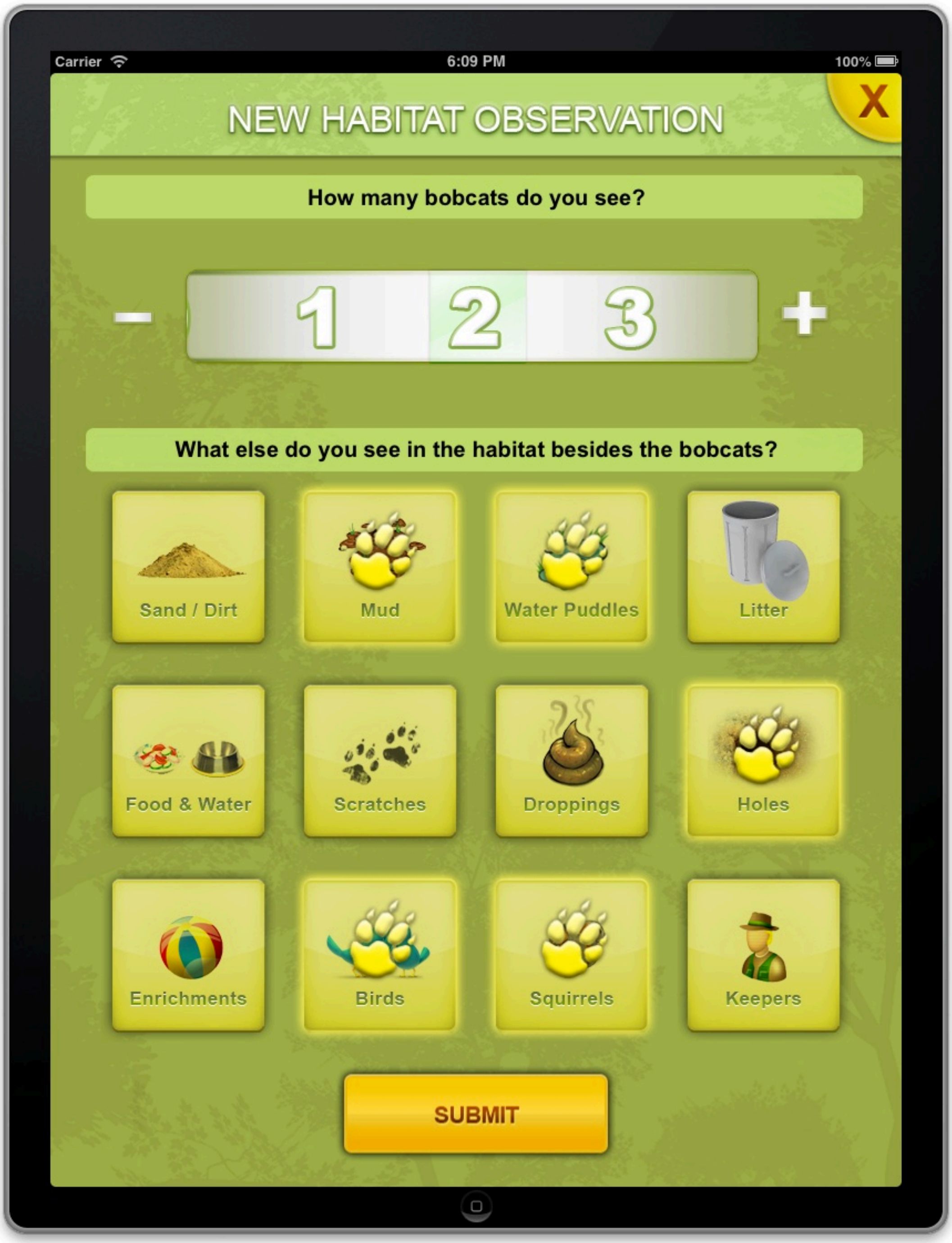

Figure 2. Sample Habitat Observation on iPad application

The third part of the curriculum takes place back in the classroom where teachers facilitate a debriefing session in which the students analyse the data they have collected. After discussing their research questions, journal entries, and observations, students use the Habitat Tracker website to browse data gathered at the museum, and analyse those data using the website's data analysis tool (Figure 3). Students create tables, charts, and graphs based on observational data, and look for relationships between variables (e.g., what time of day are bobcats most likely to be found sleeping in trees?). The Habitat Tracker curriculum concludes as students create reports and present their research findings in class.

Figure 3. Data analysis tool on Habitat Tracker website

This study documents the iterative design and development of the mobile learning application students use to collect observational data and write in their journals on field trips when participating in the Habitat Tracker project. The Habitat Tracker iPad application, along with the rest of the curriculum materials and integrated technologies, has been in development for approximately two years (since Fall 2010), and has gone through multiple design iterations. While it can be difficult to draw definitive lines between iterations as designs are constantly modified in response to user evaluations, three main iterations of the iPad application have been identified for research purposes—alpha (early 2011), beta (late 2011), and gamma (mid-2012).

Methods

To improve understanding of how an iterative, user-centred approach influences the development of mobile learning applications for science education, and to identify design principles that can help guide the development of future mobile applications for data collection in field-based learning environments, the researchers conducted an exploratory study documenting the evolution of the Habitat Tracker iPad application over a period of two years. The researchers were guided by three questions:

- How can an iterative, user-centred approach to design and evaluation help reduce extraneous cognitive load involved in technology-assisted science learning?

- How can an iterative, user-centred approach to design and evaluation help increase germane cognitive load (in this instance, understanding the process of scientific inquiry)?

- What effective design principles can be identified from an iterative, user-centred approach to developing mobile learning applications for elementary students?

This study was organised around three rounds of evaluation of the Habitat Tracker mobile learning application at the Tallahassee Museum: alpha testing in Spring 2011, during which a prototype version of the iPad application was tested on 263 students from four schools; beta testing in Fall 2011, during which a revised version of the application was tested with a larger group of 1170 students from twelve schools; and gamma testing in Fall 2012, during which the latest version of the application was tested with 385 students from four schools. Figure 4 provides a timeline of the iterative design and evaluation process.

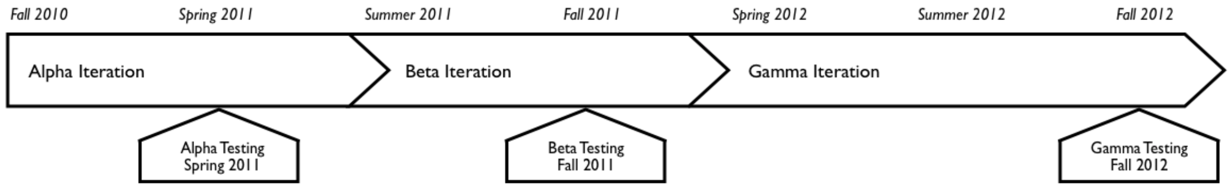

Figure 4. Iterative design and evaluation timeline

Participants

From 2011 to 2012, a total of 1818 fourth and fifth grade students from twelve different public elementary schools in three north Florida school districts participated in the evaluation and testing of the Habitat Tracker mobile learning application. Students were drawn from a diverse group of school districts, including urban, rural, and laboratory schools, serving many different socioeconomic groups. Participating schools included institutions with varied scores on the state's standardised accountability measures, and a wide range of access to technology in and out of the classroom. A team of seven researchers observed student participants using the Habitat Tracker iPad application at the museum, and recorded detailed notes and made observation reports during each evaluation session.

Data Collection

During the first round of evaluation (alpha testing), researchers observed the students collecting data using the iPads at the museum, and systematically recorded the students' interactions with the application using observation reports containing questions such as, "Do the students know how to begin a 'new' observation?," "How long do students take to make an observation?," and "What difficulties do they have?" The use of these observation reports provided critical guidance for the researchers as they observed the students at this early stage in the design and evaluation process. While making observations, the researchers focused on collecting data about the students' usage of the application, and were careful not to assist students in the use of the application unless they became intractably stuck or frustrated.

During the second round of evaluation (beta testing), researchers observed the students using the application and completed observation reports listing any usability or functionality problems students encountered at the museum. During these first two rounds, students wrote in their journals and recorded observations at only one museum habitat—the bobcats—which allowed the system developers to focus on one habitat as a design prototype. Participating students made 2083 total observations at the Tallahassee Museum—844 observations about the habitat, 751 observations about the animals, and 488 observations about the weather. They also wrote 646 journal entries at the museum, recording notes about aspects of the animal's activities they found interesting, or posing potential research questions based on their observations, such as "How do bobcats sleep and stay on thin branches?"

During the third round of evaluation (gamma testing), students were able to use the application at any of the museum's ten animal habitats, including white-tailed deer, wild turkeys, river otters, red wolves, bobcats, panthers, alligators, black bears, grey foxes, and skunks. Researchers observed the students' use of the application at the museum in order to assess whether any additional design or development changes were necessary. During this round, participating students recorded a total of 2469 observations, including 1145 habitat observations, 1093 animal observations, and 231 weather observations; they also wrote 460 journal entries.

Data Analysis

Observation reports from each evaluation session were carefully assessed to identify issues affecting the usability and the functionality of the Habitat Tracker iPad application, and system developers used this feedback to determine interface changes to be made in subsequent design iterations of the application. These design iterations were carefully examined by the researchers in order to document the evolution of the Habitat Tracker iPad application over two years. Each stage in this evolutionary process was then compared with the researchers' observations of participating students throughout the project in order to identify design principles that improved the ability of the mobile learning application to scaffold the process of data collection for elementary students. The results of this analysis are detailed in the following section along with examples of the evolution of the Habitat Tracker mobile learning application.

Results and Discussion

The research findings indicate that an iterative, user-centred design approach had a positive influence on the ability of the Habitat Tracker iPad application to scaffold the process of data collection during field-based learning experiences. Each iteration of the mobile learning application improved participating students' ability to use the application to record observations and collect data effectively and efficiently. The following four examples document the evolution of the Habitat Tracker iPad application over the past two years, highlighting effective design principles and key lessons learned from the iterative design and development process.

1. Ensuring Students Can Navigate the Application

The Habitat Tracker mobile learning application introduced participating students to the bobcat habitat and offered them several options: they could write in their online journals and record three types of observational data (animal, habitat, and weather observations). Since this interface represented the tasks the students were to accomplish while observing the habitat, it was important that navigating these options be as intuitive as possible for the students.

During alpha testing, the alpha iteration (Figure 5a) presented students with all of their options simultaneously, using a tabbed navigation bar across the bottom of the screen. While some students had used iPads previously and were familiar with this navigation style, many had no such experience and found the process confusing. Compared with the large picture and descriptive text, the navigation options were so small they were easily overlooked, and the icons representing the three types of observations were not intuitive to the students. Analysis of the evaluation reports revealed that students either overlooked these navigation options or could not figure out how to proceed, thereby hindering their ability to collect observational data and write in their journals.

The beta iteration addressed these issues by separating the single overview page into two different pages: a "habitat" page with a short video that introduced the students to the habitat and explained they could either write in their journals or make observations (see below), and an "observations" page that described the three types of observations students could make and allowed them to browse previously entered data or to make new observations (Figure 5b). Brief descriptions were added to help students understand the different types of observations they could record, while navigation buttons were made larger and more centrally placed. Illustrations for the habitat, animal, and weather observations also provided students with quick points of reference.

Observation reports from beta testing revealed that these changes dramatically increased the functionality of the application by making it easier for students to understand their options and distinguish among the different types of observations. After these revisions, very few students reported difficulties understanding the new navigation system, and there were no reports of any students unable to determine how to access their journals or make a new observation. The new introductory video was problematic for some students, as it could be difficult to hear the audio outdoors, and watching the video slowed down some students who wished to write in their journals and make observations more quickly.

The gamma iteration (Figure 5c) addressed these issues by replacing the video on the habitat page with a subtitled slideshow that students could page through at their own pace. The gamma iteration also included system-wide updates to background colours, fonts, and headers designed to make the application more uniform. Results from gamma testing showed that these changes allowed the students to navigate fluidly between habitat and observation pages, and revealed that students were more apt to view the instructions on the slideshow before making observations.

The evolution of the navigation structure highlights the need to design mobile learning applications with interfaces that are intuitive, systematic, and functional for elementary students. Relatively common navigation paradigms can still be unfamiliar to young children, and students who are unable to navigate an application will become confused when trying to accomplish even the most basic tasks while collecting data in the field. To minimise this confusion, it is important to design interfaces that scaffold students as they engage in the complex process of scientific inquiry. Dividing a navigation system into different sections, for example, where options can be presented to students one at a time in scaffolded contexts, can orient students more quickly to the navigation and layout structure of an application.

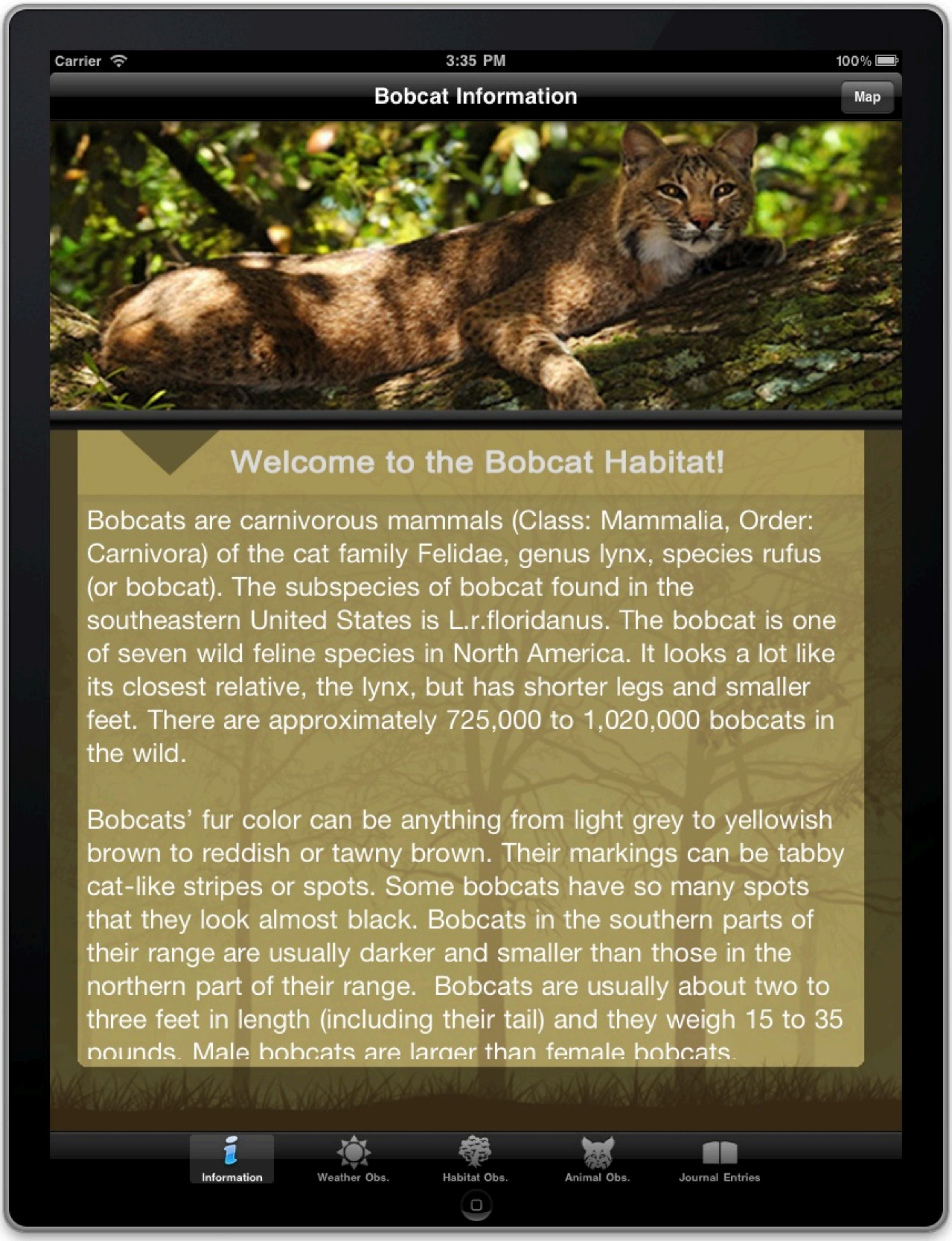

Figure 5a. Evolution of Habitat Tracker navigation structure

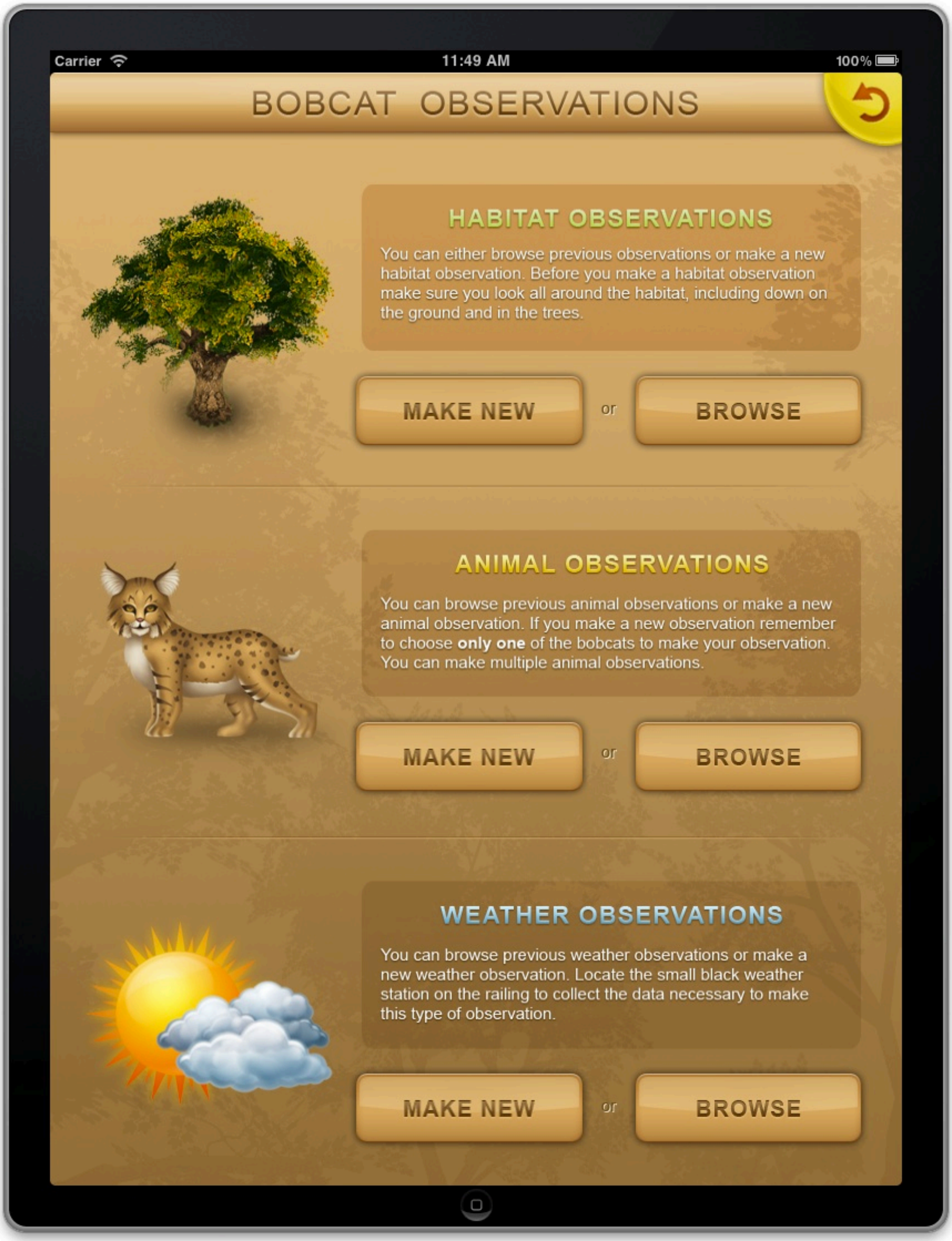

Figure 5b. Evolution of Habitat Tracker navigation structure

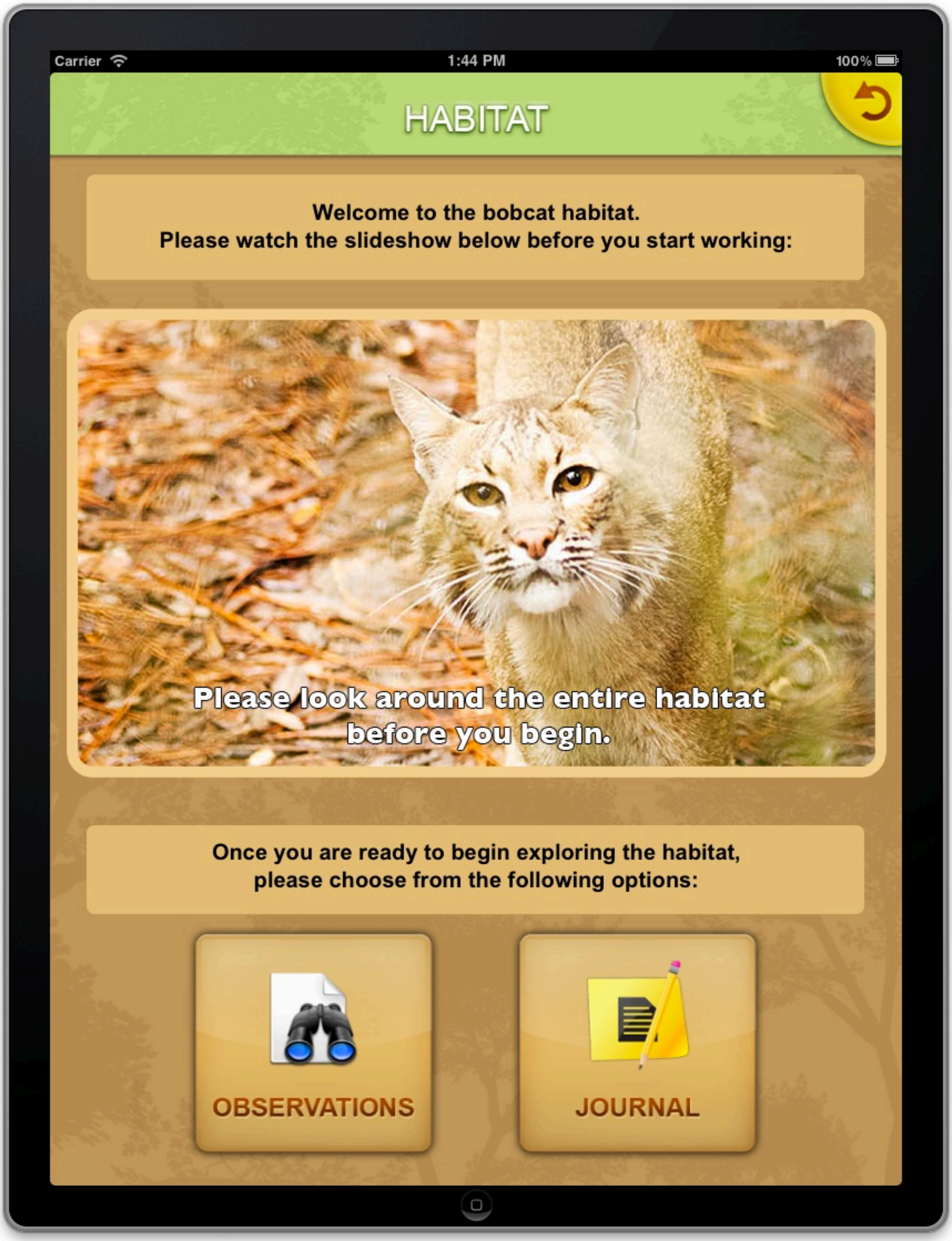

Figure 5c. Evolution of Habitat Tracker navigation structure

2. *Ensuring Visual Representations Reflect Reality*

Students who wished to make a new animal observation first had to locate a bobcat in the habitat. Finding the bobcats was challenging for some students, as the bobcats were well camouflaged, and frequently napped on branches high in the trees. Students were instructed to search the habitat thoroughly, from several different angles, until they found a bobcat to observe, at which point they used the mobile application to indicate the bobcat's location in the habitat.

The alpha iteration (Figure 6a) required students to locate their chosen bobcat on a two-dimensional, birds-eye view of the habitat. Analysis indicated that this "habitat map" presented problems for the students. The map looked more like a cartoon than an actual illustration of the habitat, and many students had difficulty placing the animal in its correct location due to the lack of detail and non-representative drawings (certain landmarks such as two large live oak trees were especially unclear). Since the two-dimensional perspective did not represent the view from which the students saw the habitat, many students had difficulty shifting their perspective to this birds-eye view, and this iteration of the interface frequently caused students to record inaccurate data about the bobcat's location.

The beta iteration addressed these issues by developing a more intuitive method of representing the habitat visually (Figure 6b). A detailed representation of the habitat was created, using a three-quarter view that more closely reflected a student's view when facing the habitat. The new illustration style had the advantage of being more realistic than the original map, but less "busy" than an actual photograph. Key landmarks such as the live oak trees and animal shelters were clearly marked on the habitat map, and the new version permitted the students to place the bobcat (now represented by a small cartoon graphic) anywhere in the habitat—up a tree, on a shelter, in the cage, and so on.

Observation reports from the beta testing indicated that these changes helped students make observations that were more accurate. The majority of the students indicated that it was easy to locate the bobcats in the habitat using the new interface, and few students expressed frustration with the new design. The primary concern raised by students with the beta iteration was that the new cartoon graphic of the bobcat always showed the bobcat in a standing position, which did not necessarily reflect the animal's actual stance (e.g., lying on a tree branch vs. standing on the ground). The gamma iteration (Figure 6c) addressed this concern by changing the graphic used to represent the bobcat's location to a neutral yellow icon showing a bobcat silhouette; this iteration also introduced a new perspective for the habitat map (showing more of the boardwalk) designed to better orient the students to the habitat while making observations. Results from the gamma testing indicated that the changes helped students more accurately position the animal icon in the habitat, illustrating the importance of scaffolding scientific inquiry.

The evolution of the habitat map highlights the importance of designing mobile learning applications so that they represent reality in ways that make sense to the target user (in this case elementary students). This is particularly important when designing mobile learning applications to support science education for novices who may be unfamiliar with scientific inquiry, and where students may be asked to work with representations of the natural world to accomplish tasks or collect data. Interfaces that feature representations of reality that more closely match the students' own mental models can help students interact more effectively, improving their ability to record data about the world they are observing by scaffolding their data entry processes.

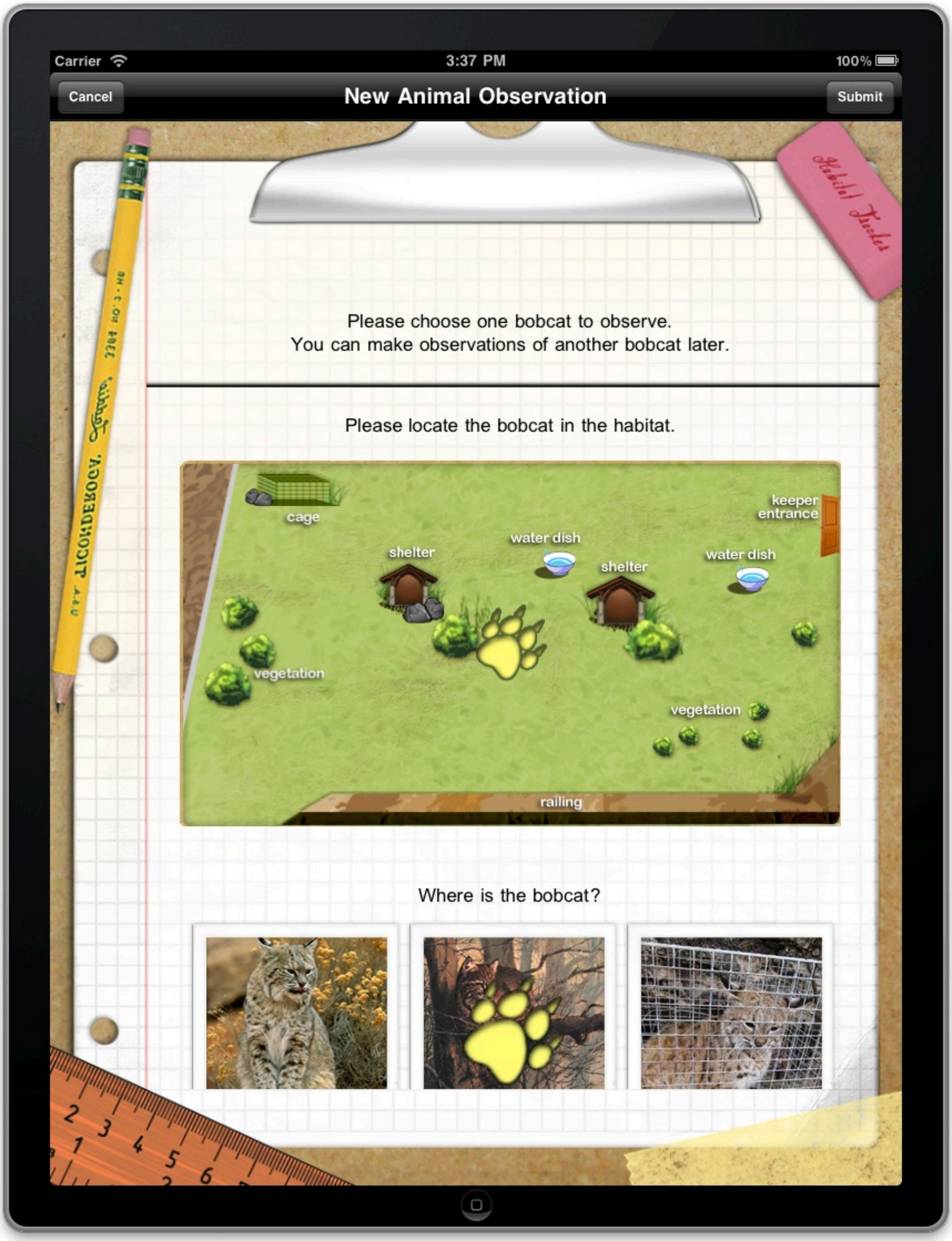

Figure 6a. Evolution of wildlife habitat map

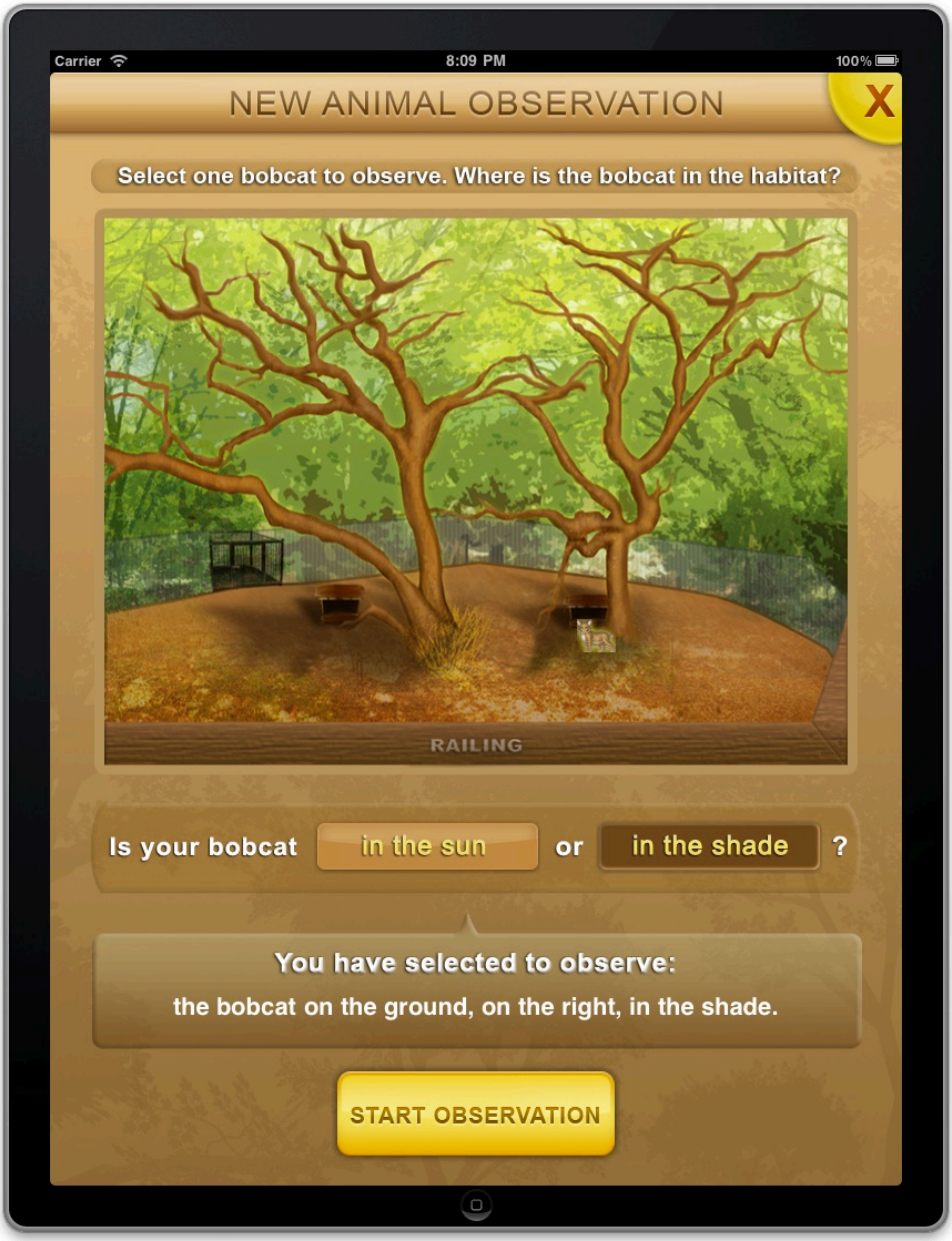

Figure 6b. Evolution of wildlife habitat map

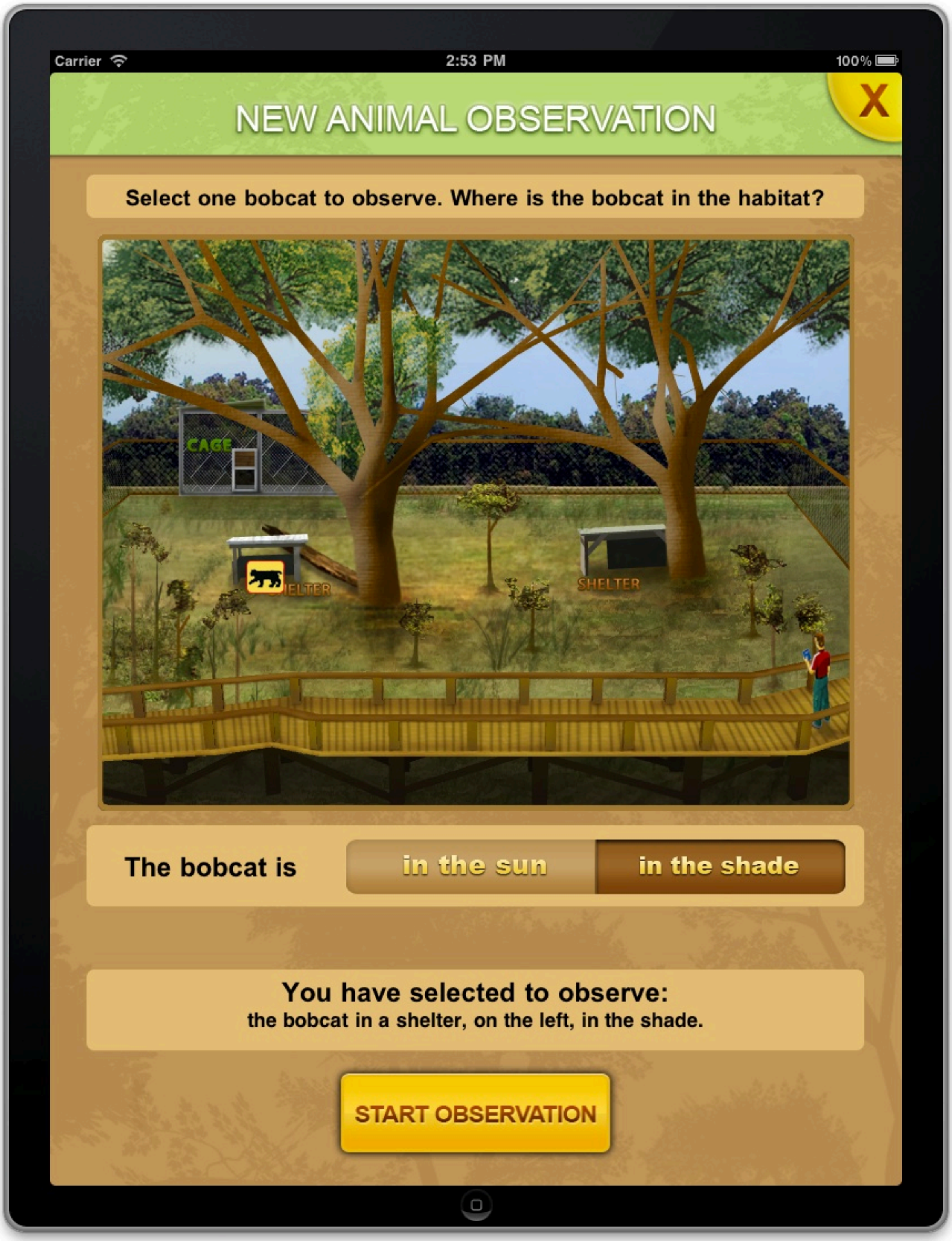

Figure 6c. Evolution of wildlife habitat map

3. Ensuring Applications Separate Complex Processes

After locating a specific bobcat in the habitat, students were asked to answer several questions about the bobcat they were observing (such as whether it was in the sun or the shade) and to record their observations of the bobcat at that time. The intention was for students to record a "snapshot" of the bobcat's activities, which could include such actions as resting, pacing, grooming, eating, drinking, or climbing. On rare occasions, students observed bobcats interacting with each other or hunting.

The alpha iteration (Figure 7a) required students to answer a large number of questions, all listed on one page on the iPad. Since these questions would not all fit on one screen, the students were required to scroll the page on the iPad to read and answer all the questions. While scrolling is a natural behaviour for touch screen devices, this was not intuitive to many students in the alpha iteration. Analysis indicated that students were confused by the interface and did not realise they could scroll down. This caused many students to try and submit the observation without completing the observation worksheet, prompting them to receive an error message. Once students did scroll down the screen, they could no longer see the habitat map at the top of the page, and risked forgetting which bobcat they were observing, or accidentally recording data about more than one bobcat.

The large number of questions asked on the worksheet also posed difficulties to the students and hindered their ability to make efficient observations. The alpha iteration of the application included 21 options for recording the animal's activities and questions about physical features (e.g., the position of the bobcat's ears) that can communicate animal behaviours. Analysis indicated that students were not able to make observations on the position of the bobcats' ears, for instance, because the bobcats were frequently too far away for students to provide an accurate observation. Unfortunately, even if the student could not see the ears they were required to select an answer before proceeding, which resulted in inaccurate data being added to the database. Finally, the small size of the buttons and the lack of illustrations meant that many students had difficulties determining the meaning of certain behaviours and selecting the appropriate buttons.

The beta iteration addressed these issues by changing the interface so that no scrolling was required. After students placed the bobcat in the corresponding location on the application (see Figure 6b) they were to indicate whether it was in the sun or the shade, and then pressed a button to begin their observations (Figure 7b). The number of observable behaviours was limited to activities students were most likely to witness (decisions that were made in consultation with the museum staff), and terminologies were tweaked to reflect more accurate descriptions (e.g., sleeping was changed to "resting" since it was not possible for students to be sure whether an animal was actually asleep or just lying still). The number of choices was reduced from 21 to 16, which allowed for larger buttons with new illustrations and clear indicators (bright yellow paw-prints) that helped students make selections more quickly, made it more obvious which options were selected, and encouraged more efficient observations.

Observation reports from the beta testing sessions indicated that these changes dramatically increased the students' ability to accurately record observations of the animal activities. Adding illustrations eliminated nearly all confusion about what any given behaviour term meant, and helped the students pay closer attention to their observations. The gamma iteration, therefore, made only minor adjustments to the interface to reflect system-wide changes to fonts, background colours, and headers (Figure 7c). Results from the gamma testing confirmed that the new observation screens allowed students to make observations without the difficulties students experienced with prior iterations of the interface. The modifications made during the iterative design process appeared to eliminate many of the challenges that students face when attempting to engage in a complex scientific practice such as making observations for the first time.

The evolution of the animal activities interface highlights the need to design mobile learning applications so that tasks are scaffolded into discrete steps that are readily apparent to elementary students. Separating complex tasks can help students focus on one problem at a time and minimise the number of concepts they have to keep track of simultaneously while collecting data in the field. Many students find it difficult to make observations because they are unfamiliar with scientific terminology, and do not know how to proceed when instructed to collect data. Adding illustrations and increasing the visibility of buttons or other inputs can help students better understand the nature of a task, making it possible for them to visualise all their options at once.

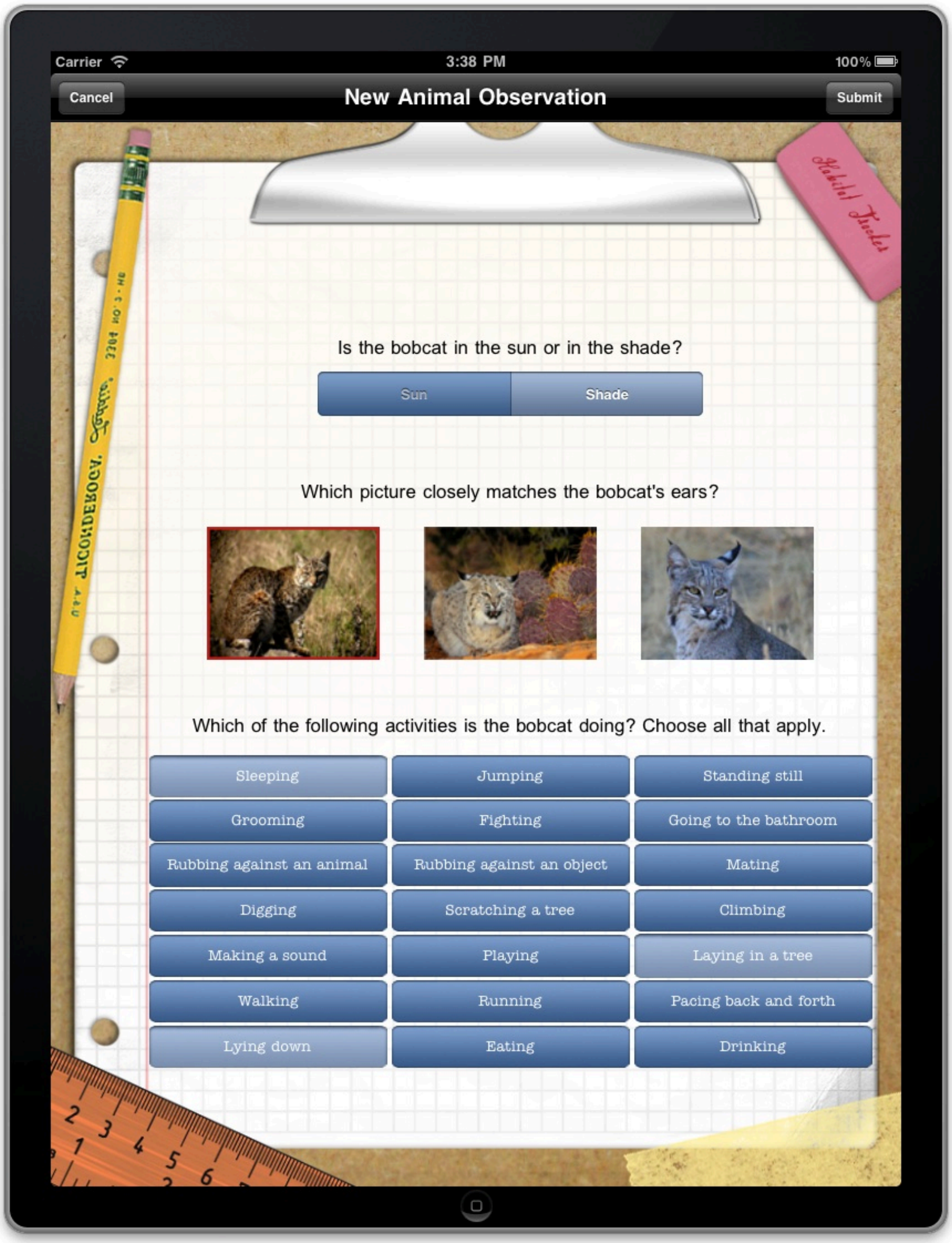

Figure 7a. Evolution of animal activities worksheet

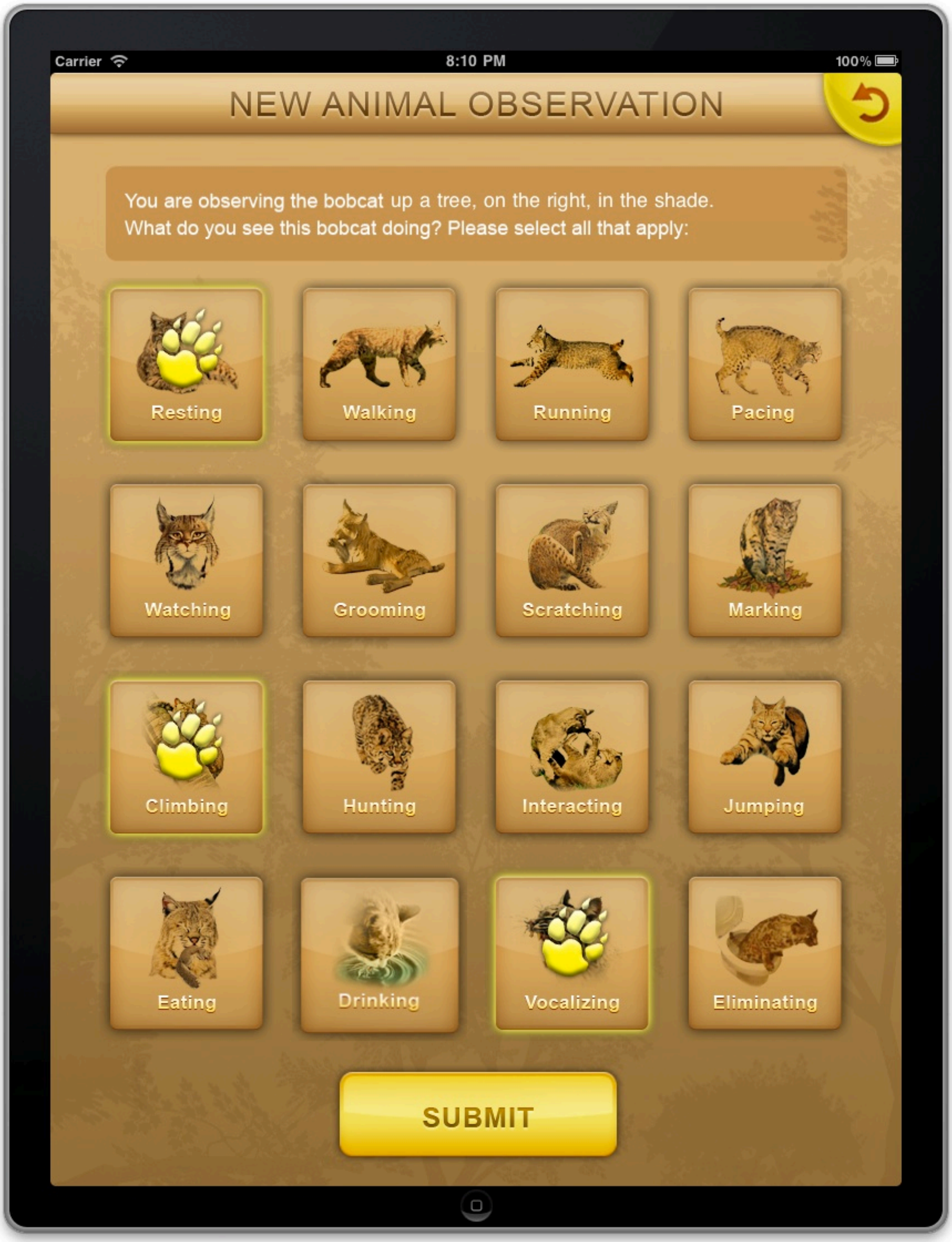

Figure 7b. Evolution of animal activities worksheet

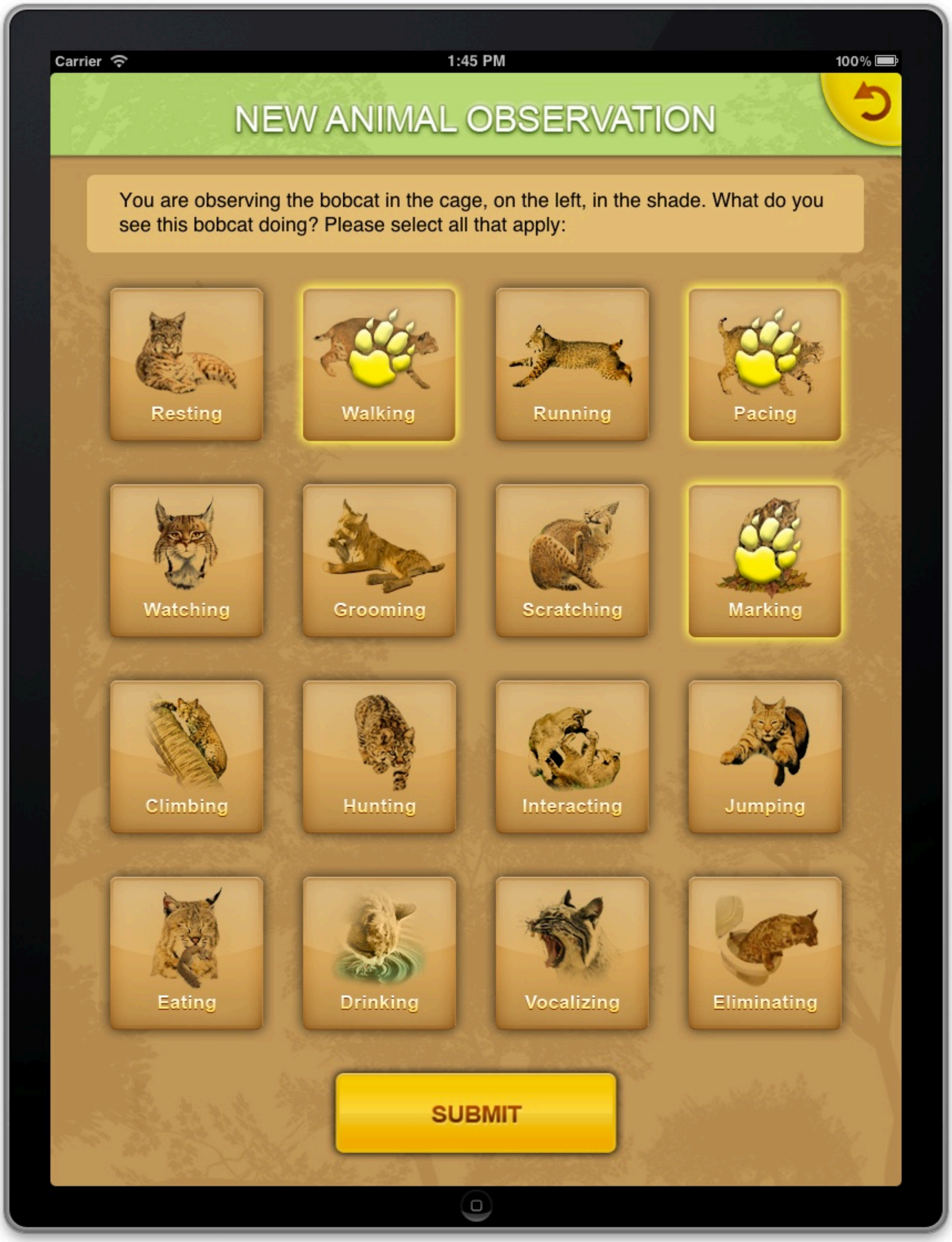

Figure 7c. Evolution of animal activities worksheet

4. Ensuring Students Can Make Accurate Observations

Along with recording observations about the animals and their habitat, students were able to use a wireless weather station (displaying temperature, humidity, barometric pressure, wind speed and direction) to make weather observations. Since weather conditions can have an impact on animal behaviours, students were asked to read specific weather data from the display screen, and then record those data in the mobile learning application.

During alpha testing, students using the alpha iteration (Figure 8a) were asked first to observe the cloud cover (sunny, cloudy, etc.) and then to input the current temperature, barometric pressure, wind speed, and humidity. The students would often skip the cloud cover observation because they did not see the instructions, which were in a small font and hard to read and were easily missed as they were at the top of the screen. The cloud cover illustrations were not intuitive without the instructions, and many students did not even realise they were buttons.

Another problem students faced with the alpha iteration was that the input controls for entering data such as the current temperature were sliders that had to be dragged, with a finger, until the student reached the desired value. The slider control was so fine-grained that it was difficult for many students to drag the slider to the desired value. Analysis revealed students experienced dissatisfaction with this interface, as they became frustrated by the long period of time they devoted to trying to locate the exact value for their entries on the screen (sometimes to the 100th decimal place for a temperature reading), eventually resulting in numerous data inaccuracies when recording weather data.

To prevent students from overlooking the cloud cover question, the beta iteration placed these options directly above the submit button so it was in their line of sight before submitting their observations (Figure 8b). The horizontal sliders were also replaced with larger, vertical scroll wheels that allowed students to input each digit individually, which made the process less frustrating, faster, and easier for students to record accurate data from the weather station.

Observation reports from the beta testing indicated that these changes increased the students' effectiveness, efficiency, and satisfaction with the application by making it easier for them to record their observations and improving the accuracy of the recorded data. Moving the cloud cover question closer to the submit button meant that very few students skipped that question, while the new scroll wheels helped students record quantitative data more quickly and easily. On the other hand, beta testing revealed that students were confused by the fact that the layout of screen inputs did not correlate with the design of the weather station (e.g., the wind speed was far away from wind direction). Also, the weather station provided indoor and outdoor measures for temperature and humidity, and many students did not know which value to record on the iPad.

The gamma iteration (Figure 8c) addressed these concerns by rearranging the input elements on the screen to make the layout more representative of the weather station display console at the museum. Notations were added to remind the students to record outdoor values for temperature and humidity, and background colours, fonts, and headers were also adjusted to reflect new system-wide norms. The gamma testing indicated the functionality worked well after rearranging the inputs. Students were able to more easily identify less-familiar items (e.g., barometric pressure, wind speed) and they were able to transfer the information they viewed on the weather station console to the iPad's weather observation page. The modifications made during the iterative design process appeared to eliminate many of the challenges that students face when they are asked to record numerical measurements as part of a scientific inquiry.

The evolution of the weather observation worksheet highlights the importance of designing mobile learning applications that support the needs of students who desire accuracy in their use of a data collection tool. Elementary students are frequently very task oriented, and can easily become frustrated when faced with a tool that does not allow them to be as precise as they would like to be. Many students, for example, find it difficult to record numerical measurements because they are unfamiliar with the concepts of precision and significant figures. Interface controls that encourage systematic and accurate data entry can help minimise student dissatisfaction, especially when students are collecting quantitative data in the field.

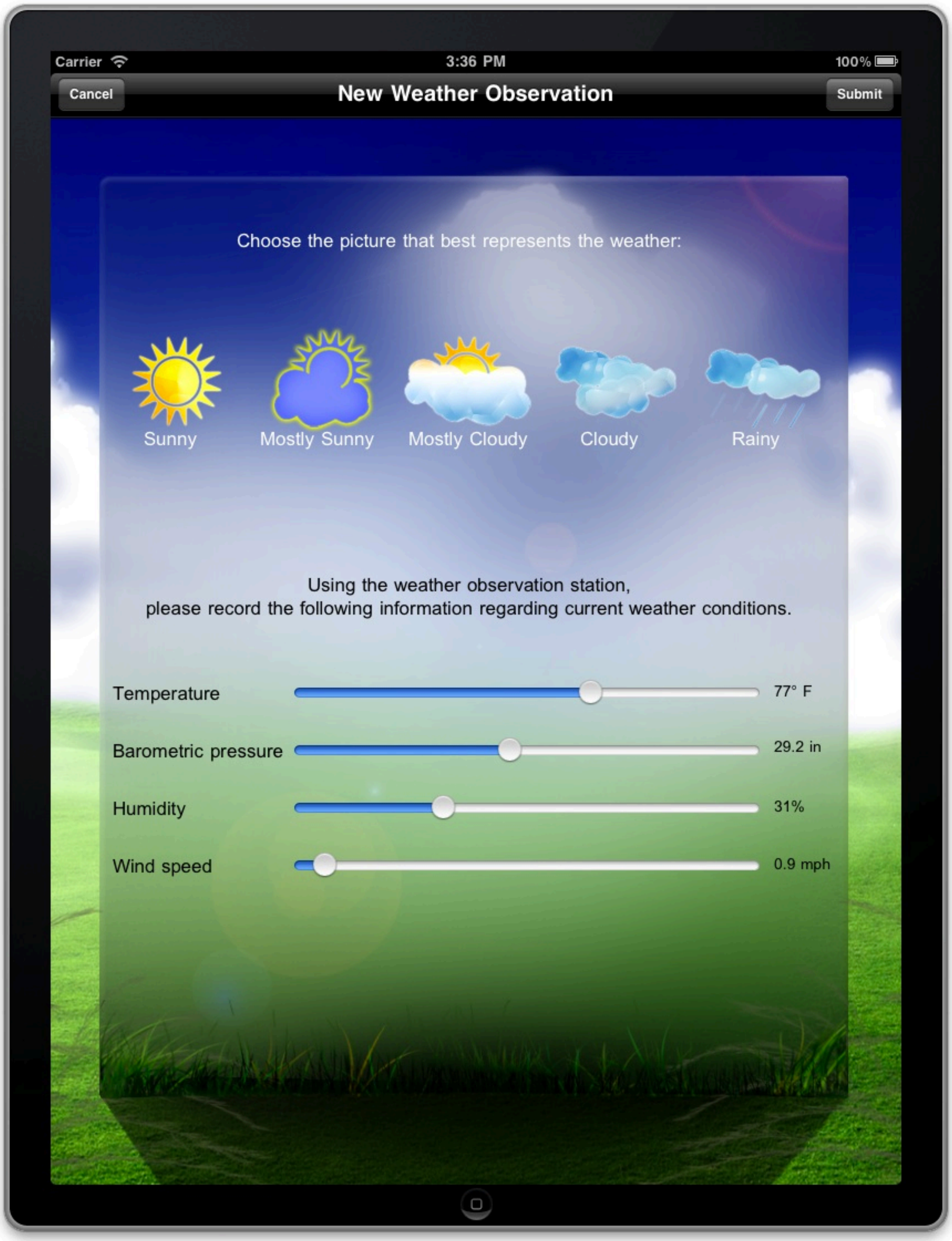

Figure 8a. Evolution of weather observation worksheet

Figure 8b. Evolution of weather observation worksheet

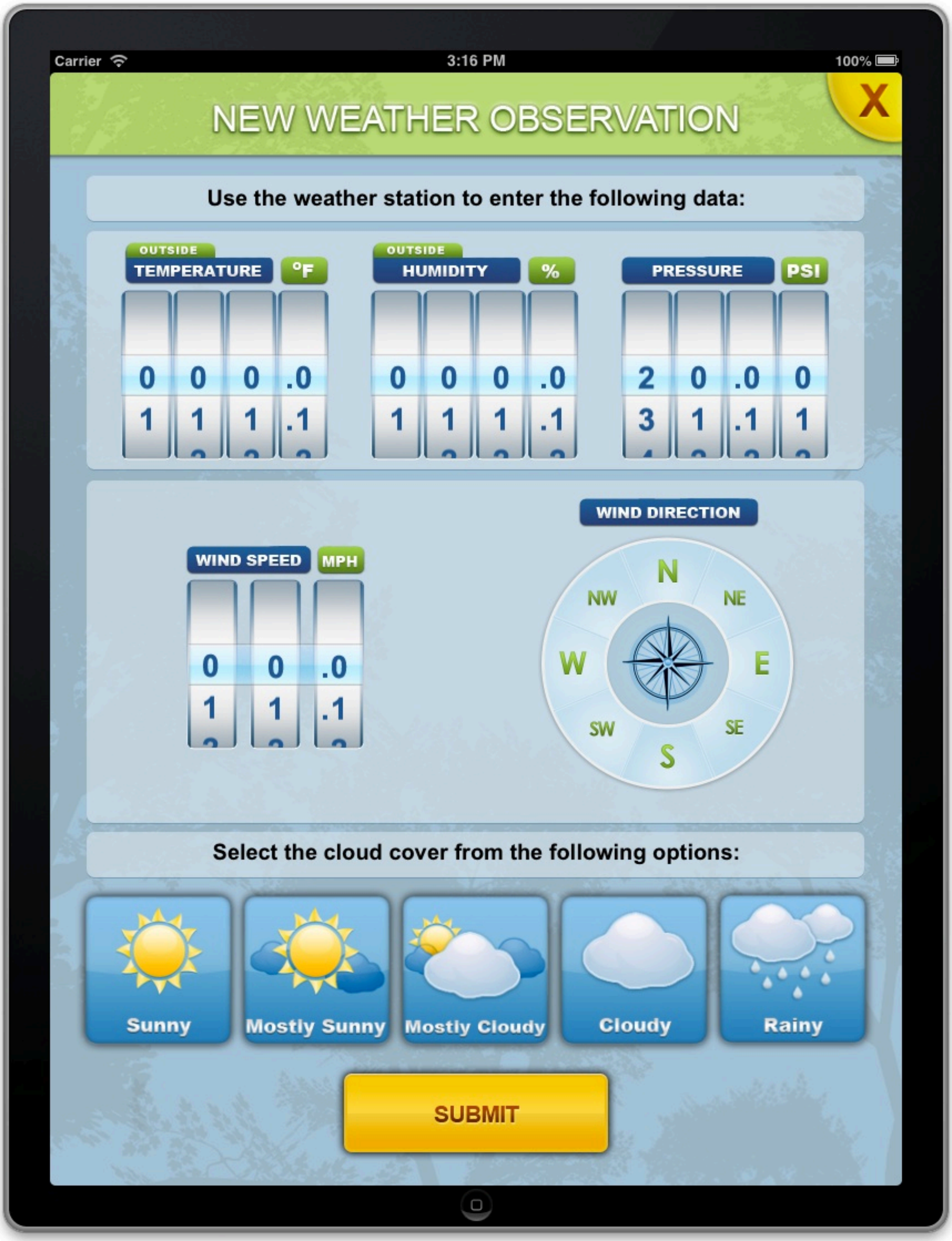

Figure 8c. Evolution of weather observation worksheet

Conclusions

The evolution of the Habitat Tracker iPad application underscores the importance of taking an iterative, user-centred approach when creating mobile applications to support data collection during field-based learning experiences. A mobile learning application is only useful when it supports “continuity across various learning experiences” and facilitates students in “making connections between what they are observing, collecting, accessing, and thinking about over time, place, and people” (Rogers & Price, 2009, p.4). The design and development of mobile learning applications for elementary students does not necessarily follow a straightforward path, and the ability to iterate designs in response to feedback from participating students can make the difference between a mobile application that supports student learning, and one that meets no one’s needs. In the case of Habitat Tracker, the iterative design and evaluation process helped improve the students’ ability to understand how the interface functioned, make effective and efficient observations, and record data with minimum frustration and maximum satisfaction.

Well-designed mobile learning applications should support the process of scaffolding novices as they engage in scientific inquiry in order to eliminate many common barriers students face when gathering scientific data, and to allow them to focus on what they are learning about the natural world rather than focusing all their attention on learning how to use the application. A user-centred approach to interface design can eliminate these barriers and allow students to engage in complex scientific practices with minimal prior experience and teacher support. System developers and instructional designers building mobile applications to support science education among elementary students, particularly applications intended for data collection outside the classroom, could benefit from adhering to the following design principles identified in this study:

1. Mobile learning applications should offer navigation controls that are intuitive and functional for students in order to minimise cognitive load.

2. Mobile learning applications should use graphics and visualisations that represent reality in ways that make sense to students in order to minimise cognitive load.

3. Mobile learning applications should separate complex processes in order to scaffold student learning so that students are building their knowledge in a logical progression rather than dealing with multiple concepts and tasks simultaneously.

4. Mobile learning applications should use input controls that minimise student frustrations and support the needs of students who desire accuracy when collecting data or making different types of observations.

The development of interfaces that are effective, efficient, and satisfying for students to use is essential for their successful adoption in and out of the classroom (Hussain et al., 2008). When technologies are designed with the student in mind they are more likely to be implemented for use in teaching, and less likely to have an adverse affect on the ability of students to achieve their learning goals (Ching et al., 2009). An iterative, user-centred approach to the design and development of mobile learning applications for science education, where interfaces are iteratively assessed and improved throughout the design lifecycle, can improve our ability to develop mobile learning applications that meet the needs of elementary students engaged in data collection as part of field-based learning experiences.

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