Playtesting *PlanetMania*: A Mobile Game for Museum Exhibits

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Abstract: *PlanetMania,* a mobile game from the Maryland Science Center, is designed to be played by preteen visitors in the *Life Beyond Earth* exhibit. The card-based gameplay expands upon exhibit content and encourages interaction with the physical exhibit. Through extensive paper prototyping and iterative development, the project team revised and simplified the game content and interactivity, striving for intuitive game rules, age-appropriate scientific content, and engaging game play and learning outcomes — all in a museum environment where players have plenty of distractions.

Introduction

For over 15 years, museums have been incorporating handheld devices into the visitor experience, but until recently, these efforts have focused on traditional interpretation with didactic content (Dowden & Sayre, 2007; Filippini-Fanton & Bowen, 2008; Petrie & Tallon, 2010; Burnette et. al., 2011). Only recently have game-based projects emerged, such as the "Tate Trumps" mobile game from Tate Modern. Games are an enticing format for museums, because they are inherently engaging, motivating, and meaningful experiences (Schaller, 2011a, 2011b). However, because games require substantial attention from the player, they create significant design challenges to ensure a satisfying experience that enhances rather than distracts from the museum visit.

To tackle this challenge, a team gathered at the Maryland Science Center (MSC) in January 2012. The group consisted of the Principal Investigator, a consultant and project manager, MSC development and implementation staff, and the authors of this paper: a learning game designer and an independent evaluator. Supported by a grant from the National Science Foundation, the team's goal was to design and produce a mobile game, eventually named *PlanetMania*, to be played by visitors at a museum exhibit about astrobiology, which was also in development at that time. In contrast to traditional didactic mobile tours, this game would appeal to children (a large portion of MSC visitors) and could help them engage with the text and images of the Astrobiology exhibit (Klopfer et al., 2005). The game is available for iOS and Android devices from the *Life Beyond Earth* web page (http://www.mdsci.org/exhibits/life-beyond.html).

A Slate of Constraints

PlanetMania faced many constraints: two (audience and content) that are common to any museum project, plus several additional constraints of platform and environment that did much to shape the final product.

Subject Matter: Astrobiology and the search for life beyond Earth, focusing on recent discoveries of exoplanets (planets orbiting other stars) and the requirements for life on other worlds.

Audience: Museum visitors between the ages of eight and twelve, visiting either with their family or a school group.

Deployment Technology: Mobile devices, specifically those running iOS (iPhone, iPod Touch, and iPad) and Android operating systems. This dual-platform deployment (and our budget) meant we had to build the game in HTML and "package" it with PhoneGap, thus limiting potential interactivity.

Game Platform: A content management system (CMS) housing all game content, so the game could be instantly updated as exhibit components changed over time. Furthermore, with the CMS, museum staff could create new versions of the game for other exhibits. This placed substantial constraints on gameplay and presentation, since we had to design a generic game that could support any subject matter.

Exhibit Environment: MSC's *Life Beyond Earth* exhibit, which was being designed concurrently. This perhaps was the greatest constraint, for the game had to enhance and expand upon the exhibit content, while repeatedly redirecting the visitor's attention back to the exhibit. If we created a game that kept players glued to the screen—normally a sign of success—we would have failed.

The Answer is in the Cards

Given these constraints, we had to relinquish what is typically a major goal for learning games: tight integration of gameplay and content. When gameplay and content are separated, essentially operating on different planes within the game, players can easily ignore the content and instead concentrate only on the game mechanics necessary to succeed. And indeed, the design team quickly set aside some promising ideas for game-exhibit connections, since they would not be re-usable with other exhibits. Instead, we developed a game concept that emulated the scientific method using interchangeable scientific content:

> The game focuses on a question at the frontiers of science, to which no one knows the answer. For the astrobiology version, it might be "Is there life on other planets?" Players choose a hypothesis, then collect "evidence cards" as they explore the exhibits. When players have collected seven cards, they are prompted to support their hypothesis, choosing the best four cards that make a strong case for it. Players then submit this "hand" of cards to earn Astrobucks and a coupon to the museum store. (Draft design document, January 2012)

A card game design accommodated all of our constraints:

- Subject matter: Astronomy is highly visual, so text and images can convey a great deal of information.
- Audience: Children are generally familiar with card games, easing the learning curve.
- Technology platform: Card-based gameplay can easily be created in HTML and "packaged" as an app with PhoneGap.
- CMS-based game platform: Cards can serve as a generic template for server-based content.
- Exhibit environment: Cards can be "collected" using keycodes embedded in exhibit panels, thus drawing players' attention to the exhibit's different areas.

This format had one other benefit, which proved to be equally essential: It was quite easy and inexpensive to playtest with children using paper card mockups.

Test, Revise, and Repeat

After further development, we began playtesting the game with children. Over four rounds of paper prototyping (see Figure 1), we revised and refined both content and interactivity, all before writing a line of HTML. Then we tested again with paper mockups after formative evaluation of a digital prototype. On its own, the core gameplay worked pretty well. Children quickly understood the basic mechanics: collecting cards, employing wild cards, and combining cards for power-ups and to form "cases." Nor was the content, on its own, a serious problem. During playtesting, we found that most card content (about exoplanets, extremophiles on Earth, and the ingredients of life) was new to children, but they generally could make some sense of it, especially when they could connect it to prior knowledge.

The problem arose not from children's imperfect grasp of the content, which was probably typical for a science museum exhibit, but from what we asked children to *do* with it. The game required them not merely to understand the card content, but also to apply it, by deciding whether or not the card supported the hypothesis. Children made valiant attempts, but often their rationales were vague, uncertain, or even whimsical. Given their unfamiliarity with our science content, this task was simply beyond the cognitive ability of most 8-10 year olds, at least within our chosen game format.

So the problem was not purely with either the content or the gameplay. It was at the *intersection* of the two. Children could make rough sense of the card content, and they had no problem with the basic gameplay. But applying their nascent understanding of the card content in the context of the game rules proved too difficult for most children. Ironically, we had managed to create a game that required that players understand the content in order to play the game well — and that turned out to be the central problem with the game design.

Figure 1: Early Designs for Game Cards

That, at least, was how we interpreted the playtesting results. But because the *Life Beyond Earth* exhibit was still in development, playtests were conducted in a vacuum of sorts, absent the atmosphere of exhibit panels and interactives, making our conclusions tentative at best. Nonetheless, we had to address these issues before building a pilot version of the game for formative evaluation. So we simplified both the content and the gameplay and built the game in HTML to be tested in the museum.

This pilot version of the game would also be our first test of the card-collecting mechanic, since it required the exhibit environment. To collect cards, players must find three-digit keycodes (posted at strategic spots around the exhibit) and type them into the game. They draw two cards, then must answer a multiple-choice quiz question about astrobiology (with the answer found in nearby exhibit text) to earn a third card. We added this step to strengthen the game's connection to the exhibit. Players repeat this process until they have seven cards in their hand. Then they begin powering-up and making cases to support the current hypothesis.

The formative evaluation found that the game was appealing to children, with a 4.1 rating on a 5-point Likert scale (all formative citations are Flagg, 2012). Girls indicated greater sustained interest than boys over several rounds, perhaps due to the text-centric nature of the game (Chudowsky & Chudowsky, 2010). The majority of children liked the card-collecting task, with six out of ten players calling it the most fun aspect of the game. As one said: *"Getting the cards and seeing all the different planets and answering the questions, you had to work and think."* Also popular were the Astrobucks, which players earn to unlock and upgrade for a coupon to the museum store. Nearly half of the children said that was the "most fun" aspect of the game. However, one-third of children criticized the reading load: *"It's more like reading a textbook than playing a game. It's not too much fun."*

The evaluation identified a number of problems that minor revisions could fix. However, it also found that the game wasn't especially educational. While two-thirds of players could report something interesting they learned from the game, even players who appeared to understand the game had trouble choosing Evidence Cards that supported the hypothesis. Why did players have such trouble with this task in the pilot version, despite our revisions after earlier rounds of playtesting? We had two suspects:

- This task became more difficult when we moved from paper to digital cards, and when we added mini-cards in the digital game (necessary given the small size of phone screens). Each card appeared full-size (with a large image and complete text) when first collected, then shrank to a mini-card as it slid into the card array. Players had to tap each mini-card to enlarge it, which with seven cards onscreen became more cumbersome than with paper cards. This may have interfered with players' ability to scan and compare the card content in relation to the hypothesis.
- The exhibit environment likely distracted players from the game. This was to be expected, but ultimately we hoped it would be balanced by the presence of relevant exhibit content. However, because the evaluation was conducted in the *SpaceLink* exhibit rather than *Life Beyond Earth*, there was no related exhibit content to support the game content.

With less than two months before the exhibit opening, we drastically simplified the game design and completely redesigned the core tasks in the game. In the pilot version of the game, players collect seven cards and then choose the four cards that best support the hypothesis. In the revised game, players collect five cards, and upon collecting each card, make two decisions: 1) whether it matches the statement and then 2) whether to keep it in their two-card hand or drop it (see Figure 2).

Figure 2: Revised Game with two-part matching and choosing sequence

Finally, and most crucially, instead of requiring players to infer the relationship between cards and the hypothesis, we established a simple, obvious, one-to-one match between card topic and the statement (formerly "hypothesis"). This made the matching task (e.g. "Does this Evidence Card match the statement?") much easier for children, both in terms of understanding the task at hand and the most likely correct answer. But it was also a gamble: the matching task was now so simple that players might easily make their decision based only on keywords or card design, ignoring the scientific content on each card.

The Game Meets the Exhibit

The game was released on the Google and Apple app stores in early November 2012. Signs near the entrances to *Life Beyond Earth* encourage visitors to download the game to their mobile phone (using the musuem's free wi-fi signal) and play it as they explore the exhibit. After each round, their Astrobucks are added to their museum store coupon, which they can show (on their mobile device) to the store cashier to obtain their discount. Summative evaluation — in the actual *Life Beyond Earth* exhibit — was done a week after the exhibit opened (Flagg & Holland, 2013), employing a pre-post quasi-experimental study in which a sample of 24 9-11 year olds were interviewed prior to and after experiencing the game and exhibit as well as observed during their exposure to the game and exhibit. Three-quarters were girls, and 29% were African- and Asian-Americans. Each child was provided with an iPod Touch and instructed to "explore the exhibit as much as you want and use the game as much as you want and when you are done, we'll talk about your experience."

Do Children Play the Game?

Players most often completed four rounds of the game while in the exhibit, and two-thirds stayed in the exhibit for the 20 minutes allowed (see Figure 3) — though as invited visitors, they were likely to spend more time in an exhibit than an average visitor. All but one participant liked exploring the exhibit with the game. Half of the participants liked it "a lot" and about half liked it "somewhat."

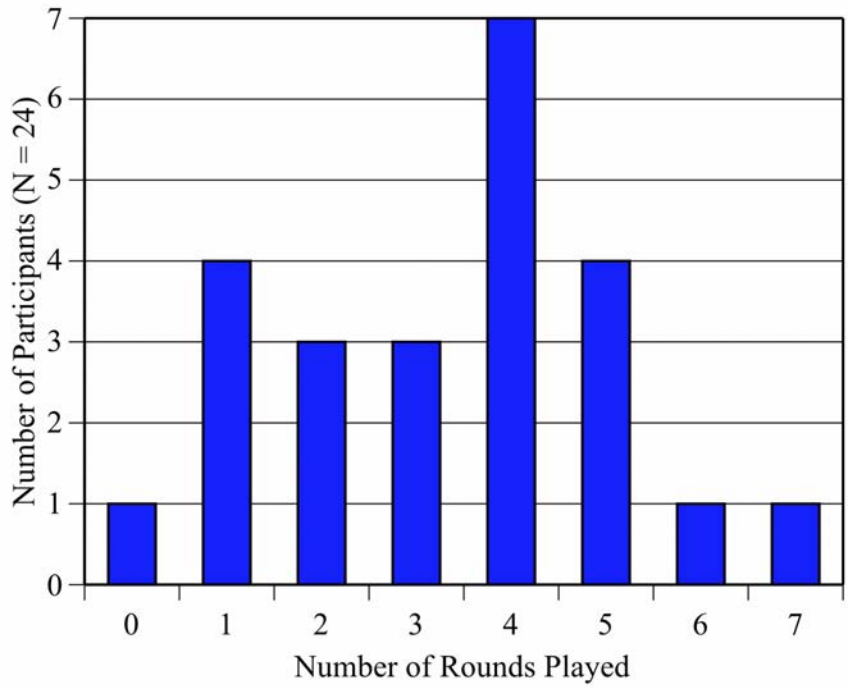

Figure 3: Rounds Played with PlanetMania Game

They exhibited a wide range of behaviors that fell into five patterns, defined by number of rounds played, scores, and interaction with the exhibit. A plurality (38%) of players drew on the exhibit to play the game but also explored the touchables and videos beyond what the game required; whereas 17% skimmed the exhibit with much less game-exhibit interaction. Some players (17%) focused only on the game, ignoring the exhibit; whereas others (13%) focused on the exhibit and ignored the game. Finally, 13% did not engage with the exhibit or the game.

A common concern about game apps in a museum setting is that young visitors will become immersed in the game and miss the museum exhibits themselves. *PlanetMania's* design encouraged interaction with the *Life Beyond Earth* exhibit via its keycodes and multiple-choice quizzes, which exposed players to most of the exhibit content. Three-quarters of our players interacted physically with one to six of the seven components.

Did the Gameplay Work?

The summative evaluation gave us our first look at the game in action in its proper environment, where we could finally see how all the elements worked together. Despite children's generally positive responses to the game, two-thirds of players reported difficulty at some point in playing the game. Most of these were usability issues which had a noticeable effect on player's experience, and we subsequently made minor modifications to address these issues. Of special concern: those players who did not understand a core task in the game – deciding whether or not each new card matched the Statement — usually reported that this matching task was 'hard' (29%). In contrast, the majority of players *did* understand that task and felt that it was 'just right' (58%) or 'easy' (13%) in terms of difficulty. Even so, a good number of players were unable to describe coherently their own matching process. Those who *could* reflect on their thinking revealed that the task is appropriate for this age group:

"I'd be looking at the picture and reading the statements and seeing if they are both alike and similar in a way. I was looking for key words in there and see if they match up."

"Life *as we know it" had a caterpillar picture and animals need the right kind of food, and that matched with the statement. It's a challenge but you can't learn unless you advance. Hard but a good challenge."*

Did the Game Enhance the Visit Experience?

Without a study that includes an exhibit-only control group, we cannot conclude that the game experience made a significant difference in visitors' learning outcomes, but our pre/post interviews reveal that almost all of the participants acquired some new or more sophisticated understanding about astrobiology. Moreover, children frequently specified the game as the source of their new knowledge. Table 1 shows players' increase in knowledge

on six questions related to exhibit and game content. Almost all (96%) participants acquired knowledge related to at least one interview question, 46% to two questions, and 13% of the participants demonstrated new knowledge for three of the six questions.

Open-ended questions before and after exposure to game and exhibit	Players with prior knowledge beforehand	Players who acquired new knowledge from game and exhibit
Why do scientists think there might be life beyond earth?	38%	17%
Describe some ways that astronomers can detect planets around stars other than our sun.	42%	33%
What do scientists look for when searching for life on other planets?	58%	38%
What kind of life do scientists think we might find on another planet?	13%	33%
What things do you think life needs to survive on other planets?	100%	0%
What are some extreme or strange places or environments on earth where you think life can be found?	54%	38%

Table 1. Percent of Participants with Knowledge Prior to Game/Exhibit Exposure and Knowledge Acquired from Game/Exhibit Exposure

A Platform to Build On?

PlanetMania successfully met its goal to make the *Life Beyond Earth* exhibit more accessible, engaging, and understandable for preteen visitors. Perhaps most notably, the game struck a good balance, as most players successfully split their attention between the game and the exhibit. This was the product of both intentional design and some luck, since we could not test this feature until the game was released. In retrospect, we learned less from paper prototyping than we realized at the time, due to the differences between the paper mockups and the digital game, along with the absence of the exhibit environment. This forced more drastic revisions after formative testing of the pilot game on iPod Touch, blunting the cost advantages of paper prototyping. In the future, we might move to digital earlier in the process and construct simple mockups of key exhibit panels to test the game in a more authentic environment. Revisions to the digital game are likely inevitable, so it's better to discover those sooner than later.

While the game was well-received, its reliance on text content and repetitive gameplay may limit its appeal. Of course, those elements are also what allow the core game platform to be repurposed for entirely different exhibits, simply by populating the game with different card content and questions. How easily could we repopulate it with new content on another topic — and would the gameplay work as well? The only way to truly answer these questions, of course, is to try it with another exhibit. Such an effort is now underway with an exhibit on electricity at MSC, scheduled to open in early 2014.

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