Martian Boneyards: Sustained Scientific Inquiry in a Social Digital Game

By

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A thesis submitted in conformity with the requirements for the degree of Doctor of Philosophy
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Abstract

Social digital gaming is an explosive phenomenon where youth and adults are engaged in inquiry for the sake of fun. The complexity of learning evidenced in social digital games is attracting the attention of educators. Martian Boneyards is a proof-of-concept game designed to study how a community of voluntary gamers can be enticed to engage in sustained, high-quality scientific inquiry. Science educators and game designers worked together to create an educational game with the polish and intrigue of a professional-level game, striving to attract a new audience to scientific inquiry. Martian Boneyards took place in the high-definition, massively multiplayer online environment, Blue Mars, where players spent an average of 30 hours in the game over the 4-month implementation period, with some exceeding 200 hours. Most of the players’ time was spent in scientific inquiry activities and about 30% of the players’ in-game interactions were in the analysis and theory-building phases of inquiry. Female players conducted most of the inquiry, in particular analysis and theory building. The quality of scientific inquiry processes, which included extensive information gathering by players, and the resulting content were judged to be very good by a team of independent scientists. This research suggests that a compelling storyline, a highly aesthetic environment, and the emergent social bonds among players and between players and the characters played by designers were all responsible for sustaining high quality inquiry among gamers in this free-choice
experience. The gaming environment developed for Martian Boneyards is seen as an evolving ecosystem with interactions among design, players’ activity, and players’ progress.
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There are so many who contribute to a work of love. My parents, brothers, and sisters-in-laws have always set such wonderful role models for me and have always given me the confidence I needed to set out on such a journey. David, my husband and my rock, is the gentle tailwind that keeps me moving forward on my path and the solid guiderails right there to catch me when I stumble. My children, Dane and Alison, give me the gift of their love and unique personalities while also leaving me alone to work without worry and guilt – every mother’s dream.

Many thanks to my advisor, Jim Hewitt, who helped shape my ideas into a research project and my committee (Erminia Pedretti, Clare Brett, and Richard Halverson) who provided insights along the way. This project would not have happened without the support of Dan Barstow, Frank Davis, Laurie Brennan, Ken Mayer, Anna Suarez, and Gerry Glaser, as well as the National Science Foundation’s Division of Research on Learning (DRL). In particular, Michael Haney has been very encouraging and supportive in our efforts to look at what learning environment may be years down the road.

Every ship needs a crew and I have the best, my fabulous team at EdGE: Teon Edwards, Jamie Larsen, Elizabeth Rowe, Elisabeth Sylvan, and Sherry Soares. Many of the ideas for the research in this dissertation also are the results of wonderful conversations with Johnny Fraser of Institute of Learning Innovation. Reed Knight and Herve Gomez are responsible for beauty of Arcadia and for my own fast-tack education on game design, as well as much of the fun we’ve all had along the way.
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For JJ CLEAT – the heart and soul of Martian Boneyards
Currently, far too many of America’s best and brightest young men and women go unrecognized and underdeveloped, and, thus, fail to reach their full potential. (National Science Board, 2010, p. 1)

While U.S. learners are becoming increasingly disengaged with formal and informal learning environments, nearly all youth and most adults are engaging more and more in Internet-based free-choice experiences (Ito et al., 2008; Lenhart, Purcell, Smith, & Zickhur, 2010). Free-choice Internet environments factor significantly into American youth and adult attitudes about science and their knowledge in science (Falk & Dierking, 2010).

The Educational Gaming Environments group (EdGE), a team of developers and researchers at TERC in Cambridge, MA,¹ is looking beyond today’s schools to envision learning environments up to a decade in the future. EdGE builds on a long history of research in learning sciences and STEM learning, and thinks ahead to new learning environments, informing formal and informal educators of what can be when learners re-engage in STEM learning on their own terms (Hulleman & Harackiewicz, 2009).

One booming environment that offers promise for STEM learning is collaborative Internet-based games. To explore the affordances of these digital games as learning

¹ TERC, formerly known as the Technical Education Research Center, is a not-for-profit research and development organization focusing on technology-based math and science education.
environments, EdGE has created a science center in *Arcadia*—a land of scientific inquiry and investigation in the new high-definition massively multi-player online environment (MMO) called *Blue Mars*.

The goal of *Arcadia* is to harness the time, energy, and enthusiasm in the growing gamer population and direct it toward free-choice scientific inquiry and knowledge building. EdGE investigators hypothesize that elements of players’ motivation and behaviors in games may be employed and directed towards productive scientific inquiry, and in turn, spark productive science learning within the community.

In an MMO, visitors create digital characters, or avatars, as their representations as they move around inside a virtually rendered world shared with many other avatars, sometimes from all over the world. MMOs are becoming a new venue for socializing, with many youth and adults (male and female) spending increasing amounts of time gaming, shopping, and meeting friends in these digital environments (Castronova, 2007; Gartner IT Consulting, 2008; Ito et al., 2008). MMOs are noted for their ability to create physical immersiveness that may contribute to participants’ connections and sense of presence with others, factors identified as important to online learning (Dalgarno & Lee, 2010; Garrison, Anderson, & Archer, 2000).

This dissertation reports on the design and implementation study of a prototype game called *Martian Boneyards* that took place in the *Arcadia Science Center*. *Martian Boneyards* ran for 4 months in summer 2010 during the open beta-test of the *Blue Mars* MMO. The game was a proof-of-concept to demonstrate whether or not (and how) a game could engage players in sustained collaborative scientific inquiry.

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2 With funding from the U.S. National Science Foundation (NSF/DRL/ISE#0917520).
This dissertation research focuses on the following components of the Martian Boneyards implementation study:

- Elements of game design and facilitation used by EdGE that were intended to foster collaborative scientific inquiry within Martian Boneyards
- The player community and their activities within the game
- The nature and quality of the community knowledge that resulted from the game.

The research uses netnographic methods (Kozinets, 2002), blending digital records with ethnographic methods such as surveys, participant observations, and interviews. The interpretation of the research considers how gaming environments can foster high-quality scientific inquiry, how they can be made sustainable, and how emergent identities in games may be useful in activating players’ science identities. The significance of this research is its attempt to support and study scientific inquiry in free-choice MMO games, an increasingly popular environment where people go to spend their time (Ito et al., 2008).

1.1 Outline of Dissertation

This first chapter outlines the goals and purpose of the research problem, the background of the researcher, and the limitations of the research. In addition, definitions and a reference list are provided of names of characters, players (pseudonyms), and designers who are described in the dissertation.

The second chapter contextualizes the research within relevant literature on learning and game design. That chapter describes the exploding phenomenon of gaming
as well as the possible opportunities this presents for education. Social games are framed as situated learning environments where players may become members of a type of community of practice in scientific inquiry.

Chapter three provides the reader with background on the design and implementation of *Martian Boneyards*. The process and criteria used for design and decision-making is described and a basic narrative of the game itself is provided. This is intended to give the reader a more thorough understanding of the design of the gaming environment and tools in order to provide a solid context for the research study.

The remaining chapters follow the more typical flow of a research dissertation. Chapter four explains the research design and methodology used in the *Martian Boneyards* implementation study. Chapter five provides results to the research questions and chapter six is a discussion of the implications of those results on future design of social digital games. Finally chapter seven is a summary and poses next steps for the development of games for scientific inquiry.

### 1.2 Goals and Purpose

The goal of this research is to study how EdGE attempted to support scientific inquiry within *Martian Boneyards* and how those efforts translated into players’ inquiry activities and knowledge building. Lessons learned from the study of this prototype game will provide guidance for the design of future EdGE games and is intended to inform other educational groups attempting to support and sustain scientific inquiry in free-choice MMO games.
This dissertation reports on a netnographic study of the design and implementation of the game, *Martian Boneyards*. The game was designed in nine months in 2009-2010 and implemented with early adopters of the *Blue Mars* environment (open beta-testers) during a four-month period in summer 2010. The research attempts to understand what design features and implementation strategies may support sustained scientific inquiry in the player community. The study addresses the following research questions:

- **Who came to play *Martian Boneyards*?** Who became involved in sustained scientific inquiry in the game?
- **What is the extent and quality of players’ scientific inquiry in *Martian Boneyards***?
- **What design elements and implementation strategies were seen to foster sustained scientific inquiry in *Martian Boneyards***?

This research uses a mixture of methods from ethnography and phenomenology to study interdependency of the gaming environment, players’ experiences, and their progress in the game. Various types of data sources including digital activity logs, user-generated artifacts, participant observations, surveys, and interviews are used to represent the distributed system of players, knowledge, and scientific tools and resources in *Arcadia* that made up the gaming environment. Together, this body of data paints a full and in-depth picture of the *Martian Boneyards* experience and the scientific inquiry that took place in the game. Armed with this information, EdGE and other educational game designers will understand the design and facilitation strategies used to harness the
potential of social digital games and be better prepared to employ the affordances for learning that gaming environments may offer.

This dissertation reports on the implementation study of Martian Boneyards that took place over four months with the beta-test audience of the new high definition MMO called Blue Mars. The research participants were all over 18 years old and came on their own accord to play the game within the MMO. There were over 600 entrants to the game, but this study focuses primarily on the 66 players who sustained inquiry in the game over the four-month period. Digital records of players’ activities within the game were combined with surveys, participant observations, interviews, and a scientific review of player-generated artifacts to provide a broad picture of the culture within the game and the experience of the game players in terms of scientific inquiry.

1.3 Statement of the Research Problem

With the phenomenon of digital games exploding in today’s society (Ito et al., 2008; Lenhart et al., 2010), it behooves the educational community to understand how this new venue can be exploited to foster productive scientific learning experiences. Many national reports and funding solicitations from educational agencies in the U.S. call for research into the affordances of gaming environments for learning (e.g., Johnson, Smith, Willis, Levine, & Haywood, 2011; National Science Foundation, 2008; NRC, 2011).

Digital games, especially social games, present interesting possibilities for science learning. The communal problem-solving activities that take place in some role-playing and social digital games have an intriguing overlap with practices of professional
scientists and also with elements of situated learning models. In games, players often work together as part of a community to solve (often domain-specific) problems with access to informational resources and tools necessary for each problem (McGonigal, 2011). Peer-review, collaboration, sharing and analysis of data, and evidence-based reasoning are occurring in many popular role-playing games (e.g., *World of Warcraft*) (Steinkeuhler & Duncan, 2008). These gaming activities are similar to the habits of practicing scientists in professional communities who share data and observations, challenge and confirm each others’ claims, and work together to build theories through a well-recognized and explicit peer-review system (Dunbar, 2000).

Gamers’ activities are also suggestive of situated learning models such as the community of practice model (Lave, 1988; Lave & Wenger, 1991). The community of practice model grows from situated learning theory, which suggests that knowledge, activity, and environments are inextricably entangled (Lave, 1988). In a community of practice, people work together on domain-specific activities using common habits, language, and cultural rules of engagement and developing an accompanying body of knowledge.

This socio-cultural point of view also posits that artifacts, tools, and environments serve as mediators that actively shape the knowledge and identity of others (Brown, Collins, & Duguid, 1989; Clancey, 1997; Lave & Wenger, 1991; Norman, 1993; Scardamalia and Bereiter, 1996). Vygotsky (1978) recognized the mediating effects of community and tools on learning and described a zone of proximal development (ZPD) that is the difference between what a learner can do individually and what s/he could do with assistance from others. Interestingly, a similar tenet of many game design models is
that tasks must be just outside the current grasp of a player—doable, yet challenging—and often requiring the assistance of other players and/or tools within the game (McGonigal, 2011).

The framework for the design of the Martian Boneyards prototype game, as well as this associated research, lies at this intersection of game design and science learning theory. EdGE created Martian Boneyards adhering to game design principles used in popular free choice-games, while also exploring the inherent affordances of the environment to support sustained, high-quality scientific inquiry in a gaming community.

EdGE designers hypothesized that an audience of free-choice gamers would engage in productive scientific inquiry (roughly at the level of an introductory undergraduate university science course) if those players felt that they needed to learn information and skills in order to solve a compelling mystery storyline taking place in a highly aesthetic and interactive MMO.

The scientific inquiry framed by EdGE designers draws from models of argumentation and knowledge building (Kuhn, 2005; Scardamalia & Bereiter, 1996; Toulmin, 1958). The inquiry tools built for the game are intended to support a process of inquiry that includes an exploration phase to generate questions and testable claims or hypotheses; a data-gathering phase where information is sought through observation, experimentation, or literature search; an analysis phase where evidence is generated from the data; and a theory-building phase where evidence is coordinated with scientific reasoning to substantiate, dismiss, or revise claims. Together this process is always building towards evidence-based, explanatory, and peer-reviewed theories. In online discussion environments in higher education and professional communities, researchers
found it difficult to observe the more intensive phases of inquiry analogous to analysis and theory building (Garrison & Cleveland-Innes, 2005). Steinkeuhler and Duncan (2008) found, however, that dedicated players of the MMO game, World of Warcraft, routinely gather data, organize them in spreadsheets, and develop explanatory models from their data to advance in the game, suggesting that either gaming environments may foster deeper levels of scientific inquiry and/or it may be easier to measure them in gaming environments.

EdGE explores the potential for sustained scientific inquiry in gaming environments by designing highly-crafted collaborative inquiry tools in a richly aesthetic environment. Employing a mystery storyline, EdGE designers facilitated the game by playing characters that helped play out the storyline and provide instructions to players on how to use the tools. The nature of the digital interactive inquiry tools and the roles designers played within the implementation of the game allowed for a unique in-depth research study that was highly integrated and iterative with the design and unfolding of the game. This dissertation is a product of that exciting opportunity.

1.4 Background of the Researcher

I am the director of EdGE and the Principal Investigator on the NSF grant that funded the design and research of Martian Boneyards. I have been a science curriculum developer (with some teacher professional development work and more recently research in online learning) at TERC for the past 18 years. I hold a B.S. in Applied Mathematical Sciences from Rochester Institute of Technology, an M.A. in Applied Math from Rice
University, and a M.S. in Physics (Astrophysics) from the University of New Mexico. Early in my career, I was a verification analyst on the Onboard Space Shuttle software for IBM (at NASA’s Johnson Space Center for missions 5-25). Later, I was a high-school Physics teacher at University High School (the lab school associated with University of Illinois). I had classes of less than 20, 99% college-bound kids who were highly talented (but not always in Physics), and my instructions were to do anything except use traditional methods to teach. I engaged my students in what I knew, which was scientific research. My teaching methods were participative and interactive from day one—I literally did not know how to teach any other way (having never taken an education course until starting this current Ph.D. program).

After my three years at my teaching post at University High School, I serendipitously discovered TERC when I moved to Cambridge, MA and found them in need of an innovative curriculum developer in Astronomy for the Hands-On Universe project for high-school students. I spent a decade learning and growing as a science educator while helping build that project and then moving on to several other curriculum development and teacher professional development projects over the years. Then, after working from 2003-2008 developing a comprehensive curriculum for high-school Astronomy classes, Investigating Astronomy, I needed a break.

I was getting burnt out from doing reform-based curriculum that was only going to see the desks of less than 5% of U.S. high-school students. The school system in the US seemed to be going downhill and decision-making in the system had nothing to do with best practices for learning. I did not feel my work was making a difference in an
increasingly broken educational system that was further crippled by a broken educational publishing business.

Meanwhile, I had been teaching online and researching online science courses for teachers and was starting to see that something was happening out there in cyberspace— a participatory revolution. I was fascinated by the sense of decentralization of knowledge and authority that could emerge in the land of Wikipedia and wisdom of crowds. In 2008, a company called Virtual Space Entertainment (VSE) came calling at TERC. It was developing content for a beautiful, new high-definition virtual world called *Blue Mars* and was looking for an educational partner. I checked it out and I was hooked. I gathered up the two most creative and passionate science educators I know, both of whom I also knew would happily jump blindly off this cliff with me. Together, we started EdGE at TERC and started writing proposals. This dissertation research is the result from the nice little ledge we found over that first cliff, where we sit, reflect, and prepare to jump again.

1.5 Limitations of the Research

Research about avatars playing a game in a virtual world is wrought with questions about how findings will translate to the real-world lives of the players. On the other hand, there are some who would argue that the distinction between real life and virtual worlds is diminishing and may one day not be meaningful (Castronova, 2007).

Turkle (2005) explains that identity and players’ sense of self, and what is salient to players, can change as they spend time in Internet-based social settings. Researchers must be careful to remember that characteristics of players, their activity, and their progress that are measured in the virtual game may or may not transfer into real-world
identity and behaviors.

Pearce (2009) notes that in avatar-based games, individual identity is particularly complex because it is both an inter-subjective and an emergent creation. In a game, a character can also become an extension of a player’s agency. In a role-playing game, individual identity is both mediated by the context of the group and emergent as the player “creates” an identity to exist in the game.

In early (textual) online environments, Turkle (1995) and Berman and Bruckman (2001) found evidence of people “trying on” new identities in online games and communities, later to enact the same behaviors in real life. EdGE researchers interviewed players by chat and asked about their real-life situations (profession, age, involvement in science). Very few participants agreed to this type of interview, likely because it interrupts the very fantasy that they came to Martian Boneyards to experience. Thus, this remains a limitation of this research. As virtual worlds increase in prevalence, the boundaries may blur and this will become less of an issue (Castronova, 2007), or researchers may need to provide greater incentives to entice this type of interview.

Another consideration unique to this particular game is that Martian Boneyards was developed and implemented within the open-beta version of Blue Mars. EdGE did not recruit outside Blue Mars since the platform was unstable and players who were not accustomed to the trials of an early adoption phase of software would have become frustrated. This means that the research sample may be skewed towards players who want to explore a new MMO environment and are motivated to work through faulty interfaces and crashes. The research findings should not be over-generalized as they may not necessarily apply to a broader user base.
Finally, some may say that a limitation of this research is the closeness of the relationship between the research and the design. The lead researcher and author was also the lead of the design team and principal investigator of the project. The research and design team worked very closely with the research, continuously informing the design. Many also might argue that this is a strength as it allowed the voice of the community (of which the designers were also immersed) to come through, as is vital in ethnographic studies (Cresswell, 2007), and allowed the design to be highly responsive to findings. This close relationship allowed researching unique insight into designers’ and players’ experience, but also might jeopardize the ability of the researchers to be objective about the design features and their success.

Some concern may also arise about the nature of the relationship between the author and the design team. The design team was interviewed by the author and their comments are used extensively throughout the study to provide a thorough perspective on the design and implementation process. The design team also either work at TERC under the direct supervision of the author or work on a contract awarded by the author’s grant, so there may be a perceived conflict of interest between the interviewer and interviewee. The interviewees were recruited on their own free will and actually volunteered to be interviewed, and it is the author’s strong impression that they were comfortable being completely candid about the project, but this remains a risk of the research.

Several measures were taken to provide a level of independence to the review. Two non-designer researchers (Elizabeth Rowe and Elisabeth Sylvan of TERC) visited the game during a participant observation session, reviewing the participant observers’ report afterwards. They also reviewed the research instruments and data analysis
throughout the study. In addition, a non-designer (Sherry Soares of TERC) conducted the interviews with players. Finally, a team of advisors, including Chris Dede (Harvard University), Brian Nelson (Arizona State University), and Diane Ketellhut (Temple University) helped guide the research and interpret the findings.

### 1.6 Definitions

EdGE and VSE designed the game *Martian Boneyards* that took place in the city of *Arcadia* in the MMO called *Blue Mars*.

**MMO** – An MMO is a massively multiplayer online environment that is shared simultaneously by many users via the Internet. Each user is represented by an avatar and users can interact using text, chat, and gestures (hugs, clapping, waving). The environment is rendered in real-time so each user’s screen is constantly updated to represent what everyone else sees. Users can see other avatars walking around and interacting with other users, and they can see any shared data immediately.

**Blue Mars** – *Blue Mars* is the high-definition MMO developed and operated by Avatar Reality, Inc. In summer 2010, it was in open-beta test with over 100,000 registered users. No active player numbers were released but informal estimates from the *Martian Boneyards* players were that a core group of 50-100 users was active in the *Blue Mars* environment regularly.

**Arcadia** – a “city” in *Blue Mars*, a region developed by EdGE and Virtual Space Entertainment to house the *Arcadia* Science Center and surrounding “Boneyards.”

**Martian Boneyards** – a prototype game run by EdGE in *Arcadia* for 4 months during summer 2010.
Participant Observer and Designer Characters – the designers played characters in the game of *Martian Boneyards*. While doing this, they also were observing and documenting their activities and the activities of the players. In this way, they were serving two roles—designer character and participant observer. Both terms are used throughout the thesis, changing to describe the role they were playing at the time.

### 1.7 Names and Characters

There are many names used throughout this dissertation report. Some are characters in the game of *Martian Boneyards*—some played by designers and some represented by skeletons in the Boneyards. There are also the names (pseudonyms) of the players who were observed and interviewed as part of the study. And finally, there are the real names of the designers who were interviewed and wrote the participant observation reports.

The characters in the game include:

- Laurel Laterne – An explorer played by Jodi Asbell-Clarke
- Tiaun – an explorer played by Teon Edwards
- Fischer Lawrence – an explorer played by Jamie Larsen
- Cameron – an anonymous donor played by Jamie Larsen
- Rusty Tropez – a previous settler played by Jamie Larsen
- Coyote – a lurker played by Jodi Asbell-Clarke
- Saxanne – a player played by Teon Edwards
- JJ Cleat – the female human skeleton buried in the Baobab tree
- Adam – the male Neanderthal skeleton found in the first cave
- Robin – the male human skeleton found at the base of the cliff in the cave.
The players interviewed include:

- Jespau – an adult female from England
- KalW – a 52-year old female from Pittsburgh, PA, a bus driver and mother of grown children
- EcoDude – an adult male from the U.S. who has an undergraduate degree in science.

The designers interviewed (and the authors of the participant observer reports) include:

- Jamie Larsen – a male science educator at TERC
- Teon Edwards – a female science educator at TERC
- Reed Knight – a male game designer at VSE.
“In the game world, the measure of a player’s success is complex and practical. Can you use your knowledge? Can you feed your people? Can you cure the patient? Can you beat Dan Snyder at his own football franchise?”

(Henry Kelly, President, Federation of American Scientists, 2006, p.13)

This dissertation is framed by an emerging set of literature that lies at the intersection of learning science, scientific inquiry, and game design. While this research in educational game design is still very young, there is much to be learned by work that has taken place in each of these disciplines and particularly by looking at the overlap of these different fields.

In the United States today, the education system must be transformed if it is to create a next generation of innovative thinkers (Collins & Halverson, 2009; U.S. Dept. of NRC, 2011; Labor, 2007). The current system—created with an industrial-age mentality with students being grouped by “date of manufacture” and pushed through a standardized training system—is failing to create innovators (Robinson, 2010).

This dissertation considers an entirely new type of learning venue where an increasing proportion of the general public is spending time: digital gaming environments. While there is much controversy about the value of games in everyday lives and concerns about the health and well being of a generation of digital natives (APA, 2010), it appears that gaming will be a major activity in many people’s lives for the
foreseeable future (Ito et al., 2008; Lenhart et al., 2010). The purpose of this research is to consider how the vast amount of time and energy that people spend in games might be directed towards productive scientific inquiry.

This study is motivated by the question on the minds of many educators: *What if the passion and blissful productivity that gamers experience while playing games were used to help improve the scientific literacy of the general population?*

To address this question, EdGE designed and implemented *Martian Boneyards*. This prototype game was designed to leverage the explosion of participatory online culture—a culture where the public uses online tools to participate in their transmedia storytelling experiences and knowledge building in social games (Anderson, 2010; Jenkins, Clinton, Purushatma, Robison, & Weigel, 2006). These are the communication tools with which our youth are growing up and the culture that will define the workplaces of tomorrow (Castronova, 2007, Gartner IT Consulting, 2007).

This dissertation reports on the implementation study of the prototype game called *Martian Boneyards*. Research questions focus on studying the audience who came to play their activities in the game related to scientific inquiry, the nature and quality of their scientific inquiry, and the design features that may be instrumental in supporting scientific inquiry in social digital games.

To lay the groundwork for this research, this literature review focuses on the importance of games as a social medium, their potential as situated learning environments, and how game design principles overlap with learning science theories on supporting scientific inquiry and identity.
2.1 The Explosion of Games in Today's Culture

There is plenty of evidence of how pervasive digital games are in our culture:

• Digital games are expected to be a $68 billion industry by 2012
• 69% of heads of households and 97% of youth play video games
• Of those who play video games, 40% are female and the average experience of players is 12 years
• Most gamers say they expect to play games for the rest of their lives.

(McGonigal, 2011, p.11)

There are different types of digital games, each with different affordances. Casual games resemble arcade video games and often involve repetitive short tasks that may promote rote learning but are unlikely to foster sustained inquiry. In contrast, social digital games often provide inherent community goals that bring people together to solve problems and build knowledge. In a social game, players can accomplish initial tasks alone, but as challenges get harder, players must work collaboratively for success.

Game designers refer to the state of complete immersion and engagement a player feels as “flow”—the feeling one gets when they are so involved in an activity that they lose all track of time (Csikszentmihalyi, 1990; Lemay, 2008). Flow is characterized by intense concentration, merging of action and awareness, loss of self-consciousness, altered sense of time, and the paradox of being both in control and pleasantly out of control at the same time. Lemay outlines the conditions for flow in games as a) clear goals, b) rapid and useful feedback, and c) challenging activity matched to a person’s skills.
This state of total immersion is also worrisome to many, particularly to the adults who did not growing up playing games. Though the American Psychological Association does not classify video games as addictive (APA, 2007), further studies on children in Singapore (Gentile et al., 2011), who spend more time playing games than their peers in the U.S., show addictive and pathological tendencies (e.g., depression). These concerns are disturbing and should be monitored. As such, the intent of EdGE is not to increase the population of gamers, but rather to leverage the hours that many gamers spend in social digital games and direct them towards productive science learning experiences.

### 2.2 Potential for Learning in Social Digital Games

A growing body of research is examining social digital gaming environments for their affordances for innovative ways of learning (Barab, Arcici, & Jackson, 2005; deFreitas, Rebolledo-Mendez, Liarokapis, Magoulas, & Poulouvassilis, 2010; Gee, 2003; Ketelhut, 2007; Lenhart et al., 2008; Steinkeuhler & Duncan, 2008). Social digital games may offer opportunities for learning workplace skills like collaborative problem-solving, multitasking, and working with simulations (Jenkins et al., 2006). Today, the practice of science—whether by professionals or learners—involves technological tools and social interaction mediated by technology (Partnership for 21st Century Skills, 2009). Learners need to be facile with evolving computational environments and those environments must foster innovation and collaboration where people generate, share, and critique work (NRC, 2011). They must be able to connect information and skills learned in different settings and contexts (Colardyn & Bjornavold, 2004; Jenkins et al., 2006).
The purpose of *Martian Boneyards* was to leverage the inquiry that gamers are seeking and to understand how to steer their inquiry towards meaningful science knowledge-building experiences. EdGE framed the design of *Martian Boneyards* to support communal knowledge building and collaborative scientific inquiry. This work builds on a long history of social learning models evolving toward a participative, community-centered model that drives the design and research of *Martian Boneyards*.

### 2.3 Social Models of Learning

Over the past half-century, popular learning models have passed from behaviorism to cognition and onto constructivism—shifting the focus from objective knowledge to knowledge that is contextualized within a set of learning tasks, as well as rooted in previous knowledge that the learner brings to the task. In the past few decades, social constructionist theories have begun to situate learning within a social context to examine ways in which the individual’s learning is mediated by their social environment and their interactions with other people. Situated learning theories often shift the focus from individual learning to a distributed learning network where knowledge building takes place across a community and its resources (Hutchins, 1990; Pea, 1996). Situated theorists also often make a shift from from an acquisition metaphor for learning to a participatory metaphor (Sfard, 1998).

Group cognition and team knowledge building have been studied in many different ways in many different types of professional communities in areas of organizational theory, management, and communications (Burke, Stagl, Salas, Pierce, &
Kendall, 2006; Salas, Rosen, Burke, Nicholson, & Howse, 2007). Some researchers posit that the group construction of mental models is a larger scale replica of individual cognitive development and thus individual and group learning are reflexive (Klimoski & Mohammed, 1994). In studies of mathematics education, Cobb and Yackel (1996) argue that neither individual nor social learning trumps one another—in fact, neither exists independently of the other.

Rather than distinguishing between individual and group learning, situative theorists claim that learning is always contextualized, and that knowing is subjective to a group-individual construction, not a truth that is otherwise defined or created (Barab & Duffy, 2000). They argue that knowledge does not reside in any one individual, but is rather a product of group construction. Greeno (1998) argued that the term “situated cognition” does not even make any sense because all cognition is situated. Bereiter (1997) agrees, suggesting that not only is learning situated within a group, so is knowledge itself.

Situative learning theorists reject traditional notions of knowledge being acquired by individuals in favor of viewing knowing as a process of participating with content within meaningful settings (Barab & Roth, 2006; Brown, Collins, & Duguid, 1989; Lave & Wenger, 1991). The principles behind the situated perspective of knowledge are that:

(a) knowing is an activity—not a thing;

(b) knowing is always contextualized—not abstract;

(c) knowing is reciprocally constructed in the individual—environment interaction—not objectively defined or subjectively created; and

(d) knowing is a functional stance on the interaction—not a “truth.” (Barab & Duffy, 2000).
Scardamalia and Bereiter (1996) make a distinction between knowledge building and learning, saying that knowledge building occurs where there is interaction among participants in which theories are crafted, challenged, tested, revised, and then lead to new questions and theories. In contrast, learning is about figuring out how to do things—how to accomplish tasks. Learning can be an individual process, while knowledge building is inherently a group activity. In a knowledge-building community, individual understanding is driven forward by a dual need—to understand the knowledge of others and to advance the knowledge of the group. This is very similar to the activities and purpose of a community of professional scientists. Its work is highly collaborative with teams of scientists’ sharing and reviewing each other’s work using a well-established set of cultural norms, terminology, and evaluative criteria and standards (Dunbar, 2000).

The social nature of learning is also apparent in the shaping of practices and behaviors of a community. Gee (2008, p. 23) explains that: “social groups exist to induct newcomers into distinctive experiences, and ways of interpreting and using those experiences, for achieving goals and solving problems.”

The design and research of Martian Boneyards are framed by this view of inextricably linked communal and individual learning experiences. This research examines the knowledge demonstrated by the products generated by the player community through their inquiry activities. Although individual learning outcomes are not measured in this study, it is presumed that individuals’ learning is not only reflexive of the community knowledge, but also responsible for it.
2.4 Situated Learning and Communities of Practice

The Martian Boneyards game, and the land of Arcadia in which Martian Boneyards takes place, create a learning environment that is intended to support community-based learning through collaborative scientific inquiry. There have been many models stemming from situated and distributed learning theories that inform the design of Martian Boneyards. The most relevant model to the framework for this research is a community of practice model (Barab & Roth, 2006; Lave, 1988; Lave & Wenger, 1991).

In a community of practice, learning is considered the result of organized, goal-directed, social activity. Lave (1997) referred to situated social practice, where there are no boundaries between the individual and the world. She describes knowledge and knowing as relations among people and their activity in a socially and culturally structured world.

Barab and Roth (2006) note that there are no clear boundaries between the development of knowledgeable skills and the development of identities, stating that both are emergent and core to the community of practice. Members of a community of practice may find appropriate roles and opportunity to participate in the community, regardless of their expertise in the domain of practice. Novices may adopt roles and participate in activities within the community that are valid and important to the task at hand, but not requiring high expertise in a given area. The learner’s identity within the community evolves as s/he acquires a different status, role, and responsibility within the community.
The idea of experts and novices can become muddled in a formal learning experience, particularly, for example, in a science class where the teacher may be closer to the students on the novice-expert continuum than to professional scientists. In contrast to teacher-centered models found in many formal learning institutions, most social constructivist learning models shift would consider the teacher as a member of the learning community. This transition from an acquisition metaphor to a participation metaphor requires careful scaffolding (Sfard, 1998).

Barab and Duffy (2000) introduce the notion of practice fields to describe environments created for the purpose of students coming together as novices to prepare in authentic, but separate, environments for the kinds of activities they will encounter outside the learning environment (Senge, 1994). In sports, practice fields are used for training for competition—they are where athletes can take risks, make mistakes, and hone skills. Using this analogy, one can consider a cognitive practice field where learners try new ideas and revise their thinking as they understand how their ideas fit with the collective wisdom of the community.

Barab and Duffy (2000) outline the following requirements for productive practice fields:

- *Ownership of the Inquiry* – The work must be directed by the learner
- *Coaching and Modeling of Thinking Skills* – The learning is often scaffolded to help the learner reach autonomous inquiry
- *Opportunity for Reflection* – The learner is prompted to reflect on what they are doing and why
• **Dilemmas are Ill-Structured** – The problems must leave room for creativity and innovation

• **Support the Learner Rather than Simplify the Dilemma** – The environment provides scaffolds that help players work within their ZPD

• **Work is Collaborative and Social** – The community serves to scaffold and motivate work

• **The Learning Context is Motivating** – The storyline must keep players engaged to sustain their inquiry.

Many of these principles are highly aligned with principles of game design. In fact, it seems that game designers have inherently adopted many of the principles learning scientists have been advocating for decades (Halverson, 2011). This serendipitous overlap has sparked a robust emergent field of research in games as learning environments.

### 2.5 Games as Practice Fields

Games may provide a unique opportunity to create practice fields among novices within a scientific domain (Barab & Roth, 2006). In a social game, as in a community of practice, people work together in a domain or context-based investigation. The problems and storyline may be initiated by game designers, but they have the potential to be very player-driven with ongoing open-ended inquiry triggering new investigations. In fact, the game industry is turning more and more to games without instructions, relying on users to figure nearly everything out on their own (McGonigal, 2011).
In his argument about how games make good learning spaces, Gee (2008) outlines features of useful learning environments. To promote and prepare learners for future problem solving, he argues that learning experiences should:

- Be structured by specific goals.
- Be interpreted by thinking—in action and after action—about how goals relate to the situation.
- Provide immediate feedback on where their expectations have failed.
- Provide ample opportunities to apply their previous experiences—as interpreted—to similar new situations.
- Enable learners to learn from the interpreted experiences and explanations of other people, including both peers and more expert people.

Games fit each of these characteristics inherently. McGonigal (2011) defines a game as having four fundamental traits: a) a goal, b) rules, c) a feedback system, and d) voluntary participation. These traits overlap considerably with Gee’s characteristics of learning environments.

Gaming communities often establish common habits, language, and cultural rules of engagement. When these practices are carefully crafted together with content learning goals, designers can create what Barab and colleagues call conceptual play spaces (Barab, Warren, & Ingram-Goble, 2006). They explain that game play can immerse players in rich networks of interactions and unfolding storylines embedding problem-solving and reflective activities. Gee also emphasizes this role of reflection with a community in learning:

Debriefing after an experience—that is, talking about why and how
things worked in the accomplishment of goals—is important. Mentoring is best done through dialogue, modeling, worked examples, and certain forms of overt instruction, often “just in time” (when the learner can use it) or “on demand” (when the learner is ready). (Gee, 2008, p. 22)

Within a gaming community, players take on tasks appropriate to their experience, tasks within players’ zones of proximal development (Vygotsky, 1978), and get increasingly more difficult tasks (or tasks with reduced scaffolding) as their expertise grows. Barab and Roth (2006) use the construct of affordance networks to describe how sets of perceptual and cognitive affordances in an environment can collectively form a network that scaffolds particular goal sets. Designers must build systems that utilize this network of resources, tools, and community to support players’ achievement of those goals. A good social game always has a new task to be accomplished and a group of people to help.

In a good computer or video game you’re always playing on the very edge of your skill level, always on the brink of falling off. When you do fall off, you feel the urge to climb back on. That’s because there is virtually nothing as engaging as this state of working at the very limits of your ability. (McGonigal, 2011, p. 24)

Shaffer, Squire, Halverson and Gee (2005) suggest that the educational value of games is due, in part, to their motivational aspects as well as the holistic and natural endeavor of problem solving that takes place. Players may be motivated by the
advancement structure of a game (e.g., leveling up), but a well crafted the game can also engage the players in content learning that is self-motivated. This situated need to make sense of the inquiry may help conceptual understandings. Barab and colleagues suggest that this type of conceptual play involves:

- Players’ projection into the role of their characters in the game
- Partially fantastical problem contexts
- The application of conceptual understandings to make sense of the game
- Opportunities for players to observe their own impact in the game.

Design research projects such as Harvard University’s *River City* (Ketelhut, 2007) and Indiana University-Bloomington’s *Quest Atlantis* (Barab, Thomas, Didge, Carteaux, & Tuzun, 2005; Barab, Sadler, Heisett, Hickey, & Zuicker, 2007; Barab et al., 2008) have used situated social gaming with an educational goal to support classroom learning. By using gaming environments as supplements to curriculum in formal educational settings, these projects show one type of example of using games for use in formal learning environments.

*Quest Atlantis* is embeds a framework for transformational play within a learning environment designed for middle-school classrooms. Students are immersed in storylines focusing on social commitment. Barab and the *Quest Atlantis* design team define transformational play as follows:

Students who play transformationally become protagonists who use the knowledge, skills, and concepts of the educational content to first make
sense of a situation and then make choices that actually transform the play
space and the player. (*Quest Atlantis* website,
http://atlantis.crlt.indiana.edu/site/view/Researchers)

In another game developed for formal learning environments, *River City* (Galas & Ketelhut, 2006, Ketelhut, 2007), middle-school students collaborate with classmates to solve problems critical to the health of a community in a possible medical crisis. Researchers use variants on the instructional design including a guided social constructivist intervention in *River City*. They use virtual and physical lab notebooks and in-class interpretive session with a situated pedagogy based on expert modeling and coaching in which students interact with expert avatars (played by college science majors) and computer-based agents embedded in the virtual environment. *River City* has proven successful in engaging traditionally underserved students, though measures of achievement varied depending on the assessment method used (Ketelhut, Nelson, Clarke, & Dede, 2010). The *River City* project has evolved into EcoMUVE (an ecology oriented multi-user virtual environment) where non-player characters (NPCs) guide students through quests with data collection and problem-solving (Metcalf, 2011). The inquiry is highly structured and the answers are provided by the NPCs on a need-to-know basis.

These two projects have made major strides in understanding game usage in formal learning environments. Recent research also suggests, however, that science learning and educational achievement may be predicted by out-of-school time experiences as much or more than in-school learning (Falk & Dierking, 2010). More and more Americans are using the Internet as a primary source for science information (ibid).
People are increasingly seeking “hard fun” activities on the Internet—activities that are fun because they are hard rather than in spite of being hard, (Papert, 2002). They are willing to invest tremendous amounts of their personal time in communities of collaborative inquiry (McGonigal, 2011; Steinkeuhler & Duncan, 2008).

One intriguing form of public inquiry on the Internet is alternate reality games (ARGs), where the game is based in the real world and occurs in real time, but the narrative is fictionalized. In an ARG, the initial narrative is written by game designers but often the storyline and content are mutually expanded over time by the designers and players. These games, like McGonigal’s I Love Bees, have engaged hundreds of thousands of players in knowledge building—gathering and analyzing data to create claims and predictions about fictional or real-world phenomena (McGonigal, 2007). In 2007, over 1800 players came together online for a month in 2007 to play out and document a fictional oil crisis in World Without Oil (McGonigal, 2011). Together, they lived out and documented a fictional oil crisis and some report to have transformed their real lives as a result. McGonigal claims that the reason that they all came to participate is:

By turning a real problem into a voluntary obstacle, we activated more genuine interest, curiosity, motivation, effort, and optimism than we would have otherwise. We can change our real-life behaviors in the context of a fictional game precisely because there isn’t any negative pressure surrounding the decision to change.

(McGonigal, 2011, p. 311)
2.6 Designing Gaming Environments for Scientific Inquiry

EdGE is particularly interested in research about scientific inquiry that takes place in these free-choice digital gaming environments. The most popular public gaming environment is the MMO role-playing game, *World of Warcraft (WoW)*. Researchers estimate that nearly 6 million years of people’s time have already been spent playing *WoW* (McGonigal, 2011, p. 52). Researchers have also found that within this remarkably large and popular online community, there is evidence of scientific inquiry that is aligned with AAAS standards for scientific inquiry (Steinkeuhler & Duncan, 2008). There is also early evidence that the strategic knowledge developed in an alternate reality game can transfer to real-world knowledge (Haring, 2010).

In *WoW*, players work in guilds combining talents and powers for successful raids and battles. *WoW* was designed for entertainment but has spawned spontaneous scientific behaviors within its community (Steinkeuhler & Duncan, 2008). Researchers found that it is not unusual for players to gather data in spreadsheets, create models of the data in the form of simple mathematical equations, and then argue about whose model was “better” in terms of prediction and explanatory scope. Users from all backgrounds work together to build situated understandings of important phenomena (physical laws, for example) that are embedded in the virtual world.

Gee (2008) notes that digital games are designed to set up certain goals for players, but often leave players free to achieve these goals in many ways within the rule-space designed into the game. Many game design features are also good structures for social learning. Battles and quests provide instantaneous feedback to players on their progress. In many games players must share knowledge with others to succeed.
Advancements structures (leveling up) allow players lots of practice applying what they have learned earlier both in similar situations (within a level) and in somewhat less similar situations (across levels).

Games also present a new type of relationship or control structure between learners and teachers (or designers). As Lock (1990) points out there are two dimensions of learner-teacher control, one along the outcomes or conclusions anticipated and one along the nature of activities that take place in the learning environment. While game designers direct much of the activity, providing tools and environment that guide what types of activities go on in the game, the outcomes and knowledge are often determined by the players.

This design recognizes the participatory revolution prompted by today’s social media (Castronova, 2007). In educational gaming environments, there is a shift from designed learning tasks to choreographed learning experiences as a whole, mediated by structured and semi-structured social interactions (deFreitas et al., 2010). Designers can prepare the initial framework, scaffolds, and even storyline for the environment but at some point the activity becomes dictated by the player community as much as the designers.

In Martian Boneyards, EdGE has used the initial storyline and tool design to choreograph and support a community of scientific inquiry. The goal of the designers was to reach an audience who may not typically be involved in science and to use the gaming environment to improve the players’ scientific literacy. This literacy includes using information available to them (e.g. on the Internet) to make evidence-based decisions about a problem presented to them or that they choose to solve. Many reports and
researchers in the past two decades have recommended that scientific literacy comes from science learning that is situated in authentic scientific inquiry (American Association for the Advancement of Science, 2003, 2009; NRC, 1996). Science content learning is not separate from practices of science and can be mediated by the environment and activities through which it is taught.

Several design research projects have explored how to scaffold knowledge building and integration through inquiry in different types of text-based online environments (e.g., Hewitt & Scardamalia, 1998; Hsi, 1997). These environments typically used prompts, from an instructor or designed interface, which are intended to generate and scaffold interactions among participants. The prompts often try to focus learners on making mental models visible to the group and how the group members co-construct knowledge from the evaluation and revision of those models.

The Community of Inquiry (CoI) model (Garrison et al., 2000) used a measure of cognitive presence for content analyses of inquiry in online discussions, building upon the work of Gunawardena, Lowe, and Anderson (1997) and Henri (1991)—describing the extent to which the participants in any particular configuration of a community of inquiry are able to construct meaning through sustained communication. The cognitive presence construct used by Garrison (2003) in online social science and business undergraduate courses examined a four-phase model of inquiry: triggering, exploration, synthesis, and resolution. Garrison and Cleveland-Innes (2005) found that online discourse they studied showed a dearth of activity in the latter two phases, synthesis and resolution.

Models of scientific inquiry (Harlen, 2005; Kuhn, 1993; McNeill & Krajcik, 2007) describe communities of learners building knowledge together through the
challenging, testing, and revising ideas in light of new evidence. In a community of scientific inquiry, discourse or scientific discussions play a key role (Lemke, 1990). Many models of scientific discourse are rooted in a theory of argumentation from Toulmin (1958) that centers on claims, data or evidence, and warrants that are principles we hold to be true.

Kuhn (2005) describes argumentation as the coordination of theory and evidence, which scientists carry out with conscious control and explicit and consistent criteria. In developing understanding, learners must also test ideas against evidence and continuously revise theories (Harlen, 2006). A learner engaged in the models of inquiry described by Kuhn and others will begin with a claim or prediction about objects and phenomena. These claims lead to causal explanations, and ultimately, an explanatory system that may involve multiple factors about why a claim is correct or incorrect. This process is inherently collaborative as players must compare and contrast their claims and evidence with those of others to advance knowledge within the community.

Models of scientific inquiry often describe an engagement or exploration phase that generates questions and hypotheses, which invoke the need for data collection. Analyses of these data lead to the identification of evidence upon which hypotheses can be tested, challenged, revised, and eventually may evolve into theories. This is all done in an iterative and collaborative fashion, incorporating the findings of others and undergoing ongoing peer review—as is typical in professional science communities (Dunbar, 2000).

One question that arises when considering scientific inquiry in educational settings is the extent to which the inquiry is guided by the teacher or left open to the learner. This can be described as the extent to which the teacher chooses a problem or
poses the questions to the learners and/or how much instruction and information the teacher provides during inquiry process (Lock, 1990).

In *Martian Boneyards*, EdGE has used a framework for inquiry that poses a broad question for players, provides intuitive tools that prompt for evidence-based inquiry, and leaves the players open on how to solve that question. The inquiry tools were modeled on four phases—exploration, data gathering, analysis, and theory building—but these phases are not necessarily sequential or linear. Some individual players may remain in the exploration or data-gathering phase, but the community as whole must progress to the analysis and theory-building phases to have sustained inquiry in the community, where evidence-based reasoning is used to find solutions and make decisions. In the case of *Martian Boneyards*, the community’s scientific reasoning is used to find a solution to the mystery presented in the alternate reality game storyline.

This research examines how well the tools and environment that EdGE designed for *Martian Boneyards* supported collaborative scientific inquiry. In particular, the research looks to see if the tools helped players move to analysis and theory-building phases, those that were underrepresented in research using the CoI model (Garrison & Cleveland-Innes, 2005). The quality of science knowledge demonstrated in the artifacts generated by the players is also used to study the effect of the inquiry tools.

### 2.7 Fostering Identity in Social Games

Social digital games may offer potential for fostering innovation and knowledge-building skills with a broad audience (Gee, 2003; Klopfer, Osterweil, & Salen, 2009), many of whom are not involved in science in their daily lives (Ketellut, 2007). Gee
(2003, 2004) argues that in game playing, people model how they need to learn and this is in stark contrast to the way learning activities are implemented in traditional learning environments. Gamers are found to construct new roles and identities (Gee, 2003; Steinkuehler & Williams, 2006) as they engage in collaborative problem solving (Steinkuehler & Chmiel, 2006) and systemic thinking (Squire, 2003).

Learners’ sense of identity and science self-efficacy are often overlooked indicators of people’s willingness to participate in furthering their science skills and knowledge (Carlone & Johnson, 2007; Carlone et al., 2008) and may be particularly important factors to consider for typically excluded members in science, such as girls or minorities (Brickhouse, Schultz, & Lowery, 2000; Brickhouse & Potter, 2001).

Identity has several definitions. Psychologists refer to identity in terms of self-image and a person’s conception of the self, based on physical perception, information they receive from others, and how they anticipate their actions will impact others (Baumeister, 1998). Anthropologically, identity is a representation of one’s self in context of belonging to a cultural group (class or ethnicity). Social psychologists see identity as non-static with people having different identities dependent on the context (McAdams, 1997). A social psychological approach may also see science identity as an emergent understanding of the self based on the experience of success working or involved in science-based activities (Fraser, 2009).

Identity can be seen as an emergent understanding of the self, based on the experience of success working or involved in a particular area. Science identity is developed not only by seeing one’s self as a science person, but also in having one’s performance and contributions recognized by a community (Fraser & Ward, 2009). Lee
and Roth (2010) argue that relationships at the community level are important mediators of scientific activity and identity. To date, science learners’ habits have been shaped largely by formal learning environments and thus may have been stifled as compared to their potential in free-choice learning environments (Falk & Dierking, 2010).

Pearce (2009) notes that in avatar-based games, individual identity is particularly complex because it is both an inter-subjective and an emergent creation. In a game, a character can also become an extension of a player’s agency. In early (textual) online environments, Turkle (1995) and Berman and Bruckman (2001) found evidence of people “trying on” new identities in online games and communities, later to enact the same behaviors in real life. Pearce (2009) suggests that some players emerge as leaders and creators through this process of improvised emergent identity formation, and many discovered and developed new talents and abilities as a result. Furthermore, when motivated and supported by group cohesion, these identities can be portable and malleable over time, and lead to a high level of productivity (Pearce, 2005; Poremba, 2003).

Pearce (2009) warns, however, that much of this potential lies in the interface design because relationships and identities are driven by the expressive mechanisms and presence allowable by the environment. deFreitas et al. (2010) also note that the strengths of the social virtual world need to be better reflected in learning design strategies and they call for attention to social interactions and pedagogic models designed to support more socially focused activities in learning environments.

In particular, three-dimensional, avatar-based gaming environments have been shown to be important for supporting immersion in the performance of tasks, as well as
for supporting deep levels of communication, collaboration, and relationship building (deFreitas, 2006; deFreitas & Griffiths, 2008). Dalgarno and Lee (2010) take the view that the constructs of presence and co-presence are key to construction of identity in gaming environments. They argue that representational fidelity (how much the avatar and environment resemble reality) and the intuitiveness and immediacy of learner interactions within the environment are scaffolds for presence. Presence can also describe what many game designers now refer to as flow—an optimal state of playing exclusively for the sake of the game.

2.8 Building Upon the Literature

EdGE designers built on this body of literature to design a gaming environment that is aesthetically compelling, realistic, and immersive using tools that support an explicit model of community-based scientific inquiry. The tools used in Martian Boneyards are designed to foster community knowledge building modeled after well-established theories relating to scientific inquiry such as argumentation and knowledge building. The game elements encourage peer review and evidence-based reasoning, established best practices in professional scientific communities. EdGE designers used these game elements and facilitation techniques to foster high-quality scientific inquiry within the Martian Boneyards community.
Chapter 3: Design and Implementation of Martian Boneyards

EdGE designers designed *Martian Boneyards* as a prototype game to study how a cutting-edge environment could be used to get players involved in high quality scientific inquiry. This chapter outlines the design decisions and constraints that shaped the project, and thus laid a context to the research.

### 3.1 Designing for a Gaming Audience

In an attempt to build a gaming environment that would entice gamers to games of scientific intrigue and mystery, EdGE developers created the land of *Arcadia* in the MMO, *Blue Mars* (see Figure 1). *Arcadia* is a city\(^3\) in *Blue Mars* that contains an abandoned Science Center and extensive grounds around the Center. *Martian Boneyards* is a prototype game with a mystery storyline that takes place in *Arcadia*.

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\(^3\) Each region rented and developed on *Blue Mars* is called a city. *Arcadia* is a city and has its own entry point on the *Blue Mars* launch page. All *Martian Boneyards* activity happened within the city, *Arcadia*. 

Figure 1. The land of *Arcadia* in *Blue Mars*
**Martian Boneyards** was designed to attract the early adopter MMO audience who were already interested beta-testing the *Blue Mars* environment. EdGE designers are not seeking to make more gamers in the world, but rather to provide productive scientific inquiry to those gamers who are out there seeking “hard fun” (Papert, 2002).

Gamers are attracted to a compelling and coherent storyline, a reward system for advancement, and a highly engaging interface (Rollings & Morris, 2004). A mistake many educational games make is not using the polish required by a savvy gaming audience (Isbister, Flanagan, & Hash, 2010).

EdGE designed **Martian Boneyards** with a team of expert game designers from VSE, developers who were already established in *Blue Mars*. VSE had a team of designers, programmers, artists, and engineers—some of whom had come from LucasArt, Industrial Light and Magic, and other Hollywood-caliber production and gaming studios. VSE had already developed another prototype city on *Blue Mars* that was often featured in the early press releases for *Blue Mars* and was credited with showing the full potential of the graphical capabilities of the MMO. This was clearly acknowledged when *Blue Mars* beta-testers came to Arcadia. Players remarked that they could identify the work as being from VSE, recognizing its talent in development.

### 3.2 Designing for Scientific Inquiry

The designers had to make many design decisions because of relatively limited resources and the limitations of development in the beta-test *Blue Mars* environment. Designers focused their priorities on crafting tools to support evidence-based reasoning and providing compelling and accurate scientific artifacts to stimulate inquiry. They used
the default *Blue Mars* tools as the vehicles for inexpensive and flexible game facilitation. The designers were left feeling that they did the best they could with what they had, but knew there were many opportunities to exploit with more funding.

The *Arcadia* environment and the embedded tools were designed to scaffold sustained collaborative scientific inquiry, building upon a model of argumentation and coordination of evidence and theory (Kuhn, 2005; Toulmin, 1958). The tools and resources naturally fit a theoretical framework with three categories of scientific inquiry: data gathering, analysis, and theory-building.

Very early in the design process, the team agreed to provide players with a Personal Digital Assistant (PDA) for data-gathering. Players could click on an artifact with the PDA to capture an image (see Figure 2). This would simulate finding and cataloging an artifact and allow the player to bring it back to a lab for further study. The designers originally envisioned that players would be able to find artifacts and mark their location similar to how a scientist would in a real-world anthropological dig (possibly with flags or GPS coordinates on a map displayed in a Map Room back in the Science Center).

*Figure 2.* Screenshots of a player using the PDA to scan
Designers also imagined that players would be able to pick up the bones (or at least copies) and take them back to a lab area in the Science Center for analysis. The design for the analysis workstation included tools to:

- Sort all artifacts scanned by the player
- See two views of a bone (one view in some cases)
- Take and record two linear measurements (say length and width) for each view
- Calculate averages for a measurement
- Compare and sort communal artifacts.

The type of measurements used in the averaging tool was deliberately left open to see if the community would negotiate ways of measurement, realizing the need for standardization to make sense of the averaging.

A theory-building board was designed for players to post claims about what they found in the Boneyards and how it got there. It was intended to allow players to add, edit, and publish their theories and comment on others’ claims. It was envisioned that each claim would require evidence from the analysis workstation. A player could include an image of an artifact and then describe the tagging or measurements as evidence to substantiate their claim. Other players could comment on the claim, adding their own evidence to counter or confirm the original posting. There was also to be a peer-review area, where after an author felt the claim was ready to publish, the community could rate the claim (see Figure 3).
Figure 3. Theory-Building Tool in the Science Center

The theory-building board was originally envisioned to have the following capabilities:

- **Claim List** – This is the summary format for all the claims, including: Creation date, Title, Creator, Date of last update, Name of last updater
- **Add New Claim Button** – Allows players to add and edit claims.
- **Sort Options** – A drop-down box allows the player to choose from the following sort options: Creation Date, Status (Peer Review, Published), Title, Creator, Name of most recent commenter, and Most recently updated
- **Reverse Sort Direction** – A checkbox let the players reverse the direction of their current Sort method
- **Filters** – A series of check boxes that allows the player to filter data according to the following criteria: Created by me, Commented by me in last 24 hours, Commented by me in last 7 days, Based on artifact I have scanned, Based on
theory I have posted, Highly contested, My vote differs from majority, and
Marked as favorite

- **Text Search** – Enter text to view only theories with text that included Checkboxes for Title, Body, Comments

- **Help** – Displays a separate help screen.

The financial limitations once again scaled back development substantially. The final design had dropped many of the sorting options and all of the filters.

### 3.3 The Design Process

An essential part of the design process was its collaborative nature. The communication about the design process that occurred between EdGE and VSE was very fluid and tightly knit. The process was initiated with a 3-day design meeting with the entire team. The three EdGE designers (including myself, Teon Edwards, and Jamie Larsen) met with the production manager of VSE, Hervé Gomez and the game designer, Reed Knight, along with his team of artists and programmers. This team of five spent a total of 10 working days together in person and held phone/Skype meetings at least once weekly during the one-year design and implementation period.

Hervé kept track of the production process and was the conduit of information to the VSE team from the EdGE/VSE team. Along with Hervé, Reed worked closely with EdGE throughout the entire process to create the storyline, scientific assets that were artifacts in the game, and the player interfaces for the tools.
The format of the in-person meetings was informal and creative. Goals were set for the end of the meeting with a general breakdown of topics to be covered. The design and creativity was freeform with emphasis on possibilities and direction, as opposed to the “nuts and bolts” of how to build each tool, which was left for the phone meetings. Reed explained:

When we got together we were an amazingly good team – we were all over the map but we could also synchronize.

Teon, an educator from EdGE, says the leap of faith that she had to take in the design process was profound but well warranted. Because she felt out of her realm of expertise in game design, she had to rely on VSE to take her pedagogical ideas and turn them into something beautiful, engaging, and compelling. She says:

Early concept art and VSE’s previous work in Blue Mars made that leap of faith very easy. Each time I saw what they had produced, it always exceeded my expectations.

Because the game was in an MMO, the design process felt much more liberating to Reed, as compared to commercial games he had developed before. He says:

In a virtual world you can try anything and it will be successful for a small slice of people out there in a virtual world.
Reed also describes the design process for Martian Boneyards as very different from his past experience as a game designer. Not only was the Martian Boneyards team smaller, but working at a distance (with VSE in California and EdGE on the east coast of the U.S. and Canada) was also new for him. Reed also notes:

> Working on a game about social good and improving education feels very different than building games to make money. I enjoy working towards a larger goal of building a community’s understanding of how science is done, and feels it is more rewarding than designing game for personal achievement.

Within two months of the start of the project EdGE and VSE had created a design document that included the game storyline, requirements for each of the tools, a player “walk through” of the game experience, and decisions about the reward system. This document evolved and became more defined over the development period, but its structure served as the basis of the contract between EdGE and VSE on what was to be developed (see Appendix 3 for design documents).

### 3.4 Tensions and Balancing Objectives

EdGE and VSE designers worked carefully and thoughtfully together, recognizing the tension between compelling game play and effectively scaffolding rich scientific inquiry. Often tool design started going too far down the road of leading the player into a guided experience that might make it feel too structured or have too much with text-based
instruction. With five people in the design, at least one would always lead the group back to the goal of open-ended inquiry that would appeal to gamers, reminding the team to resist putting in too much overt structure or “cookbook” experiences. The design team often had to trust that the players would work things out without explicit instructions, but they were ready to fill in with facilitation methods if players needed help.

The team prioritized the development funds towards aesthetics in the environment, the quality of the scientific assets, and functionality of the inquiry tools. The game lacked a front-end introduction of the game or tutorials of any kind on how to use the tools. This was beneficial in many ways, but also risked turning off inexperienced or less inquisitive players.

Teon explains:

We were right to trust the players, but it was scary. At the beginning, I was worrying about what the heck we had gotten ourselves into. But as a result, we came up with something so much richer than we could have possibly planned for. This leap of faith is what made us really responsive to where the players were and moving them through their ZPDs via prompts, questions, and storyline elements. We built and create a really strong, beautiful, well-designed base on which we then just let the game play out, with us being part of how that worked—not to guide where they were going but to help them get there.
It was important to design the game elements with minimal guidance in the initial trials to see if players could figure out how to proceed on their own. With little scaffolding, designers could build up as they went along, but it would be impossible to work in the opposite direction. Once scaffolds are in place, designers would not know what players were able to do without them. This strategy likely limited the accessibility of the game to a wide range of players, retaining only those who found it entertaining to learn the game mechanics on their own as well as the science and storyline, but it provided very useful information to the design team along the way.

3.5 Rolling Out the Game

The design of Martian Boneyards had two components, the pre-game design and the on-the-fly design decisions made during implementation. The pre-game design took about nine months, from the early design meetings until the game was ready for the first players. But that was not the end of the design period. During the 4-month implementation period, EdGE designers continued to help shape the experience continuously and provided much of the structure for the game by playing characters within the game.

Since the budget was tight, concerns about time and resources often affected decision-making. It was, however, primarily a design decision to use designer characters as key elements to the game structure. EdGE designers felt this was one way to keep things flexible and nimble throughout implementation. Teon notes:
We were designing this game up until the awards ceremony in the last 72 hours, but it didn’t send off any of my procrastination sensors—it was just-in-time design!

During the implementation period of June – Sept. 2010, the gaming area was available 24 hours per day for anyone who registered and entered Arcadia in the Blue Mars MMO. During the implementation, the three EdGE designers played their characters in the game. In the first few weeks, the designers spent several hours nearly every day and evening to understand when players were most active and then scheduling “events”—regular times where the team would be there to help facilitate the game.

It quickly became clear to designers that the hours of 5-10 p.m. EDT were when most players from all over the globe, particularly North and South America and Europe, were in Blue Mars. Within the second week of the game, the Blue Mars community director (not prompted by EdGE) had scheduled a hunt in the Boneyards for a Tuesday evening at 5 p.m. EDT (two hours before a popular trivia hour in the Blue Mars welcome area). About 10 people came to this first session and arranged to come back the next night at the same time. This became an established time for events, at first Monday through Thursday nights at 5 p.m. EDT, and then later moving to only Tuesday and Thursday nights. The changes in the scheduling were intended to be specific and regular enough that people seeking other players would know when it would be a good time to find them, while also being broad enough to make sure most people could play.

Each event lasted approximately two hours. Designers used this time to update players on the evolving storyline. The designers also helped facilitate “think-alouds” to
ensure that as much player thinking as possible was recorded in the text chat. The designers’ characters asked many questions in the context of the game. They often prompted for explication of players’ inquiry by asking “what would make you say that?” or “what evidence do you have for that?” when a player made a claim. The designers also sometimes suggested that players post their ideas publicly and made explicit attempts to get players to share their ideas, emphasizing the need for others to see important new information to help solve the mystery.

The designers did not release the entire game all at once. The first phase of the roll out included the Science Center with a functional PDA and the closest region of the Boneyards to the teleporter (a transportation device to go from one region of Blue Mars to another) from the Center. The workstations came online for testing and debugging during the first phase.

In the second phase, the workstations were operational and the theory-building board was available for testing. The second phase also included a new cave area with more bones, evidence of human activity (e.g., a fireplace) and a dart gun. By the third phase, all tools were functional. The third, fourth, and fifth phases offered new regions to explore in caves with waterfalls, savannah regions with large Baobab trees, and spectacular arches with vines and foliage (see Figure 4).
3.6 The Story of the Martian Boneyards

The designers created an extensive timeline of the backstory events that happened in *Arcadia*, including a cast of characters that died and whose bones were scattered around the Boneyards (see Appendix 3 for details). The storyline was a guide of where and what types of bones were placed and also other clues such as cave paintings and personal accessories that were left around in the caves. However, this storyline was never told to the players and designers never tried to steer players away from storylines of their own that they might pursue.

In addition to the “characters” represented by the skeletons, the designers each played one character that was known to the players as connected to the game design
team. They also each played at least one other character who may or may not have been part of the original storyline but were not overtly part of the game to other players.

3.6.1 Cast of Characters

Laurel Laterne is the director of the team who has been sent to explore the Science Center. She is played by Jodi Asbell-Clarke who is the author of this dissertation. Laurel’s team of explorers consists of Tieaun played by Teon Edwards and Fisher Lawrence played by Jamie Larsen, both designers and science educators at EdGE@TERC. Laurel, Tieaun, and/or Fischer were present for every scheduled event in Martian Boneyards. They facilitated the game play by keeping people up to date with the storyline and helping people learn how to use the tools. This also allowed Jodi, Teon, and Jamie to serve as participant observers, documenting all the activities of the players and of their own.

The protagonist of the Martian Boneyards story is JJ Cleat. She was a scientist who had come with the early settlers of Blue Mars to conduct genetic research that was not allowed on Earth. JJ Cleat’s (female human) bones can be found in the core of a very large Baobab tree in Arcadia that was revealed in the final phase of the game. JJ is mentioned on posters and by the designers’ characters in the game and is the subject of a journal that is unlocked by keys in the poster. There was also a lone female human bone found in the first phase of the Boneyards.

The other characters represented by bones found in the Boneyards include Skully1 and Skully2 (these are the names the players gave them). Skully1 set of male Neanderthal bones (who designers call Adam) who was found in the first cave with a
nearby dart gun that looked like a tranquilizer gun and a sneaker. Players concluded, as
designers had intended, that Adam been shot by one of the humans in the cave. The
second skeleton, Skully2, was found at the bottom of a cliff, where players presumed he
had been pushed.

The designers also played a host of other characters in the storyline. Jodi also
played Coyote, an impish female character originally designed to lurk in the center at
night so that researchers could capture a screenshot of the chat window (one had to be
logged in to see the chat window). Players noticed her, but she stayed very quiet and
wouldn’t respond to people’s “friend” request because the designer wanted her away-
from-keyboard (afk) status not to be noticed when Coyote was unattended. This gave her
a mysterious quality designer used as the story evolved.

Jamie had two alternate characters. When he was not playing Fischer, he was
playing Rusty Tropez or Cameron. In fact, when Jamie had access to more than one
computer, he occasionally logged in as more than one character at time. Rusty Tropez
(who’s avatar name was Russ Tei) is a male character found working around the Science
Center from time to time. Cameron was a male character who also did not “friend” other
players and was very quiet in the early game.

Teon Edwards played Saxanne, a male character who behaved simply like another
player, with no particular storyline element at all. Saxanne was used to communicate with
players as a peer—asking what was happening or what to think about the science—as a
manner of think-aloud that was different from when one of the explorer characters asked
questions. The designers thought that players might interact with Saxanne differently not
knowing he was connected to the design team.
3.6.2 The Storyline

When players first came to Arcadia, they landed in the foyer of the Science Center (see Figure 5). In the teleport arrival area, there is a handwritten note from three explorers—Laurel, Tieaun, and Fischer—that explains the backstory and calls for their help. They are told that this Science Center seems to have been abandoned by previous researchers and contains semi-functional research tools from previous settlers of Arcadia. The explorers have recruited them to help figure out what types of research the prior settlers were doing and what had happened in the Center.

The note also warned players that during the explorers’ efforts to restore the tools, they found a gruesome discovery. There were bones scattered all over the surrounding outside area. That is when the explorers knew they had to call in a group of players to help them figure out what had happened in Arcadia. A call went through the Blue Mars community to recruit people to help solve the mystery.

Figure 5. Entrance hall to the Science Center in Arcadia
Laurel, Fisher, and Tieau explained to players that there was an anonymous donor who had been sponsoring their research since they found the boneyards and was very curious about the outcome. Their characters explained that since they had just discovered this abandoned Science Center, their technical team had not worked out all the bugs in the tools. Sometimes, they mysteriously stopped working or did strange things. The players quickly incorporated the debugging of the environment as part of the mystery storyline and the designers did nothing to dissuade that process.

Conspiracy theories and fear about who might be behind the faulty equipment and who was the anonymous donor were rampant among the players, typically not initiated by the design team. When Laurel happened to mention rats in the basement of the Center, the players speculated that it might be the rats chewing the wires to the workstations, or even something more dangerous.

Once the skeletons were found, players tried to put together a story that explained the existence (and death) of the previous scientists and the types of information they found on the posters. The posters only had titles but the text of most of the information was scrambled and in another language.

Meanwhile, the characters that the designers were playing, particularly Rusty and Cameron, were meeting up with players and seeding them with more clues about the storyline. Rusty obviously knew a lot about the Center and what had happened before but was reluctant to say much to anyone. Relatively early in the game, graffiti started appearing in the Science Center saying things like “Rusty, I’m onto you”—implicating him as a character in the storyline. Rusty eventually let on that he had been very fond of
JJ Cleat. He had been a young technician at the Center when she first arrived and was quite smitten.

Players got to know Cameron slowly in the first weeks of the game. He was sneaky and did not reveal his motives. Players surmised that he was the anonymous donor but did not know why. He asked players a lot of questions about the science that had been going on there and, in particular, if they found any bones that could be a female.

Players decided that the previous scientists had been involved in genetic engineering on this newly terraformed planet and that they had created a Neanderthal male, and there was still much speculating about mischief among previous inhabitants of the Center.

There were many ideas floating around in the community but players were not formulating them into concrete claims. The designers needed a new storyline element to scaffold the theory building.

To solve this, Laurel was called away to a conference on interplanetary exploration sponsored by the council who initiated the mission to Arcadia. Laurel returned the following week with news that several interplanetary explorers had been reported missing and the council is offering an award to the community who provides the most convincing evidence of what may have happened to them. This was a previously unplanned element in the storyline that emerged from the need to both explain a Laurel’s absence for a week (while occupied in real life) and also to create a need for the community to accelerate the pace of their analysis and theory-building.

The council award gave a structure to the rest of the game. Most of the subsequent updates from Laurel involved news from the council with further queries about the bones
the players were finding. Laurel was very excited and proud of the players’ work as it was garnering recognition for *Arcadia*. She explained that the council saw *Arcadia*’s work as leading the quest for the missing scientists. By the last month of the game, Laurel had announced that the council had decided to host its annual meeting (with the announcement of the big award) in the *Arcadia* Science Center. This spurred the player community on to finish their research before the award ceremony.

Meanwhile, the designers felt a need to tie the storyline together and also to reward players for their hard work in translating posters that held virtually no meaningful content. This inspired the idea to use the irrelevant poster content as fodder for a clue to JJ’s journal—a journal that described her final days and how she died.

The journal told a story of genetic testing (as presumed by the players) in the Science Center and a character named Adam, whom JJ had cared for since a baby. JJ didn’t want the researchers to find Adam and feared for her own life as she had broken her leg while hiding in the cave. By this point, the players had now put together that Adam was one of the skeletons in the cave, a Neanderthal male who was likely the product of JJ’s genetic experimentation in *Arcadia*. Players used the dart gun and shoes found near the human male skeleton in the cave to reason that the second skeleton may have killed Adam, but up to this point they had not found a female skeleton. They had only found a lone femur among the many other bones in the cave. The final chapter documenting JJ’s death was released just as the players found the final skeleton, a female who had been placed ceremoniously in the hollow trunk of the large Baobab tree, missing one leg.
This entire storyline was an evolving narrative that began with designers’ placement of the artifacts, but was then guided and fleshed out by the players’ imaginations. The designers played their characters in a very improvised manner, often chatting with each other outside the game as the storyline twisted and turned during each evening. In this manner, the resulting game experience was a product of the players’ activity and progress as much as the original design.
Chapter 4: Methodology

This research examines one group’s efforts to craft a scientific mystery game that can engage a diverse audience of MMO players in sustained scientific inquiry. The EdGE team strived to support a community of scientific inquiry where players work together towards an evidence-based theoretical solution of the mystery.

This dissertation uses netnographic techniques to examine:

- Who came to play Martian Boneyards? Who became involved in sustained scientific inquiry in the game?
- What is the extent and quality of players’ scientific inquiry in Martian Boneyards?
- What design elements and implementation strategies appear to foster sustained scientific inquiry in Martian Boneyards?

This chapter describes the research design and methods used along with the sample for the implementation study. Also included is a discussion of the measures used to study scientific inquiry in Martian Boneyards and the data sources used in the implementation study.

4.1 Research Design

This research study uses methods borrowed from ethnography to study the context within which players act and from phenomenology to study how players
experience the gaming environment. Ethnographic research is characterized by the study of a culture of a community, in an attempt to describe its shared patterns of behavior, beliefs, and language while phenomenology focuses on the shared experience itself (Creswell, 2007). Netnography, also referred to as virtual ethnography, blends analysis of digital records from Internet-supported interactions with ethnographic methods used when the researcher is immersed in the community of study (Kozinets, 2002; Hine, 2000).

Netnography incorporates digital records of avatar activity along with traditional ethnographic methods such as participant observations, surveys, and interviews. It is an increasingly important method for researching virtual environments where the interactions among people and information that create the environment’s culture are objects of study.

Netnographic methods are particularly useful when studying potential communities of practice in digital game environments. As communities emerge in a social digital game, their patterns of behavior can be seen through the analysis of digital activity logs. These methods have been used in River City (Nelson, Ketelhut, Clarke, Bowman, & Dede, 2005) and Quest Atlantis (Barab et al., 2005). Discourse analysis has been used with transcripts from World of Warcraft and other role playing games to examine scientific inquiry and identity (Steinkuehler & Duncan, 2008).

In Martian Boneyards, designers (including the author) played characters in the game and serve as participant observers. This offered several advantages in terms of data collection, but it also ran the risk of biasing the research. Fine (1993) identifies several types of bias that ethnographers can fall into such as becoming a candid ethnographer...
who is too involved to maintain an ethical perspective, or an observant ethnographer who falsely believes they have observed everything because they were involved.

Several avenues were taken to mitigate bias in this study. The author was one of three on the participant observer team and did not lead the authoring of the participant observation reports. She contributed and reviewed the reports as a team member, but Jamie Larsen and Teon Edwards, who also played characters in the game, were the primary authors of the reports. In addition, two other researchers, who were not designers, validated one observation report by observing concurrently with the designers and reviewing the report. An independent (non-designer) member of the EdGE research team also reviewed all descriptive research.

The participant observation data is supplemented with other ethnographic and netnographic methods to create a more well-rounded description of the gaming community and their patterns of behavior. Analysis of electronic records of avatar motions and actions added a micro-detailed view of players’ activities where each click on a game tool was associated with a phase of scientific inquiry. This focused the researchers’ attention on top players so that they could learn more about what sustained their inquiry.

A researcher (a non-designer member of the EdGE team) conducted semi-structured interviews over Skype with three of the top players—those who were most engaged in the scientific inquiry in Martian Boneyards. In addition, players completed a demographic survey that was tied to their activity data. This wealth of data helped to provide a well-rounded picture of the behaviors and culture of the participants in the
Martian Boneyards community, as well as their experience within the gaming environment.

4.2 Sample

The overall player population for this study is all entrants (N=613) to Arcadia, which includes anyone who took the registration survey at the teleporter landing spot between June 1, 2010 and Sept 30, 2010. Entrants must have stated that they were 18 years or older and consent to be “keytracked” (anonymously monitored for clicks on Arcadia tools) to be included in the sample.

The implementation study took place during the open beta test period of Blue Mars. The platform was open to the public but required download of a very memory intensive application that only ran on high-end PC computers (with high-quality graphic cards and extra memory). Blue Mars was also unstable during this period, often crashing at least once or twice for each user during a game session. People who chose to participate in this beta-test community were dedicated to exploring the Blue Mars environment and were seeking activity in the new virtual world.

The qualitative analysis examined the design documents and participant observer records from the design and implementation of the game. These were developed by a team of five educational designers and game designers. Of that team, two educational designers (Teon and Jamie) and one game designer (Reed) were interviewed to gain a deeper perspective into the design process.

In addition, three players were interviewed (avatar-to-avatar via in-world chat) about their experience in Martian Boneyards, in particular regarding their science
identity, their motivation for playing, and their sense of value of the experience in terms of game play and for science learning. Researchers found that avid players were eager to be interviewed while non-players were much more reticent to arrange a time for an interview. In seeing this, researchers chose to use the interviews to explore the core of avid players more deeply.

4.3 Measures

The design and implementation study examined the relationship between the game design, players’ activity, and players’ progress in Martian Boneyards. Though examined separately, designers focused also on the interaction among these elements, viewing them as an interconnected system in the gaming environment.

4.3.1 Game Design

The game design is described as the set of decisions designers made while developing and implementing Martian Boneyards and the Arcadia Science Center. This research focuses on the decisions and facilitation strategies used by the designers intended to support and sustain scientific inquiry. These decisions include choosing the scientific resources, crafting collaboration tools, conceiving a storyline, and placing all of this in an environment conducive to game play. Please see Appendix 3 for the team’s full design documents.
### 4.3.2 Player Activity

Players’ scientific inquiry activity in *Arcadia* is measured in several ways. Quantitatively, the digital data show the frequency of avatar interactions with each of the inquiry tools and the duration of play for each player. Frequency measures are also provided for each phase of inquiry: data gathering, analysis, and theory-building. Because there were no tool clicks directly associated with exploration, this phase was not represented in this manner.

The number of times each player scans an artifact with the PDA is a measure of their data gathering activity. The extent of players’ analysis activity is recorded as the number of their interactions (tagging/measuring/comparing) with the analysis workstations. The extent of their theory-building is recorded as the number of interactions with the theory-building board.

This numerical measure of theory-building is actually an underestimate of players’ activity in this phase. The *Arcadia* theory-building tool did not have the functionality desired by players for easily posting images and links, so players adopted an external tool, the discussion board of the *Blue Mars* web forum, for much of their theory-building activity. The numbers of posts and replies on the theory-building board are reported separately, and nearly all pertain to the topic of claims and activity within the game.

The second measure of the extent of players’ inquiry is their overall duration of time spent in *Arcadia*. Because most of the activity in *Arcadia* was observed to be pertinent to the game-play, and in particular pertinent to the scientific inquiry, the
duration of game play becomes an interesting measure of participation in the collaborative inquiry process.

The avatar activity logs recorded each avatar’s entry and exit into each room or outside area in Arcadia. Typically core players were in the game for the 2 hours of an event or perhaps for an hour or more during the day between events. Sometimes a record would show that an avatar came to the Center and stayed for 5 or 10 or even 20 hours. Many of these records were likely caused by players who logged in and then were “away from keyboard” or occasionally if the player was in when the server crashed or when the research database refreshed. These cases were not always easy to identify.

To avoid including the idle players in the research data, the records that were greater than one hour in duration were removed if there was no other activity recorded by that avatar subsequent to the one hour. In other words, if a player came in a room and stayed for more than an hour without clicking on any other tools, that record was not included in the duration measurement. Some records were as long as 10 hours but had player activity during the entire period, showing that some players did actually spend that long in one sitting at the game!

4.3.3 Player Progress: Quality of Scientific Inquiry and Content

In this study, player progress is represented by the quality of the scientific inquiry and content generated by the player community in Martian Boneyards. To conduct this evaluation, a team of three scientists who specialized in paleo-anthropology and biology and also teach this content at the undergraduate level reviewed a set of user-generated
materials that represented their knowledge building in the game. These materials included postings from the theory-building board (with supporting evidence), postings from the Blue Mars web forum that players used for supplemental discussion, and one excerpt from one in-game chat (over 200 text entries in total).

The materials reviewed were all the entries in the theory-building areas that were relevant to scientific content of any kind. Researchers removed posts that were purely social or purely about the storyline (e.g., sightings of characters or translations of posters without scientific discussion). They also included one segment of chat collected by participant observers because it was the only place a certain topic of inquiry (the size of the Baobab tree) was discussed by players. The nature of this exchange was completely user driven—it was not related to the designers’ storyline at all—but observers thought it was one of the more interesting examples of scientific inquiry so researchers included it in the scientific review.

The panel of scientists used a simple rubric to rate:

- The extent of the scientific inquiry
- The sophistication of the scientific inquiry
- The accuracy of core ideas in the primary content area(s)
- The depth of core ideas in the primary content area(s).

The team of scientists rated the quality of the entire set of materials along each dimension on a 5-point scale (poor, fair, good, very good, excellent) related to a project conducted in an introductory undergraduate class for non-science majors.
Two teleconference meetings were held with researchers and reviewers, one to review the instruments and rating procedures and the second to compare the ratings they had each done independently. In the first meeting, the scientists had already read through the materials once and came to a quick agreement that comparative anatomy was the core area that was covered in most of the materials. The materials touched on other topics such as evolution, genetics, and botany but the sustained inquiry was in the area of comparative anatomy.

For the second meeting, the scientists had reviewed the materials again and rated them using the research rubric. They were told to use the highest rating they found evidence for in a substantive part of the materials. In other words, if there was a substantive section of the discussion that they considered very good, but other parts were weaker, they could still use the very good rating. They were not to average over the entire set of materials, but they were to give an indication of how much of the materials were represented by their highest rating.

The review team achieved consensus on ratings very quickly. They were comfortable that their ratings represented the overall quality of the materials and noted that there were very few exceptions to the accuracy of content ratings or quality of the science information resources used in the game. Most of the variability in the ratings across the set of materials could be attributed to the extent of inquiry in the natural ebb and flow of the discussion. Researchers wrote a summary of the findings and circulated it to the reviewers, each of whom approved the report with no suggested revisions (Please see Appendix 4 for the rubric and Appendix 6 for summary report).
To look at game-based progress, researchers used the closing ceremony awards given by the designer characters leading the game as indicators of players’ game advancement. There was no formal advancement system in the game, such as points so the awards were used to assess progress. The same designers who were conducting the participant observations selected the candidates for the in-game awards, so the game advancement of players is reflexive of the progress perceived by the observers.

The two top awardees in the game (as well as one of the next tier of awardees) were interviewed and examined more closely for deeper study. Less participative players, and thus those who had less game advancement, were harder to access and reluctant to become involved in a further study, a more representative sample of players for deeper study.

### 4.4 Data Sources

The netnographic techniques used by the researchers draw on a variety of digital sources to get a broad and deep look at the context that is mediating the game play, the environment and the community, and the player’s experience within that context. The data sources include surveys, avatar logs, participant observations, design documents, and interviews.

#### 4.4.1 Surveys

Players were required to take an initial survey at the entrance to *Martian Boneyards*. When providing consent for access, entrants were asked their gender, race,
age, science involvement, and virtual world experience (see Survey 0 in Appendix 2). Players were asked to report on their real-life identities. This survey was delivered in a flash interface that would not allow entry without completions, and would not allow advancement without all fields being completed, so all data were obtained from all entrants to Arcadia. All survey responses are tagged with an anonymous ID allowing them to be linked together with the other digital data collected.

4.4.2 Avatar Log

Each time a player clicked on any tool in the Science Center, the interaction was recorded with a time stamp and the anonymous player ID. Each tool was associated with one phase of the inquiry cycle: data gathering, analysis, or theory-building. Please see Appendix 7 for a sample of the Player Activity Log.

4.4.3 Participant observations

The team of three designers who played characters in the game also served as participant observers. They recorded their own actions during each 2-hour event (at least twice per week) and also recorded the tone and events of the players’ activities during events and any non-event times they monitored during each week. At least two observers (and often all three) were present at each event.

Observations focused on storyline, social dynamics, and how designers supported scientific inquiry. Observers recorded any storyline details they added during the session (with justification if it was a new “on-the-fly” decision) and players’ response to the

---

4 Theory-building was called interpretation in the research database, a residual from early design.
evolving storyline. They took note of any remarkable characteristics or roles of players and the general tone of the community. They particularly noted ways in which players helped each other, supported inquiry, or advanced the storyline. Finally, the observers took careful records of decisions and emergent structures that aided scientific inquiry within the community. The emergent structures include social bonds that grew between players or tools that players brought in from outside the game.

One of the observers wrote a summary report of nearly every event or sometimes a couple of events together (totaling 28 observation reports). The reports were reviewed and modified by the two other observers. Two additional members of the research team, who were not designers or regular participants in the game, validated the interpretation of the participant observations by co-observing and reviewing summary reports once during implementation.

4.4.4 Design Documents

Designers (EdGE and VSE) recorded their decisions throughout the process and made these available to the research team. The design documents focus on the scaffolding of evidence-based research in the design of the inquiry tools, embedding scientific inquiry within an evolving storyline, and making the environment as attractive and immersive as possible with limited funds. The design documents laid out the original vision for the tools as well as modifications that were made during development and implementation. (See Appendix 3 for design documents.)
4.4.5 Interviews

The top three players were selected for interviews. Originally researchers also hoped to interview three mid-activity players and three players who only played once or twice but did not return to the game. Players in these latter two groups did not agree to be interviewed.

Researchers used a semi-structured interview protocol to conduct avatar-to-avatar interviews, situating the interview in the studied environment (Turkle, 2005). The interviewer was an assistant researcher and project coordinator for EdGE. She was not a designer and had not previously been playing a character known to the players in the game.

Players and the interviewer met in the Science Center and communicated using the text chat typically used in the game. Players were asked what attracted them to Arcadia, what they felt contributed to the value of the game in terms of enjoyment and science learning, and how their experience in Martian Boneyards changed the way they think about science. The designers did not read the players’ interview transcripts until after implementation was complete to avoid influencing on the play.

Upon completion of the implementation process, the author conducted interviews with three members of design team on Skype (with audio-only) using a five-question open-ended protocol. The designers were asked about their overall impression of the design process, ways in which inquiry was scaffolded in the design, the way in which that design was compromised, and other elements of the game design that became important to the design team through the implementation process. Finally, the designers were asked about lessons they learned to use in future game design for supporting inquiry.
4.4.6 Player-generated Artifacts

Players posted all of their communal knowledge building in the theory-building area in the Arcadia Science Center or on a web-based discussion board on the Blue Mars website. On the website they could include images and links to other web sites in their postings. All of these data were collected and archived by researchers. These artifacts became the basis of the independent scientist review as well as a resource for illustrative examples for patterns and language usage noted by participant observers and described during player interviews.

4.5 Risks and Limitations

This study looks at the Martian Boneyards experience from a variety of perspectives. Each has its strengths and limitations. Using digital data to track players’ activity provides a powerful new lens into the potential knowledge building process and may be able to provide unique information about learning. It is also limiting in that it only tells “what” happened without qualifying how or why it happened.

This study, therefore, attempts to look deeper into the nature of the scientific inquiry that occurred in Martian Boneyards through surveys, participant observations, interviews, and review of player-generated artifacts. Surveys were used very minimally because of their disruptive nature to the game play. It was very important that the research not interfere with players’ enjoyment of the game, in order to promote sustained inquiry in the game, so researchers only used five short demographic survey questions in the initial consent and registration form.
Participant observations were very powerful tools for research in this study, as observers played characters within the game who were there interacting with players most of the time. The limitation, a very considerable one, is that the observers are also designers of the game. This dual role of designer and researcher lends itself to excellent response and communication for formative design research, but does limit the objectivity of the observations and reporting. This was dealt with by having three observers collaborating on the reports and by having one session validated by an external (non-designer) researcher. More than one validation session would have been preferable, but was not feasible. The independence of the science review, being conducted by three external scientists who were not connected to the design team at all, helped alleviate some of the risks of internal nature of the designer/researcher team.

Finally, interviews were only possible with three top players. This puts a strong bias on the type of player described in the study. This compounds the skew already existing in the data because the sample is from a beta-test audience of a new MMO, so they are already heavy virtual world users. These results, therefore, should not be generalized to a more average audience, particularly those with less gaming experience.

Through a combination of digital records, observations, surveys, interviews, and review of player-generated artifacts, this research is able to describe what happened in Martian Boneyards and explain what design features were seen by players and designers as useful for sustaining ongoing, productive scientific inquiry.
Chapter 5: Results

The results from the Martian Boneyards implementation study are reported as a descriptive study of what happened in the game along with inferences about what design features were seen by players and designers as helping foster scientific inquiry. This is achieved by looking at the patterns of behaviors of players in the game, the nature and quality of scientific knowledge generated by the player community, and the design decisions the team made before and during the implementation of the game. The results address the following three research questions:

- Who came to play Martian Boneyards? Who became involved in sustained scientific inquiry in the game?
- What is the extent and quality of players’ scientific inquiry in Martian Boneyards?
- What design elements and implementation strategies were seen to foster sustained scientific inquiry in Martian Boneyards?

Overall, Martian Boneyards engaged the core of the beta test audience in sustained scientific inquiry, including analysis and theory-building. Although the majority of the initial game audience was male, it was females who did the bulk of the deeper inquiry.
5.1 Player Audience and Activity

This research study looks at 3 telescoping sub-samples in the original sample, determined by players’ level of activity in the game. The characteristics of the players varied depending on whether they were visitors who entered once or twice but never engaged with the game players or whether they participated in the gaming activity to a moderate or extensive level. There were over 600 entrants to the Arcadia, but data analysis only was conducted on those who engaged at least once with the Martian Boneyards game tools. All Players (N=228) are those who interacted at least once with an inquiry tool in Arcadia. Core Players (N=66) are those who used the inquiry tools > 20 times and Top Tier Players (N=18) are those who used the inquiry tools > 100 times.

All entrants were asked their age, gender (Male, Female, choose not to answer); race/ethnicity (Hispanic or Latino; American Indian or Alaska Native; Asian; Black or African American; Native Hawaiian or Other Pacific Islander; White); Science Involvement (Science Researcher, Science Student, Science Teacher, Science Technician, Not Involved in Science, Read or watch TV about Science); and virtual world involvement (spend nearly all time in virtual worlds, spend a lot of time in virtual worlds, spend a little time in virtual worlds, this is the first time in a virtual world). Questions pertaining to race and science involvement allowed for multiple answers. A participant profile was created for each core player with demographic data and avatar activity (the duration of time spent in Arcadia; the number of all inquiry tool interactions; and the number of data-gathering tool, analysis tool, and theory-building tool interactions).

The typical Martian Boneyards player is a 36-year old white male who is not involved in a science career but may read or watch TV about science. He spends a lot of
time in virtual worlds. The only notable difference in demographics in looking through the telescoping samples is that women make up a larger part of the sample when filtered down to the top tier and the player base also excludes more non-whites as it narrows (see Table 1).

Of the three players interviewed, each confirmed that the demographic information that they reported on the entrance survey was their real life identity. One was a 52-year old female, a school-bus driver and mother of two adult sons. Her husband was a geologist and, though he did not play the game, she discussed game content and science with him. She reported that she was not science-oriented, but after playing the game she wished that she studied more science as she found the investigation very fun.

The second player was a female, age not shared (but over 18), and she was from the UK. She described herself as very non-science oriented and an avid gamer. She described her early work in the game as just following her curiosity but very unscientific. Later, as she garnered attention and respect from the community due to the high quality of her work in the game, she reported that she felt more confident with her scientific activity, though she was still very surprised at the community’s reaction to her. She described herself as an introvert and very determined.

The third interviewee was a 26-year old male who held a bachelor’s degree in ecology and was a lab technician for a concrete company. He was also an avid gamer and enjoyed building 3D content in virtual worlds. He came to the game upon the suggestion of someone in Blue Mars and stayed because he enjoyed the storyline and the community of players.
The demographics of these groups are reported separately in Tables 1 and 2.

Table 1

*Gender, Race, and Age of Martian Boneyards Players*

<table>
<thead>
<tr>
<th></th>
<th>All entrants (N=613)</th>
<th>All players (N=228)</th>
<th>Core players (N=66)</th>
<th>Top players (N=18)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>29%</td>
<td>29%</td>
<td>32%</td>
<td>50%</td>
</tr>
<tr>
<td>Male</td>
<td>66%</td>
<td>66%</td>
<td>60%</td>
<td>50%</td>
</tr>
<tr>
<td>No Answer</td>
<td>5%</td>
<td>6%</td>
<td>8%</td>
<td>0%</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>74%</td>
<td>78%</td>
<td>76%</td>
<td>83%</td>
</tr>
<tr>
<td>Non-white</td>
<td>26%</td>
<td>22%</td>
<td>24%</td>
<td>17%</td>
</tr>
<tr>
<td>Age (yrs)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-27</td>
<td>31%</td>
<td>32%</td>
<td>35%</td>
<td>39%</td>
</tr>
<tr>
<td>28-37</td>
<td>27%</td>
<td>27%</td>
<td>27%</td>
<td>33%</td>
</tr>
<tr>
<td>38-47</td>
<td>23%</td>
<td>20%</td>
<td>15%</td>
<td>11%</td>
</tr>
<tr>
<td>48-57</td>
<td>13%</td>
<td>13%</td>
<td>12%</td>
<td>11%</td>
</tr>
<tr>
<td>58-67</td>
<td>5%</td>
<td>7%</td>
<td>9%</td>
<td>6%</td>
</tr>
<tr>
<td>68+</td>
<td>1%</td>
<td>1%</td>
<td>2%</td>
<td>0%</td>
</tr>
<tr>
<td>Mean age</td>
<td>36.00</td>
<td>36.16</td>
<td>35.71</td>
<td>33.00</td>
</tr>
</tbody>
</table>

*Note.* Core players had >20 tool interactions, top players had >100 tool interactions.
Table 2

**Science and Virtual World Interest of Martian Boneyards Players**

<table>
<thead>
<tr>
<th></th>
<th>All entrants (N=613)</th>
<th>All players (N=228)</th>
<th>Core players (N=66)</th>
<th>Top players (N=18)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science in daily life</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not involved</td>
<td>26%</td>
<td>22%</td>
<td>33%</td>
<td>28%</td>
</tr>
<tr>
<td>Interested</td>
<td>48%</td>
<td>51%</td>
<td>44%</td>
<td>44%</td>
</tr>
<tr>
<td>Involved</td>
<td>25%</td>
<td>27%</td>
<td>23%</td>
<td>28%</td>
</tr>
<tr>
<td>Time spent in virtual world</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nearly all</td>
<td>12%</td>
<td>9%</td>
<td>9%</td>
<td>0%</td>
</tr>
<tr>
<td>A lot</td>
<td>55%</td>
<td>58%</td>
<td>54%</td>
<td>50%</td>
</tr>
<tr>
<td>A little</td>
<td>20%</td>
<td>21%</td>
<td>26%</td>
<td>39%</td>
</tr>
<tr>
<td>First time</td>
<td>14%</td>
<td>12%</td>
<td>11%</td>
<td>11%</td>
</tr>
</tbody>
</table>

*Note.* Core players had >20 tool interactions, top players had >100 tool interactions.

### 5.2 Players’ Scientific Inquiry

The players’ activities are reported in terms of the extent and quality of their scientific inquiry. Three measures are used: the frequency of players’ interactions with tools in each of the phases of inquiry (data-gathering, analysis, and theory-building); players’ duration in the game; and the quality of the scientific inquiry and content as rated by independent science educators.

The data show evidence of high-quality scientific inquiry in a variety of ways. The analyses show that core players engaged primarily in data gathering (scanning artifacts with the PDA) but also substantive activity was recorded in analysis and theory building. Players’ duration of play varied widely, with some players exceeding 200 hours.
during the 4-month implementation study. The average duration for core players was approximately 30 hours over the 4-month period.

An independent review by scientists of the player’s posts on the theory-building board and associated discussion forum shows that scientific inquiry was very good in both content and sophistication of the inquiry. In addition, participant observers noted that the inquiry was highly collaborative and that players’ interactions were largely focused on the inquiry as opposed to other social activities.

5.2.1 Extent of Scientific Inquiry

The extent of the scientific inquiry is measured by the frequency of interactions with inquiry tools and duration of play in the game. Each game tool was associated with one of three phases of inquiry: data-gathering, analysis, or theory-building. This allowed researchers to track the extent of players’ activities in each of these areas.

5.2.1.1 Frequency of Interactions with Inquiry Tools.
Table 3 shows the frequency of inquiry tools used by core players in the game, overall and disaggregated by participant characteristics. Overall, approximately 74% of players’ interactions were in the data-gathering phase of inquiry, which is consistent with players’ own statements during think-alouds that they like quests and hunting in virtual worlds.

Interestingly though, 15% of the interactions were in analysis and another 11% were using the theory-building tools. These phases are similar to the synthesis and resolutions phases of the Community of Inquiry model used to study inquiry in online
educational environments (Garrison et al., 2003). Those researchers found inquiry lacking in these later phases in online communities of inquiry (Garrison et al., 2005). This finding may suggest that MMO games like Martian Boneyards could be better at scaffolding inquiry and/or that these methods are more able to capture this type of inquiry.

Table 3

*Distribution of Inquiry Phases by Demographics for Core Players (N=62)*

<table>
<thead>
<tr>
<th>Player Variable</th>
<th>Total tools</th>
<th>Data gathering</th>
<th>Analysis</th>
<th>Theory building</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
<td>118.27</td>
<td>87.00</td>
<td>17.95</td>
<td>13.32</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male (n=41)</td>
<td>91.78*</td>
<td>71.41</td>
<td>12.49*</td>
<td>7.88*</td>
</tr>
<tr>
<td>Female (n=21)</td>
<td>170.00*</td>
<td>117.43</td>
<td>28.62*</td>
<td>23.95*</td>
</tr>
<tr>
<td><strong>Race</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-white (n=13)</td>
<td>79.31</td>
<td>68.69</td>
<td>6.69</td>
<td>3.92</td>
</tr>
<tr>
<td>White (n=49)</td>
<td>128.61</td>
<td>91.86</td>
<td>20.94</td>
<td>15.82</td>
</tr>
<tr>
<td><strong>Science in Daily Life</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-career (n=48)</td>
<td>123.42</td>
<td>94.60</td>
<td>15.94</td>
<td>12.88</td>
</tr>
<tr>
<td>Career (n=14)</td>
<td>100.64</td>
<td>60.93</td>
<td>24.86</td>
<td>14.86</td>
</tr>
<tr>
<td><strong>Time spent in Virtual Worlds</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high (n=42)</td>
<td>98.38</td>
<td>71.83</td>
<td>15.02</td>
<td>11.52</td>
</tr>
<tr>
<td>low (n=20)</td>
<td>160.05</td>
<td>118.85</td>
<td>24.10</td>
<td>17.10</td>
</tr>
</tbody>
</table>

*Note.* N=62 because the 4 players who chose not to identify gender are not included in analyses.  
*p < .05
Figure 6 shows a histogram of the frequency of inquiry tools used by core players in the game, for everyone and disaggregated by males and females. The average participation with the inquiry tools is higher for females than males in the core group (F(1, 60)=5.209, p<0.05). Females also have higher participation in analysis (F(1, 60)=6.156, p<0.05) and theory building (F(1, 60)=4.674, p<0.05) activities. The only inquiry phase where activity is not significantly different between males and females is in data gathering.

![Histogram of frequency of inquiry tools by phase and gender](image)

**Figure 6.** Histogram of frequency of inquiry tools by phase and gender

### 5.2.1.2 Duration of Play.

The duration of play became a meaningful measure of scientific inquiry as participant observers noticed that nearly all the activity during players’ time in the game
was devoted to inquiry. There was little purely social interaction (discussions not related to the game) as players tended to leave Arcadia and go to other areas in Blue Mars for that. For this reason, researchers collected exit and entrance data for each avatar in each area of Arcadia and used these records to calculate each player’s total time in the game. Records indicating possible “away from keyboard” or idle time were removed from the calculation. This means that the resulting measurement was a good estimate of the time that players spent participating in scientific inquiry while in Martian Boneyards.

Table 4 shows the duration of play, in hours, of players—overall and disaggregated by player characteristics. The 66 core players spent an average of nearly 28 hours in Martian Boneyards. A large number of players spent less than 20 hours in Arcadia, but some players spent upwards of 200 hours in the game. Because of the skew, particularly among the top-tier players, the apparent large difference in means between males in females is not significant (See Figure 7 for the histogram).

The average duration for all players is nearly 30 hours, the number of hours spent in class for a typical 10-week university course. Some players spent as much as 200 hours in the game, which is equivalent to a part-time job (50 hours per month). There are also many players who only spent a few hours in the game, so the distribution is important to consider rather than the average.
Table 4

*Time Spent in Game by Core Player Types (N=66)*

<table>
<thead>
<tr>
<th>Player Type</th>
<th>Mean Duration (hrs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Overall</strong></td>
<td>27.68</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
</tr>
<tr>
<td>Male (n=40)</td>
<td>20.80</td>
</tr>
<tr>
<td>Female (n=21)</td>
<td>40.78</td>
</tr>
<tr>
<td><strong>Race</strong></td>
<td></td>
</tr>
<tr>
<td>Nonwhite (n=13)</td>
<td>13.70</td>
</tr>
<tr>
<td>White (n=49)</td>
<td>30.15</td>
</tr>
<tr>
<td><strong>Science in Daily Life</strong></td>
<td></td>
</tr>
<tr>
<td>Non-career (n=51)</td>
<td>26.19</td>
</tr>
<tr>
<td>Career (n=15)</td>
<td>26.00</td>
</tr>
<tr>
<td><strong>Time spent in Virtual Worlds</strong></td>
<td></td>
</tr>
<tr>
<td>high (n=42)</td>
<td>23.28</td>
</tr>
<tr>
<td>low(n=24)</td>
<td>31.20</td>
</tr>
</tbody>
</table>
5.2.2 The Quality of the Community's Scientific Inquiry

The quality of the scientific inquiry in the game was measured through a review of player-generated artifacts by an independent panel of scientists (see summary report in Appendix 6 for details). The team was given a set of artifacts selected by researchers to contain most of the substantive inquiry that took place in the game. They used a rubric to rate the accuracy and depth of the scientific inquiry and scientific content demonstrated in the artifacts. The team of three scientists concluded that substantive scientific inquiry took place in the game. They were particularly impressed that the players independently sought and used external Internet resources (not provided through the game design) to support their inquiry. These resources were all found to be scientifically valid sources and the information was of high quality.
The artifacts reviewed by the scientists include all claims posted on the theory-building board (with supporting evidence) along with postings on the Blue Mars web forum that players used for supplemental discussion. They also examined one excerpt from one in-game chat on a topic not well represented in archived postings (over 200 text entries in total). The player community engaged in scientific inquiry—asking questions, making claims, substantiating claims with evidence—to an extent that would be considered very good in an undergraduate introductory science course. The content generated in the area of comparative anatomy was rated very good on accuracy and good on depth.

Reviewers noted that the game motivated a level of inquiry among some players that was similar to top students in a class who were interested in material beyond the scope of the course. One reviewer commented:

Those top players reminded me of those students you get once in a while that just have a burning desire to learn.

Reviewers also noted that most, if not all, Internet resources used by players were from reasonable scientific websites (including Wikipedia, as well as well accredited sites from universities and national labs). There were no links to personal blogs or websites from non-scientific interest groups. One criticism voiced by the reviewers was that some of the related topics were dealt with superficially (players did not dig deeply into evolution or functional morphology, though there was conversation leading in those directions). Reviewers agreed that nearly all of the content in comparative anatomy was accurate and players’ arguments in these areas were scientifically valid.
5.3 Design Features for Sustained Scientific Inquiry

There are several design suggestions that can emerge from this work that show promise to transcend the circumstances of Martian Boneyards, and may inform social digital games for knowledge building in general. Designers and top players attributed the following features to the games success at fostering sustained scientific inquiry:

a) A compelling and evolving storyline in an aesthetically-pleasing environment

b) Facilitation of play (but not-content delivery) by characters in the game.

c) Well-crafted tools and environment to stimulate and scaffold collaborative inquiry

d) A game advancement system that recognizes players’ contribution to a communal knowledge base.

There are also several examples of constraints or decisions that may have hindered players’ open-ended inquiry. One of the most frustrating restrictions for the design team was when players asked for more tools that would be useful in their data gathering and analysis, and the designers could not provide them. Players asked for metal detectors, carbon dating instruments, genetic sequencers, and other tools that would have made the game even richer in both science and game design. Development in Blue Mars was expensive and designers realized during the game that the limited audience that the high-end MMO offered would likely not merit much more investment.

The players’ activity suggests that they will engage in evidence-based theory building when it is posed as “rules” of the game. This still leaves a question on how to
design tools to best scaffold that evidence-based reasoning. EdGE designed the theory-building area to only accept claims when they were posted with evidence from the analysis workstations. Players caught on to this rule, to the extent that when they moved to a less restrictive web-based discussion area, they continued to post evidence with their claims. Observers noted that players used the structure of the tools as rules of the game, so that inquiry became part of their language and ways of organizing their thoughts. It will require further study to understand to what extent this can be used to transfer to scientific inquiry, and to what extent these inquiry skills will be useful for innovation and knowledge building in other areas.

Three top-tier players (two females and one male) were interviewed to understand their perspective of the game experience (see Appendix 8 for transcripts). They explained that they were motivated to play the game by the beauty of Arcadia, the social community with the players, and the need to solve the mystery that was laid out in front of them. They found Arcadia, the environment in which the game was embedded, to be an exemplar of what could be found on Blue Mars and said many came to explore its beauty and intrigue before they got caught up in the story,

KalW, a top player, enjoyed learning the science and talking with her husband (who did not play the game) about the questions she had. When asked what compelled her to spend over 200 hours in the game, she explained that she loved Martian Boneyards for the layout, the idea, and the learning.

I love the mystery... the need to look further into things(nosey) :P.
KalW explained she first came to *Arcadia* because:

I saw what was written and just had to check it out, it intrigued me!
The idea is amazing! Oh and love the place :) 

Players referred to their need *as gamers* to solve the mystery of *Martian Boneyards*. Players were drawn to the subtlest detail in the environment that may lead to a clue, often fabricating intricate stories even where designers had no intention of leading them. Another female top player, Jespau, spent over 200 hours in *Arcadia* and said she spent many more collecting information and organizing files for *Martian Boneyards*. Jespau explained that she spends over 50 hours per month playing *Martian Boneyards* because:

*Arcadia* allows me to learn and play... I do not know how many hours I have spent on the internet, on Wikipedia, and on science related sites to find information about the mystery. I have a folder with over 200 things in it!...It was a matter of getting to the conclusion by whatever means. If it be science, then that's fine...I am a gamer. We never give up!

The players also noted that their affinity for the game grew as they got to know the player community and the characters, particularly those played by the designers. They wanted to know more about the characters’ backstories and their “lives” in *Arcadia*. The mystery storyline focused on skeletons of dead characters who also became objects of interest and intrigue for the players.
EcoDude, the male interviewee, said about his interest in the game:

Well the mystery would have to be interesting to me. And on the other hand I wouldn't be interested without other people being involved.

The next tier of core players, those who regularly came to events, but were not spending numerous hours doing analysis outside the group times, seemed (from the frequency of their activities) to be more motivated to play when new storyline and environment elements were released. Unfortunately, only top-tiered players agreed to be interviewed so this could not be confirmed, but researchers noted that players’ activities increased when new phases of Arcadia were opened. Researchers perceived that players enjoy their privacy in the game, as they go there to escape from real life. The players that did agree to answer real-life questions stated that they were the same gender in real life that they portrayed as avatars. Designers had the strong sense after four months of interactions that most of the players were not very different in their real lives than their characters. When they did talk about their real lives, their stories were consistent with their character (e.g., female characters referring to the duties of being a mother), but, of course, there is no way to tell how accurate this is.

The rest of this section will discuss each of these design features in more detail: environment and storyline, facilitation, inquiry tools, and methods for fostering community recognition and identity.
5.3.1 Highly Immersive and Aesthetic Environment

EdGE chose to use the Blue Mars platform because it uses the CryEngine2 gaming engine, the same used in state-of-the-art first-person shooter video games in 2010. Research has shown that learners see a disconnect between most educational games and the games they would play in their personal lives. Game designers attribute this difference to the polish generated by a professional production (Isbister, 2010).

When players first came to Arcadia, they were often interested in exploring its environment. VSE’s ability to create spectacular immersive scenery was most apparent in players’ early chat when they arrived in Arcadia. Players commented “This is so clearly VSE,” noting that they had seen VSE’s excellent work at a recent Blue Mars showcase video. Players were fascinated with new caves, waterfalls, arches, and trees in the Boneyards. Teon notes:

I don’t begrudge a penny that went into the environment. Players were there because it was beautiful and they were picking up on details that were only possible in the realistic environment. The environment added to the inquiry. What direction the wind is blowing and what season it might be given the leaves on the Baobab tree. These were great questions that we never expected. It wouldn’t have worked in an unrealistic or ugly environment.

The players often commented on the beauty and intrigue of Arcadia. The awe of the high-quality scenery and novelty of being immersed in a high-definition 3-D environment was observed to be a high draw to most players. Arcadia was one of the
most developed regions on *Blue Mars* during the implementation study and offered *Blue Mars* beta testers one of the few sustained activities beyond trivia games, bowling, and shopping. Participant observers noted that players chose to come to *Martian Boneyards* because it was a place to spend time with their friends in *Blue Mars* and gave them a fun activity to focus on. Once players came because of that “hook,” the core remained because they became involved with the characters and were focused on solving the mystery. The number of players at events rose each time a new stage was opened.

The designers also selected the type and location of each artifact within the environment to provide evidence of an intricate storyline that designers had documented, though if players took the storyline in another direction that also fit the evidence, designers would not correct them. For example, a femur bone from a nearly full skeleton may have been found some distance away. It was near a stream and there were lemur bones nearby. Was it moved from their original location by scavengers or water or other means? Did a skeleton wind up at the base of a cliff due to being pushed or having fallen, or just dying in that place?

Designers had planned on using scientific models from a prominent scientific institution with highly accurate 3D models of many types of bones. This collaboration was delayed and eventually did not occur so designers had to greatly restrict the artifacts that could be modeled for the game. Each asset required extensive personnel and time that could otherwise have been applied to other details of the game. Designers chose to use only two views for each artifact (rather than a full 3D model) and limited the number of artifacts (thus species) that would be involved in the storyline. These limitations were chosen to preserve the authenticity of the scientific artifacts that were used in the game,
which designers agreed was the right decision, but it did compromise the interactivity allowed by the tools.

Observers noted that many prominent features in each new stage of the environment became objects of inquiry. For example, an underground waterfall in Phase 3 attracted crowds as much as the cave paintings that were also introduced at the same time. Quickly though, players began to focus more on the cave paintings, figuring they would contain more potential clues to solve the mystery. Jamie noted in the participant observers log:

Mado had some of the keenest observations to end the night. In particular, he said that the ‘cave painting points toward someone observing scientists and taking offence to how they were interacting with wildlife then killed the guy with tranq gun.’ Not too far off from the storyline we have. He went on, but we asked him to post in forum or on board so we could have time to ponder since it was all coming off fast in the chat box.

Designers also decided to leave the bones and other artifacts in place so that other players could discover them even after the early players had been through the Boneyards. This meant that the realism of players’ experience of finding artifacts was compromised. This was, however, necessary to extend the game for a large number of players.

Overall, the designers felt constrained by the budget and would have reprioritized some of the tool development, but were also glad with the choices they made and felt that the development of Martian Boneyards was a valuable learning experience. Teon notes:
Looking back on how the resources were spent in design and development, I would invest more time and effort in the tool development because this took longer than anticipated. More time and money should be invested in the PDA and analysis workstations and next time we should just rely on the web-based discussion board for the theory building.

Occasionally the environment “distracted” players from the storyline and science that designers anticipated, but brought in completely unintended lines of inquiry. For example, the large Baobab tree sparked early discussion, even before Arcadia was launched. A Blue Mars user happened to enter Arcadia during a few hours of open testing before the game began. He recorded and posted a machinima video and images of Arcadia on his blog and included paragraphs from Wikipedia about the regions where Baobab trees grow and what their fruits are used for. He was already trying to piece together a backstory for the environment before the game had even begun!

5.3.2 Compelling and Evolving Mystery Storyline

Though players and designers agreed that the storyline was possibly the most important element for the success of the game, ironically it was one of the least pre-planned elements of the design.

The designers had a very intricate backstory in mind when they laid out the evidence, but did not impose any of the plot on the players. They allowed players to create a storyline that made sense with their own interpretation of the evidence they
found. Designers let the players take the storyline where they wanted it to go and tried to facilitate their scientific inquiry about whatever claims and questions came from the player community. This dynamic and evolving storyline was critical for engagement of players and also for the ability of the design team to respond to what they were learning from the player community. It also required close attention and constant facilitation by the designers’ characters during the implementation period.

The initial storyline presented on the poster in the Arcadia entrance hall was vague and stated only that Laurel, Fischer, and Tieaun (the designers’ characters) had discovered the Science Center, along with the surrounding Boneyards, and needed the community’s help to figure out what had happened before they had arrived.

It was clear very early to the designers that intrigue and mystery were of paramount importance to several of the players. While everyone enjoyed the quest of hunting, those who came back night after night wanted more information about the backstory. When core players arrived at the center, they typically started hunting for bones or analyzing data that they had already collected, and they discussed the storyline. The amount of non-game related discussion in the game was remarkably little. Players were there to solve the mystery.

Top players, mostly female, asked many questions about the (fictional) lives of the explorer characters. They were quick to pick up on any (often spurious) pieces of information that characters dropped that could be taken as a clue. For example, early in the game Laurel (with no particular goal in mind) mentioned that the bones seemed hard to see in the river when the sand had buried them. That provoked a group of players to
form into a search party spontaneously to comb the river. They spread out in a line and went row by row over the grounds to search for bones (see Figure 8).

![Image](image.png)

*Figure 8. Players organize in a search party to hunt for bones*

The posters in the Science Center present another example of the players running with an incidental “clue” that was brought forward by the players but used by the designers as a new opportunity. The posters were created for artistic effect in the center and were not crafted to contain any scientific information relevant to the mystery storyline. EdGE designers did not anticipate the attention the posters would command, which was a problem because the content was virtually unreadable. Players, however, spent days using Google translator to decode the posters line by line and finally figured out that they were the lyrics to a song (*Life on Mars* by David Bowie) and a chapter of *War of the Worlds* by H.G. Wells that had been translated into a combination of Welsh and Esperanto. When the designers saw the players’ fascination with the posters, the
designer characters used this opportunity to seed a new clue. They told players that they had found a journal that needed a password to unlock. Players identified the password from the posters and launched an entirely new game element, JJ’s journal, a somewhat spontaneous and ultimately vital element in bringing the storyline to a close.

5.3.2.1 Character Development within the Storyline.
The characters that designers used in the storyline were useful in holding players’ interest and motivating further scientific inquiry. Players’ relationships with the designers’ characters changed throughout the storyline, without intention on the part of the designers other than their responding the best they could to where the players wanted to take the storyline.

Players were at first mistrustful and cautious with the designers’ characters, but as their trust began to grow (and sometimes wane again) the participant observers felt it was the relationship that players developed with these characters that brought them back night after night. Players were initially quick to mistrust and play out their fear in the mystery game. Participant observers noted:

The storyline advanced a lot tonight. Fischer and Laurel talked about a guy who had been in the center earlier asking a lot of questions about if the bones are human and male or female. He also wants to know who is finding the most bones. Jespau is spooked and thinks he is going to kill her. We assured her that we think he is more likely to reward her.
As the story unfolded, graffiti appeared threatening to Rusty. As soon as Rusty was portrayed as a potential victim, the community seemed instantly to become protective. It was unclear at this point if they had connected the avatar known as Russ Tei with Rusty or if they were just sympathizing with a perceived victim. When a player found a poster with threatening graffiti spray towards Rusty (see Figure 9), she called the entire player group in there. This began a flurry of activity to sort out the relationships among the characters and the roles they may each play in the mystery.

![Figure 9. A poster in the Science Center with graffiti from the storyline](image)

Jamie went into the game as Rusty later that week to spark some more intrigue:

My main addition to the day was having Rusty pay a visit to Jespau in world earlier. I ran past her at the entrance (she tends to be there around 10am ET or so) and into the cave. Once in cave I began to talk to myself hoping that she would catch on. She relayed her message to others, quite excitedly I think, as she tends to take the game very
seriously. She even posted a quite extensive overview the next day to
the forum.

KalW had indeed posted a summary of their conversation on the
community on the discussion forum. She used the details Russ had told her about
his in-game life to support his story of why he would be would be a good source
for information. She used each piece of information that Jamie provided as a
launching point for a line of claims and questions:

Hi!! Fischer did say Rusty reminds him of the guy on Blade
Runner!!! Oh and Rusty is a native of Mars (though natives are not
highly thought of), and as a kid Rusty coded the system, so it is
presumed that he is involved with the bots on New Venice!! Rusty
has a nice place in New Venice but it is very hard to find.

Rusty also thinks that Cameron might have offered himself as
collateral if they (who we do not know) let Laurel go, during that
lost time that Laurel and or us did not know where she was at or
what happened to her!!! Rusty has also made enough money with
his skills he never needs to work again. Rusty said he would keep all
his eyes open, yes all his eyes!!!

Here is the new message on the map room board as of yesterday - C
is either dead or hiding. I'm worried but have ways to disappear F
knows nuff to get help breaking JJ clues. Rusty said she(JJ) told
him about it (bracelet) that if she went missing to try and locate the
signal, that would be activated! That is how he knew to send us back in the Caves to find the bracelet, and to keep it away from anyone that might come looking for the bracelet!!! We believe that JJ liked to create anagrams when she was young and that may be the clues to breaking the code, Fischer is working on that right now. Fischer says he trusts Rusty!

Cameron(C) may have disappeared do to his nosing around the investigation and it is possible Mars founders are the ones involved in C's disappearance!!! Normal in the old days the Founders stayed out of things. C pays for our investigation, and Fischer does not really trust him!!! Fischer is not jealous of C for he is to old for Laurel (:P) hmmm!!!

JJ the one who owns the bracelet we found in the cave said she has left clues as how to get in to her entries or journals, is worried or was worried about things enough that she was trying to keep records in case something HAPPENED!!! JJ may have sisters with the names Tia Tessa(TT) and SSS, I need to confirm the SSS name!! and they could be Cameron's daughters????

hugs and love jamt

Later, near the end of the game, when the players had determined the role that Rusty played in the storyline (that he had protected JJ Cleat and was probably in love
with her), they became even more protective of him. When he visited KalW, another top player, they had the following chat while alone on the afternoon of Sept. 30. It was not about the mystery, but more about compassion for Rusty’s well-being:

KalW : Hi Russ
KalW : are u ok
KalW : can we help
KalW : i like this dress also same as Coyote and how is she doing!!!
KalW : Can u help us help u and the team
RussTei: hello KalW.
KalW : Hi RussTei :) 
RussTei: I can't friend anyone, sorry.
RussTei: Coyote is ok, scared but ok.
KalW : ok and sorry to hear that
KalW : awwww
RussTei: I just came to check some things.
KalW : ok dont let me stop you
KalW : give coyote a hug ok
RussTei: Not friending is safer. Nothing personal, I trust you in fact. you are helping.
KalW : awww ty and when u feel u want to be my friend just say so ok :))))
RussTei: thank you for that. tell Jespau and others thank you too.
KalW : ok I will they will like to hear that from you ! :)

Players opened up to characters, and asked them many questions about their lives outside Arcadia. They wanted to know how long Laurel had lived there, where she lived before, and a few players were intent on implicating Laurel in a love story with Cameron. Designers went along with these plot lines, not introducing them per se, but not denying them either.

Interestingly though, players were reluctant to address the designers in the game if the designer stepped out of the role of their character. For example, often KalW would stay late after an event. One night, after a particularly rough night of tools crashing and players losing data, when everyone else had left, Tieaun and Laurel expressed to KalW how much they appreciated her help with “newbies” (training new players) through the technically difficult evening. They relaxed their roles in the game and started talking more as Teon and Jodi about the development process for Arcadia and the educational research. KalW quickly re-addressed Laurel as the explorer and leader of the center and shut down any conversation that did not have to do with the game. Once the designers understood this, they were still able to ask players about their line of thinking or about game features they would like improved—but remaining in the role of, say, Laurel the Arcadia Science Center director.

The characters that designers played in the game enabled them to facilitate the evolving storyline and respond to players’ interests without over-prescribing anything in the game. This technique became useful when the opportunity arose to introduce new game elements that could tie the storyline together.
5.3.2.2 Key Storyline Element – JJ’s Journal.

To reward players’ efforts for translating the posters, the designers told players that they had found a journal from one of the previous scientists, JJ Cleat. The journal appeared to need a code to open it. The players had heard about JJ Cleat from the explorers and knew that she was likely important to the storyline. This awareness seemed to make them even more persistent to get to the clue. Players finally figured out that the title to the song was the code and when they got it from the translations, with much effort, they were able to open the first entry to JJ’s journal.

Even though it was never explicitly promised in the beginning of the game, designers became increasingly aware that players expected there to be a solution to the mystery in the end. The designers accommodated this need by providing closure to the story through JJ’s journal and also rewarded players’ and the community’s evidence-based claims with awards at the end. JJ’s journal consisted of no more than a series of postings on the web-based discussion board that players used for communication, but was absolutely essential for providing closure to the game experience for players. The creative writing style of the journal gave just enough information to answer players’ questions about happened while also leaving room for their imaginations (see Figure 10).
The designers created the journal as a tool to document the details of what may have happened to the scientists. The designers did not write the journal until the players had gotten far enough along to determine a rough storyline of their own so that the journal could be consistent with their evidence and reasoning. They used the journal to document JJ’s last days before she died, revealing what she knew about the activities of the previous settlers in Arcadia and what type of research they were doing in the Science Center.

The journal contained a story (over about 5 entries) that gradually dispensed clues to tie together much of the evidence the players had found. The players, and the designers, remarked how sad they were at finding JJ, expressing attachment to a character, who never had a physical presence of any kind in the game, yet became a beloved member of the community.

JJ’s journal is an example of a game element that emerged from opportunity and players’ interest. Designers used players’ intrigue in translating the posters to plant a clue.
to unlock the next phase of the story. The entries to the journal were written after the community had made many of their own claims about the storyline. Designers used the journal to bridge the state of players’ findings with the skeleton and other artifacts they were about to find in the final phase of the game.

### 5.3.3 Facilitation and Implementation Features

The design team credits several factors to its ability to entice and sustain scientific inquiry in the game. The phased roll-out of the game allowed designers to build suspense and reward activity with more of the environment to explore. Having designers play characters in the game was also vital, as they were able to deliver the evolving storyline and also able to receive and respond to input from the players. They also found that players were highly invested in finding pertinent information from external websites (such as eSkeleton) so they did not rely on designers for content delivery. Finally, the beauty and realism of the environment made it possible to both hook players and also make the game scientifically interesting.

#### 5.3.3.1 Phased Roll Out.

The game was implemented in 5 phases starting on Jun 1, 2010 and ending October 7, 2010. Each phase corresponds to the opening of a new area of the Boneyards. Phase one lasted about 7 weeks while the other four phases were each closer to 3 weeks. The staged roll out of Arcadia allowed designers to schedule the opening of each new phase at the right time for the community.
Designer characters were able to roll the timing of the phase releases into the storyline as well, using them as rewards for the good work the community was doing. Players were told new sections could be opened because the Center had received more funds from an anonymous donor who seemed to have a vested interested in their solving the mystery.

The opening phase revealed the Science Center and the adjacent outdoor space with a teleporter pad, a stream, and about 25 bones scattered about. Since all the tools were not working for everyone in the first few weeks, the second stage was delayed until the second month.

In the week of July 22, the second phase was released and the dialogue transitioned towards the storyline more than debugging the tools (which were now reasonably functional for most players). The later phases contained nearly full skeletons (human and hominid) placed in and around other artifacts that gave more evidence for a murder mystery storyline. The mixture of caves and underwater falls with wide open savannah and jungle-like regions kept players eager to see what was next, thus spurring them on to do more work.

The designers told players that their donors would pledge more money to open new areas when they could see progress on the theory-building board (or the forum) in the form of solid evidenced-based reasoning about what had happened in the Boneyards. From the players’ perspective, when they made a new major claim (with evidence) about the storyline, they were rewarded with a new area. In reality, a new build with a new area took about 1-2 weeks to release (and pass through the build-testing process involved with
the *Blue Mars* platform) so designers planned for the build as they could see when players would likely reach the next milestone.

Observers noted that players encouraged each other to gather more data so that they could validate the findings and thus others could use them as evidence in their claim. It is not clear, however, that players were able to encourage others to engage in analysis and theory building for the sake of getting a new area. Those who participated most visibly in the analysis and theory building (those who posted the most evidence) were top players who stated that they were more interested in solving the mystery. This of course, entailed opening new areas, but top players did not cite new areas as their main motivation.

**5.3.3.2 Dynamic Facilitation with the Evolving Storyline.**

The design of the game was evolving all during the roll-out and implementation. Since designers were playing characters in the game and serving as participant observers for the research study, they were highly engaged with the players and were constantly strategizing about what to do next with the storyline, facilitation, and roll-out of the game. During this type of prototype study, designers learn as they go along, so this evolving storyline was critical.

The designers communicated nearly daily between the game sessions and were also connected by Skype during the game so they could improvise the storyline if necessary. The storyline was an ongoing discussion among the designers as they played their characters and responded to the ideas and activities of the players. This process required at least 20 hours per week from three designers throughout the 4-month period. The team of three arranged so that at least two of them could be in the game for 2 hours
on 3-5 nights per week, which was quite restrictive on designers’ personal time during the implementation study.

The process of changing the actual Blue Mars environment was costly and also had a long “build” process while it was tested and integrated into the MMO. This limited the number of ‘on-the-fly’ changes that could be made to the environment. The designers, therefore, created screens in the Science Center that enabled streaming of a Flash interactive from the web. Designers were then able to create a simple web page and have it show up for the players to see in Arcadia, even when the designers’ characters were not there. This tool, referred to by designers as a flashboard, became essential for posting game updates. For example, designers posted temporary fixes for problems so that players could make use of the workarounds until the next build was released. Throughout the game, the flashboards were also used to communicate basic instructions on how to use tools, storyline components (e.g., essential questions for players to focus on), and posters of scientists using a comparative approach to studying bones.

5.3.3.3 Instruction and Content Delivery.

The team constantly sought a balance in how to deliver a compelling and evolving storyline, how much instructional design to include in the game, and how to help the players organize their evolving ideas while also providing a community-centered entertaining game. Evidence was placed within the environment to fit a backstory that the designers had in mind, but they never imposed that story on the players. They also made a few informational sources available to players in the Science Center. There were a few posters that showed bones of various species and posters that gave inklings about genetic
engineering and terraforming, but there was no actually content delivery through assets in the game.

The role of designer characters was crucial in the absence of direct instruction because it offered designers opportunities for facilitation and participant observations. The designers played explorers in Arcadia who had found the abandoned Science Center and knew no more than the players about what had happened. As non-experts, they were able to ask questions in a natural fashion that facilitated “think-alouds” to both support players’ inquiry and also to produce valuable opportunities for participant observations. This both scaffolded the players’ articulation of their evidence-based arguments and also prompted impromptu “think-alouds”, enabling researchers to see the players’ explanations of their scientific thinking in text as they respond in the chat box.

Players spent many hours searching the Internet for information. Interestingly, all sites that were posted by players with information (including Wikipedia and various natural history museums) appeared to be scientifically accurate to the research team’s independent science reviewers. For example, Jespau posted:

I may have identified the Skully 2 skull. it is 22.73 cms length by 19.45cms wide. An adult skull is 21-22 cm. long (8.6 in) (from forehead to occiput) and 17-18 cm (7.08 in) wide. That means it is a bit longer and a bit wider than modern humans but the picture scan shows it is not like us and might be HOMO SAPIENS IDALTU - the earliest known homo genus like us to be found dated 160,000 years ago in Ethiopia. Has extended brow, long shallow cranium and vertical alignment of brow, nose, front teeth, An older but close vesion of homo sapiens sapiens!
Within the same discussion, KalW posted:

Hi! We have come a long way baby! 😁 Ok now I do not know if you guys have found this site or not it is

http://www.whyevolution.com/chimps.html and I forgot all about Pittsburgh's Carnegie museum of Natural History!!! May take a road trip also

Jespau and others also often cited the University of Texas science site, http://www.eSkeleton.org/, for much of their research.

The research activity seemed to be a part of the players’ enjoyment and intrigue with the game, and the lack of prescribed content allowed a dynamicism of the storyline that would have otherwise been more difficult. Incorporating players knowledge into the game design and storyline may be key to a participatory model where a community sustains inquiry, but this also requires mechanisms for responsive facilitation. The designers’ roles as characters in the game were vital for this facilitation in Martian Boneyards.

Players were rewarded for producing the best evidence-based claims about what had happened in the Boneyards. This post-positivist type of closure—that this answer is the best we can do with the evidence provided—is intended to mirror understandings in a scientific community, where theories are always evolving as new evidence becomes available.
Sometimes the players’ analysis of the environment raised scientific issues that might not be supported by further evidence in the Boneyards. The designers usually just let this go without response. For example, the observers noted:

KalW led a discussion on what the environment told us about how the bones were distributed. She thinks wind and flood common on outside, talk of river running into cave. She noted related campsite location to how you select a campsite in RL: “u pick the highest most protected spot” which she thought the campsite in Arcadia seemed to represent. Francie and she disagreed a bit. KalW thought that the river looks like a wash and floods from time to time. Francie said that there should be a waterline somewhere depicting this if it were the case. KalW said she’d expect things to collect in certain places (note: we did originally plan to have a place in the underground river where bones got trapped, but this is not in the current environment).

When the game first opened in June, there were no instructions for the tools as they were still undergoing testing and refinement. Players took it all in stride and so the designer characters did as well. The testing and reporting of problems with the tools became part of the storyline. The designer characters told players that they had found the center in disrepair and had a technical team trying to bring the tools back online as quickly as possible so players could help figure out what they had been being used for. Players’ reports of bugs in the tools were “being sent to a tech team for repair” which rang true in both the game and real world.
By early July, participant observers (the designers) had noticed:

We probably need to put up directions on how to use the theory board. (Jespau felt it was overly complex, and I tend to agree, but I said it's kind of like the PDA, we just need a few folks to figure it out and then help others.

The designers initially thought they should have a special event to gather people to show them how to use the theory-building board, but in the end it happened more informally throughout the duration of the game. Once players mastered the use of the PDA, they trained new players on the correct and most efficient way to use it. Jamie explains:

As the game progressed, new players were immediately taken under the wing and taught how to use all of the tools available to them. Initially it would begin with a trip to the Boneyards and a lesson in finding an easy artifact, scanning it, and tagging it. Then they would move on to other artifacts with lessons on how certain ones were harder to scan than others. After helping them find enough bones to whet their appetite, the newbie was taken back to the Science Center and shown how to upload and use the analysis workstations. Ultimately, they were introduced to the theory-building board as the place to link evidence they found (artifacts, analysis, external resources) with their best explanation to what happened at the
Science Center. Usually just enough was given to get a new player involved in finding and uploading artifacts. This was usually a good indicator. If the player stuck around to find more, and came back the next day, then they would become part of the regulars who played the game.

5.3.4 Tools and Resources

Collaboration was a main driver for the design of the scientific inquiry tools. EdGE developers were intent on producing a social learning experience fostering community knowledge-building, and did not want to develop a series of individual gamers experience in the MMO. Teon explains:

It’s all about the communal experience—that was true from the start. Design decisions about the tools, the world, and the storyline were intended to support community progress. Players came in and joined the community where they were in the game, no matter when the new player started. The data verification process was specifically designed for collaboration—players needed to have 20 people having also found the artifact to be able to use it in a claim. That made the community work together to make sure people found bones so that they could analyze them together.
The framework for the scientific inquiry tools fell naturally out of the design of the game play. In the first design meeting between EdGE and VSE, the designers were looking at a whiteboard on which they had written all the game elements they had designed for the community. At one point Hervé, the production manager, got up and drew circles around independent groups of all the items. He said “It looks to me like these are all sort of exploration tools, these over here are for data gathering, those are analysis tools, and these over here are…” and an EdGE designer finished his sentence “theory-building tools.” The model of inquiry that was implicit in the educators’ design immediately became explicit on the whiteboard so that the game designers could put a name to each tool. Teon notes: “The team was amazingly in sync. When Hervé circled the four phases on the white board—it all gelled for everyone”.

This symbiosis of the game tools and the inquiry model became essential for the design of the game and research study. By having each tool match with one and only one phase of inquiry, designers were clear about the priorities for each tool’s functional design. Researchers, meanwhile, had a natural way to measure the extent of players’ activity in each of the different phases in the science inquiry framework.

The designers remarked that they could not imagine building this type of game in a relationship where the educators “handed over” the goals to a game designer and then just reviewed the final product (as they had experienced with other educational software products). They explained that key to this development process was the very close-knit relationship between designers and educators, which may be difficult to reproduce.
5.3.4.1 Communication Tools.

In addition to the EdGE-designed inquiry tools described in the next sections, players used the default communication tools supplied in Blue Mars for general communication. The designers delivered most of the storyline through the chat box (see Figure 11). Though the tools for socializing were still quite limited in Blue Mars, observers and players found that the sense of presence in the MMO was increased from other digital settings. Audio, controlled by the proximity of one avatar to another, was just being tested during the implementation of Blue Mars. It did not work well and was rarely used by players.

Early in the game, the explorers set a tone of mystery and intrigue using the chat box. As Laurel delivered the storyline, she often used the staccato nature of text chat to draw out the mystery. The text boxes would read:

- When we arrived here in Arcadia
- We found this Science Center
- It seemed to be abandoned
- And while we were bringing the tools back online
- We made a gruesome discovery outside....
- bones...
- lots of them...
Players became aware of when Laurel or someone else was telling a story and tended to stop chatting as to not interrupt the flow. When Laurel introduced the council and the award, there was a lot of information to pack into a live chat session. The designers commented:

*We need to distill Laurel’s Interplanetary speech down into bullet points for a board. Anything more than a few lines in Bubble Chat gets lost. Although maybe it was a language issue because Laurel repeated it in French. If so, do we need French and English boards?*

Laurel, fortunately, was functional enough in French to facilitate the game in two languages. Once, with assistance, she facilitated the game for a German player as well. Although there were often non-English speaking players in the game, they typically used
Google translator to read and write in the chat window. This likely meant that those players were not reading every post, as this would have been nearly impossible when many players were chatting. The French contingent often had a group of players to help interpret. This provided an opportunity for observers to see how information was filtered or edited as it was communicated from one player to another.

5.3.4.2 The PDA – data gathering.

The designers embedded tools in the Arcadia environment that were designed to scaffold sustained collaborative scientific inquiry, building upon a model of argumentation and coordination of evidence and theory (Kuhn, 2005; Toulmin, 1958). The tools and resources naturally fell into three of the four categories of scientific inquiry described in the theoretical framework: data gathering, analysis, and theory-building.

The primary activity in the game was hunting bones, or data gathering, with their PDA. This required players to move their avatars all around the Boneyards, zooming in to scan for very small pieces of bones sometimes obscured by bushes or sand. Designers strived to make discovery of artifacts simple enough to not be frustrating or lose players but also challenging enough to keep players engaged.

When the designers first envisioned players using the PDA to scan the bones, they imagined:

... that a few years of Martian dust storms, seismic activity, and the geological stresses of terraforming have left most artifacts partly or fully buried. These will be made separately and placed on, or submerged partly in, the surface. Some may be found under rock
slides, emerging from under bushes, etc. Artifacts are pickable, but won't highlight when the player selects them (the scan will fail or succeed depending on whether they click an artifact).

When developing the software, designers had to abandon the underground artifacts as they required indicator and detection modes that were too complex for quick development. Moreover, they did not add anything substantive to the scientific inquiry in the game. The team agreed that keeping it simple made more sense. The PDA allowed players to have fun with the quest-like aspect of the bone hunting, after which they could turn their attention to the analysis and theory building that would help them address key questions: What types of animals were these? How did the bones get there?

Originally, the PDA was envisioned as a researcher’s toolkit with a futuristic twist along the lines of an iPad. Designers initially wanted to offer several crucial apps—find an artifact, tag it (with species name, common name, general observation, and notes), collect it (via a picture)—and then add new apps. The new apps would be available as players either asked for them to help better find and identify an artifact, or as the complexity of the game required them. Fundamental to this idea of an expandable and adaptable PDA was that as the players’ abilities and science skills improved, the game could respond with more sophisticated tools. Such apps could provide better image capturing capabilities (3-D captures, x-ray imaging), radiometric dating, DNA sampling, and in other field measurements. Ultimately, due to time and interface and development constraints, the designers were limited to basic applications that included:
Scan – Players click on an apparent artifact, and an image is displayed in a list of found artifacts. If the player clicks on something that is not an artifact, then it tells them that no artifact is found.

Browse – Once an image is added, players can add three tags (species, name, and general) in short textual fields and a longer notes field. The Browse option can be called up anytime to see information on bones in the field. The Browse window shows found items in a columnar format and provides limited ability to sort found artifacts (by ID for example). It also allows players to look at found artifacts in a note card type of format, sort through slightly larger images, and edit their original entries.

Since players were depending on others to scan and “verify” artifacts before they were considered valid evidence, players were eager to have everyone in the community contribute their findings. Leaders emerged in the group early, those whom the designers were able to rely upon to help facilitate the game. For example, the designers initially were reminding players to sync their PDAs with the analysis workstations (to add their data to the communal database), but then players took over this duty as they were waiting for the data. At no time was any player observed trying to hide their inventory or not readily sharing their data.

Often one player would be seen standing near bones, pointing them out to others. One character was seen moving from bone to bone until another player scanned it—but never saying a word about what he was doing. Sometimes a player would stand near a bone and say “It is just near my left foot.” The player would stand still until all the other players found the object and scanned it. Sometimes the player would joke “Hey—are you all done scanning, my foot is going to sleep!”
5.3.4.3 Workstations – analysis.

The workstations in the Science Center enabled players to share and analyze the data they collected with the PDA. The ability to upload to the Science Center Database was automated (players simply had to click on the “orbs” that represented the workstations in the analysis room of the Science Center) to simplify the process. This was originally thought of as a design limitation, but Jamie remarks “as many things turned out to be, the more we got into the game, keeping it simple paid off.”

The data in each player’s PDA was automatically synced with the communal database when they clicked on a workstation (see Figure 12). Once they were synced to the central system, they could access all players’ records for any artifacts they had found and other players could use theirs. A player’s observations did not contribute to the number of times each artifact had been scanned (important for the verification of data) until they shared it with the community, so players encouraged each other to remember to sync to the analysis workstations before they left each evening.

![Figure 12. Players using the workstation for measurement and comparison of artifacts](image-url)
Artifacts would only show up on a player’s table if the players themselves had found them. This was meant to inspire players to work together to make sure everyone found all the artifacts. Collaboration was also built into a verification process where an artifact had to be found by a certain number of people (originally 20) before it could be verified and available for use as evidence for a proposed claim on the theory-building board. This constraint was meant to both foster collaboration and slow the pace of early players so that the community had time to grow, and also to mirror a peer-review process in science where data is not taken seriously until replicated in some manner by colleagues. Near the end of the game, the level was lowered so that the core players could finish without depending on a larger returning community.

During the first several weeks, players were occupied with learning how to scan the bones and exploring what they might be finding. The other phases of scientific inquiry did not mature so quickly. Even in July, the predominance of discussion was speculative. Jespau posted:

_Fireplace - someone could make fire? How? Who made it? It might be Mars cavemen as modern scientists would not 'make fire'. Neanderthal made fire. Does this mean there were Martian inhabitants like Neaderthals already there? Did they cause problems for the settlers? Did they EAT the settlers! OR did the scientists 'make' (genetics) some Martian mutations and 'observe' them? Did these mutants make the fire? Did the scientists venture_
out to communicate with these mutants and it went wrong? If so, where are these mutants now?

By late July, however, the first indications began to emerge of strong ties between data measurements and scientific claims. As people continued to discuss how they measured bones, it became clear that there was no standard. The designers suggested that people write about how they measured each bone in the comments section of their workstations, as this was designed to be shared information. Players chatted about standardizing their measurements but did not use the tools to create a formalized system.

On July 22, observers noted:

Francie brought up how to tell male from female again re: using pelvis as well as ratios of bones. We suggested she follow up (she's busy) but encourage her to post theory to get others involved. Mentioned Cameron wants to know male/female of any human bones found.

And then on July 26, they recorded:

Francie and I engaged in discussion of shoe size, is it 11 inches, therefore size 11? Does that make it a male shoe or female shoe, consensus was that it is too big for female, therefore Scully is male. They are linking shoe and bones by shoe to Scully, that is good, but they need to do some more comparison/measurements to link the bones to each other via a theory. This also led to how bones can give
you clues to height, Francie thought that you multiplied bone length by some number (2.6?) to get height but she wasn’t sure.

At this point, other players had started identifying species that the bones might be from. They brought in external sources (all scientifically valid) to inform their analysis. One player had noticed the skulls that were displayed in cases in the Science Center as a Homo heidelbergensis and suspected that the researchers were doing genetic research.

Soon the measurements became very detailed and players began to compare their measurements to outside information. Jespau posted the following (note: the headings B-11-XXX refer to the artifact IDs used by the game tools):

**FEMUR: Thigh bone**

The average adult male femur is 48 centimeters (18.9 in) in length and 2.34 cm (0.92 in) in diameter. This is the longest bone in the human body and a quarter of the body length. (Brothwell 1981: 35).

5 Femur bones have been found. A person's height can be calculated from these measurements. These two bones match in size and could be from the same living thing. This is short for a Mature HUMAN but could still be a younger person.

B-11-HQ1: 35.82 cms x 8.55 cms (width) 2.73 (mid width) (14.10 inches x 1.07 inches)

B-11-UE1: 35.82 cms x 8.73 cms (width) 2.91 (mid width) (14.10 inches x 1.14 inches)

Colour: Beige and the other a bit more sandy but close match.

Height: 143.28 cms or 4 feet 7 inches.
Only one found. To short for human. ANIMAL?

B-11-MK1: 17.22 cms x 3.04 cms (mid width) (6.77 inches x 1.19 inches)
Colour: Light Tan
Height: 68.88 cms or 2 feet 3 and three quarter inches.

These two bones match closely in size, are close to HUMAN length and could be from the same HUMAN of short stature.

B-12-DW1: 41.36 cms x 2.64 (mid width) (16.28 inches x 1.03 inches)
B-12-QG1: 41.64 cms x 2.27 (mid width) (16.39 inches x 0.89 inches)
Height: (averaged) 166 cms or 5 feet 5 inches.

Colour: DW is ancient looking and white with tan blotches. QG1 is more grey with no tan blotches. So not a great match for colour but both found in Cave 12. These last two bones are not verified yet so no picture evidence available. See your workstation for examples.

Another player saw that her measurements differed and decided to take the average:

I was measuring the femurs, like I say my measurements maybe different form yours, I took the average Numbers! Area 11 femurs - HQ1 is 31.27, UE1-20.99 hmmm! Area 12 femurs - DW1is 35.33, QG1-34.64! Area 13 femurs- OB1 is 31.27, UF1-31.23. Area 24 I have not found any but LF1 could possibly be the end of the other sawed of one in area 25!!! Area 25 femurs TF1 is 37.63, UE1-37.68!!! Okay now there is another femur that I found in Area 25-
OC1 measuring at 37.82, and the other sawed off bone which is the end of a femur PI1-11.4 so if they fit then that bone would be 44.99(?)!!! Now if u look at view 2 on the Area 25 - PI1 the sawed off one at the sawed ended there is a red dot, I cannot get a good view of it, could it be like the transmitter on the bracelet!!! love and hugs – KalW

The community never formally standardized their measurements, but did acknowledge that some sort of normalization would have to occur to compare their data. In the end, they used ratios of measurements to identity species so the raw measurements were not as important.

5.3.4.4 Theory Building Area and Discussion Boards.

Like all of the Science Center tools, the theory building board did not initially provide directions for its use. As players started having trouble, the designers created a simple “How to Use” text description and posted it both on the theory-building board in Arcadia and also on the web-based discussion forum that players had started using. It read:

*Composing* - Click on the compose button and enter title, reasoning, and add artifacts as evidence for a claim. Be sure to save your claim before exiting! The author is the only one that can see the claim at this point. Note: If there is a problem with your claim - illegal
characters or claim is too long, you will get an error message be sure to correct and resave.

*Review* - Once you are happy with your claim, click on Present for Review button. This will make your claim visible to others for comments. They may add comments in the right column, add artifacts or other claims in the evidence column on left, and you can add amendments to your reasoning in the middle column. If you want to publish your claim for rating by others, click on the Publish Claim Button. Only do so when you are done editing, as you will not be able to edit your claim after you publish it.

*Rating Claims* - Once you publish your claim, others can vote on it by clicking the appropriate radio button on the right. Your peers will determine if they think the evidence you offer supports your claim.

Note: The author can discard their claim at this point. However, if a claim is discarded, it is lost forever!

The theory-building board was not functional early in the game and was never the medium of choice for players who wanted to share text along with images and URLs to Internet resources (this was still awkward to do in *Blue Mars*). Players used a web-forum (hosted for the *Blue Mars* community) to share information about the game. Some players posted their entire inventory of artifacts, along with descriptions of where they were found, to help other players.

Players used the web forum to organize and share their analysis from the workstations along with comparisons from other sources. At least once, players offered to make a PowerPoint presentation and post it on the web to help *Arcadia* win the council
award, but this never occurred. Players did, however, make numerous postings about the storyline, their data, evidence and interpretations—both on the theory-building area in the game and, more frequently, on the outside web-based forum. Some interspersed their notes about data collection and analysis in posts that were much more informal and contextualized in the game play. Reed stresses the need for an in-game asynchronous discussion board built into the UI (user interface) in future games.

*We didn’t have time to get a really robust UI that supported collaboration. The best thing we had in world, other than the data sharing tools, was the chat tool. The players seemed to prefer the (web-based) discussion board for asynchronous communication.*

The players never converged on one substantiated set of claims that could emerge into one theory. They rather had various versions of the storyline, all very much overlapping and some having much more detail than others (depending mostly on the time and imagination expended by the player). Jespau often posted her notes, which were very detailed, integrating her claims and evidence (with accompanying images in Figures 13 and 14):

*My notes:*

*Terraforming needs to be maintained - so it must be some kind of computerized shield, possibly a radiation shield, a water producing mechanism, force field generator or something similar. The message under the map on the wall of the right room in the lab says: Trigger event - 001.3 RT ORIDE,BOT.PRI.SITE1 and we think it was put there by Rusty Tropez, a citizen scientist from the Founder team,*
who is still on Arcadia. (His name appears on another poster in left room)

I propose this means something like:

Start the first event number 3 - Radio Telescope (or Radiation shield) Override - Primary Robot at Site 1 (possibly Site 11 the boneyards) In other words - turn off the shield for terraforming. We shall expect some weather changes like the sky going darker and radiation to begin to burn things. Water will dry up. Air might become unbreathable.

2. I remember laurel talking about flooding in the basement of the lab (jamt also remembers), many rats and how she said papes were 'spoiled'. This is possible evidence of deliberate sabotage or some freak weather conditions. That evening the sky also seemed to be more violet, as fischer pointed out. We all looked skywards and yes it was getting darker. Up to that point the weather had remained constant at bright sunshine with no nighttime.

How did Cameron, our sponsor, know the skeleton was in the cave? Why was he 'relieved' and why was he relieved it was male? Did he expect a female skeleton? If so, why and who could it be? Is Cameron a geneticist? Was he part of the genetics team? Or did the Founders find something he wants?

After this I also showed laurel and fischer the skeleton bone map on the wall of the workstation room in the lab - the ones with mixed
bones in it that I have posted about before - and I pointed out the strange bones in the skeleton face.

There are no eye sockets. The sockets are covered with square shields. fischer agreed it did not look human. laurel just said oh I see. fischer then pointed out the DNA double helix behind that skeleton in the poster. An obvious pointer to the genetic experimentation both NoTail, KalW and I have been talking about for months. I believe this may be definite proof. Pictures below:

*Figure 13. Jespau's post entitled Bone or skeleton map in workstation room*
Ultimately the designers felt limited in their ability to be more responsive to the community in terms of tool development. They wanted to be able to produce the tools that players were requesting. During early informal focus groups with players, the designers asked them what they would like as rewards for their participation. Many wanted tools to help solve the mystery. Players suggested they wanted metal detectors (to find more artifacts such as the food cans that were around the fire pits) and carbon dating tools that determined the age of the artifacts they were finding. Teon recalls:

There were lots of things we were able to leave open for storyline, but the artifacts and evidence had to be pre-built. We could be very responsive to the community in some ways, but when we asked them what type of tools they would like to have—we couldn’t produce them. We had wanted to give players who are more advanced new tools that they actually asked for—that would have been the ultimate in responsiveness, but we didn’t have the resources to do that.
While the designers felt frustrated at not being able to deliver the tools that players were asking for, they also felt encouraged that there was a community wanting deeper exploration into scientific mystery games. They also wondered whether players would be equally curious in a game hosted on a less expensive and more accessible platform, such as Flash and HTML, where they could use resources to develop more tools in response to players’ interests.

5.3.5 Community Recognition and Identity

A number of interesting observations were made about the collaborative and communal play in Martian Boneyards. Players became recognized for their roles within the community and designers used those identities to help structure the game. Players who were interviewed cited their relationships with the characters and other players, and their involvement in the storyline, as factors in their motivation for sustained inquiry.

Observers noted that the play was collaborative right from the start. Possibly because the call from the designers’ characters went out as a call for help to the community, players came in and quickly worked together to start exploring and gathering data. Some features of a scientific community appeared to develop very rapidly. Players adopted the language of inquiry supported by the scaffolding and language used in the tools and facilitation.

To further encourage collaborative scientific inquiry, designers used spontaneous rewards (“swag”) and an award ceremony at the end of the game to recognize and thank players for their contributions. This strategy appeared successful in sustaining players’
interest and inquiry and also in nurturing identity associated with scientific competence and behaviors.

5.3.5.1 Building a Culture of Inquiry.

Participant observers noted that players quickly adopted the “rules” of the inquiry tools, and the scientific language and behaviors promoted by the game were adopted within the community. By week 8 of the game, players were making such statements as “we can’t use it as evidence until it has been verified,” and “before we can post a claim we have to find evidence to support it.” Players were using this language as one might explain the rules of a game to a new player, but later speaking about the need for evidence to substantiate theory building became commonplace in the community. Even as players moved to using web-based theory-building boards, they still used language suggesting that they were trying to form evidence-based arguments. For example, Jespau posted:

There are Neanderthal skulls in glass cabinets in the laboratory hall. Why are they there? Are they artifacts that were collected by the scientists? And the bone map on the wall of the lab where the workstations are sited, has a mixture of ape, Neanderthal and human bones on it in the shape of a hunched animal or man. Does this mean they were trying to make a mixed version of life that could survive in the Martian world?

Evidence: Posters are on the walls of Arcadia lab talking about Genetic research by the scientists. The word NuHoms is there. I
researched NuHoms and they are in fact a system for transporting and storing depleted nuclear waste. This might be relevant by I propose that the meaning of the word NuHoms is actually = New Humans!

Although the heading purports to be about genetic research, the content of the poster is actually in welsh and not anything at all to do with genetics. This is probably to stop us finding out about their research.

Evidence: In the new dry cave 12 there are various bones, a skeleton who has been either attacked, or fell off a cliff and no evidence so far of a perpetrator. But theories are about that perhaps there is an animal loose, perhaps a mutant made by the scientists or a leftover person from the expedition who is responsible for "Skully"'s death.

Only once or twice during the game did someone enter the Science Center in a way that was completely incongruous with an educational game. The observers recorded:

Telus brought in his friend Hooters to take picture because his scanner wasn’t working. Hooters was in a bikini purchased from a new store. Laurel suggested it was inappropriate attire for a science center. She wasn’t there long. What to do about this in general?

Fortunately, the designers didn’t have to deal with this very often. EdGE had commissioned a Blue Mars designer to make lab coats and appropriate clothes for the designers’ characters. Players were able to win these as prizes for
their participation. In the rare cases when players steered the discussion in the
Science Center towards something flirtatious or potentially offensive, the
designers simply had to say “Ahem…decorum…” and that ended the
conversation. In fact, in the later parts of the game, it was players who were
admonishing other players if they started joking in a flirtatious manner, often
using the same line “Ahem…decorum…”

5.3.5.2 Rewarding Community Contributions.
Initially, EdGE used an informal reward system that relied on the designers’
characters to give out awards to recognize players’ activities. The nimbleness of this
approach allowed designers to respond to the players’ stated desires and designers’
observations of what seemed to motivate productive game play. EdGE commissioned a
clothes designer in Blue Mars to make t-shirts (see Figure 15), cargo pants and vest (with
lots of pockets for collecting bones), and a water bottle—all items one might need on an
archeology dig.

The designers selected players each week that received this “swag”. They
identified those who contributed to the game’s activity – particularly new people who
found a lot of new data or players who posted evidence to the theory-building area
Later in the game, the designers realized an award ceremony would be a way to wrap up the storyline, and also have a community event where players would be publicly recognized. Laurel’s announcement that the award ceremony was going to be held in the Arcadia Science Center created much excitement among the players. Teon notes:

They were that invested communally—they weren’t just going to go off to work alone, they were going to MEET and do it!

This spontaneous set of decisions by the designers became a useful game element to close the game. The award ceremony brought back players from the past and hosted the largest number of players present at one time in Arcadia.

The promise of a community-based award was all that was offered to players, though when the ceremony took place, individual awards were also given. Players were
excited in the build-up to the awards ceremony—planning outfits and discussing who would be there. When the evening arrived, over 40 players showed up in full evening wear that they had purchased from the stores in Blue Mars (see Figure 16). People gathered in the entrance hall until called en masse into the theory-building room.

There was an ongoing slide show on the screen that usually held the theory-building board, announcing the two overall awards from the council (to Jespau and KalW) and also nine individual awards to other players from the Center. The recipients of the awards were chosen by the designers, with the two top players being clear choices based on their activity. The other recipients were acknowledging core players who contributed in many events or had made crucial advancements along the way.

Interestingly, the players noticed that designers did not give an award to Saxanne, the character played by Teon but who behaved like a regular player of the game. Saxanne
had become useful to the designers because he could ask naïve questions when he had been gone for a week or two and players would “fill him in” in a way that may have been different if they knew he was a designer. At one point, Saxanne was involved with the players on an evening where they made crucial discoveries about assembling a collection of hand bones they found together and identifying it as a chimp. Saxanne had facilitated the conversation and then posted some resources that others had recommended on the discussion board. When the awards were given, the players noticed that Saxanne was not recognized and one player very politely emailed the next day to suggest that Saxanne be added to the award list. His award was added to the others posted in the forum the next day.

5.3.5.3 Nurturing Identity.
Observers noted many interesting cases of identity revealed in the interactions among players. People demonstrably took on roles in the game. As players became recognized in a role of competence, it seemed to further stimulate their productivity. Some players clearly took on the role of teacher or docent, greeting people when they arrived and showing “newbies” how to find bones. Being in-the-know appeared to be a sign of status for some players, one that might be leveraged to foster science identity in other social digital games.

Participant observations revealed that even early in the game, top players Jespau and KalW were emerging as leaders, but their leadership was not a product of a strong confidence in their own science abilities. When Jespau told designer characters (via in-game chat) that she had many files of information on her computer containing measurements and Internet sites with data, the designer characters asked if she wanted to
share it with others. She replied, “Why would anyone else want to see it? It is not like I know what I’m doing. I just do this for myself because I am a little OCD …lol.” Designers rewarded players like Jespau for their persistence, innovation, and ability to teach others. For other players, these science leaders became the heroes of the game. A male player said of Jespau,

I nicknamed her "Doc" because for me...she was the person who had the most, the acutest brain. I followed her around eschewing the company of other so-called "Scientists"…Jespau and I became suspicious. Stories did not ring true. We or perhaps I decided to trust no one except Jespau…Her account explains so much.

Jespau gradually became spokesperson for the group and took it upon herself to post for the group on the web forum and the theory-building area and tell the story. She was also a major contributor of the information in the story but was quick to include and credit others and was a natural group facilitator. She posted:

Please excuse long read but its what we have decided to do as a group.

THE STORY OF ARCADIA

with content from laurel, fischer, Idtei, jamt and ilko.

Please add any other parts to the story and we can begin to try and build up the whole picture - as we agreed in the lab a few days ago. A group story writing....This is the beginning of our search for the true story of what happened in Arcadia and I will start with what we
Players also took on roles of teachers, although sometimes they took on that role in response to a request from another player. On June 24, Jespau was lingering after an event with Sigfreid, a player who had many technical troubles with Blue Mars, yet still came to nearly all of the Martian Boneyards events in the first months. Near the end of the evening, Sigfreid said to Jespau “I don’t think I’ll be coming back until the workstations are up, there is nothing for me to do here anymore.” Jespau said “oh darn, I thought you’d come back and help me find more bones.” Sigfreid replied “oh yeah – I guess I could come back and help other people” and agreed to “see you soon.” Sigfried was back many times after that, often showing others how to find bones (see Figure 17).

On July 29, the observers noted:

It’s also very cool that folks are readily spreading the credit, for example, when trying to find the second dart, who found it came up. Kalw said that “Notail showed me where to find it” and Notail then gave credit to Jikaka. One gets the feeling that these players if in a real science lab would argue about letting each other go first on the publication list! Refreshing.

Later in the game, in August and September, the observers continue to report that the tone in the game was very collegiate. They described the player dialog as:
Much like you’d get in a lab or field site where folks have been working together for some time. In particular, the talk moved between, “scientific” like what a bone might be, where it might be located, etc and good natured humor/ribbing of each other. The scientific discussion is mixed in with comments about someone wearing “bunny slippers” in the field.

Figure 17. Sigfreid hunting for bones in his bunny slippers

Players and observers noted several factors that were responsible for emergence of a community in Martian Boneyards. The storyline gave purpose to players’ time in the game, the player community was working towards a common goal: to understand what had happened in the boneyards. There was sufficient information in the game to keep players exploring, but they were also required to go figure out much of the information on their own. The inquiry was unguided in the sense that players were not given direct
instruction or content delivery. This allowed roles to emerge among the players as some became more adept at data gathering and others at sourcing background information.

In summary, the design elements that appear key to fostering this inquiry are a compelling and evolving mystery storyline, the close connections players felt with the characters in the storyline—some played by designers—and the highly aesthetic and scientifically-rich environment. This dynamic design and implementation has led the design and research team to see social digital gaming environments as an ecosystem comprised of the design features of the game, the players’ activity, and the players’ progress in terms of establishing of a knowledge-building community. All these factors contribute to the evolving game experience and environment. This ecosystem model will be discussed more fully in Chapter 6.
Chapter 6: Discussion

Social games such as *Martian Boneyards* are indicators of an emergent participatory culture where the public is taking control of its own learning (Falk & Dierking, 2010; Jenkins et al., 2006). This dissertation research shows how designers can leverage this phenomenon to engage the public in a new type of learning, one that may be more inviting and also more productive than many educational endeavors of the past.

In an effort to understand the potential of gaming environments for learning, this research considers who came to play *Martian Boneyards* and who engaged in sustained inquiry in the game. It looks at the nature of the scientific inquiry that took place among the player community and most importantly, the design features that were used to help foster high-quality sustained scientific inquiry within the game.

The immersion of the participant observers as both designers and characters in the game gave them an extraordinary perspective on the emergent culture of the *Martian Boneyards* community. As formative researchers they were able to guide the storyline and game experience while being responsive to players’ activities and interests. They were able to let the gaming environment evolve as the community’s knowledge building proceeded. This intricate interaction among the game design, players’ activities, and the player community’s progress became the basis of an ecosystem model that will be discussed in section 6.3.

First, in sections 6.1 and 6.2, the player community and the nature of their activities will be discussed. This implementation study is limited because it was
conducted with the beta-test population of *Blue Mars*. This kept the sample relatively small, and skewed towards players who are very involved in MMO gaming. They do not necessarily represent a general population in their interests. The players also tended to not be involved in science in their daily lives. While there are important first lessons to be learned from *Martian Boneyards*, it is important to not over-generalize the findings.

### 6.1 The Martian Boneyards Community

The players of *Martian Boneyards* primarily came from the existing *Blue Mars* beta-test community. They were generally experienced virtual-world users and not typically involved in science in their daily lives. The average age of the players was 36 years old and there were more males than females and more whites than non-whites that started playing the game. Interestingly though, the top tier of players were disproportionately female (50%) and female players interacted with the analysis and theory-building tools more than their male counterparts.

The typical American video gamer is a 35 year-old, white male (Lenhart et al., 2010) which fits the typical *Martian Boneyards* player. It would not be a stretch to generalize results from this study to the experiences and perceptions of gamers in other non-violent social games. One must remember, however, that these are experienced gamers and those who have chosen to socialize in a new (and thus sometimes unstable and frustrating), highly computer-intensive environment. Many of the players mentioned that they had previously spent time in *Everquest* and *There.com*, other quest-oriented virtual worlds that have since closed.
As the designers from EdGE look to expand their audience, they will likely move to a web-based environment that is more easily accessible by the general public. The MMO offers interesting opportunities to provide a supplementary social venue for avid avatar-based gamers, but at the current time the platform is limiting to the audience and provides possibly unnecessary development expenses.

### 6.2 The Nature of Scientific Inquiry In Martian Boneyards

EdGE designers hypothesized that by developing a game that was appealing to a savvy gamer audience they could also engage those gamers in sustained scientific inquiry. In many ways EdGE succeeded at this quest, but of course, there were also several shortcomings and limitations observed.

The tools, environment, storyline, and facilitation were all designed to support multiple stages of scientific inquiry among players including data gathering, analysis, and evidence-based theory building. The model used to design the game’s inquiry tools followed a framework of argumentation and the coordination of evidence and claims in building towards explanatory or predictive theories (Kuhn, 2005; Toulmin, 1958).

The findings suggest that a core of players did indeed participate in sustained scientific inquiry within the game, including the important later phases of analysis and theory-building, as measured by their interactions with the inquiry tools. This appears to be an improvement over previously reported online communities that stalled in the earlier phases of exploration and triggering (Garrison and Cleveland-Innis, 2005).

The measurements of analysis and theory building assume an association between the players’ interactions with the game tools and each of the steps of the inquiry
framework. Each time a player scanned an artifact with the PDA, it was recorded as a data-gathering interaction. Similarly, when they clicked on the workstations it was registered as an analysis interaction and when they clicked on the theory-building board, it was registered as a theory-building interaction. This simple counting metric offers a means of assessing activity level at each stage of inquiry. However, it does not capture the subtlety of how and why players engaged with the inquiry tools, or indeed, whether their actions would be considered inquiry by other measures.

To assess the quality of the scientific inquiry, a team of independent scientists reviewed the discussion generated by the players on the discussion boards and theory-building area in the game. The bulk of the players’ online discussion was in the area of comparative anatomy. There were several other areas explored, including some genetics and environmental science topics, but the deepest inquiry was in the area of anatomy and identification of the bones in the Boneyards. The reviewers rated (unanimously) the inquiry skills and content understanding as very good compared to their undergraduate students in introductory science classes. They were overall very impressed with the self-direction and motivation for inquiry in the game, the accuracy and relevance of the outside information that players found, and the creativity and inquisitiveness of the players. The only potential weakness the reviewers noted was that the level of science was still relatively consistent with introductory understandings, and there was no evidence yet for deeper reasoning that would be expected as players progressed to more sophisticated challenges.

*Martian Boneyards* was structured for community inquiry in a mystery for which the solution is unknown. Players’ contributions to the scientific inquiry were judged by
their value to the community of players, not against “right” or “wrong” answers known by some external authority. Though the questioning was not open-ended in the sense that there was evidence laid out in the game according to a prescribed possible storyline, this inquiry was not guided by the any direct instruction. In terms of Lock’s dimensions of inquiry (1990) that looks at the directedness of inquiry, the conclusions were not completely open for interpretation by players because the evidence had been placed by designers to fit one very definite storyline. If players chose to interpret the evidence differently, however, the designers did not correct them. Similarly, the activities were somewhat prescribed by the functionality of the tools and the nature of the storyline, however no one told the players how they were to go about solving the mystery – they were to use the tools and resources provided (and find their own resources) to pursue their investigations.

The players independently gathered all the information they needed to identify the bones they found. They decided themselves if information was valid and satisfied their own criteria for evidence. They engaged in peer review and generation and revision of claims from community-based findings. Educators have claimed for years that although this type of collaborative knowledge building is the vehicle of professional science (Dunbar, 2000), inquiry in educational settings must be highly scaffolded and guided by an expert or teacher (AAAS, 2003; NRC, 1996). This research suggests that, although teachers have a very important role in the classroom, well-crafted gaming environments may offer a way to make open-ended scientific inquiry appealing to a wide audience of learners outside of school.
6.3 Designing Evolving and Participative Gaming Environments

The intertwining of the initial game design, players’ activities, and players’ progress became evident quite early in the implementation of Martian Boneyards. The gaming environment can be viewed as an ecosystem where the game tools and resources laid out by the designers spawned initial player activity. This model of an ecosystem frames the analysis and interpretation for the research in this dissertation (see Figure 18).

In an ecosystem model, the interactions among the elements of the gaming environment are key to overall game experience. The designers kick off an initial environment with resources and a storyline, but that environment design is far from static. It is the interactions of the players with those design elements from which the game arises. Player activity creates player progress, which in turn feeds into the evolving gaming design. The ultimate game storyline and activity is a product of the player community, with the structures carefully designed by the design team.

![Figure 16. A model for a gaming ecosystem](image-url)
This framework of an ecosystem for games is not unique. Gee (2004) describes a game as just this type of complex system that is emergent between the system that a designer puts in place and the way the player interacts within the system. Cormier and Siemens (2010) describe learning environments as systems that foster and support the creation of communities and that are designed to be consistent with how learners learn. Li, Clarke, and Winchester (2010) use a learning theory they call “enactivism” to describe how learners can influence their own learning environment, particularly in gaming.

In this model, a game is not delivered to the community, but rather emerges from it. Game designers create an environment with tools and resources, and create an initial storyline that evokes player activity. Much thought and research goes into how to develop: a) an environment that will draw players in, b) tools that make it easy for players to do the activities they are meant to do, and c) a storyline that compels them to continue on. The difference is that the design is not finished once the players start interacting with the game.

The players create social structures and form into a community while interacting with the game tools and resources and with each other. Game designers play characters who help facilitate the gameplay, allowing for an evolving, nimble game experience that it responsive to the player community. Players’ activity results in their progress in the game in terms of their advancement within the game (points or status) and also their individual and community knowledge develops over time. Then their new roles, knowledge, and social structures they have established become an integral part of the
designed game, creating an evolving interdependent ecosystem of design, activity, and progress.

This ecosystem framework requires researchers to analyze what is happening in the game and help designers to respond in an on-the-fly manner. The design features initially include the tools, storyline, and resources that the designers start with as well as the facilitation roles that the designers assume. Players’ activities consist of their interactions with the gaming tools and resources, and the social structures that emerge as they interact with each other. Progress occurs at the player level (players’ advancement in the game, their emergent identity in the game, and their individual learning) as well as at the group level (the knowledge developed by the player community as a whole).

In this form of design research, one must be very cognizant of the evolutionary, and sometimes tenuous, nature of the research that is informing the design. As a designer, one strives to achieve a desired outcome from the design, and when that outcome presents itself designers may be quick to attribute the outcome to the design. As a researcher, one must take a much more critical view, not only in measuring whether or not the outcome was achieved, but also considering all of the other factors that may have caused the outcome. For example, the designers were excited by *Martian Boneyards* players’ use of the inquiry tools and sensed early in the game that the storyline and the designers’ characters were motivating players to come back to the game. The designers responded by increasing storyline features such as clues and character plots. By doing this, the designers had implicitly not chose to build on other facets that may have increased other players’ activity and inquiry. Ultimately, the research must explain the reasons for the outcomes, either intended or unintended by the design.
This dissertation research focuses on several elements of this gaming environment ecosystem model, leaving others for future research. The examination of any element of the gaming environment can provide some information to educators and researchers, but the interaction among the elements should not be forgotten. The linkages between the social structures that emerge from players’ activity, the knowledge building that occurred within the community, and the evolving storyline and facilitation that designers use to scaffold the dynamic design are among the most salient features of this ecosystem model.

6.3.1 Game Design

The design team made many decisions during development that they (and players) attribute to the sustained inquiry exhibited in Martian Boneyards. These include the decisions: i) to create a high-resolution, visually engaging environment, ii) to introduce a mystery storyline, and iii) to personally forge bonds with the players. There were also missed opportunities noted by designers, where under other circumstances they may have been able to do more to support players’ inquiry. This section details the how the game environment, storyline, facilitation, and implementation decisions played a role in the game design.

Players were initially attracted to the aesthetics that the MMO Blue Mars provided for the Arcadia environment. This attraction enticed them to explore Arcadia. While they were there, they found interesting artifacts, a storyline, and a friendly community of co-explorers. Players were supported both by the characters that the designers played and the inquiry tools provided. The need for scientific knowledge to solve the mystery provoked players to collect and analyze data in Arcadia and to search
for information on the Internet to confirm or counter their claims about what had happened in the *Martian Boneyards*.

The insular nature of the gaming environment (being a high-end MMO, it is still in beta-testing) also curbed the ability of *Martian Boneyards* to reach a wider audience and inhibited some of the ability for designers to be responsive to players’ interests. Development was expensive and cumbersome in the MMO so designers were often frustrated that they could not fulfill players’ scientifically interesting requests for new tools or modifications.

### 6.3.1.1 Environment and Storyline.

Though the aesthetics of the *Arcadia* environment drew people in, it was the *Martian Boneyards* storyline that kept them coming back. The storyline began with a basic call for help. The explorers—Laurel, Tieaun, and Fischer—had found an abandoned Science Center and a land full of skeletons and mystery. They called upon players to help them figure out what had happened.

The bones and artifacts were laid out by designers with an intricate storyline in mind, but the designers let the players choose how to interpret that evidence. Overall, the storyline that players came up with was very similar to the original storyline. This was not a great surprise since designers did drop clues and create artifacts later in the game that supported the original (and emergent) storyline. Designers did not steer players’ inquiry away from alternate lines of questions, but rather tried to use those efforts to provide direction for additional game play. For example, the designers leveraged the extensive amount of time players dedicated to translating (originally irrelevant) posters
by planting a clue in the poster that opened a journal to release the next piece of the storyline. Designers did not, however, deliver any of the scientific content necessary to guide the players’ inquiry. The interpretation of the scientific evidence—the comparison and identification of the bones—was all achieved through player-led analysis and research.

The top players in *Martian Boneyards* were enticed by the intricacy and immersiveness of the gaming environment, as has been reported by Dalgarno and Lee (2010), However these same qualities may have prevented others from digging deep enough in the technology and storyline to get hooked. Further studies with a variety of platforms and levels of scaffolding would be needed to understand what mechanisms may draw a larger audience.

### 6.3.1.2 Level of Instruction.

The game design framework that EdGE used in *Martian Boneyards* included a principle of providing minimal direct instruction or content delivery. This is the practice of many professional game designers (McGonigal, 2010) but is very different from most educational games (Isbister, 2010).

Progress in *Martian Boneyards* relied on designers’ characters who periodically gave storyline updates to players and let the information diffuse mainly by players through the game networks. There is some evidence that this method was successful in that key players gained status and a role in the game by helping others with storyline and game mechanics. On the other hand, more players may have stayed and engaged with the game had there been more instructions on how to get started.
This research suggests that minimal instructional design is desirable in the form of text or even video-type tutorials; however, the UI for the tools needs to be highly intuitive (McGonigal, 2011). Today’s gamers have many accepted norms of where buttons should appear and how interfaces are expected to work. These should guide the user interface as much as possible so that tools behave the way a player expects. There can be some flexibility (e.g., whether buttons are on the right or left) but designers should take advantage of common elements players know to look for (e.g., an arrow in the lower right of a screen likely means a click will turn to the next page).

Martian Boneyards players frequently brought in resources from the Internet to help the community solve the game. In fact, they were frustrated by the limitations of being unable to display external websites within the Science Center. Integration of these media would have allowed this audience to use the Internet as their “library” in the Science Center. The links that players posted on the discussion board were from scientific cites and rated as suitable by the expert reviewers. Players referred to various sources of information, both physical spaces they knew about in their real lives and other web sites, including some seeded by designers. For example, one player posted:

I forgot all about Pittsburgh’s Carnegie museum of Natural History!!! May take a road trip also 😊)) You would not believe what they have in that museum!! Oh jepau noticed on the sign in the work station area that it says btw jj - checkout arcadiashare.terc.edu did it always say that about jj ? love and hugs kalw 😊
These findings may suggest that less design effort needs to go into finding and filtering appropriate content for players’ investigations (as long as the designers know quality material is readily available on the subjects at hand). Instead, designers might spend more time on the user interface of the tools and the attractiveness of the environment and on ensuring that the storyline yields many opportunities for high-quality scientific inquiry. This notion is closely aligned with principles outlined in many emerging commercial game design philosophies as well as other research on participative and transmedia communities of practice (Jenkins, 2006; McGonigal, 2011) that rely on the users to generate not only the activity, but also a majority of the content.

6.3.1.3 Facilitation.
EdGE found that the designers’ facilitation of the community was central to shaping the experience and the environment. The designers’ participation as characters within the game and their ability to provide a dynamic and responsive storyline helped support a participative culture and promote independent high-quality scientific inquiry in Martian Boneyards. Designers explained that the sustained inquiry observed in Martian Boneyards was made possible by the flexible and evolving storyline that was initiated and facilitated by the designers.

Teon explains:

Our design relies on community input and not overly structuring the inquiry. We try to give a really strong scientifically accurate base but let the community take it where they are going to take it. In Martian Boneyards, we made a deliberate choice that the game player
community was part of our design team—we were going to let them help us design something we couldn't do alone. We were modest enough to realize that what we would do with them would be so much better in the end.

The close relationship among the educational designers, the game designers, and the player community was essential for the success of the game. The team of designer facilitators kept in close contact while playing their characters (and serving as participant observers) in the game. At least one of them, and often 2 or 3, were in the game for each event and were often on Skype together back-chatting while they dynamically let the storyline unfold. Spontaneous comments made by the characters often spun into a new line of inquiry so designers began to be more careful in their “off the cuff” remarks. They also used this time to build a social storyline (building on players’ questions about romance, divisions, and alliances among the characters) to add the drama that players seemed to crave in the game.

6.3.2 Players’ Activities

The previous section explained the design features that were important in fostering scientific inquiry. This section reports on the activities that resulting from, and influenced, the progression of that inquiry. In the ecosystem model used as a framework for this analysis, the game design, activities, and player progress are examined both individually but also as they relate to one another.
6.3.2.1 Players’ Interactions with Tools and Resources.

The data log and participant observations show that players spent the first several weeks almost entirely in the data-gathering phase, and that data gathering was further stimulated by periodically introducing new areas to explore. The analysis workstations and theory-building board were still being tested in the first part of the game, and this could explain why players took so long to move to the analysis portion of the game. However, even when the workstations were operational for most players, only a few players used them. More players began the analysis in the third phase when players were trying to compare two skeletons to each other.

Soon, players posts became collaborative in their efforts to hone in on which animals could be represented by each set of bones.

“Hi kalw –

1. Nice work on chimps. I spent ages today researching them after your idea and you are right. They are our closest primate relative. Only 1 chromosome different. Thats what’s on the painting i think.”

Humor and science could be completely entangled in the dialog. The players’ dialogue endeared them to the designers. Jespau and others were speculating on how the bones would have become so clean. When someone suggested that insects or other creatures may have cleaned the bones Jespau cried out:

I draw the line on researching maggoty things!
The participant observers made a prominent note of this in both the log and in conversation—it became a touchstone for them to revisit when wanting to remind themselves about the dedication of the players;

But remember...Jespau won't research maggoty things!

Overall, designers were impressed with the persistence and curiosity that players exhibited in the quest to solve the mystery. These attributes are sometimes associated with such concepts as “flow” or “states of arousal” (Csikszentmihalyi, 1990; McGonigal, 2011). Designers had anticipated that they would need to do more to keep players interested in the science, They found, however, that players’ distractions were not social in nature, but rather were often caused by the environment, which inspired tangential lines of inquiry not directly related to the storyline. This occurred with the large baobab tree and the terraforming content that players found in the translated posters. Although these discussions did not help them solve the mystery by the fastest route, they were still fascinating and arguably worthwhile areas of scientific inquiry, perhaps more so because these were the lines of inquiry spawned entirely by the players’ own curiosity.

6.3.2.2 Social Structures.
Top players attributed much of their attraction to the game to social factors; they bonded with a community that included characters played by designers and other characters who were only represented by skeletons—but who took on a life of their own in the game storyline.
As early as the first month, a strong culture of collaboration was emerging in the game. Textual communication occurred primarily through chat and asynchronous discussion boards, but gestures of the avatar also became an interesting addition to the social presence. Avatars were able to wave, hug (a “dry hug” and a more intimate hug), clap, and dance along with many other gestures. Players used these occasionally to animate their play. For example, players often waved at new players when they arrived and on a few occasions the whole group would break out into a dance party in the Boneyards. One spontaneous dance party was prompted by Laurel, who was just learning to dance. When players typed “/dance” in their chatboxes, their avatars danced for about 15 seconds. When Laurel tried it, the rest of the community took it as a sign to let loose and join the party. For about 3 minutes players kept their avatars dancing together. That night seemed to set a relaxed tone subsequently—a kind of bonding experience in the community.

Over the course of the game, the characters played by designers provided the core of the social narrative of the game, but players also refined their relationships with the designers and other players. Roles began to emerge in the community where NoTail was known as “eagle eye” because she was so good at spotting the small bones. Jespau became “Doc” as she became the go-to authority on the storyline and bone identification. KalW was always there and acted a bit like a Mom in the game—always making sure that newbies were taken care of and becoming the caring and devoted friend to all the characters.

Once in the game, these social structures were observed to transcend the virtual environment. Late one night after a long session of hunting and analysis, a few core
players were left in *Arcadia*. NoTail announced that she would not be in the game for a couple of days and that afterwards she was not sure she would be able to help as much seeing the small bones. She was having surgery on her eye. It took a few lines of chat for people to realize that she was talking about real life. The outpouring of sympathy continued:

- **Laurel:** Awww...NoTail, are you really having surgery?
- **NoTail:** Yes, I have to get surgery on my retina. I don’t know if I will be able to help as much after that.
- **Sinsa:** Oh NoTail...are you okay?????
- **KalW:** NoTail!! What will we do without you?? You need to rest and take care of yourself!!
- **NoTAIL:** I think I can be back in the game soon (a couple of days at most) but not certain I will see well.
- **Damino:** Oh NoTail...is there anything we can do for you? Where do you live? Hungary? Do they have good medical care????

At the final awards ceremony, over 40 players joined together, most dressed in formal attire they had purchased for the occasion. When each award was announced, nearly everyone clapped (by typing “/clap”) and many hugged the winners (by clicking on their avatar and requesting a hug—once accepted by the other player, the two avatars embrace). See Figure 19. All the designers commented that it was an emotionally charged event. The observers wrote:

- The players were amazing. They all felt so formal and into it. They were so proud of each other and the work they had done. When the
awards were all announced they were beaming. Their hugs really felt like hugs.

Figure 19. Players applaud at the awards ceremony

6.3.3 Players’ Progress

In the ecosystem model of gaming environments, the players progress as a result of their interactions and social structures that emerge in the game. This progress is seen as players’ advancement in the game, as identities emerge in the community, and as knowledge is built among the group and within individuals. This progress then feeds back into the evolving game design.

6.3.3.1 Player Identity.

Identity is an important construct that emerged as part of this research. A social view of identity places emphasis on a person’s role and reflection within a community
(Shanahan, 2009). As a person becomes recognized within their community for their achievement they gain not only status within the community but also an identity within themselves that comes with confidence, enthusiasm, and eventually competence within that field (Fraser, 2009). The basic behaviors and attitudes of expressed by players in *Martian Boneyards* have interesting overlap with those reported for communities of professional scientists by Dunbar (2000). This leads to questions about how gamer identity might be leveraged to promote science identity in games.

Most *Martian Boneyards* players were not involved in science in their daily lives, but they did spend a lot of time in virtual worlds. This implies that if one can infuse scientific inquiry into a game that compels these players to spend time playing, a new audience can be reached for science education. The overlap between the characteristics that make a good gamer—persistence, curiosity, and problem-solving skills—and skills needed by a scientific workforce are striking. Game players are building science skill and knowledge but they do not necessarily associate their activities with science.

The top players of *Martian Boneyards* credited their persistence, curiosity, and inquisitiveness with their abilities to gather and analyze data, create evidence-claims, seek more evidence to support or counter those claims, and use reasoning to advance the scientific knowledge of the community—behaviors associated with practicing scientists (Dunbar, 2000). EdGE researchers are interested in how gamers’ science identity can be nurtured and leveraged to improve players’ attitudes towards science and to increase the extent and quality of their science activity in real life. This may mean improving performance and interest in science classroom activities for students and/or increasing the scientific literacy of youth and adults in the general public.
The community’s knowledge was advanced when a player scanned a new artifact, or confirmed an artifact needing verification. Similarly when players added tags and measurements to the communal database through the analysis workstations— or more visibly, when they posted their claims and theories in the theory building areas—their contributions were recognized by the designers and other players. Players’ confidence seemed to increase with this recognition. For example, the following series of posts are the introductory statements to Jespau’s posts over time (often followed by long, detailed explanations of what she is studying in the game):

July 13 - This is speculation by me but I will continue to search for more evidence. Please add comments and artifacts you feel might be helpful. Or refute my statements.

July 24 - I propose that this means that F items belong to one person and things they have made, like the fire. We may find more F tags.
No evidence apart from this is available yet so I link to the fireplace and tin can until F items are all fully verified.

August 18 - After much PDA scanning and information gathering i have come to the following conclusion (pending possible change with new information).....

September 6 - I reckon these are useful clues we can use later. What do you think team?
In this series, one can see her move from speculation to proposing a claim to substantiating a claim with more certainty (though still open to new evidence) to becoming a more expert facilitator of the inquiry within the community. This is the same player who spoke of herself as knowing very little science and not understanding why anyone else would be interested in her thoughts. When asked what motivated her to play the game, she called upon her identity as a gamer to explain her persistence:

I am a gamer I never give up!

Designers “called out” the top players by awarding them with t-shirts, cargo vests, and other swag that they could wear to show their status in the game. Jespau and KalW were the players who were clearly valued by the designers and player community for their leadership in the scientific inquiry process and thus, it was no surprise to the community that they received the top awards. Other players were pleased to see their accomplishments recognized. They would likely have been eager and capable to take on many facilitation tasks, especially if rewarded with new privileges and information in the game.

The roles and identities that emerged in the game are an important element of a community of practice (Lave & Wenger, 1991). The recognition of players’ contributions by their peers may be reflected in their own sense of purpose in the game. This was evident in Jespau’s changing from being quite deferent to others and insecure about her usefulness to the community, to later taking command of the storyline and leading others’ efforts to help solve the mystery. The examples of identity emergence seen in *Martian Boneyards* are resonant with the view that science identity can be activated when an
individual’s activities are recognized as scientifically interesting and valid by their peer community (Fraser, 2009). These findings also raise interesting questions about the overlap between gaming behaviors and science identity.

6.3.3.2 Player Advancement.

Players’ advancement in a game is usually recorded by an award system that may include badges, achievement levels, powers, and rewards (Gee, 2008; McGonigal, 2011). The reward system in Martian Boneyards was not well formulated, primarily because of budget, but also because the flexibility in design allowed designers to respond to players’ desires in how to be rewarded. The designers spent most of the budget on the environment, tools, and resources and then relied upon the their characters to give awards to deserving players on an ad hoc basis. As true in many facets of this project, the skeletal nature of the design provided ample opportunity for designers to learn about what might work.

Early in the game, designers learned through their informal in-game focus groups that players would be enticed to participate by accessories, or “swag” for their avatars. Avatars’ clothes and accessories show status in the game (e.g., an avatar t-shirt might only be worn by players of a certain expertise). Role and status in gaming communities are important to players (Gee, 2003; McGonigal, 2011) and are often used to reward productive behaviors. Educational designers can take advantage of this phenomenon to promote strong group leadership and community facilitation in future games of evidence-based scientific inquiry.
The final awards ceremony for Martian Boneyards was very well attended by the community and highlighted the strength of the community bonds in the game. It showed that there was great community spirit in Arcadia and players were attracted to an event that recognized their community knowledge-building as well as their fellow players.

EdGE plans to build on this community knowledge-building model to create advancement systems in games that involve community-rating systems, where players use social networking tools to reward others for the value of their contributions to the community knowledge-building process. Such a reward system might have a combination of participation, peer review, and leader review.

Players will earn participation points for making contributions that stem from data gathering (from real world and online resources); for using tools to create evidence from the data (mapping, graphing, sorting, and comparing); and for making claims, posting evidence, and modifying others’ claims. Players’ participation points are a measure only of the extent of their participation in the challenges.

Players will also earn science quality points by having their contributions rated by other players. The rating system will be designed to use a crowdsourcing approach to evaluate the quality of other players’ contributions (in terms of science knowledge-building), much like a review of a book on Amazon.com or hotel on TripAdvisor. For example, they might rate the validity of the Internet sources that other players use or whether or data provided by a player are complete. Players could also check to see if useful evidence is posted along with other players’ claims. A player’s science score would be an accumulation of the science quality points from each challenge and could be used as the game-based assessment of their science skills and knowledge. A rating guide
might be provided that would help players rate the other postings and would also provide an inherent scaffold that the players can use themselves to get the highest science quality ratings on their own contributions.

In this type of reward system, players could also judge other players’ contributions for their innovation and value to the knowledge-building process. Players might earn mastery roles in the community for their recognition as outstanding contributors and/or reviewers. Designers could use this score to help identify emergent leaders in the game who may become facilitators in later games.

6.3.3.3 Development of Community Knowledge.

One of the most interesting facets of the Martian Boneyards game, in terms of a learning environment, is how players joined together in a learning community to solve the mystery. The EdGE designers introduced a storyline that required the players to figure out what had occurred using the evidence of the bones in the boneyards. Players took it upon themselves to go seek information from external sources, such as eSkeleton and science museum sites, to learn enough about bones to identify various species.

In Martian Boneyards, players routinely challenged each other’s claims and encouraged each other to take multiple perspectives, constantly incorporating new information. Players’ data-gathering activities (both scanning artifacts with the PDA and finding information from outside resources), their analysis, and their discussion using evidence to make claims about what had happened are all fundamental elements of a theoretical framework for scientific inquiry that draws from argumentation models of Toulmin (1958) and Kuhn (2005) as well as knowledge building described by Scardamalia and Bereiter (1996).
This type of scientific inquiry is strived for by US educational systems (NRC, 1996) but is rarely observed (U.S. Department of Labor, 2007). One constant struggle is to find assessments that can be used in educational systems that will measure and advance scientific inquiry. The research in Martian Boneyards may lead to future studies that leverage and measure the scientific inquiry that takes place in digital social games in increasingly sophisticated ways. These assessments might be framed in such a way that a player’s success or failure in the game is largely a function of the value that the community assigns to his or her contributions. The players could discuss and decide answers to complex problems, without validation from any external and prescribed authoritative source. The work is judged by its merit to the task at hand. This may be more reflective of the workplace of the future than our current educational models.

6.3.3.4 Individual Knowledge.
For social gaming environments to make a transformative impact on how educators think of formal learning, the communal science learning that takes place in games will have to be measured in terms of individual learners’ progress. Such assessments need to be rigorously validated. Some researchers argue that embedding learning assessments within a game may threaten its attraction to players (Barab et al., 2005; Gee, 2003). Other research has shown that traditional assessments, such as tests, are not good metrics of game-based learning (Ketelhut et al., 2010). This presents quite a conundrum for developers of game-based assessments.

Researchers have long advocated for learning assessments designed as tools that both measure and foster deeper inquiry and collaboration, and provide strong feedback
and recognition of students’ progress (Clark, Englert, Frazee, Shebby, & Randel, 2009; Lee, Chan, & van Aalst, 2006). In social games, and increasingly in media of all forms, learning is a more participatory experience, emergent in nature rather than prescriptive (Jenkins et al., 2006). This begs for a shift in paradigms for assessment, one that is being sought by today’s educators and researchers.

Some researchers are trying to develop game assessments that build from the evidence-centered approach to assessment design (Mislevy, Steinberg, & Almond, 2003) and create Bayesian networks or other methods to predict learners’ paths through a game (Shute, in press; Koenig, Lee, Iseli, & Wainess, 2010). This is useful in a prescriptive environment where there are structured paths because a game can guide players to the next phase based upon their assessment in the previous step.

In EdGE’s ecosystem model of a gaming environment, the game design and the player activity both interact to support players’ advancement and the community’s scientific knowledge-building. One may presume that community knowledge-building will result in individual learning, but the actual measurement of individual learning is much more difficult to ascertain. Games built around individual learning measures risk losing the entertainment value for players and also will take extensive validation studies to be able to claim that they are impacting learning in a rigorous manner. This is an extremely important and interesting avenue of study, but beyond the scope of this research.

6.4 Summary of Discussion

The findings from the Martian Boneyards show that a core group of MMO
players will engage in scientific inquiry and knowledge building activities when motivated by a compelling storyline with strong characters and community. Design features that can foster that kind of community include a highly aesthetic environment, regular events where designers play characters that facilitate the game play, and a nimble and dynamic narrative that allows designers to be responsive to players’ knowledge building and interests.

The framework that emerges from this research integrates three components of a social gaming environment: game design features, players’ activity, and players’ progress. Designers kick off a game in an environment with an original set of resources and a partially derived storyline, and then facilitate the evolving narrative as the players’ activity and progress help shape the game. Players interact with the tools, with outside resources, and with other players to build knowledge that contributes to the narrative and the knowledge base of the community.

Players improve individually through increased understandings and skills, game advancement, and the formation of roles and identities within the game. The knowledge developed by the community feeds back into the game design as players add resources, new information and evidence, and build a set of claims to solve the problem at hand.

The interplay of these game elements, and the constant evolution of the gaming environment in response to players’ activity and progress is key to the development of transformative social games that serve as learning environments.
Chapter 7: Conclusion and Further Questions

This research on the design and implementation of Martian Boneyards adds to the growing evidence that gamers’ vast amounts of time, energy, and “blissful productivity” in well crafted gaming environments might be harnessed to foster productive scientific inquiry. One of the products of this research is a framework for future games that envisions gaming environments as evolving ecosystems. There are still many questions remaining, however, about assessment of learning in social digital games and the sustainability of gaming environments that can be used for promoting long-term public scientific inquiry. This chapter explores some of these issues and discusses future areas of research in game design.

In participatory gaming environments, as framed by this research, science educators and game designers work together to design an initial tool set, environment, and storyline—a framework that both motivates and responds to players’ activity. The initial design must be enticing and intriguing, with many opportunities for exploration. It also must be directed enough to sustain the inquiry. The key to this level of direction for Martian Boneyards was the close involvement of the designers as characters in the game, which allowed them to keep the game malleable and responsive to players’ activity. The players’ progress in terms of scientific inquiry, resource gathering, and social structures all fed back into the evolving game design.

The initial game design of Martian Boneyards blended a compelling storyline and an aesthetically pleasing environment along with collaborative inquiry tools—

leaving the information gathering and much of the imagination up to the player community. A participatory model was key to this design and scaffolds were used to support collaboration much more than to provide content. Players were able to find content on the Internet and the community was able to serve as a filter for quality through peer review.

The players’ activities were remarkably persistent and dedicated to scientific inquiry in the game. The players had come from other quest-like virtual worlds and were looking for activities that they could delve into—they were looking for “hard fun” (Papert, 2002). *Martian Boneyards* was the most complex form of social activity in *Blue Mars* (as compared to bowling, trivia contests, and shopping) and was able to engage a large fraction of the core population of the MMO community.

The game design, and its inherently collaborative storyline, were designed to promote community-based scientific research. There was little sense of competition among the players. Players chipped in to help newbies learn the tools and readily pointed out bones to other players’ who had not found them yet. Designers promoted this collaboration by having all artifacts require multiple scans (verification) before they could be used as evidence.

The original intention of the theory-building area was to have players rate one another’s claims and evidence according to how helpful they were to the community’s theory-building. When the players moved to the web-based discussion board for their primary communication, the designers let this game element drop, but they will build upon it in future games.
These findings raise many interesting questions for further study, which are discussed at greater length in the following sections.

7.1 Assessment and Learning

We are approaching a time when high-school and university students, and then the first wave of professionals to enter the workforce, are learners who grew up in a digital world—they are the digital natives. These are likely very different learners than their parents and teachers, and will likely be very different workers than the managers who hire them.

The sample for this study was drawn from a group of adults, ages 18 years and older, so the results cannot necessarily be generalized to school-age learners. The official age cut off for *Blue Mars* was 18 at the time the study began, so human subjects approval was only for players aged 18+. The registration for *Martian Boneyards* showed that there were over 25 players that claimed that they were between 14 and 18 years old, so their data could not be used for the study since parental consent was not requested. This does show evidence, however, that youth are also seeking games like *Martian Boneyards*.

This new generation is deeply familiar with social networks and their lives are distributed across media and across social and learning contexts in ways that yesterday’s educators never could have imagined. But now we must imagine. We must take on the challenge to change an educational system that was originally developed for the industrial age, whose most important criteria for grouping learners is, as Sir Ken Robinson says “their date of manufacture” (2010).

Although *Martian Boneyards* is an educational game, it decentralizes authority and provides no clear source of authority of knowledge. This runs very counter to current
educational hierarchies in academia. EdGE is considering advancement and assessment systems for future games that recognize and foster a participative approach to knowledge building, one that is prominent in new social media and is garnering attention in industry, science, and business (Howe, 2009; Surowiecki, 2005). Surowiecki explains that this group generated knowledge, or wisdom-of-crowds predictions, can be surprisingly accurate and effective when a large community has a wide diversity of expertise and opinions and is motivated to find a solution. Sites like Amazon’s Mechanical Turk are bringing crowdsourcing to the workforce and changing how knowledge is created online.

7.2 Reaching a Broader Audience

EdGE, along with many early adopters and venture capitalists, anticipated that Blue Mars would be highly popular with commercial sponsors and become a platform rich with commercial opportunities. EdGE hoped to leverage this wave of interest to reach a community that was emergent and growing in a new venue. Instead the beta-test population reached a plateau of an estimated 50-100 regular visitors during the implementation period.

The recession of 2008 may have been responsible for the lack of growth of Blue Mars during the past 2 years. Blue Mars currently appears to be winding down its PC-only platform development and was anticipated to go onto the “cloud” in 2011, making it available on any platform including smartphones, so integration into the game will be much easier. This is still in its early stages and may also mean several more years of beta-test service from Blue Mars.

As the look forward to future game development, EdGE designers are taking a
more transmedia approach to alternate reality games. They will be judicious with its use of MMO technologies, using them only when physical immersion offers distinct educational advantages. This may include social events, where players are invited to the virtual science center to meet one another for simultaneous viewing of communal datasets on a map, which can be aided by live chat and avatar gestures.

EdGE’s upcoming game, *Canaries in a Coalmine*, uses a highly artistic and interactive web interface with social networking tools to deliver a game that includes real-life events and augmented-reality on hand-held smartphones. This transmedia approach is an attempt to reach a wider and broader audience.

EdGE developers believe the essence of what is important to learn about gaming environments is not tied to any one medium. The revolution in participatory culture and the desire for social gaming is likely to be longer lived than Facebook or Twitter or even than avatar-based worlds and smartphones. Flexible displays and controller-less interfaces may soon make our current devices seem clunky and unnecessary. Eventually, there may not be a need for separate devices at all to integrate virtual and physical reality. However, EdGE designers predicts that throughout many changes in tools, the desire to create, to build knowledge, and to work together to solve interesting challenges will persist and evolve in form that can be adapted to suit whatever social media are available.

### 7.3 Sustainable Models for Gaming Environments

EdGE is considering several ideas about how to make a social digital gaming environment dedicated to scientific inquiry that is also financially self-sustaining. While
they have been very fortunate to receive US federal funds for the research and development of gaming environments, in the long term EdGE strives to build an ongoing environment that is not reliant on grants.

One strategy is to use the top players as volunteers to lead the game for other players, similar to a docent model for a museum. The top players in Martian Boneyards took naturally to mentoring their peers and taking charge when it came time to organize their thoughts for the council award competition. With some coaching from the designers on how to scaffold inquiry in the game, this seems like a strong potential model for reducing the reliance on expensive designers.

*Martian Boneyards* relied heavily, however, on the nimbleness afforded by having designers’ constantly in the game. This allowed the designers to adjust quickly to new storyline elements that emerged from the user community and also to be able to roll out new tools and resources when they were available. As noted several times in the research, their spontaneous decisions often rippled into large story elements. Another risk is that the participant observers’ ability to provide a thorough portrayal of the community and environment may be compromised if they are not playing key characters in the game. Their role and interaction as characters mediated the learning process and their observations of the process, all of which would change if a third party stepped in to lead the game.

Ultimately, EdGE and other educational designers will need to address these questions of sustainability, assessment, and many others if social digital games are to penetrate the formal and informal education communities in any large-scale manner. In the meantime, there is increasingly compelling research that there is a growing untapped
opportunity for rich and productive scientific inquiry among a previously unengaged science audience. *Martian Boneyards* is one of the first of what will likely be a long wave of social digital games that continue to inform the educational community on how to benefit from this social revolution.

### 7.4 Diffusion of Knowledge

The nature of the collaborative inquiry that emerged in *Martian Boneyards* also raises questions about how information and innovation propagates through a social gaming environment. Researchers agree that social communities are crucial in the knowledge building that takes place in games (Barab et al., 2005; Gee, 2003; McGonigal, 2011), but little work has been done to use methods from social network research to examine gaming communities.

Everett Rogers called the process of ideas spreading through a network as “diffusion of innovation” (Rogers, 1995) and defined it as the “the process by which an innovation is communicated through certain channels over time among members of a social system” (Beal & Bohlen, 1955). Based on the work of Sylvan (2005; 2007) one might propose that the networks and stages of scientific inquiry in a game are related to the stages found in the adoption of ideas in other communities: Awareness, Interest, Evaluation, Trial, and Adoption (Rogers, 1995). All stages of diffusion of innovation involve sharing of information and data. This model has interesting overlap with data gathering and analysis stages of inquiry where individuals may work together, but are also building individual inventories of information. The latter stages of both models involve people challenging and revising ideas based on the interactions and sharing with
others.

There are also properties of social networks that have been shown to influence the diffusion of knowledge. In the social network within a game, some players may be in better social positions to influence the development of scientific knowledge than others. For instance, research suggests that weak ties—the social connections or “bridges” that connect individuals to social networks that otherwise would be unconnected—allow people to gain resources or information that they otherwise would not be able to access (Granovetter, 1973; 1983), particularly if those weak ties connect an individual with others who are rich with resources (Lin, 2001).

People who function as “social bridges” may be critical to learning communities because they allow science content and inquiry to permeate different groups within a community and support dialogue among individuals who otherwise would not be aware of one another’s data, theories, or analysis. It is through these social bridges that knowledge can diffuse and therefore be adopted and adapted by other gamers. In addition, some players are most able to benefit from their social ties either because those ties connect them to particularly useful resources, because they play particular roles in the community, or because they are affiliated with particular subgroups (such as the avid bone collectors or data analyzers).

In future EdGE games, researchers plan to use models of diffusion of knowledge and innovation to frame research on scientific inquiry in social digital games. They will be looking at how player roles develop within a social network in a game to see what types of player roles and diffusion mechanisms promote high-quality scientific inquiry.
7.5 Final Thoughts

EdGE, and their funders, took a first important step in working towards a social digital gaming environment that can be transformative for learning and education in the future. The prototype game, *Martian Boneyards*, was a proof-of-concept game that yielded evidence of how sustained scientific inquiry can be scaffolded, facilitated, and observed in a gaming environment. This study has examined the nature of the community who came to play *Martian Boneyards*, their activities in the game, and the design features and strategies that helped foster that inquiry.

Within days of the final writing of this dissertation, EdGE received an award for four more years of funding to build a transmedia gaming environment with embedded crowdsourcing assessments that can be validated for meeting high school educational outcomes. This future work will benefit greatly from the *Martian Boneyards* study.

I truly hope to continue to work with my phenomenal team of EdGE, as well as form many new collaborations with many of the fine researchers and designers whose work I’ve drawn upon in this dissertation. It will take all of us working together to solve the challenge of transforming education. I know there is a fabulous community out there ready to take on this next epic quest.
References


Galas, C., & Ketelhut, D. J. (2006). River City, the MUVE. *Learning and Leading with Technology, 33*(7), 31-32.


National Research Council (2011). *Learning Science Through Computer Games and Simulations.* Committee on Science Learning: Computer Games, Simulations, and Education. Margaret A. Honey and Margaret L. Hilton (Eds.), Board on Science
Education, Division of Behavioral and Social Sciences and Education. Washington, DC: National Academies Press.


Appendix 1: Ethics Protocol

UNIVERSITY OF TORONTO
Office of the Vice-President, Research
Office of Research Ethics

ETHICS REVIEW PROTOCOL SUBMISSION FORM FOR
SUPERVISED AND SPONSORED RESEARCHERS
(For use by graduate students, post-docs and visiting professors and researchers)

SECTION A – GENERAL INFORMATION

1. TITLE OF RESEARCH PROJECT

The Blue Mars Science Center: Supporting the emergence of a community for scientific collaboration

2. INVESTIGATOR INFORMATION

Investigator:

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<td>Jordis (Jodi) Asbell-Clarke</td>
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<td>Phone</td>
<td>902-425-6208</td>
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<tr>
<td>Fax</td>
<td><a href="mailto:jodi_asbell-clarke@terc.edu">jodi_asbell-clarke@terc.edu</a></td>
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Level of Project

- Faculty Research [x]
- Post-Doctoral Research [ ]
- Student Research: Doctoral [x] Masters [ ]
- Student Number 955844332

Faculty Supervisor/Sponsor:

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<tr>
<td>Dr</td>
<td>James Hewitt</td>
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Co-Investigators:
Are co-investigators involved?  Yes ☐  No☒

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Please append additional pages if necessary.

3. UNIVERSITY OF TORONTO RESEARCH ETHICS BOARD

Health Sciences ☐  Education ☒  Social Science & Humanities ☐

Please consult [http://www.research.utoronto.ca/ethics/eh_rebs.html](http://www.research.utoronto.ca/ethics/eh_rebs.html) to determine which Research Ethics Board your proposal should be submitted to.

4. LOCATION(S) WHERE THE RESEARCH WILL BE CONDUCTED:

If the research is to be conducted at a site requiring administrative approval/consent (e.g. in a school), please include all draft administrative consent letters. It is the responsibility of the researcher to determine what other means of approval are required, and to obtain approval prior to starting the project.

University of Toronto ☐
Hospital ☐ specify site(s)
School board or community agency ☐ specify site(s)
Community within the GTA ☐ specify site(s)
International ☐ specify site(s)
Other ☒ in a virtual world called Blue Mars specify site(s)

The University of Toronto has recently reached an agreement with the University-Affiliated Teaching Hospitals, regarding ethics review of hospital-based research. Based on this agreement, certain hospital-based research is now exempt from ethics review at the University of Toronto. If your research is based at a University-Affiliated Teaching Hospital please consult the following document to determine whether or not your research requires review at the University of Toronto [http://www.research.utoronto.ca/ethics/eh_where_tahsn.html](http://www.research.utoronto.ca/ethics/eh_where_tahsn.html).
5. OTHER RESEARCH ETHICS BOARD APPROVAL(S)

(a) Does the research involve another institution or site? Yes ☒ No ☐
(b) Has any other REB approved this project? Yes ☒ No ☐

If Yes please provide a copy of the approval letter upon submission of this application.

If No, will any other REB be asked for approval? Yes ☐ TERC (please specify which REB) No ☒

6. FUNDING OF THE PROJECT

(a) Please check one:

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If one protocol is to cover more than one grant, please include all fund numbers.

(b) If waiting for funding, do you wish to postdate ethics approval to the release of funds? Yes ☐ No ☒

(c) For funded research, will more than one protocol be submitted to cover all research funded by the respective grant? Yes ☒ No ☐

If Yes, this is # of

7. CONTRACTS

Is there a funding or non-funded agreement associated with the research? Yes ☒ No ☐

If Yes, please include 3 copies upon submission of this application.

8. PROJECT START AND END DATES

Estimated start date for this project: October 2009
Estimated completion date for this project: Dec 2010

9. SCHOLARLY REVIEW

Please check one:
The research has been approved by a thesis committee, or equivalent
(required for thesis research)

☐ The research has undergone scholarly review prior to this submission for ethical review
   (specify review committee)

☐ The research will undergo scholarly review prior to funding
   (specify review committee)

☐ The research will not undergo scholarly review apart from this ethics review

10. CONFLICTS OF INTEREST

(a) Will the researcher(s), members of the research team, and/or their partners or immediate family members:

   (i) Receive any personal benefits (e.g. financial benefit such as remuneration, intellectual property rights, rights of employment, consultancies, board membership, share ownership, stock options, etc.) as a result of or in connection to this study?  Yes ☒  No ☐

   (ii) If Yes, please describe the benefits below.  (Do not include conference and travel expense coverage, or other benefits which are standard to the conduct of research.)

   This research is connected with my employment at TERC for which I receive a salary.  My salary as well as travel and related expenses will be paid from a grant to develop and research the Blue Mars Science Center.  My position at TERC is not dependent upon this thesis research, but the dissertation research will contribute to the body of work for which I am funded to do at TERC.  Educational designers, Teon Edwards and Jamie Larsen, are on staff at TERC and will serve as participant observers.  Elisabeth Sylvan and Elizabeth Rowe, also from TERC, will be staff researchers – conducting interviews, helping with database design and data coding, and reviewing data analysis.  These team members have no more or less conflict of interest as I do regarding the outcome of the project.

Scientist Reviewers will be paid a small stipend for their work (no more than $2500/yr) and will have no conflict of interest with the outcome of the research.
(b) Describe any restrictions regarding access to or disclosure of information (during or at the end of the study) that has been placed on the investigator(s). This includes controls placed by sponsor, advisory or steering committee.

n/a

(c) Where relevant, please explain any pre-existing relationship between the researcher(s) and the researched (e.g. instructor-student; manager-employee; minister-congregant).

A few of the subjects in the study may be colleagues of mine (educators and scientists), but not in a position of authority-subordinate in any way with the researchers.

SECTION B – SUMMARY OF THE PROPOSED RESEARCH

Please include a list of appendices for all additional materials submitted.

11. RATIONALE

Describe the purpose and background rationale for the proposed project, and, if relevant, the hypotheses/research questions to be examined.
The proposed research will study scientific collaboration within game, Martian Boneyards, taking place in a virtual world called Blue Mars. In virtual worlds, learners create digital characters, or avatars, to represent themselves. These avatars move around inside a virtually rendered world shared with thousands of other avatars. They socialize with others, interact with media, collaborate on projects and explorations, share data and tools, do experiments, and present their ideas. These exciting graphical opportunities will be embedded in constructivist learning experiences.

TERC is developing the very first science center located in a virtual world. The Blue Mars Science Center will focus on the initial STEM content themes of a) Mars Exploration, b) Climate and Terraforming, and c) Human Origins. For the proposed research, early adopters of the Science Center will be studied in a variety of ways to learn what it is that brings them to the Science Center, what promotes longer visits and return visits, and what types of supports they hope to find in the center. Martian Boneyards is a prototype game that will take place within the Science Center.

The proposed research will address the following overall research question:

What types of social and scientific resources promote scientific collaboration in the Blue Mars Science Center?

Sub-questions that will guide the study include:

1. What social factors and conditions are necessary to support scientific collaboration among visitors?
2. In what ways can digital interactive media and tools support scientific collaboration?
3. What kinds of factors and conditions appear to interfere with efforts to develop community and/or scientific collaboration for any type of visitor?

12. METHODS

Please describe all formal and informal procedures to be used, settings and types of information to be involved, as well as how data will be analyzed.

Attach a copy of all questionnaires, interview guides or other non-standard test instruments.

The study will use netnographic methods such as records of avatars’ motions, use of digital STEM resources, and interactions with other avatars. These data will be analyzed along with interviews and participant observations. Because this environment is brand new and the methodologies quite new themselves, more data may be collected than necessary and the analysis will proceed in directions that appear fruitful and along the priorities of the research questions.
Data Sources and Collection

Entrance to the Center will be allowed only after the visitor agrees that their avatar’s actions and interactions can be monitored for research purposes and will remain completely anonymous. The sources of data collected during the research study include:

**Avatar Activity Logs:** All interactions, gestures, and motions of avatars within the *Blue Mars* Science Center and using Science Center activities will be logged and archived with time tags for major events for avatar motion (such as entrance into the Science Center) and log textual or video transcripts of events.

**Surveys:** Upon entrance to the Science Center, all participants will be required to take a short survey asking about their age, real-life sex (M or F), and science background. All visitors will be asked to take several further surveys during their time in the Center. Visitors consenting to further surveys will be asked about their desired outcomes from spending time in the Science Center and their perceptions about scientific collaboration, the scientific resources, and social supports in the Science Center. Survey data will be coded anonymously and tagged so that it can be linked to data for the same participant in avatar logs, interview data, and any other data sources used.

**In-world interviews:** Interviews of extended study participants will be conducted by the two members of the TERC research team who have a PhD and are highly experienced in interviewing and research protocols. They will work with the investigator to design and use a semi-structured protocol focusing on the participants’ interests relevant to the *Blue Mars* Science Center and on their perceptions of what is helpful for fostering scientific collaboration in the Center. The protocol will reflect researchers’ questions in clarifying perceptions gained from surveys. The interviewer and interviewee will be interacting using their avatars and synchronous text communication at least once during the three-month period. Interviewees will be selected from the consenting population to form a representative sample of approximately 10% of the respondents (or at least 18 interviewees).

**Participant Observations:** Three members of the TERC design team (including Asbell-Clarke) will serve as participant observers in the *Blue Mars* Science Center during the three-month research period. These researchers will work together to develop a protocol true to the design principles, monitoring their facilitation strategies, and perceptions of scientific collaboration in each event. Each event will be time tagged and so that it can be associated with the corresponding electronic data containing avatar activities and transcripts for the same events. Each participant observer will record his or her data individually and enter them into a common database. The observation protocols will focus on describing the participants encountered, the activity of the participants, the tone and nature of the interactions among participants and between participants and STEM resources, and strategies used by the participant observer to foster scientific collaboration.

**Artifacts:** The products of scientific collaboration will include a global map of the Martian surface constructed from visitor-gathered data and a growing log of Bonobo ape track sightings in an effort to find their home. The evaluation of these artifacts by external science content experts will serve as evidence of scientific collaboration. The scientist reviewers will be active researchers in the area of science content for the investigations. They will be recruited from TERC’s network of scientific organizations and universities. All avatar data will remain anonymous to the reviewers.
Data Organization

The design of this database that contains all these data will be central to the development of a learning model for virtual scientific collaboration.

Data from avatar tracking records will be used to measure duration of stay, which scientific resources are being used, and social clustering patterns among participants. Participant observations will provide insight into social conditions under which collaboration thrives or is stifled. Interviews and surveys will provide participants’ perspectives on the experience. All of these data will be organized into events, denoting a session of activity that was observed by a participant observer so that they can be triangulated and associated with each other.

The extent of scientific collaboration will be measured for each event the discussion transcripts using the following measures:

• The number of new pieces of scientific evidence introduced
• The number of decisions during the event that directly impact the development of the scientific community (e.g., future events scheduled or design decisions about tools)
• The number of new science artifacts generated during the session (e.g., uploaded data, new graphs or documents)

The quality of the collaboration will be measured by having the depth, accuracy, and relevance of sample event discussions and artifacts rated by expert scientists. The experts will use ordinal ratings so that the quality of collaboration in one event is compared to other events but not to any objective standard since that would be difficult to establish.

Survey and interview data will also contribute to the body of data for purposes of clarification, extension of ideas and questions, and validation. Consenting participants for an extended study will first be asked about their reactions to the supports and resources provided in the Science Center. They will also be asked about their perceptions of the scientific collaboration in the Center. These data will be used to confirm or challenge the interpretation of the participant-observers’ findings.

Analysis and Interpretation

The analysis involved with this study will include highlighting findings, identifying patterned regularities, and contextualizing the information within a broader analytic framework of scientific collaboration. The analysis will focus on the following sub-questions of the study:

• What social factors and conditions are necessary to support scientific collaboration among visitors?
• In what ways can digital interactive media and tools support scientific collaboration?
• What kinds of factors and conditions may interfere with efforts to develop community and/or scientific collaboration for any type of visitor?

Initial survey data will be used to create visitor profile categories describing their age, sex, and scientific background. Participant observer records, survey and interview data will be used along with avatar activity data to describe the scientific activity associated with the Science Center. Avatar logs and observation records will be coded and mapped using social network analysis procedures to look for patterns in collaborative groupings or leadership and/or dominant behavior that will affect the collaborative process. Interviews and surveys will tap the participants’ perceptions of what is helpful and motivating for scientific collaboration and the data will be examined to see if there is evidence that those activities or communications do indeed stimulate more activity.

Validation
To avoid bias, participant observers will independently enter data from field observations in a common database, paying close attention to the research questions in the most objective manner possible. If actual coding is performed for any transcript analysis, inter-rater reliability of 90% will be required among coders using a 10% sampling.

13. PARTICIPANTS OR DATA SUBJECTS

Describe the participants that will be recruited, or the subjects about whom personal information will be collected. Where active recruitment is required, please describe inclusion and exclusion criteria. Where the research involves extraction or collection of personal information, please describe from whom the information will be obtained and what it will include.

Participants will include scientists, science educators, teachers, high school and university students, as well as virtual world enthusiasts recruited by the networks of colleagues of TERC and VSE. As recruitment and word-of-mouth spreads, the population is expected to grow rapidly to include virtual world enthusiasts seeking interesting content and science enthusiasts exploring new venues for collaboration. This may include minors although they are not purposely being recruited.

All entrants to the Science Center during the first year of development (which includes the three-month data collection period for this study) will be required to consent to anonymous participation in research studies. (Please see attached: Consent_Form1.doc) They will consent to having their motions and communications recorded but coded for anonymity and not reprinted in any forum without further permission. In addition, in-world incentives will be offered for participation in the extended research study in which they will be asked to consent to interviews and surveys. (Please see attached: Consent_Form2.doc).

Based on the estimates VSE is projecting for growth of the virtual world, a conservative estimate of the visitors to the Science Center during a three-month span in early
development is 1000. If the Center has a 20% retention rate for ongoing engagement and 50% of those consent to participate in the study then there will be at least 100 participants to choose from for sampling from which at least 30 will be chosen for interviews and surveys. We anticipate more than that to be available, but this is a minimum. At least three researchers from TERC, including myself, will serve as participant observers in-world. We will greet new visitors and try to support visitors’ engagement and collaboration as they interact with scientific immersive resources associated with the content areas of the Blue Mars Science Center.

**14. EXPERIENCE**

For projects that involve collection of sensitive data, methods that pose greater than minimal risk to participants, or involves a vulnerable population, please provide a brief description of the researcher’s/research team’s experience with this type of research.

All of the researchers have experience collecting and handling data in a multitude of educational research projects at TERC.

**15. RECRUITMENT**

Where there is formal recruitment, please describe how and from where the participants will be recruited.

Where participant observation is to be used, please explain the form of insertion of the researcher into the research setting (e.g., living in a community, visiting on a bi-weekly basis, attending organized functions).

Attach a copy of any posters, advertisements, flyers, letters, or telephone scripts to be used for recruitment. See massmailing.doc

The Blue Mars Science Center will be promoted through other virtual worlds and science education venues (e.g., email lists and blogs). The Blue Mars platform will be freely downloadable to anyone with high speed Internet and a recent computer. Participation in the basic anonymous research will be a requirement of entrance into the Science Center on Blue Mars.
Participant observers will be in the *Blue Mars* Science Center, represented by their avatars, interacting with visitors during all peak periods of activity (roughly a 40-hour presence per week). They will host events such as “release parties” for new science media and for presentations and workshops with scientists. The Participant observers will both organize and facilitate interactions among visitors but also document them.

### 16. COMPENSATION

(a) Will participants receive compensation for participation?

<table>
<thead>
<tr>
<th>Option</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In-kind</td>
<td>Yes</td>
<td></td>
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</tbody>
</table>

No □

<table>
<thead>
<tr>
<th>Option</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

(b) If **Yes**, please provide details.

Participants will be offered nominal compensation in the form of *Blue Mars* currency or gadgets to be used in the virtual environment in the study.

(c) Where there is a withdrawal clause in the research procedure, if participants choose to withdraw, how will you deal with compensation?

They will be able to keep any compensation previously given but not future rewards.

### SECTION C –DESCRIPTION OF THE RISKS AND BENEFITS OF THE PROPOSED RESEARCH

### 17. POSSIBLE RISKS

1. Indicate if the participants as individuals or as part of an identifiable group or community might experience any of the following risks by being part of this research project:
(a) Physical risks (including any bodily contact or administration of any substance)? Yes ☐ No ☒

(b) Psychological/emotional risks (feeling uncomfortable, embarrassed, anxious or upset)? Yes ☐ No ☒

(c) Social risks (including possible loss of status, privacy and/or reputation)? Yes ☒ No ☐

(d) Is there any deception involved? (See Debriefing, #21) Yes ☐ No ☒

2. If you answered Yes to any of the above, please explain the risks, and describe how they will be managed and/or minimized.

Careful consideration will be given to establishing appropriate methods of protecting the rights of participants in virtual environments equivalent to those in face-to-face settings. No identifying data will be published and in no way will participants intentionally be embarrassed or publicly criticized for their behaviour. Virtual worlds introduce additional considerations for privacy and social risk.

Avatars in virtual worlds can create a new identity and thus essentially keep their real life identity anonymous. In an effort to retain this level of confidentiality for general participants all avatar logs and transcripts will be coded for complete anonymity. Participants will be asked for further consent to permit interviews and surveys, in which case their ID codes will be sued to associate the log data with the interview and survey data. This provides all participants to enjoy the Science Center activities without feeling risk of having their real identity exposed.

There is the potential in any social setting of damage to one’s reputation or professional status stemming from the unpredictability of what anyone might say or do. In virtual worlds, visitors may be less (or more) inhibited to act inappropriately thus embarrassing themselves or another individual. TERC facilitators will strive to set a tone and culture that respects personal privacy and falls within most people’s definition of socially appropriate behaviour, while also encouraging development of socially accepted norms within the emergent culture.

Each visitor to Blue Mars during the study period will be coming on their own volition. There is no social coercion in recruiting or retaining participants. They are also free to explore other parts of the Blue Mars if they choose not to consent to the
avatar logging that takes place in the Science Center. Any children under 18 entering the Center will be asked for parental consent to their participation to ensure informed decision making.

18. POSSIBLE BENEFITS
Discuss any potential direct benefits to the participants from their involvement in the project. Comment on the (potential) benefits to the scientific/scholarly community or society that would justify involvement of participants in this study.

The proposed work will offer the first step in understanding how virtual worlds can be used to motivate and support productive scientific collaboration for entertainment purposes. This work builds from early work in virtual worlds that show that learners become highly engaged in virtual collaboration and that people who voluntarily play virtual games such as World of Warcraft frequently engage in key scientific practices in their collaborative play. This work takes advantage of an unprecedented opportunity to shape a new exquisitely crafted virtual environment and learn how to foster innovative and transformative science learning experiences.

19. THE CONSENT PROCESS
Describe the process that the investigator(s) will be using to obtain informed consent. Please include the experience of the team member with this participant population and/or training that this person will receive prior to recruitment. If there will be no written consent form, please explain (e.g. discipline, cultural appropriateness, etc.). Please note, it is the quality of the consent, not the format that is important. If the research involves extraction or collection of personal information from a data subject, please describe how consent from the individuals or authorization from the custodian will be obtained.

For information about the required elements in the information letter and consent form, please refer to [http://www.research.utoronto.ca/ethics/eh_best.html](http://www.research.utoronto.ca/ethics/eh_best.html).
Where applicable, please attach a copy of the Information Letter/Consent Form, the content of any telephone script, letters of administrative consent or authorization and/or any other material which will be used in the informed consent process.

All entrants to the Science Center will be required to consent to anonymous participation in the study so that we can record their interactions with others. In addition, in-world incentives will be offered for participation in the extended research study where they consent to interviews and surveys. Data will be collected from as many participants as possible. As the study questions become refined to identify particular patterns of interest, purposeful sampling of the data will be done accordingly.

Please see attached consent forms: consentformswithparents.doc

20. CONSENT BY AN AUTHORIZED PARTY

If the participants are children, or are not competent to consent, describe the proposed alternate source of consent, including any permission/information letter to be provided to the person(s) providing the alternate consent as well as the assent process for participants.

If participants are under 18, we will arrange to send an email to request consent from their parents before they are allowed entry.

21. DEBRIEFING

(a) If deception will be used in the research study, please explain what information/feedback will be provided to participants after participation in the project.

Please provide a copy of the written debriefing form, if applicable.
(b) How will participants be informed of study results?

The results of the study will be publicized in the Blue Mars Science Center as well as in research publications.

22. PARTICIPANT WITHDRAWAL

(a) Where applicable, please describe how the participants will be informed of their right to withdraw from the project. Outline the procedures which will be followed to allow them to exercise this right.

This will be noted in the consent form. They can leave the basic study by exiting the Science Center. They can withdraw from the extended study by declining to complete a survey or interview invitation.

(b) Indicate what will be done with the participant’s data and any consequences which withdrawal may have on the participant.

A participant will be able to stop future contacts for interviews or survey Anonymous avatar tracking data collected while they are in the Science Center will remain part of the permanent database, but any interview or survey data for a participant will be removed upon their request.

(c) If participants will not have the right to withdraw from the project at all, or beyond a certain point, please explain.

n/a
23. CONFIDENTIALITY

(a) Will the data be treated as confidential?  Yes ☒  No ☐

(b) Describe the procedures to be used to ensure anonymity of participants or informants, where applicable, or the confidentiality of data during the conduct of research and dissemination of results.

During the first year of research and development, entrance into the Science Center will be allowed only after the visitor agrees that their avatar’s actions and interactions can be monitored for research purposes and will remain completely anonymous. This will enable a complete social network analysis and, if desired, transcript analysis on full discussions without worrying about having to drop participants. Data collected automatically will include all avatars’ motions and interactions (e.g. clicks) and transcripts of all synchronous and asynchronous communications. These will all remain completely anonymous.

Participants in the extended study will be coded so that they can be tracked within the anonymous data without unnecessarily revealing their identity or the identity of other visitors. Identifying information will only be used to contact consenting interviewees but will never be related to the data for publication.

(c) Explain how written records, video/audio tapes and questionnaires will be secured, how long they will be retained, and provide details of their final disposal or storage.

All data will be stored digitally on password protected storage devices. They will be maintained for retrieval for at least three years past the end of the project. At the end of three years past the project, all digital data will be destroyed.
(d) If participant anonymity or confidentiality is not appropriate to this research project, please explain.

n/a

24. PRIVACY REGULATIONS

For research involving extraction or collection of personal information, provincial, national and/or international laws may apply. My signature as Principal Investigator, in Section G of this protocol form, confirms that I understand and will comply with all relevant laws governing the collection and use of personal information in research.

SECTION F – CONTINUING REVIEW OF ONGOING RESEARCH

RISK MATRIX: REVIEW TYPE BY GROUP VULNERABILITY AND RESEARCH RISK – check one:

<table>
<thead>
<tr>
<th>Group Vulnerability</th>
<th>Low</th>
<th>Medium</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Low</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
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<td>2</td>
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<tr>
<td>High</td>
<td>2</td>
<td>3</td>
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<tr>
<td>3</td>
<td></td>
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</tbody>
</table>

See the Instructions for Ethics Review Protocol Submission Form for detailed information about the Risk Matrix.
Briefly explain/justify the level of risk and group vulnerability reported above (max 100 words):

There is no physical risk to subject and minimal emotional or social risk.

**Review Type**

Based on the level of risk, please submit the appropriate number of copies of the Protocol Submission Form for Review Type:

- **Risk level = 1:** Expedited Review
- **Risk level = 2 or 3:** Full Review

Information about individual REBs, including the number of copies required for each review type, can be found here: [www.research.utoronto.ca/ethics/eh_rebs.html](http://www.research.utoronto.ca/ethics/eh_rebs.html)

Please note that the final determination of Review Type and program of Continuing Review will be made by the University of Toronto REB and the Ethics Review Office.

**SECTION G – SIGNATURES**

All researchers and their respective Departmental Chair/Dean or designate must sign below:

As the Investigator on this project, my signature confirms that I will ensure that all procedures performed under the project will be conducted in accordance with all relevant University, provincial, national and international policies and regulations that govern research involving human participants. Any deviation from the project as originally approved will be submitted to the Research Ethics Board for approval prior to its implementation.
For student researchers, my signature confirms that I am a registered student in good standing with the University of Toronto. My project has been reviewed and approved by my advisory committee (where applicable). If my status as a student changes, I will inform the Ethics Review Office.

Signature of Investigator:  
Date:

For Graduate Students the signature of the Faculty Supervisor is required. For Post-Doctoral Fellows and Visiting Professors or Researchers, the signature of the Faculty Sponsor is required.

As the Faculty Supervisor of this project, my signature confirms that I have reviewed and approve the scientific merit of the research project and this ethics protocol submission. I will provide the necessary supervision to the student researcher throughout the project, to ensure that all procedures performed under the research project will be conducted in accordance with relevant University, provincial, national or international policies and regulations that govern research involving human subjects. This includes ensuring that the level of risk inherent to the project is managed by the level of research experience that the student has, combined with the extent of oversight that will be provided by the Faculty Supervisor and/or On-site Supervisor.

As the Faculty Sponsor for this project, my signature confirms that I have reviewed and approve of the research project and will assume responsibility, as the University representative, for this research project. I will ensure that all procedures performed under the project will be conducted in accordance with all relevant University, provincial, national or international policies and regulations that govern research involving human participants.

Signature of Faculty Supervisor/Sponsor:
Date:

As the Departmental Chair/Dean, my signature confirms that I am aware of the proposed activity. My administrative unit will follow guidelines and procedures which ensure compliance with all relevant University, provincial, national or
international policies and regulations that govern research involving human subjects. My signature also reflects the willingness of the department, faculty or division to administer the research funds, if there are any, in accordance with University, regulatory agency and sponsor agency policies.

Name of Departmental Chair/Dean (or designate): ______

Signature of Departmental Chair/Dean: _________________________
Date: ______
(or designate)
Appendix 2: Player Consent Form and Entrance Survey

Blue Mars Science Center Design Research Program
Principal Investigator: Jodi Asbell-Clarke, TERC and OISE/UofT

Consent Letter for all Entering Participants

Welcome to Martian Boneyards. This game is under study by TERC (a non-profit education firm) and University of Toronto. We want to understand how to make these games better for everyone. We hope you’ll help. All data will stay completely anonymous. If you don’t want to be part of the study, you won’t be able to enter the Science Center until the study is done.

To begin the game, please agree to the simple terms below. Nothing harmful, no gimmicks, just letting us collect a log of your avatar’s actions and bubble chat while you’re using the game so we can make it even better. Thanks!!

<More information about the study: > information from below in scroll box

ACCEPT – I am over 18 years old.
UNDER 18? That’s fine – just, Click Here. If you have your parental consent code enter it here ______

DECLINE (goes back to where they came from)

*** next page****

Welcome!! Here is your basic start up package. Other game play instructions....
To help our research, please tell us a bit about your real life self. It will remain anonymous.

1. Sex: M or F
2. Age: ___ years
3. State/Province of residence
4. Which best describes you (choose one from each column):

<table>
<thead>
<tr>
<th>I am not very interested in science</th>
<th>This is effectively the first time I’ve been in a virtual world</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am a science enthusiast but do something else for my day job.</td>
<td>I’ve spent a little in virtual worlds</td>
</tr>
<tr>
<td>I am a professional scientist</td>
<td>I have a lot of time in virtual worlds</td>
</tr>
<tr>
<td>I am studying to be a scientist</td>
<td>I am a true, all out virtual world junkie</td>
</tr>
</tbody>
</table>

*************** link is inside a scroll box that must be agreed to before continuing.

link for under 18*:

Please enter an email address where we can send a link to your parents to complete and send. You will then get an access code to register.

An online form on our web will be linked to a parent consent form with all the terms below. They will be asked to give consent and the code will be emailed to them to give their child to enter on the opening form.

* in more information scroll box: Under a grant from the National Science Foundation (US), researchers at TERC (a non-profit educational research and development firm in Cambridge, MA) are studying the development of the Science Center over its first year. The study focuses on how people work together to do scientific activities in the Center and how we can support them.

If you agree to be part of the study:

- All of your avatars’ motions, communications, and interactions will be tracked, but only when you are in the Science Center or using Science Center activities located in other places within Blue Mars.
- You may leave the Center and stop using scientific resources at any time. When you do, your activity will stop being monitored until you return to the Science Center. These activities will be clearly marked.
- All your identifying information will be removed from the avatar transcripts and replaced with an anonymous code.
- Some people in the Science Center may be asked to be part of individual or group interviews. These may take place within the Science Center, with other avatars, or on the phone. You can always choose whether or not to be part of...
these interviews. You will be given more information about them and what we do with those data at that time.

- All research data will be stored as digital files and will be password-protected. Only TERC researchers will have access to the files. Data will be kept for three years following the end of the study.

- The results of the research will be published in academic journals, presented at conferences, posted on websites, and used to inform the future development of the Science Center.

- Your participation in this research study does not add to your risk of being in an online environment. The results of the research will help us build better places for learning in virtual worlds.

* Contact Link: Jodi Asbell-Claarke, a researcher at TERC, is leading this study. If you have questions you may contact her at bluemars@terc.edu. If you have concerns about the research and want to talk to someone who is not on the project, you may contact Jim Hammerman of TERC’s Oversight Board for Human Participants in Research (IRB) at jim_hammerman@terc.edu, or 617-547-0430.
Appendix 3: Design Documents

Summary of Design Process
Authored by Jamie Larsen, senior designer, EdGE

Science – Our knowledge of the natural world and the process through which that knowledge is built. The process of science relies on the testing of ideas with evidence gathered from the natural world. Science as a whole cannot be precisely defined but can be broadly described by a set of key characteristics.

From Understanding Science – How science really works
(http://undsci.berkeley.edu/article/intro_01)

The Blue Mars Arcadia design process began with the idea of creating challenges that would require players to exhibit their current understanding of science content and process skills as well as allow them to uncover further scientific understanding. This would be done through hooks (an engaging science-based storyline) and supportive exploration and collaborative tools built in to the game. Arguably, a game is not the natural world. But for many who play such games, this might be the closest they come to concentrating or even thinking about science in their lives. If the science they uncover transcends the game, all the better, but minimally players should find themselves immersed in a science-based mystery that requires them to “test ideas with evidence.”

The two challenges were initially defined as:

• **A Planetary Geography Location Game** - Identifying where on Mars a new terraformed city is based. This was to be done by collecting in world data (images) and bringing them back to a central area where tools would be available for processing and sense making.

• **A Wildlife Game** - Identifying what animals where present in an area of a terraformed Mars by collecting artifacts and bringing them back to a central area where tools would be available for processing and sense making.

Both challenge where considered for a time. Development began to focus on designing tools and scaffolding process skills that could be used for both. However, after several meetings, consideration of time, money, and personnel limitations, and with the possibility of a partnership with the Smithsonian Museum of Natural History, it made sense to focus more on the wildlife game. Out of this our working definition of the game became (as defined in Game Flow Overview 01):

... a research project that simulates anthropological research, in the context of mysterious discoveries on a terraformed Mars. Unlike most games, the success or failure of the players comes almost entirely from consensus and cooperation. The players must discuss and decide the answers, without verification from the game’s rule set or some other authoritative source. Over the course of three months, TERC researchers will interact with and observe players, and gauge the
level of interest in, and the degree of learning derived from, the activities presented.

Out of this flowed various design documents and revisions (TERC Wildlife Game Design Docs 01-10) based on meetings and discussion among the developers (TERC and VSE). Development began on Arcadia, the world in which the game would reside, and the Science Center and Tools that would facilitate players’ interaction with the game, including data collection in the form of artifacts or measurements made through analysis), and making sense of the data collected (through further research and ultimately posting ideas supported by evidence. The important aspects of the Design Documents and their realization revolve around these Phases of Game Flow, in particular:

**Discovery** - Players explore the dig site to find bones and other artifacts. This is the simplest “phase” of play, consisting primarily of moving around and looking for imprints, bones, and tools - generically known as artifacts.

**Data Gathering** - This phase begins when the player points their PDA at an artifact. The PDA records some information automatically and generates an image for the player to reference from then onward. Players can use other tools from the PDA to assign more detailed information. As a player gains experience, their PDA can be upgraded to provide more tools for data gathering.

**Artifact Analysis** - The goal in this phase is to come to consensus on the nature of each artifact. Players assign tags to artifacts to sort them into categories, using deduction, discussion, and persuasion. Some reference materials are provided on-site, but web searches may be necessary to find required information.

**Interpretation** - Players advance theories about the relationship of artifacts to each other, to aspects of the site, and to what is known about the identified species. Theories can be based on properties of artifacts, or on other theories. Ultimately, questions along the lines of “What species were found at the site?” will be voted on by players.

**Overarching Limitations**

Primary to keep in mind relative to “design considerations” is the realization that resources we thought we’d have in the form of digitized assets (bones in particular) from the Smithsonian did not materialize. This was due primarily to our (TERC and VSE) timeline and cost limitations, Smithsonian timeline limitations, and development platform limitations.

Initially, a potential partnership with the Smithsonian seemed to offer access to a large number of already digitized assets that our developers could readily convert to a form that could easily be used to populate Arcadia and the Boneyards (the area where artifacts were to be found). When it became clear that we would not have access to these assets, we had to greatly restrict the artifacts we could have in world as each had to be developed using VSE/TERC personnel and time that could otherwise have been applied to other details of the game. Suffice it to say that this realization had huge impacts on our ability to deliver content in the form realistic artifacts, in particular bones, to find in world. How
this impacted the project in general, and the science learning we hoped to study in particular, will be covered in context as follows.

At the basis of our design we wanted to encourage and give players the chance to exhibit or uncover their “scientific habits of mind”. For example, as outlined in Understanding Science 101 (http://undsci.berkeley.edu/article/0_0_0/whatisscience_02) we wanted our game design to facilitate players:

- **Question what you observe** – Finding a bone, or other artifact like a firepit, should not only cause reflection on a driving questions we propose, but also result in **new** questions from the players.
- **Investigate Further** – Players should apply and exhibit, in the truest Dewey fashion, what knowledge they bring to the table, but more importantly, be open to looking beyond their own knowledge to include what other players may know as well as what external resources tell them about what they find.
- **Be skeptical** – Players should not accept claims by other players that are made casually or lack evidence to support them.
- **Try to refute your own ideas** – Players should be open to questioning their own bias, assumptions, and limitations, especially as they learn more as the game progresses.
- **Seek out more evidence** – The more evidence one has to back a claim, the more likely it will stand the test of time. In particular, evidence and claims gain credibility when they are repeatable and/or predictive. For example, a bone that has been identified, as evidence of a particular animal being present is more powerful when others find the same bone and come to the same conclusion based a proposed argument. In addition, an argument is more valid if other bones or artifacts, like footprints, are found that provide further supporting evidence.
- **Be open-minded** – One should be open to competing ideas. If other players offer more credible and/or well thought out evidence, a player should be willing to change their mind.
- **Think creatively** – Players should come up with a variety of explanations for what they observe. Limiting options only comes as evidence helps to hone explanations due to evidence that supports some ideas over others.

The rest of this document will discuss the **Phases of Game Flow** with the Expectations (relative to science concepts associated with each), **Design Considerations** (includes limitations, tradeoffs, or compromises), and ways we **Monitored and Adjusted** (as the game was changed due to feedback or limitations discovered along the way).

**Phases of Game Flow**

**Discovery** - Players explore the dig site to find bones and other artifacts. This is the simplest “phase” of play, consisting primarily of moving around and looking for imprints, bones, and tools - generically known as artifacts.
We decided that collection and analysis would focus primarily on bones and not on soft tissue, clothes, or other extensive artifacts to minimize the level of forensic and other analysis players were required to make. Given the short time we had for developing assets, with limited scaffolding to teach any in-depth science processing skills, we focused more on what players may already know, identified what they needed to know, as well as how they cooperated to find and share helpful information and resources that helped resolve the scientific challenges the bones presented. Focusing on bones streamlined the discovery, analysis, and interpretation process. We prompted players to answer several questions to help drive the game:

1. What types of artifacts are in the Boneyards?
2. How does a comparative view help make connections between the bones?
3. What does the form of a bone tell you much about its function?
4. Do any of the bones share and reflect a common origin (a specific species/individual) or a common ancestry?

All of these questions were played out in the different phases, and TERC facilitators—through in world involvement or comments on forums, or key prompts on Flashboards—kept players focused on answering these questions, or questions that arose as the game progressed. In addition, the bones were put in the context of an overarching science-based mystery to be solved while driving game play: How did the bones get to this area of the terraformed Mars.

The Endgame would be players presenting their ideas answering the original questions as well as any interesting questions that came up along the way. The ideas, with supporting evidence would be evaluated and rated by their peers and players would be rewarded with game points or BLU.

**Expectations**

Ideally in world exploration and discovery would be modeled after a real life anthropological expedition, like that documented as part of the recent documentary on *Ardipithecus* on the Discovery Channel Web site (http://dsc.discovery.com/tv/ardipithecus/handbook2/handbook2.html).

Players would search for bones or bone fragments distributed on the surface, buried or scattered through (simulated) natural means in the area where they lived and died. The ideal scenario was that players would share techniques of discovery and work together to point out where they found artifacts as well as work together to develop methods to effectively search an area.

As per the original Design Document (04) we’d envisioned:

“... that a few years of martian dust storms, seismic activity, and the geological stresses of terraforming have left most artifacts partly or fully buried.
Above ground - These will be made separately and placed on, or submerged partly in, the surface. Some may be found under rock slides, emerging from under bushes, etc. Artifacts are pickable, but won’t highlight when the player selects them (the scan will fail or succeed depending on whether they click an artifact).

In some cases, multiple artifacts will be found in close proximity. These will come in two scenarios:

- A natural grouping, like a collection of teeth or ribs. Each item will be pickable separately, but will reference the same ID number. When the scan comes up, the group will be pictured not as found in the dirt, but laid out in a pattern, as if arranged on a lab table.

- Non-groupable artifacts may be very close together, like a skull obscuring a partly submerged clavicle. In this case, when the player sees the scan of the skull, they should realize they need to scan the clavicle separately.

Underground – These artifacts technically don’t exist in the scene. What is substituted for the artifact itself is the following:

- Artifact Indicator – A designated position above where the artifact is ostensibly buried. The Artifact Indicator contains the Artifact ID number.

- Detection Nodes – Placed evenly spaced a circle around the Artifact Indicator, known as the Scan Circle. There can be anywhere from 2 to 6 of these objects. Around the site, scan circles can vary in size, but the detection nodes themselves should have a standard radius.

Players within detection nodes will receive a detection signal; players facing the Artifact Indicator will be able to cooperatively scan the object. Different artifact’s scan circles can overlap (and should, to increase the challenge). Detection nodes should never be placed directly on top of each other, although a little overlap is fine.”

Design Considerations

However, the actual distribution and ability to discover artifacts was limited by how Avatars could move through and interact within Blue Mars. As such, we had to make discovery of artifacts relatively simple while still challenging enough to keep players engaged. This included dispersal locations that could be somewhat explained by understanding how skeletons from dead animals might be distributed about an area. For example, were bones moved from their original location by scavengers or water or other means? Did a skeleton wind up at the base of a cliff due to being pushed or having fallen, or just dying in that place?

Additionally, we abandoned the underground artifact indicator and detection modes as being too complex and not adding anything substantive to the game. Keeping it simple made more sense. This allowed players to find bones and then focus on how they could better understand and answer the questions related to the bones.
We also had to leave bones in place so that others could discover them. This meant that the reality of finding artifacts in real life had to be compromised. This was necessary, as otherwise players would find all the artifacts leaving an engaging activity—finding objects in the game—limited to a small number of players.
Monitor and Adjust

We discovered early on that players were quite astute at finding bones through gaming the system. Within days of opening our first area of the Boneyards, players had learned that they could change display resolution and take away some of the layering that provided “cover” for artifacts! Although an artificial method to increase success, it was a sharing of knowledge. Just as an anthropologist shares a hard earned technique to extract or preserve bones, players readily shared their tricks of the trade. More interesting was the formation of search lines, like one that was organized to find bones in a river once people found a bone in the river. Players proceeded to search step-by-step as they progressed from one end of the river to another trying to insure that no area was left unexplored.

Since we opened areas of the Boneyards in phases, our designers tried to hide bones a bit more in subsequent areas, attempting to counter the resolution fix. It was interesting to see that, like in real life, some were better than others at the “skill” of artifact hunting, and these people became the “go to” players for helping others find artifacts faster.

Data Gathering - This phase begins when the player points their PDA at an artifact. The PDA records some information automatically and generates an image for the player to reference from then onward. Players can use other tools from the PDA to assign more detailed information. As a player gains experience, their PDA can be upgraded to provide more tools for data gathering.

Expectations

As in the Discovery phase, we envisioned that players would be able to find artifacts, mark their location as you would in a real world anthropological dig (possibly with flags or GPS coordinates on a map displayed in a Map Room back in the Science Center), then be able to pick them up (at least copies) and take them back to a lab area in the Science Center for analysis.

Again, the ideal was a real dig, but technology and resource limits tempered expectations. We soon settled on providing players with a Personal Digital Assistant (PDA) that they could use to click on an artifact to capture an image. This would simulate finding and cataloging an artifact, and by capturing an image of the artifact, allow a player to bring it back to a lab for further study. The PDA was defined as having the following basic functions (06):

- **Home Screen** – This would display game news and player status. It would also have the for scanning and tagging an artifact, triangulating to find buried artifacts, browsing artifacts found, uploading artifacts to a common database for use by others, and help.
- **Scanning** – Players would be able to triangulate and select objects to scan. This would capture images (originally taken from a variety of view as well as 3D rotatable scans if available) for analysis back in the Science Center.
• **Browsing and Tagging** – This function would include (an assigned) reference ID, player tags (like name, species, general tag), and notes (that could be made in the field to help remind players of such things as locations, initial thoughts, etc).

• **Uploading** – Once satisfied, or when done for the day, players could “save” or upload the artifacts to the central database. We’d envisioned that to encourage exploration, 20 players would have to find, or verify an artifact to make it accessible to all players for using to make claims.

• **Associates Screen** – This would allow players to identify other players they worked with on a regular basis. The idea behind this screen is that players would form teams that would represent specific skills—ability to find artifacts, ability to compare and measure, ability to research or make sense of what was found—much as a team comes together in the real world of science comprised of people with specific skills.

**Design Considerations**

Originally, the PDA was envisioned as a researcher’s toolkit with a futuristic twist along the lines of an iPad. We wanted to initially offer several crucial apps—find an artifact, tag it (with species name, common name, general observation, and notes), collect it (via a picture)—and then add new apps. The new apps would be available as players either asked for them to help better find and identify an artifact, or complexity of the game called for them. Fundamental to this idea of an expandable and adaptable PDA was that as the player’s abilities and science skills improved, and the questions they might ask paralleled newer levels of understanding, we could respond with better tools. Apps we hoped to include were better image capturing capabilities (3-D captures, x-ray imaging), radiometric dating, DNA sampling, and in other in-field measurements. Ultimately, due to time, interface, and development constraints, we settled for basic applications that included:

• **Scan** – players could click on a perceived artifact, and an image would show up in a database of found artifacts. If they clicked on something that was not an artifact, then it would tell them that no artifact was found.

• **Browse** – Once an image was added, players could add three tags (species, name, and general) that were short (20 characters?) fields and a longer (256 characters?) notes field. The Browse option could be called up at anytime to see information on bones in the field. The Browse window showed found items in a columnar format and provided limited ability to sort artifacts found (by ID for example). It also allowed them to look at found artifacts in a note card type of format and would let users walk through slightly larger images and edit their original entries.

The ability to upload to the Science Center Database was automated (players simply had to click on the “orbs” on the sorting table back in the Science Center) to simplify the process. This was originally a design consideration, but as many things turned out to be, the more we got into the game, keeping it simple paid off!
It is important to note that learning to use the PDA, like the other tools in the Science Center, was to take place through discovery. There was an intentional design decision to not provide directions for these tools to see how players would react. The idea was that, when placed in the context of citizen scientists asked to make sense of a science mystery around an abandoned Science Center, with some tools that they could use, players would strive to figure out how tools worked, what they could do, and then share what they learned with others. It was open ended inquiry through discovery.

*Monitor and Adjust*

The PDA was probably our first real introduction to the difficulty of creating tools in the Flash-based environment (for interactives) of Blue Mars, as well as a lesson for the designers to “keep it simple” and the need to supplement with (at least) minimal scaffolding on how to use the tools.

We did see the players, especially a few early adopters, become “experts” on using the PDA. Although we did not provide the ability to note Associates in the PDA, and later in the Sorting Room, players formed groups based on skills that permeated the game throughout. Some were best at finding artifacts, others at finding resources on the internet, and (as in real life!) some more interested in writing up their research than others. In terms of using the tools, some became proficient at teaching others how to use them.

Players readily helped us debug problems with the PDA (and other tools), and, once they mastered the use of the PDA, routinely trained newbies on the correct and most efficient way to use it. As the game progressed, new players were immediately taken under the wing and taught how to use all of the tools available to them. Initially it would begin with a trip to the Boneyards and a lesson in finding an easy artifact, scanning it, and tagging it. Then they would move on to other artifacts with lessons on how certain ones were harder to scan than others. After helping them find enough bones to whet their appetite, the newbie was taken back to the Science Center and shown how to upload and use the Sorting table. Ultimately, they were introduced to the Claim Board as the place to link evidence they found (artifacts, analysis, external resources) with their best explanation to what happened at the Science Center. Usually just enough was given to get a new player involved in finding and uploading artifacts. This was usually a good indicator, if they player stuck around to find more, and came back the next day, that they would become part of the regulars who played the game.

The sharing of knowledge, essential to the scientific process, was well met and exhibited in use of the PDA. Players not only showed others how to use, but also provided tips on what they put in to the different tag and note field, and how to most efficiently use the tool.

We ended up posting a “fix” for a problem that kept the PDA (or any Flash interactive) from working, on what became known in world as Flashboards. We realized that some scaffolding was necessary, and we needed an in world way to get across important news,
instructions, or story components. Our designers built us six in-world Flashboards that allowed us to post information at any time. They were used to communicate the fix (mentioned), basics on how to use certain tools (like PDA, Claim board), storyline components (like the essential questions we wanted players to focus on), and hints on how scientists might use a comparative approach to studying bones.

Artifact Analysis - The goal in this phase is to come to consensus on the nature of each artifact. Players assign tags to artifacts to sort them into categories, using deduction, discussion, and persuasion. Some reference materials are provided on-site, but web searches may be necessary to find required information.

Expectations

In this phase, we wanted to provide players a way to analyze potential evidence (artifacts) to help them answer (using the Claim Board) some of the questions we posed, but also new questions they might come up with in their exploration. Originally referred to as the Tagging Table, the name seemed to morph into Sorting Table. We wanted the design to allow players to easily sort (filter) artifacts by fields (such as date found, player who first found it, number of times found, tags, etc) and to compare artifacts and measure them. In addition, we provided the ability to add additional tags notes and to see what others had entered about each found artifact (tags, notes, etc).

Initially we had also looked to provide enhanced images for artifacts, including typical views one might have if holding an artifact (particularly a bone) in one’s hands—we’d hoped to model the look (if not the feel!) of handling a bone, or at least provide something along the lines of www.eskeletons.org. This included, where possible, 3D or enhanced (like CT or MRI) views. We also envisioned the ability to group and even put certain bones together to try and construct a skeleton as part of the initial design.

Central to the design was the requirement to measure a bone—including length, width, density, and other measurements that would help make sense of what the bone might be and what species it might belong to.

Artifacts would be displayed (through various filters) and the user would be able to click to select and observe various views, measure as they saw fit, and make notes. In addition, we wanted players to be able to select two or more bones to group them for comparison. For example, we envisioned players grouping all bones that looked alike—femurs—and then compare similarities and differences based on questions they might have, like:

- Are they of similar size, and possibly from the same individual?
- Is one different than the other (more of a prominence here, a groove there, thicker in diameter, etc) and therefore from a different individual or species?
- Do certain small bones belong to a foot or hand?
- Does this bone (or group of bones) belong to a biped or quadruped animal?
The fundamental idea behind the sorting table was to allow for analysis through additional observations, quantification through measurements, the beginnings of potential answers to questions, and generation of new questions. Central to this was to be a comparative approach to make sense of what they found.

**Design Considerations**

Like the PDA, our original ideas had to be streamlined quite a bit due to the same limitations as noted for the PDA. Additionally, the loss of Smithsonian assets meant that we had to severely limit the bones, and the views of bones we could offer—we had to create all these assets ourselves. We settled for the ability to sort, the ability to see no more than two views of a bone (one view in some cases), and to only record two measurements (say length and width) for each view. The tool also automatically calculated averages for a measurement (but this depended on people taking a standard measurement for it to be accurate) and allowed for limited comparison and sorting.

These limits, in particular the number of views and measurements, greatly impacted the ability of players to make observations. Observing, comparing, and asking questions about bones is hugely dependent on being able to manipulate them to get different views, to look closer at the various parts of a bone to determine how its form might be influenced by its function—or even to identify if it is from one species or another. For example, chimpanzee finger bones may look a lot like their human counterpart when viewed from the dorsal or palmer vies. But when viewed from the medial or lateral side, they show a curvature that would help one to differentiate the chimp from human. Not offering such a view (which we did not do) made the task of differentiating and identifying that much harder.

In addition, artifacts would only show up on one’s table if they had found it. This was meant to inspire players to want to find artifacts they didn’t have, but other players may have found and told them about—some even posted images on the forum on a regular basis of the bones they’d found and were quite proud of having found the most. This was built in to a verification process, whereby an artifact had to be found by a certain number of people (originally 25) before it would be verified and available for use as evidence for a proposed claim (see Claim Board in Interpretation section).

**Monitor and Adjust**

Having said this, players definitely made the best of what this tool (and others) did offer. They looked closely at the views available, used the compare feature to group bones—like femurs—and measure them. In addition, they shared this information through in world chat, via the notes field, on the Blue Mars forum, as well as in the claims they made using the Claim Board. In addition, they were also asking for new functionality and suggesting ways to improve the tool.
Like the PDA, we did not give a great deal of direction on how to use the sorting table, and the players took it upon themselves (with some nudges given through Flashboards) to learn how to most efficiently use the tool and then train others on its use.

In hindsight, we could have further streamlined the tool—it was often referred to as too complicated—and some of the features not used a great deal, like some of the sorting options, could have been left out for a cleaner and easier to use tool. Also, it was apparent that better views and ability to measure in a variety of ways would have increased its value to our players, and to the ability to use it for analysis and honing evidence to support claims.

As a general note, it was quite interesting to see how even those players (especially the women) who did not consider themselves science literate, even bad at science, engaged in the use of these tools. Sharing, as we’d hoped, how they grouped bones to make comparisons and why, how to standardize on making measurements, and to generally “own” the tool and see its value to their science challenge—they saw it as a way to answer and even generate questions using evidence, as well as making sense of what they found.

**Interpretation** - Players advance theories about the relationship of artifacts to each other, to aspects of the site, and to what is known about the identified species. Theories can be based on properties of artifacts, or on other theories. Ultimately, questions along the lines of “What species were found at the site?” will be voted on by players.

**Expectations**

The original purpose of the Theory Board (renamed Theory-Building or Claim Board) was for players to use artifacts and other research as evidence to post theories or respond to existing theories. It was ultimately thought of as a way for players to exhibit their understanding of how the evidence helped them answer scientific questions. It would allow players to add, edit and publish their theories and comment on others theories. It would have the following capabilities (06):

- **Theory List** – This is the Summary format for all the theories, including: Creation Date, Title, Creator, Date of last update, Name of last updater
- **Add New Theory Button** – Allows players to add and edit theories.
- **Sort Options** – A drop-down box allows the player to choose between sort options by: Creation Date, Status (Peer Review, Published), Title, Creator, Name of most recent commenter, Most recently updated
- **Reverse Sort Direction** – A checkbox let the player reverse the direction of their current Sort method
- **Filters** – A series of check boxes to include the following items from the list: Created by me, Commented by me in last 24 hours, Commented by me in last 7 days, Based on Artifact I have scanned, Based on Theory I have posted, Highly Contested, My vote differs from majority, Marked as Favorite
• **Text Search** – Enter text to view only theories with that text included. Checkboxes for Title, Body, Comments
• **Help** – Displays a separate help screen.

**Design Considerations**

Again, as the reality of developing for the Flash Interactives in Blue Mars hit, we ended up cutting back the functionality quite a bit. As mentioned below (Monitor and Adjust) we renamed the misnamed theory board, dropped many of the sorting options and all of the filters. Ultimately, this was not a major issue as using the Board was complex enough as it was. Like all of the Science Center tools, we did not initially provide directions for its use, but soon found that the complexity of both the tool, and what we expected from those using the tool, warranted the need for simplification and a minimal tutorial. We created a simple “How to Use” that we posted in both the Claim Board and on the Blue Mars Arcadia Forum. It read (note word claim substituted for theory in original version):

1. **Composing** - Click on the compose button and enter title, reasoning, and add artifacts as evidence for a claim. Be sure to save your claim before exiting! The author is the only one that can see the claim at this point. Note: If there is a problem with your claim - illegal characters or claim is too long, you will get an error message be sure to correct and resave.

2. **Review** - Once you are happy with your claim, click on Present for Review button. This will make your claim visible to others for comments. They may add comments in the right column, add artifacts or other claims in the evidence column on left, and you can add amendments to your reasoning in the middle column. If you want to publish your claim for rating by others, click on the Publish Claim Button. Only do so when you are done editing, as you will not be able to edit your claim after you publish it.

3. **Rating Claims** - Once you publish your claim, others can vote on it by clicking the appropriate radio button on the right. Your peers will determine if they think the evidence you offer supports your claim. Note: The author can discard their claim at this point. However, if a claim is discarded, it is lost forever!

We also soon found that our original plan to require 25 people to find an artifact—called verification—was problematic. Initially the thought was to require players to find all of the artifacts, or at least encourage them to explore and facilitate this by not allowing unverified artifacts to be used as evidence. A player could use the artifact with the Sorting Table, but not include it in a claim unless it had been verified. Given that our consistent number of players was small, and, some of the artifacts, notably smaller bones or pieces of bones, were difficult to find, even by our most dedicated of players, we ended up lowering the number needed for verification. In hindsight, the threshold for verification should have initially been five, as using the evidence to support claims was important and became problematic toward the middle and end of game as some people became proficient at finding artifacts and posting claims, and did so before an artifact was verified.
Overall, the flow of the game had the Claim Board as the place to publish and get peer reviews of one’s ideas. The focus was on linking evidence to support these ideas explaining questions that helped solve the mysteries surrounding Arcadia and the Boneyard.

Monitor and Adjust

Just as society wrestles with the meaning of the word theory, we initially placed too much emphasis on the use of the word, which opened up a line of misconception that would have been better to avoid. Do the players propose a hypothesis or theory that they can test based on collecting evidence and drawing conclusions? In the truest sense of science, no—after all, this is a science-based game. However, players would be going through the process of scientific inquiry as outlined in the Understanding Science site (http://undsci.berkeley.edu/article/scienceflowchart) including:

- **Exploration and Discover** – Making observations, asking questions, sharing data and ideas, and exploring resources.
- **Testing Ideas** – Gathering and interpreting data.
- **Getting Community Analysis and Feedback** - Publishing, engaging in peer review, discussing, and even replicating work done by others. In turn, this incites new questions and hypothesis/theories.
- **Benefits and outcomes** – Especially building knowledge and satisfying curiosity.

Ultimately, to avoid misconceptions around the use of the word theory, and due to the nature of the game, we ended up calling the board a Claim Board. This is where they proposed explanations to answer the questions we asked, or the questions and ideas they came up with over the course of the game. Going back to the original quote at the beginning of this paper—The process of science relies on the testing of ideas with evidence—perhaps we should have called it the Idea Board. This, together with the Forum, is ultimately the way it operated. Players posted ideas with evidence they had gathered, then others either tested their ideas, by weighing the evidence posted, or gathering evidence that supported or called into question what was posted.

We found, as the game progressed that the mechanics and limitations of the Board got in the way of players forming ideas, linking in evidence, and discussing it. We began to push players towards the Blue Mars Arcadia forum so that ideas could be better organized into threads, commented on, and generally more accessible in the real world. This made a lot of sense since players were further limited from citing evidence and resources—like web sites, images, or non-verified artifacts using the board. There was also a character limit of the Flash interactive and problems displaying comments that further limited their ease of use and value.

The major lesson learned here is that the tool should not get in the way of both the flow of the game or the ideas. A threaded discussion, especially around stated questions (to prompt thinking), that could be fed into a screen in world would work much more
efficiently and effectively. It also would benefit from most players being familiar with how to use such forums as they are relatively common.

**Final Thoughts**

Did our game and its design allow people to engage in science—uncover what they knew, what they needed to know, and exhibit their understanding to solve a science-based mystery? By reflecting on our interactions with the players while we were in character, by examining the artifacts from the players—like the forum, sorting table tags and notes, and claims made—we should be able to come to a qualified “yes”. Were they engaged in science and exhibiting science process skills? Again, yes.

Using the Understanding Science site, and their *Science Checklist - How scientific is it?*, consider the following conclusions:

- **Focuses on the Natural World** – Although we used a computer game instead of the natural world, the challenges were, as much as limits allowed, based on what one might see in the natural world. We focused on artifacts, like bones, that were modeled after what can be found in the natural world and generated questions that could be answered by thinking scientifically. What is this bone? Is it a leg bone? Are there other bones that I can find that are from the same animal? What does its form tell me about how the animal lived or died?

- **Aims to explain the natural world** – Finding a bone and inspiring questions did lead to players trying to explain, through their discussions in world, on the forum, and on the claim board, what they found. Again, not the natural world, but modeled after that world.

- **Uses testable ideas** – Although this may seem like a more difficult concept to measure, the game was structured so that players could test ideas. For example, finding and identifying two bones as femurs lead to ideas like: These bones are enough different that they belong to two separate species. Or, These bones are similar enough, that they may come from the same individual. Although we didn’t fixate on hypothesis and theory forming, for example forming an if/then hypothesis, we did see ideas being put forth and tested. Players surfaced ideas that some bones belonged to different species or the same individual, offered their evidence, and tested these ideas through further exploration and analysis. This was not done in an experimental sense, but in a more observational way.

- **Relies on evidence** – Using the tagging, comparison, and measuring capabilities of the PDA and Sorting tools, players used artifacts and offered them up as evidence to support their ideas. In turn, they did an amazing amount of research, finding equations, looking for matching bones, ecology and life histories of different species, standardizing measurements, including Internet and more traditional resources. How rigorous those efforts were may be debatable, but given that many who played the game did not consider themselves scientists, were even a bit science phobic, the level of detail and research supports that they understood the need to rely on evidence.
• *Involves the scientific community* – The players in the game were the scientific community, along with the facilitators playing along with them. They readily reached out to each other. This was especially apparent when a newbie came to the game and they peppered him or her with questions about their scientific expertise!

• *Leads to ongoing research* – Clearly, players came up with more questions than answers. As a science educator and researcher, this was quite satisfying to witness. It might be worth a follow-up to ask players to reflect on how the game might have changed the way they approach the real world. For example, if they see a bone in a desert, do they think they would react to it differently? Would they be motivated to determine what it was and what animal it belonged to?

• *Benefits from scientific behavior* – It was quite clear that when players focused on scientific behavior (making accurate observations, standardizing technique, sharing knowledge, finding supportive resources), the game progressed. The fictional component, although sometimes disconcerting, did not overly detract from the science. In fact, the social aspect of the game, the friendships and interactions that were displayed by the players from a diverse set of backgrounds, strengthened the scientific behavior as each player pushed the other to pitch in.
The Wildlife game is a research project that simulates anthropological research, in the context of mysterious discoveries on a terraformed Mars. Unlike most games, the success or failure of the players comes almost entirely from consensus and cooperation. The players must discuss and decide the answers, without verification from the game’s rule set or some other authoritative source. Over the course of three months, TERC researchers will interact with and observe players, and gauge the level of interest in, and the degree of learning derived from, the activities presented.

The overall design doc for the Wildlife Game is broken into these sub-documents:
1. Game Flow Overview – This document
2. Story – Discussion of the back-story, large and small, and how the game uses it
3. Notification – How will players learn of the experience?
4. Dig Site – How is the dig site organized and implemented
5. Science Center – What’s there, and list of player reference material
6. UI Design – For the PDA, sorting systems, and other functions
7. Progression Elements – PDA, Player, and Staging progression
8. Project Research & Data Capture
9. Endgame – How will the player experience the end?
10. External Media – Forums, wikis, RSS feeds, blogs, and other supporting media

Game Flow in brief

There are six phases to the game experience. Phases 2-5 are highly iterative, and players can switch between them at any time, or skip one or another phase to focus on what they enjoy most.

Notification
Players are notified (ideally through viral means) that strange bones have been found in an isolated site some distance from New Venice. A science center has been established to research this and other phenomena, and players are invited to participate.

Discovery
Players explore the dig site to find bones and other artifacts. This is the simplest “phase” of play, consisting primarily of moving around and looking for imprints, bones, and tools - generically known as artifacts.

Data Gathering
This phase begins when the player points their PDA at an artifact. The PDA records some information automatically and generates an image for the player to reference from then onward. Players can use other tools from the PDA to assign more detailed information. As a player gains experience, their PDA can be upgraded to provide more tools for data gathering.

Artifact Analysis
The goal in this phase is to come to consensus on the nature of each artifact. Players
assign tags to artifacts to sort them into categories, using deduction, discussion, and persuasion. Some reference materials are provided on-site, but web searches may be necessary to find required information.

**Interpretation**
Players advance theories about the relationship of artifacts to each other, to aspects of the site, and to what is known about the identified species. Theories can be based on properties of artifacts, or on other theories. Ultimately, questions along the lines of “What species were found at the site?” will be voted on by players.

**Endgame**
This is the ‘finale’ of the endeavor. Players gather to hear a summary of the game, gain rewards for their participation, and get a preview of the next location to be researched.

**Game Components**

**Story**
The back-story of these discoveries is not known to the player, but only suggested through hints and learned through the research process. At present, the story exists in only a vague sketch, and only a small portion of it will be revealed by the end of the prototype. This is intentional; we hope to use player feedback and our own experience to fill out the story down the line.

In short, the story is inspired by Jurassic Park. About 30-50 years ago, some unknown person decided to assemble a ‘zoo’ of creatures, and put them in synthetic environments on Mars. This menagerie was made up of extant species, extinct species resurrected from genetic material, and invented hybrids - both healthy specimens and tragic miscalculations. Among these species were early hominids.

The creator kept this enterprise a secret from the public and governments, working with a select group of zoologists, anthropologists, and other specialists. But somewhere along the line, things went horribly wrong, and for reasons yet unspecified, the experiment collapsed very quickly. The creatures escaped, killing many of their captors and each other. Some stayed in the general vicinity, while others migrated into the wilderness to flee each other and find survival on the land.

This setup lets us include almost any species, including invented species, and the potential to find any of these creatures extinct or thriving in the region. Because most creatures fled the original site, we can focus on outposts of discovery with fewer art requirements before potentially letting the player root around in “ground zero” down the line.

See the Story doc for more information as it develops.

**Location and Travel**
For now, the Science Center and the dig sites exist entirely in their own pockets of the world. The player can learn aspects of the game in New Venice, but will exclusively use the Teleport method to access both the science center and the ‘protected’ dig sites.
Eventually, we’ll take these sites and place them in the world to be accessed by overland travel (perhaps exclusively).

Breaking up the sites in this way gives us a great deal more control over frame rate, terrain, the ultimate location of the sites, and the ultimate layout of New Venice. It also aids in the development of the Mars Mapping game, avoiding the problems of “real” Mars scale, letting us teleport the player to any location on Mars for the game.

**Dig Site(s)**

We’ll have one or more dig sites that the player can visit to find artifacts. Each site should be large and complex enough that players will need to move around to find everything. Dig sites will be physically closed off (and perhaps visually so), depending on what the artists can accomplish in the time allotted.

Dig sites may have multiple sections (or stages) for players to unlock. See the Staging section and the Dig Site document for more details.

**Artifact Capture & Verification**

Artifacts and the theories they generate are at the center of gameplay. All artifacts are found at the dig sites, and remain there. Players find and “capture” images of the artifacts with their PDAs, and thereafter work off the images of the artifacts captured in their PDAs.

Every artifact must go through a verification process, where X number of players need to scan it in the field and capture it. Until it’s verified, only those who have personally captured it can apply analysis to it. Once it is fully verified, any player can access the image of the artifact for analysis.

**Science Center**

The Science Center is the hub of player research when not “in the field”. Here, players will find a large map of the dig site(s) with discovered artifacts plotted out by location, as well as other displays exhibiting the “state of the game” and the most recent discussions and theories. While most game functions are PDA based, the Science Center is the only place that players can use the Theory Board, and the only place they can work with artifacts they haven’t personally captured on their PDA.

The building itself will have an explorable design, with diagrams and displays here and there that will give the player context for their theories. Initially at least, since the player teleports in, there will be no exterior. See the Science Center & Reference doc for more details.

**TERC Monitoring and Research**

This project is set up to capture as much information and analyze from player activity as possible. Among the capturable data will be player discussions, aggregate and individual player progress, all player data entry like tagging and theories, etc. TERC representatives will be in-world as avatars, and recognizable, so they can generate discussion, influence.
player direction, and answer questions. In addition, we may want to set up a wiki and forums for players to populate, to create a magnet for inevitable out of game discussion. See the Project Research & Data Capture doc for more details.

**PDA & Upgrades**

The player is equipped with a tool that we generically call a PDA, useful for “capturing” artifacts in the field. Once an artifact is captured, its image remains accessible by the PDA, and the player can perform other functions on it like measuring and tagging.

The PDA has several functions, some available immediately and some available via “upgrades”. This upgrade system gives the player a sense of progress, choice, and specialization. It also gives them a reason to revisit the dig site and find more artifacts, or refine the data on artifacts already discovered. See the Progression Elements doc for more detail.

**Staging**

At the start, the player base will have access to perhaps 20% of all explorable protected areas. As they proceed through the game, they will need to unlock each succeeding site by showing progress on the previous site (and overall). These stages may be extensions of a previous site, visible from an open stage, but sealed off with a barrier. Staging will serve several purposes:

- New players get a chance to interact with new material at the same time as veteran players. This gives new players a natural entry point to the game even at the latest stages.

- The staging process simulates the process of researching, demonstrating your findings, and applying for a grant to do further research.

- We can control the “narrative” of the game more tightly. For instance, we can reveal a tantalizing preview of future discoveries in later stages.

- Anticipation will build for future discoveries, especially if bits of evidence can be glimpsed from an existing stage. The periodic opening of each new stage will be something of an event.

- We can control the amount of time it takes to play, to slow down the game if it’s being played too fast.
Player Progression
As players work on components of the game, they’ll earn research points in various categories. Player progress will enable them to upgrade their PDA and receive titles visible to other players in the game (possibly in the form of apparel). See the Progression Elements doc for more detail.

Tagging & Sorting
Tags are descriptive words applied to artifacts to aid in sorting. For example, an artifact may have the tags: Skull, Australopithecus, and Broken assigned to it. Then when players want to sort a list of images, they can choose to view all images with Australopithecus assigned, or all images with both Broken and Skull assigned.

A player assigns tags, often within categories like “body part” or “species” to an artifact via their PDA. These tags are each player’s observations on the details of an artifact; they can’t overwrite tags assigned by anyone else. However, the tags are tracked in aggregate; players can view and sort by the tags of the entire player base, and even use this list of existing tags to assign (or reassign) their own tags.

2D Visual Sort
As players receive access to the artifact imagery, they’ll be able to sort them in an interface that allows them to compare them to each other visually. This will let them check bone fragments against each other for possible matches, compare the size of items, try to match a footprint with a foot skeleton, etc.

Reference
Also known as Dioramas, these are isolated artifacts, standing skeletons, diagrams, charts, and other images placed around the Science Center for players to see and learn from. When players find a new bone, they can compare it to existing reference to see if it looks most like a femur or a humerus, etc. Some references will be oblique, like a camel skeleton with a bone structure close enough to Australopithecus to suggest a tag for a similar artifact.

Theory Board
As artifacts are gathered and analyzed, players can begin to form theories using the Theory Board. This is a structured system that allows players to posit a theory and back it up with evidence from artifacts, or back it up with other theories. A sample theory may be “These three bone fragments are portions of the same femur”.

After a theory is posted, it can undergo a free-comments period (essentially a peer review) and be improved upon or retracted. Finally, it gets “published” and the player base can weigh in, deeming it supported or unsupported by the evidence.
Note that theories are never confirmed by an outside source. A theory will exist on a spectrum of credibility as the player base weighs in, and theories based on other theories will be subject to the credibility of the underlying theories.

**External Platforms**

Forums, blogs, wiki pages, tweets, Facebook notification and other social media outlets will (A) give players a place to touch base and organize, and (B) give us another source of research data. Any platforms allowing player input used on the project require people to consent that their input will be monitored for research purposes.
What’s NOT included

Among the things that we’ve cut from the first iteration of the project, possibly to be included later:

- **Assembly** – Players can compare specimens visually, but they won’t be able to assemble them into a skeleton. We may trigger the display of fully assembled skeletons as part of the endgame.

- **Certain Measurements** – To simplify the interface (and because the utility of these measurements are limited at the moment) we’ve cut Mass, Volume, Angle, and other measurements.

- **Large Story Details** – We’ll be hinting at a larger story but only including the isolated elements of it now. This will give us freedom to incorporate player theories and new ideas down the line.

- **DNA** – Any measurement or comparison of genetic material.

- **Replayability** – Ideally, this project would be something that can relaunch periodically for a new generation of players. Planning for this replayability takes time, however, and we may want to refine the experience based on how it goes the first time out. Eventually, we should be able to retrofit the game to make it work for new players, but we won’t plan for it out of the box.

Also likely on the chopping block are:

- **Rotatable 3D Models** of the artifacts. Depending on how difficult our engineers consider this, we may have rotateable models for particular specimens.

- **Friends & Group** social mechanisms. While highly desirable to have these within the game system, we’ll probably have to rely on the general Blue Mars grouping mechanisms for now.
**Game Flow in Detail**

Apart from the first and last phases, players can work through these phases are highly iterative. Players will likely switch between these “phases” several times in a given session, for several different artifacts.

1. **NOTIFICATION**

NOTE: The Notification experience will be in flux for a while, depending on how the core game fleshes out. See the Notification doc for more discussion.

In the Notification phase, players learn about the TERC experience in order to gain access to the science center, and then to the dig site. We’ll “advertise” the experience in a few different ways, but ideally we want to fall short of stating it outright. Examples include:

- Players find a mysterious item just off a regularly trafficked location.
- Mysterious images and questions show up in the rotating advertisements in New Venice
- “Mis-sent” messages from the Science Center show up in the mail system
- An avatar sets up a table and hands out fliers declaring that the end is nigh because the ancients have been found on Mars.
- A graffiti message is divided between two distant walls, but can be viewed via telescope as one message.

The next step is from player’s knowing that something is up, to getting access via Teleport. The player may need to demonstrate some volition, like sending an e-mail to a mysterious contact, or using an item in a location, to receive a new location accessible from, say, their condo travel booth.

A fairly small push should be enough to get people talking, and within the Science center we can provide a way for people to send invitations to their friends.

Related documents: Notification

2. **DISCOVERY**

Discovery is the simple act of spotting something visually in the dig site. Once the player uses their PDA on whatever they’ve spotted, they’ve already moved on to Data Gathering.

The burden of design in the discovery phase is to keep players from finding things too quickly. Here are some strategies to keep that from happening:

- Each phase of the dig site should be of a reasonable size. The visual benchmark I’m using is approximately the size of the parking lot outside the current VSE building.
- Some artifacts will be underground, requiring players to use a metal-detector style signal to triangulate a signal to find it, then to scan it.
- Scrub, terrain changes, boulders, and other elements will obscure the player’s approach, so they will have to look around, over, under, and through to get the full picture.
- False leads that resemble footprints and bones can confuse the issue.
- Fog or dust storms can limit player vision and confuse navigation slightly.
- Use relatively redundant items in quantity, like footprints, to keep players busy being thorough

Related documents: Dig Site, Player & PDA Progression

3. DATA GATHERING

The PDA is the key to data gathering. These are the functions it will support in this mode:

**Field Only**

- Capture – When the player points their PDA at an artifact and presses a button, the PDA “scans” the object and saves an image. Technically, we’re unlocking an existing asset, allowing the player to view it on their PDA.
- Assign ID – Each artifact has a unique field ID, derived from its location on a grid, and subsection of that location. This will be the ID by which artifacts are referenced by players unless they start coming up with nicknames on their own.
- Image – The PDA will “scan” the artifact and derive an image to be used thereafter. Note that this isn’t an in-situ photograph; it will look as if the specimen was placed against a simple background and photographed.

**Science Center Only**

- Upload – The player must travel to a kiosk in the Science Center to upload any finds they’ve made in the field. Until they upload, the find isn’t considered part of the verification process. [Design question: Will the player need to upload any other changes over time?]

**Anywhere**

- Player Notes – The player can attach notes to any given item. A player’s notes are theirs alone to see.
- Measure – Using the Image, the player will take measurements of length, width, and depth, which will be entered automatically into measurement fields. Players will need to consult with each other and reference for the best way to measure bones.

4. ARTIFACT ANALYSIS
Players tag and sort artifacts to aid in drawing connections between them. NOTE that until an artifact is verified by a given number of people, no public information about an artifact will be available; players will be working entirely with their own data.

**Tagging**

Players use the PDA or a kiosk in the Science Center to assign tags to artifacts, which enable sorting and classification of each specimen.

Each artifact comes with a few built-in categories with singular and unique roles (like Species and Body Part). There are also a handful of fields that can be used for any tags, like Broken, Hominid, Carnivorous, etc.

When players fill in tags, they can see all the existing tags in those fields, and just select one from that list if they wish. They can also revisit their own earlier tags and change them (for instance to refine Leg to Femur).

**Sorting**

The Sorter is analogous to a picture viewing tool like ACDSee or Adobe Bridge. Players can view all pictures in thumbnail form, zoom in on them, compare up to 6 pictures side-by-side. They can also sort by tags, or by a number of filters that we’ll provide. We won’t have a puzzle-like bone assembly tool in the first round, but the Sorter will enable players to see 2 or 3 fragments together and speculate on their connections.

**Commentary**

In order to facilitate discussion, theorizing, and persuasion about each artifact, a text screen of temporary commentary will be attached to the item. This is meant to be something between the ephemeral chatter of in-game discussion and the clutter of a permanent forum, so the buffer for comments will be of limited length, and anything beyond that will get pushed out of the public record. Players can choose to “Promote” an entry, and the 5 most popular entries will remain at the top of the queue.

5. **INTERPRETATION**

In this phase, the discussion gets lifted beyond the particulars of each specimen, into the discussion of how they interrelate, and what larger theories they suggest. A general wrangle of loose theorizing will already be underway throughout the player base; we’ll give them the tools to formalize the process.

The Theory Board, described above, is designed to let players work from specific claims based on collected artifacts, to general theories based on collections of earlier claims. Any given theory will have a life-cycle along these lines:

1. Present – The theory is introduced with links to supporting evidence, or supporting theories
2. Peer Review – Players can comment on the theory, point out weaknesses, and suggest ways to strengthen it.
3. Refine – The owner of the theory refines it in response to comments
4. Publish – The theory is published for evaluation by the player community. At this point, discussion is over and players have to settle on one of the following options:

   a. Supported by Evidence – The theory appears to be correct and supported by existing evidence
   b. Refuted by Evidence – The theory is refuted by existing evidence
   c. Insufficient Evidence – There isn’t enough current evidence to support this theory
   d. Remove – Players can seek to have a theory removed from play for any reason. When they choose Remove, they can select from a drop down list that will include options like “Duplicate of another theory” or “Frivolous Claim”. If a specific number of players select Remove, the theory is removed from play.

5. [Optional] Withdrawn or Removed – The theory can be withdrawn from consideration by the player who presented or published it. If a theory hasn’t been published within two weeks of it’s presentation, it is deemed premature and removed from play. In either case, the player must rebuild the theory from scratch if they want to try again.

To create some early guidance (and an early sense of mystery) we will devise a handful of Guiding Questions, such as “Who is out there?” and “Why are they there?” These are top-level questions that should take plenty of evidence to even begin to answer with confidence, and even when the prototype is over, we should expect some questions to remain unanswered, but subject to several competing theories.

6. ENDGAME

   The endgame is designed to give closure to an experience that, unlike most computer games, resists closure. Here are the goals of the endgame experience:

   ▪ Celebration – Players will be able to gather and celebrate their accomplishments as a group. Trophies and the like will be awarded to those who participated at various levels of involvement.
   ▪ Social - Players will have a chance to hang out one last time as a group. They’ll also be able to discuss the project with the TERC staff, perhaps more informally than they had before now.
   ▪ Closure – Players will hear conclusions from the TERC staff, and the standing skeletons of the dig site discoveries will be unveiled.
   ▪ Preview – If available, the next chapter of the game will be previewed with concept art of the dig site.

   Like the Notification phase, the Endgame phase will likely be shaped around the existing experience. See the Endgame doc for more details as they develop.

TERC Wildlife Game Design Doc
Story (02) – Phase I

The general story for the TERC project is contained in the Overview doc, and will eventually be fleshed out in larger form in another document. This doc fleshes out the back story for Phase I and hints generally at the distribution of artifacts that will support the story.

For a detailed layout of which artifacts will appear in which location, see the Dig Site document.

Overview

Here are the guidelines that influence the direction of the Phase I storyline:

- **Low impact** – Since the larger story isn’t fully fleshed out, this story should be considered an introductory scenario; a side story that supports the big picture, but doesn’t constrain it.

- **Create ongoing, solvable questions** – As players work through the phases, questions should continually arise and be answered. Obvious questions would be “What is this bone part of?” but less obviously “How did this creature die?” and “Why is this leg bone way over here?”

- **Create lingering questions** – When all is said and done, the players should know that more expeditions like this are needed to solve the big mystery. They’ll know that X exists on Mars, but not how it got there, etc.

Proposed Storyline:

Here’s a suggested (and admittedly melodramatic) storyline that allows for a single dig site with four discovery phases:

As the Jurassic Park style zoo was beginning to fall apart (for reasons TBD), various creatures took advantage of holes in the security. Among them were two hominids, one male (Adam) and one female (Eve), who killed one of the livestock for food and carried it with them as they fled.

They eventually found their way to a cave in a scrubby ravine. The cave led back some ways, eventually opening up into a small cavern with an underground stream. They lived off the purloined livestock and then fashioned weapons and started hunting for other food, occasionally dragging back one of the creatures that had been imported (or genetically developed) to populate the relatively new Martian biosphere.

After a few weeks, one of the zoo personnel (Bob) tracked down the hominids with a dart gun, spotting them at the edge of the cave. He managed to get Eve with the dart, but Adam immediately charged. Bob wounded Adam with a pistol shot but received a knockout blow in return. Adam beat him to death (and beyond) with his own dart gun.

Bob was left to rot and be picked apart by scavengers, but Eve scavenged a few things, including his lighter and heavy flashlight. She used the lighter to make fires to stay warm
(still ate food raw). Eve nursed Adam temporarily back to health, but infection from his wounds eventually killed him. She buried him near the back of the cave.

Hunting was already difficult, but hunting alone was nearly impossible. Eve weakened for lack of food. One day as she dragged a kill back to the cave, she was followed by a predator, who tried to steal the carcass. She fought him off with Bob’s cudgel-like flashlight, but received a mortal wound in the fight. She hid the carcass near the back of the cave, piled some rocks on it, then crawled off to her bed and died with the flashlight in her hand.

(Story questions: Is it possible/likely that Adam and Eve would have eaten Bob? Do we want to go there?)

**Storyline Traces**

Based on this storyline, here are the artifacts we get to deploy:

**Footprints**
- Hominid
- Animal tracks

**Bones**
- Hominid/Human
  - Male Homo Sapiens (Bob)
  - Male Hominid (Adam) (buried and intact)
  - Female Hominid (Eve)
- Animal
  - Creatures brought/known from modern Earth
    - Goat (Adam/Eve’s stolen food)
    - Various eaten, scattered bones
  - Extinct creatures – restored on Mars
    - Eve’s last meal; some possibilities:
      - Dodo
      - Tasmanian Tiger
      - New Zealand moa
  - Genetic hybrids/creations
    - Cave bats

**Tools and Miscellaneous**
- Stone tools (hominids were taught to make primitive tools at the facility)
  - Knives
  - Axes
  - Bowls
- Torches
- Broken Dart gun
- Two Darts
- Pistol evidence
  (The pistol story: It was fired twice by Bob, one bullet hit Adam. Adam and Eve experimented with it then brought it for hunting. They managed to shoot one animal with it before it ran out of bullets, so they dropped it out in the wilderness.)
  - Bullet casings from pistol
  - Bullet slugs
    - One in Adam
    - One among animal remains
- Destroyed cellphone
  - Shot experimentally by Adam and Eve
- Bed made from furs
- Flashlight (partly smashed)
- Lighter
- Campfire remains
- Boots/Belt traces (used for campfire fuel)
Order of Discovery
The phase system gives us an opportunity to present and answer questions gradually, draw out the story, tease future discoveries, and challenge existing theories with new discoveries. Here is a general discussion of what each phase presents to the player. The specific per-site asset list can be found in the Dig Site document.

Phase 1: Outside the Cave
- Bob’s skeleton in disarray
- Various animal bones
- Dart gun, bullet casings, bullet slugs, destroyed cellphone
- Hominid and animal prints
- Stone axe
- Dart

Phase 2: Just inside the Cave
- Large Campfire
- Bullet slug in animal remains, Dart
- Goat head, and various animal bones
- Stone knife, Stone bowl
- Legbone from Eve
- Campfire fuel traces

Phase 3: Deep inside the Cave
- Eve
- Bed
- Flashlight
- Torches
- Goat and other animal bones
- Hominid and animal prints
- A few bones from extinct animal

Phase 4: Underground stream
- Adam (buried at the edge of the stream, but now partly washed away)
- Lighter
- Well-preserved extinct creature
- Bat bones
- Torches
- Goat and other animal bones
- Hominid prints
TERC Wildlife Game Design Doc
Player Notification (03)

Following is a list of ways we can notify the player that the game exists and where to find it. These will be highly dependent on budget and time, so it’s more of a menu of options to pick from.

We shouldn’t underestimate the potential virality of this project. It’s very likely that we’ll need to tell just a small handful of people to get the ball rolling. But there is bound to be drop off after the initial viral impulse passes, so we’ll need a continued form of notification present in the world.

The message we want to deliver potentially has to modes: subtle or direct. We want subtlety to tease and intrigue; players should be led to look for more clues or ask other players. Direct messages point directly to the Science Center. The ideas below generally fall into either category; the challenge will be finding the best bridge between subtle and direct messages.

**Travel Booth buttons**
Just having buttons in Travel Booths that say Science Center will drive people to the SC out curiosity. What’s not so great about that is that they’ll show up with no context and perhaps feel unwelcome or unprepared and just leave.

Some preamble to the Science Center button, like a token you need to make it show up, or at least signs next to the Travel booth may help. We might also consider limiting travel to a single booth, or making a special booth that allows only travel to the Science Center, so the whole enterprise feels a little more exclusive and secret.

As discussed below, there could be ways to hide the button or make it inaccessible until you know a little about why you want to go there. One simple method would be a password required to continue once you press the button.

**Signs & Banners**
Signs and banners can be of the “Go the Science Center variety” or a more mysterious “What’s out there?” style. Signs and banners will generally appear to be sanctioned by the powers that be, or sponsored by the Science Center. Home-made looking signs jammed into the grass will look more like a grassroots paranoia fest.

**Graffiti**
A variation on mysterious signs. We have graffiti hidden in the world already; we could add a few along the lines of “What’s out there?” Just repeating the message will get people asking each other.

**Video Content**
Announcements: In the spirit of signs and banners, these will be basic images and words cycling through the usual video screen content.
Animations: We could feature blurry Bigfoot-style video clips in some context, like a news report or agitprop advertisement (What are they hiding? Demand answers!)

Interrupts: A more paranoid style can be achieved if the usual video roll gets interrupted by static and then a wild talking head comes on (with talk bubbles) to rant about ‘Children of Big Man’ or whatnot.

Owned Flyers
These can be either surreptitiously slapped around or found in an official capacity on a billboard. Clicking on the flyer will put it in your inventory where you can read it for more details. A new flyer will show up a few minutes later for the next user.

The details in the flyer may lead you directly to a fully active Science Center travel booth, or to somewhere in town where a key can be found that activate the travel booth.
Personal Invites
E-mail or messages directly to people (assuming either is supported by ARI). For instance, you may get a message from Joe Paranoid saying “I’ve heard there are experiments… scary experiments… at the science center. No good can come from this!”

Found Objects/Artifacts
Like flyers, these could be placed around the city, glinting in the sun to attract player interest. Picking up an object may trigger a UI message: “You’ve found an interesting bone! Maybe someone at the Science Center will want to know about it.” It’s a bit ham-handed but pretty common in games.

One possible found artifact could be one of our low-tech PDAs that says “Property of Science Center. Please return as soon as possible. Reward!”

Ephemeral Observed Phenomena
Strange footprints near the water, very distant hunched over figures observed through a telescope, people complaining about stolen food, etc. This kind of thing usually is targeted at a small audience eager to look for clues, like the early clientele of an ARG.

The right design for one of these can be rare but repeatable to maintain the mystery.

Town Cryer/Lunatic/Contact
A character with simple animations can cycle through a long litany of complaints, announcements, or gossip using bubble talk. This could be one step in a chain of discovery, or a single explicit step that leads directly to the Science Center.

A more complex version of this would be a character that you find and click on, who then relates some information and gives you his old PDA or a key for the travel booth. This character would need to be hinted at in some other way, so the player will know to click on them.

Facebook Group
We can create a Facebook Group called something like “The New Venice Archaeological Society” that would simultaneously advertise both New Venice and the Wildlife game. Users who join can be given a password to access the science center.

ARG-like web presence
The Blue Mars website (or a brand new website linked from various friendly sources) can hint at the “What’s out there?” theme. This could be an information-rich route, teasing players before the game begins, telling the story from a given character’s perspective, etc. This could also introduce scientific principles and flow in a sidebar, discuss previous archaeological discoveries and frauds, and talk about why finding certain things on Mars is clearly impossible.

Combo Example:
Here’s an example (not necessarily the simplest to create) of the above elements combined:
1. You spot low-tech signage along the lines of “What’s out there??” and a picture of a bone with “It Doesn’t make Sense!!”.
2. We plant a “lost PDA” with the instructions “Property of Pedro. Please PM if found.”
3. The player sends a Private Message to Pedro and gets a reply (automated script); he’s sitting in the butterfly building on the bridge.
4. When you find him, he’s just an avatar looking like a bit of a wreck; he cycles through saylines, says he doesn’t want the PDA anymore but activates it for you, which lets you into the science center. This is PDA Lite described in the UI doc.

**TERC Wildlife Game Design Doc**

**Dig Sites (04)**

This document describes the following components of dig site design:

- Artifact Placement
- Phase delineation & review
- Phase opening
- Miscellaneous Components

For a breakdown of which artifacts appear in what location, see the **Artifacts List** document.

**Artifact Placement**

When wandering the dig site, the player’s assumption should be that a few years of martian dust storms, seismic activity, and the geological stresses of terraforming have left most artifacts partly or fully buried.

**Above ground** - These will be made separately and placed on, or submerged partly in, the surface. Some may be found under rock slides, emerging from under bushes, etc. Artifacts are pickable, but won’t highlight when the player selects them (the scan will fail or succeed depending on whether they click an artifact.

In some cases, **multiple artifacts** will be found in close proximity. These will come in two scenarios:

- **A natural grouping**, like a collection of teeth or ribs. Each item will be pickable separately, but will reference the same ID number. When the scan comes up, the group will be pictured not as found in the dirt, but laid out in a pattern, as if arranged on a lab table.

- **Non-groupable artifacts** may be very close together, like a skull obscuring a partly submerged clavicle. In this case, when the player sees the scan of the skull, they should realize they need to scan the clavicle separately.

(Note: We should try to give the player confidence that they don’t need to scan every bump of bone when faced with multiple artifacts. The player should sense the natural
groupings of items visually and only feel the need to click on things that were obviously not part of previous scans in an area.)

**Underground** – These artifacts technically don’t exist in the scene. What is substituted for the artifact itself is the following:

- **Artifact Indicator** – A designated position above where the artifact is ostensibly buried. The Artifact Indicator contains the Artifact ID number.

- **Detection Nodes** – Placed evenly spaced a circle around the Artifact Indicator, known as the **Scan Circle**. There can be anywhere from 2 to 6 of these objects. Around the site, scan circles can vary in size, but the detection nodes themselves should have a standard radius.

Players within detection nodes will receive a detection signal; players facing the Artifact Indicator will be able to cooperatively scan the object.

Different artifact’s scan circles can overlap (and should, to increase the challenge). Detection nodes should never be placed directly on top of each other, although a little overlap is fine.
Phase Delineation & Preview

Phases will be delineated by an evident “velvet rope” between areas. The nature of this barrier should be concepted, but one example might be a series of posts with a glowing barrier that only shows up when bump into it. Players trying to move into a yet-to-open phase should act as if they walked into a wall.

Beyond the barrier, players should be able to see the following items:

- Rovers (like in the docks area) travelling on semi-random paths, stopping and emitting sprays and puffs and anything else that makes it look like they’re preparing the area. Some or all of these rovers will have spotlights that move over the terrain as they fly.
- Floodlights will be present on the site, but not lit up.

Phase Opening

New phases will open in “real time” to provide a gold rush flavor as people spill into the site. However, it is probably too time consuming for us to find a way to make the various phase preview components change in real time as players watch.

For this reason, Travel Booths to a dig site will become inactive for 2 hours before a new phase opens up. Players hanging around the site will be warned, they have to return to the Science Center. If they still hang around, they’ll get kicked back to the Blue Mars home portal just before new phase opens.

Just before opening, the following will happen

- New phase
  - Maintenance bots will be removed from the new phase
  - The “velvet rope” will be removed
  - Floodlights will be turned on

- Next unopened phase
  - Maintenance bots will be activated
  - “Velvet rope” will be activated
  - The travel booth to the site will be turned back on.

Miscellaneous Components

Travel Booths – There will be one travel booth placed in any dig site, at the earliest phase for that site. It will remain usable at all times, except for the 2 hours preceding the opening of a new phase.

Ramps & Bridges – Part of the preparation for any given phase may be the installation of floating ramps and bridges that players can use to access tricky locations. These, if we use them at all, will be rare. The general idea is that since players can’t jump and climb, we provide them with a way to get up to a ledge or nook where the hominids might have climbed to sleep, etc.
This document describes the elements required in the Science Center. Sketches and concepts will be available as separate files. NOTE: Any user interface mentioned here is described more thoroughly in the UI Design doc.

Overview

The Science Center is at the center of the Wildlife experience. As the only jumping off point for all the dig sites, and the only way to get back to New Venice, the Center should be a hub of activity and information for all participants.

Design Guidelines

Within the fiction of the game, the Center was recently constructed after the discovery of a ruined old research complex of mysterious origin. This is an entirely new building, but will contain some artifacts of the old complex in cases here and there. The new Center is still not fully up to speed; signs of unpacking, temporary storage, and underutilized space can be found all around. In addition, locked doors and blocked off stairwells hint at expansion areas, for use with projects like Mars Mapping.

For the prototype, only the interior of the Center will be available, but should be built with an eye towards a specific exterior that can be plopped into the outskirts of New Venice later on.

The Center should ideally have a slightly inefficient (not confusing) design, forcing people move around and through the central area to accomplish their goals.

Science Center Components

This is a list of the essential components of the Science Center, and the function of each.

Atrium

This the first room players will see when they join the project, so it should orient them and give them a safe place to look around before heading towards the Map room.

Several displays should be available, some informative and relevant to the Wildlife project, some just to deliver the visual goods and make people want to explore some more.

A kiosk is available with FAQs for first time players, and a bin full of PDAs with a sign (“Just starting out? Make sure you pick up a PDA!”) should be hard to miss if the player begins exploring inward.

Players heading past the Atrium will find themselves in the Map room.
Map Room

The map room is the centerpiece of the science center. The rest of this wing of the Center (i.e. whatever players can access during the Wildlife project) is organized around it. This room is where most of player activity in the center will take place, in various functional nodes on 2 physical tiers.

The Dig Site map occupies one large wall of the room, in a theater-like setup. It contains plan-view images of all the stages in the project, contiguous or otherwise. See the Dig Site Map Operation section for more.

Travel Booths

The Center contains two Travel booths. One in the Atrium leads to New Venice. Another at the highest level of the Map Room travels to each non-contiguous site. Players returning from a dig site should exit with a full view of the map in front of them.

Upload Kiosks

Three of these kiosks invite players to upload data from their PDA to the Science Center computer banks. After the upload, an overhead panel ticks out the changes registered to the database. See the Uploading PDA Data section for more information.

Kiosks are located (1) near the Dig Site Travel booth, (2) next to the Atrium Travel booth (signs say “Don’t forget to Upload!”), and (3) tucked away in a back hallway near the equipment counter.

Reference Dioramas

Reference dioramas are used by the players to learn the proper terms for tagging artifacts, forming theories, and generally understanding the scope of the project. They are scattered around the entire building, roughly disguised as (and mixed in with) ambient artwork.

We call them “dioramas” but technically they can be dioramas, posters, standing skeletons, diagrams, brief animations, microscopes with close-up views, whiteboards with scribblings, or anything else that gives off the impression of scientific vigor.

Dioramas are, for the most part, non-interactive. The information gleaned from them must be something players can observe without the use of a special UI.

A list of specific dioramas will be developed as an appendix to this document.

Theory Board

The Theory Board is signified by a kind of electronic whiteboard. Clicking on it will bring you to the Theory UI.
If it’s technically feasible, we should update the Theory Board with a flow of most recent information. Otherwise, we the boards should contain a static list of guidelines for entering theories and remaining civil. We could also find a middle ground, where a series of number textures update (Theories updated today: 132) to match current database numbers.
Tagging Tables

These are stations at which people can tag artifacts. These tables should be evocative of tables that people would gather around to work together (with representative artifacts), but only the table itself is selectable for use.

Clicking on the table will bring up the Tagging UI, with a filter to view all found artifacts, or just the ones you personally have discovered.

When the player leaves the tagging table, they’ll be reminded to visit an Upload kiosk to sync to the data they just entered to their PDA. (Alternately, we could put a sync button right in the tagging table interface, or just posit that using the tagging table effectively syncs their PDA on the fly).

Equipment Bank

This is a kind of vending machine device near Uplink Kiosk #3. Players approach it to receive a UI that exchanges Research Credits for PDA upgrades.

TERC Representatives

At least one TERC representative will be on site at all times to field questions and guide players. TERC avatars will be distinguishable by special TERC logo clothing and tag alongside their name.
Uploading PDA Data

Players can approach an Upload kiosk at any time to upload their PDA information to the main computer. When they click on the kiosk, they see a confirmation screen that explains what will happen.

For any artifacts that the player has personally scanned into the PDA:
1. All relevant data from the PDA will be integrated into the main DB
2. Player information entered at the science center will be integrated into the PDA
3. Personal notes on artifacts are left on the PDA

In addition, if the player has the proper add-ons, they’ll receive news and overall game stats to their PDA as well.

The player should understand that their PDA only contains information they themselves have entered personally, only on items they have scanned personally.

The upload/download process contains a bit of old-fashioned hand-waving to get the point across. A list of artifacts contained on the PDA will scroll by quickly like so:

```
S14B  Australopithecus  Left Femur ...Processed.
S12C  Australopithecus  Skull     ...Processed.
S22G  <untagged>  Footprint      ...Processed.
S32A  <untagged>  <untagged>    ...Processed.
```

News Updated.
Updating Game Information...

If the upload discovers that any artifacts are new to the system, it pauses, skips a line, and says:

```
NEW ARTIFACT!
Registering ID...........
S15D  <untagged>  <untagged>   ...Processed.
```

When the upload is finished, a summary of changes (“44 new tags uploaded” etc.) will be presented.
Dig Site Map Operation

Benefits

For our purposes, the dig site map offers the following benefits:

- Provide a functional component to organize the building around
- Look as cool as we can make it
- Provide a natural gathering site for people to observe and chat about the project
- Create a large canvas that can be swapped out for other textures as needed (Endgame announcements, for instance)

For the players, the map offers these benefits:

- Get a bird’s eye view of the site
- Look for any found artifacts to verify
- Observe artifact distribution and gain ideas on where more artifacts may be found
- Select artifacts for detailed information and tagging
- Watch real-time updates on which artifacts which are receiving the most activity

Visuals

The map will be a plan-view of the site, with blocking features (trees, cave roofs, etc) removed. Stages that haven’t been opened up yet are visible in silhouette.

Each artifact will be represented by an LED-style light, and if feasible, by a tiny inset drawing. The lights will change behavior based on their status:

- Blue - Fully-verified artifact
- Green - Artifact that needs more verification
- Blinking - Artifact has just received an update to tags or measurements.
- ??? - A theory based on this artifact has been published in the last 10 minutes.

If possible, we should put a few high-level stats on the map, updated in real time (“Site Y opens in 3 hours, 23 minutes”).

Interacting with the Map

Artifacts - Click on a given artifact’s light to bring up a purely informational interface about all known aspects of the artifact.

Sites – Each site will have its own “Info” button. The player can click on this button to see a number of statistics about the site
## Reference Diorama Asset List

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Purpose</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camel</td>
<td>Skeleton (labeled)</td>
<td>Teach bone names through rough parallels</td>
<td></td>
</tr>
<tr>
<td>Game Phase List</td>
<td>Whiteboard</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proposed Future Sites</td>
<td>Whiteboard</td>
<td>Gossip, anticipation</td>
<td>Map Room</td>
</tr>
<tr>
<td>Guiding Questions</td>
<td>Poster</td>
<td>Poster with guiding questions for theorizing</td>
<td></td>
</tr>
<tr>
<td>Human</td>
<td>Skeleton (unlabeled)</td>
<td>Give players a sense of humanoid assembly</td>
<td></td>
</tr>
</tbody>
</table>

## TERC Wildlife Game Design Doc

### UI Design (06)

This is a list of design requirements for each element of UI in the game. Actual layouts for the UI may be embedded in this doc or contained in separate files.

NOTE that UI is defined here as a personal player interaction, a Flash interface that covers a part of the screen. For this document, UI is not an entity in the world that everyone can see. (Shared Flash interfaces may become a part of the game in a later iteration and will be added to this doc.)

### List of required UI elements

- Beginning Players
  - Consent Form – Player must consent to being monitored by TERC before they can play
  - Intro Prompt – For first-time players when they enter the Science Center
  - FAQ Kiosk – For beginning players
- Science Center Installations
- Dig Site Map – The large map in the Science Center
- Tagging Tables – For tagging and measuring artifacts
- Theory Board – Players to posit and judge theories here
- Upload Kiosks – Allows player to sync PDAs to the Science Center databanks.
- Equipment Bank – Players can upgrade their PDA and get game rewards here
- Reference Dioramas – Most of these aren’t UI objects, but any that are will be detailed here.

- PDA Functions
  - PDA – Players normal PDA
  - PDA Lite – Player’s first PDA

- Other
  - Project Status – Overall status of the project; # of theories and artifacts, etc.
  - Leaderboards – Allows players to see how their efforts compare to others
  - Notification UI – Any requirements TBD from the Notification phase
  - Travel Booths – Booths for going to Science Center, Dig Sites or New Venice
BEGINNING PLAYER UI

Consent Form
TBD – Consent Form UI is dependent on text and requirements determined by Jodi

Intro Prompt
Ideally, we can guide the first time player with signs and the FAQ Kiosk. If that proves insufficient, we’ll need to create a simple screen that pops up when a player without a PDA first shows up in the Atrium. The prompt will consist of a few sentences and an OK button.

Frequently Asked Questions Kiosk
Ideally, we can guide the first time player with signs and the FAQ Kiosk. A sign overhead with an arrow will say “Click on the screen for Frequently Asked Questions”. The FAQ UI should be basic, just a list of questions that the player clicks on directly. Here is a starting list of questions for the FAQ, not necessarily in this order:

- What is TERC?
- What is the Science Center for?
- Did someone really find dinosaur bones?
- What should I do next?
- Where can I get a PDA?
- Any general tips?

If possible, we’ll want to keep the FAQ list down to one screen. People will have more fun by just running into the field and scanning.
SCIENCE CENTER INSTALLATIONS

DIG SITE MAP

See the Dig Site Map Operation in the Science Center doc for an overview of this.

Artifact Info

Purpose: A non-interactive screen with an overview of the chosen artifact
Access: Click an artifact on the big map

Information displayed:
- Artifact ID
- Artifact Image
- First found by: Player Name
- Number of Verifications Needed OR the phrase “Fully Verified”
- Situation (“4.5 feet underground”)
- Average Measurements
- Top 3 tags for…
  - Name
  - Species
  - General
- # of theories involving this artifact

Interactive Elements:
- Exit Button

Stage Info

Purpose: A non-interactive screen showing stage info
Access: Click one of the Stage Info buttons on the big map

Information Displayed:
- Stage name
- Date Opened
- # of Artifacts Found
  - Above Ground
  - Underground
- # of Artifacts Verified (x of y)

Interactive Elements:
- Exit Button
TAGGING TABLES

Purpose: Allow players to tag and measure artifacts that they haven’t personally captured.

Access: Click one of the Tagging Tables. Any Tagging Table accesses the same UI and data.

Browser – This is the default mode. It displays all known artifacts in a thumbnail form. (Size and # of thumbnails TBD). Arrows and/or numbered pages let people jump to more thumbnails

- **Sort Options** – A drop-down box allows the player to choose between sort options
  - Artifact ID
  - Most Popular Tag - NAME
  - Most Popular Tag – SPECIES
  - Validation Level
  - Most Recent Activity

- **Reverse Sort Direction** – A checkbox let the player reverse the direction of their current Sort method

- **Filters** – A series of check boxes to include the following items from the list
  - Scanned by player
  - Not scanned by player
  - Bones
  - Footprints
  - Other (i.e. not Bones or Footprints)
  - Player NAME tag is empty, or differs from majority
  - Player SPECIES tag is empty, or differs from majority
  - Artifact is highly contested
  - Marked as Favorite

- **Tag Search** – Enter text to view only artifacts with that text somewhere in all tags
  - “Refine previous search” checkbox – if checked, the previous search is ANDed with the current one.

- **Help Button** – Displays a separate help screen.

- **Exit Button**

Artifact Display – When players click on an artifact from the browser, they end up in Artifact Display. This interface should be very similar to the Artifact Info screen found on the Map in the science center, with the following exceptions:

- Instead of the “Top 3 tags” in each category, there is an entry field for each category with a drop-down list. The drop-down accesses the top 10 choices for that category with percentages listed. Players can select from one of the drop-down options, or type their own in the entry field.

  After the NAME and SPECIES category is a GENERAL tags box. This allows the player a free-form method of entering tags. The three most popular GENERAL tags are listed under the box.
Add to Favorites checkbox – Player can select the artifact as a Favorite for filtering purposes.

Measure Tools – Player can click on a Measure tool to measure the artifact. Here is the procedure for measurement.
   1. After the tool is clicked, the cursor changes and instructions appear
   2. Clicks on the measurement starting point.
   3. As the mouse moves, a line draws between the cursor and the click point, and a measurement readout appears next to the cursor, changing as the mouse is moved around.
   4. Click the ending point.
   5. A popup screen shows up asking the player what kind of measurement it was
   6. Clicks either the Length or the Width button and the screen closes.
   7. The measurement is recorded next to the heading Length or Width, replacing the previous measurement, if any.

Average Measurement is listed after the player’s own measurements

Discussion Page – Players can click the Go To Discussion button to see bring up the Discussion Page window
   - Comments are listed from newest to oldest in discrete blocks
   - The buffer for comments is intentionally limited, so unpromoted comments may eventually be shoved off the bottom of the page.
   - Each comment contains a Promote button for players to rate the comment. Next to is are the words “XX players have promoted this”. The top five comments will remain at the top of the Discussion Page. Once Promoted by a player, the button will change to Unpromote if the player changes their mind.
   - Push the Leave Comment button. A box pops up where the player can enter a comment, limited to a set # of characters. A Post Comment button closes this window and posts the comment.

Return to Browser button
THEORY BOARD

Purpose: Using Artifacts and other theories as evidence, players post new theories and respond to existing theories.

Access: Click one of the Theory Boards. Any Theory Board provides access to the same UI and data.

For readability, I’ve broken out the three main sections below, but at the high level, the hierarchy is as follows:

- **Theory Board** (top level entity, represented by a 3D object in the world)
  - Theory Browser (accessed by clicking on the Theory Board object)
    - Theory Display (accessed by clicking on a theory summary)
    - Theory Entry (accessed via Add New Theory button)

**Theory Browser** – This is the default mode. The browser is analogous to a list of categories or messages in an online forum, presenting the highest level information, a set of filters and sort options. Arrows and/or numbered pages let people jump to more thumbnails.

- Theory List – This is the Summary format for all the theories. Each exists in a 1 or 2 line block with the following top-level info:
  - Creation Date
  - Title
  - Creator
  - Date of last update
  - Name of last updater

- Add New Theory Button – takes player to Theory Entry window

- Sort Options – A drop-down box allows the player to choose between sort options
  - Creation Date
  - Status (Peer Review, Published)
  - Title
  - Creator
  - Name of most recent commenter
  - Most recently updated

- Reverse Sort Direction – A checkbox let the player reverse the direction of their current Sort method

- Filters – A series of check boxes to include the following items from the list
  - Created by me
  - Commented by me in last 24 hours
  - Commented by me in last 7 days
  - Based on Artifact I have scanned
  - Based on Theory I have posted
  - Highly Contested
  - My vote differs from majority
  - Marked as Favorite
- Text Search – Enter text to view only theories with that text included
  - Checkboxes for Title, Body, Comments
- Help Button – Displays a separate help screen.
- Exit Button
Theory Display – All elements are non-interactive unless otherwise indicated.

- Theory Info
  - Status (Peer Review or Published)
  - Title
  - Creator
  - Description
  - List of Evidence - All components of evidence are listed here as links. Players can click on the links to bring up one of these two modal screens.
    - Artifact Info
      - Artifact ID
      - Artifact Image
      - Situation (“4.5 feet underground”)
      - Top tag for Name (and % of player base using it)
      - Top tag for Species (and % of player base using it)
      - Top 3 General tags (and % of player base using each)
      - Average Measurements
      - Exit Button
    - Theory Info
      - Title
      - Description
      - Status (Published Only)
        - Supported by Evidence %
        - Refuted by Evidence %
        - Insufficient Evidence %
        - # of Removal Requests
      - Exit Button
- Add to Favorites checkbox – Player can select the theory as a Favorite for filtering purposes.
- Edit Theory button – Seen only by theory creator. Leads to Theory Entry screen described below.
- Community Area – This area will display either either Discussion (during Peer Review) or Resolution (after the theory has been published).
  - Discussion Box – A delineated area for discussion
  - Resolution Box – A delineated area that contains several functions for resolving this theory. NOTE that comments and reasons are intentionally disallowed. Discussion should have been worked out in the Peer Review phase and incorporated into the theory.
  - Vote – A dropdown list with the following entries.
    - <no vote>
    - Supported by Evidence
    - Refuted by Evidence
    - Insufficient Evidence
    - Remove
A confirmation box explains that removal is only for Frivolous or Duplicate claims. They must click “Yes, Remove” or “No, Nevermind”

- **Status Report**
  - Supported by Evidence %
  - Refuted by Evidence %
  - Insufficient Evidence %
  - # of Removal Requests

- **Return to Browser** Button

**Theory Entry** – An entry form for adding new theories or editing existing ones

- Title – A one-line text entry box
- Description – A multi-line text entry box
- List of Evidence – A list of evidence marshaled by the player to support their theory. This is the same as the Theory Display → Theory Info → List of Evidence screen, with the exception of the Remove button described below
  - Remove button – A simple X button next to each piece of evidence. Pushing this button brings up a confirmation box. Pressing OK removes the evidence from the Theory.

- **Add Artifact Button** – Leads to the Artifact Browser window, described here
  - Browser - a simplified list of artifacts for players to select from. The browser lists only FULLY VERIFIED artifacts, with the following fields
    - Artifact ID
    - Top tag for Name (and % of player base using it)
    - Top tag for Species (and % of player base using it)
    - Top 3 General tags (and % of player base using each)
  - Filters – players can use these to narrow the search
    - Name (text entry)
    - Species (text entry)
    - Favorites Only (checkbox)
  - Exit Button

- **Add Theory** Button – Leads to the Theory Browser window, described here
  - Browser - a simplified list of theories for players to select from. The browser lists only PUBLISHED theories, with the following fields
    - Title
    - Supported by Evidence %
    - Refuted by Evidence %
    - Insufficient Evidence %
    - # of Removal Requests
  - Filters – players can use these to narrow the search
    - Title (text entry)
    - Favorites Only (checkbox)
  - Exit Button
- Post Theory Button
- Cancel and Return to Browser Button
UPLOAD KIOSKS
Purpose: Transfer data to/from the PDA. See the Uploading PDA Data section in the Science Center doc for more information
Access: Click on an Upload Kiosk

Upload Window
- Information – Describes what will happen when the upload takes place
- Progress window - downloaded/uploaded data speeds past in this window
- Help button
- OK button
- Cancel Button

Help Window – Brief help text
- OK button

EQUIPMENT BANK
Purpose: Provide upgrades for the PDA
Access: Click on the Equipment Bank

Shopping Window
- Browser – Single-line listing of available upgrades and the price of each in Research Credits. Clicking on any item brings up it’s related entry in the Description Box.
  - Items that are too expensive feature the price in RED
  - Items that are already bought aren’t on the list.
- Description Box – Describes the selected item in full with price (in RED if too expensive)
- # of available Research Credits
- Help button
- Exit button

Confirmation Window – To confirm a purchase and return to the Shopping Window
- OK button
- Cancel button

Help Window – Brief help text
- OK button

Maxed Out Message – If player accesses the Equipment Bank while when their PDA is maxed out, they receive this message
- Exit button
REFERENCE DIORAMAS

<Descriptions TBD, in case we create an interactive diorama>
PDA FUNCTIONS

PDA

Purpose: The players all-in-one tool for research and analysis

Access: Depending on where the player is (and their PDA upgrade status), up to three usable icons will show up on the player screen.

- Science Center: PDA
- Dig Site: PDA, Scan, Triangulate

Overall Function Hierarchy

- Home Screen
  - Desktop Theme
  - Game News
  - Player Status
  - Artifact Browser Button
    - Artifact Browser
    - Artifact Display
  - Player Notes Button
    - Player Notes Screen
  - Associates Button
    - Associates List
    - Associate Detail
  - Help Button

- Scanning
- Triangulation
- Upload

Home Screen – The default view for the PDA. Contains the following items. Items in italics may be accessible only through PDA upgrades.

- Desktop Theme – Skin colors or background imagery
- Game News – Any recent game news, listed in reverse chrono order
- Player Status – Player status in the disciplines, # of 1st finds, # of verifications, and whatever else will fit

- Artifact Browser button
- Player Notes button
- Associates button
- Help button
Artifact Browser – This options described below represent the same interface as the Artifact Browser described in the Tagging Tables section, but tailored for a device in which only player-entered information exists.

- **Sort Options** – A drop-down box allows the player to choose between sort options
  - Artifact ID
  - Player Tag - NAME
  - Player Tag – SPECIES
  - Most Recent Activity

- **Reverse Sort Direction** – A checkbox let the player reverse the direction of their current Sort method

- **Filters** – A series of check boxes to include the following items from the list
  - Bones
  - Footprints
  - Other (i.e. not Bones or Footprints)
  - Player NAME tag is empty
  - Player SPECIES tag is empty
  - Marked as Favorite

- **Tag Search** – Enter text to view only artifacts with that text somewhere in all tags
  - “Refine previous search” checkbox – if checked, the previous search is ANDed with the current one.

- **Help Button** – Displays a separate help screen.

- **Exit Button**

Artifact Display – Like the Artifact Browser, this is a “personal” variant on the Artifact Display screen described in the Tagging Tables section

- **Tag Entry fields** – Vanilla text entry fields for entering tags
  - NAME (text entry)
  - SPECIES
  - GENERAL tags box.

- **Add to Favorites checkbox** – Player can select the artifact as a **Favorite** for filtering purposes.

- **Measure Tools** – As described in the Tagging Tables entry.

- **Return to Browser** button

Player Notes Screen

- **Notepad** – A text entry box with a scrollbar. Cut & Paste enabled.

- **Return to Home** button
Associates Screen

- Associates List – A list of players that the user has named as Associates. Each player name is listed with the following info. Clicking on an Associate Entry will bring up the Associate Detail screen
  - Associate Name
  - Researcher Level
  - Last Date/Time Online (or ONLINE)
  - Current Location
  - “Click on an Associate for details”

- Clicking on an Associate leads to
  - Associate Detail screen – Outlines various details of this Associate (discipline levels, # of 1st finds, etc.)

- Add Associate Button leads to
  - Add Associate Dialog
    - Name (text entry field)
    - Add... button
      - Depending on whether player is recognized:
        - “Player Added as Associate”
        - “Player Not Found”
      - Return to Associates button

- Return to Home button

Help Window – Brief help text

- OK button
SCANNING

Only available in the field, this allows players to scan artifacts visible aboveground. Here are the steps:

1. Click on the **Scan** icon (on player screen, not PDA)
2. A guide window comes up telling you to click on an item, and make sure you’re close enough.
3. Click item on ground you want to scan (note that the item won’t highlight in any way)
4. If player isn’t close enough OR doesn’t click a scannable item:
   a. A “No artifact found in proximity” screen pops up
   b. Player clicks on OK
   c. Return to 1
5. If player is close enough AND clicks a scannable item
   a. If player has already scanned this artifact:
      i. An “artifact already scanned” dialog pops up
      ii. Player clicks OK
      iii. Return to 1
   b. If player hasn’t scanned this artifact before
      i. Remove control from the player
      ii. Bring up PDA
      iii. Go straight to **Artifact Display** screen
      iv. The UI outlines of the screen draw immediately, but artifact image draws in over the course of 20 seconds or so - a theatrical conceit – while the **Scanning** flashes on the screen.
      v. The artifact ID flashes into view
      vi. Tagging, measurement, and other UI come into view.
      vii. Return control to the player for tagging or measurement. Player can Exit at any time.
TRIANGULATION

NOTE: Following a conversation with TERC, we’re trying a new version of triangulation that is less complex than the previous one. This version relies more heavily on chance and cooperation, and will give players a chance to strategize on how best to sweep the site for underground artifacts. The previous Triangulation approach is attached to the end of the document.

Overview

Triangulation is subsurface imaging that requires multiple people to pull off. (NOTE: We should consider a better name for this; there are terms out there like subsurface imaging, etc.) The general idea is to make it moderately challenging and require cooperation. Here’s an overview of the steps required.

Setup: Underground artifacts require anywhere from 2 to 5 people to be in the right position at the right time. For each detectable artifact, a number of detection nodes are placed equidistant from the artifact’s designated location, and equally spaced apart. The detection nodes are large circles that give off the strongest signal at the center.

Step 1 – Acquire triangulation – Players must buy the triangulation component to their PDA. Once they have it, it turns on in the field automatically.

Step 2 - Detect the artifact. When all of the detection nodes attached to a given artifact have a player in them simultaneously, players in those nodes will receive a signal. If anyone leaves the node, the signal for all players will be lost.

Step 3 – Fine-tune the signal. The signal is weakest when the player is at the edge of each node, and strongest at the center. Using a hot/cold search strategy, players try to find the center of their node.

Step 4 – Face the artifact. Once players are each at the center of their detection nodes, they have to face the artifact. When all players are in the correct node locations, the centerpoint of the figure defined by their locations is where the artifact lies. For instance, for 3 players, each will have to face a point between the other two players. For 4 players, each will have to face the player on the opposite corner of the diamond defined by their positions.

Step 5 – Scan the artifact. When all players are facing the artifact, a Scan Underground button will be enabled and must be pressed. After one minute and some fancy pyrotechnics, the artifact appears in each participant’s PDA.

An interesting aspect of this approach is that players will be tempted to “flood the zone” with a large number of players to increase chances of finding something. In that case, they may find enough underground artifacts that they won’t know which way to face. Players will have to figure out a strategy to signal out noise and concentrate on the signals they need to use.
This approach eliminates the need for Scan Groups, and also enables extra players to ‘piggyback’ on an existing scan by standing in the right location at the right time. (If this bothers anyone, we could try to prevent it, but it’s probably not worth the trouble.)
Triangulation UI

Detecting and Locating an Scan Position

1. A Triangulation Icon (TI) appears onscreen below the Scan Icon if the player (a) has bought the upgrade AND (b) is standing at the dig site. The icon cycles a “searching” anim until something is detected.
2. If the player moves into a detection node at the same time that all matching detection nodes have someone in them:
   a. The icon changes and a sound begins to play.
   b. Other player in matched detection nodes get the same result.
3. As player moves around, both the icon and sound change to indicate proximity.
   a. If any detection node is abandoned, all players lose the signal.
   b. If player leaves a detection node, that player loses the signal.
4. When the player reaches the perfect location, the icon/sound will make clear that they shouldn’t move. At this point, they need to face the correct location.

Determining Scan Direction

1. When all players have reached their spots, they need to turn to face the artifact.
   a. Communication with other players, who may still be searching for the best location, is up to the player base to standardize. It may be chat bubbles, dance moves, whatever they figure out.
2. Players turn to their best approximation of the right direction.
3. Only when ALL players are facing the right direction will the Underground Scanning widget pop up for each player. It has one button: Begin Underground Scan.

Scanning the Artifact

1. Each group member pushes their own Begin Underground Scan button.
2. A mild pyrotechnic display accompanies the scan.
3. When the scan is done, a 3d holographic version of the artifact appears over its location underground, then vanishes.
4. The Underground Scanning widget disappears
5. The PDA UI appears to each members, set to the Artifact Display screen with the just-scanned object.
6. Kaching! Research Credits all around!

When any member of the group uploads data from their PDA to the Science Center, it is registered with the SC databanks. Every player who was part of the first scan of the artifact gets credit for 1st Find..
PDA LITE

The PDA Lite is the player’s first version of the PDA. It contains a bare minimum subset of the regular PDA, and can hold only as many items as will fit on one screen of the Artifact Browser

- Home Screen
  - Default Desktop Theme
  - Player Status
  - Artifact Browser Button
    - Artifact Browser
      (Contains no sorting functions, filters, etc. Player can only click on an artifact to view it, or exit.)
      - Artifact Display
        (Contains nothing except the Artifact ID, Image, and Exit button)
  - “Upload Enabled – Return to Science Center” reminder when PDA is full
  - Exit button
OTHER

Project Status
  ▪ TBD

Leaderboards
  ▪ TBD

Notification UI (TBD as Notification is worked out)

Travel Booths – These work just like the ones in New Venice, with a few exceptions:
  Booth #1: ToNew Venice – Looks like a normal Travel Booth, but has only the option of going to a single dropoff point in New Venice.
  Booth #2: To Dig Sites – Overhead display says “To Dig Site”. The buttons available change depending on which dig sites are open. A single dig site with multiple stages will have only one destination, at the edge of the first stage.
  Booth #3: From Dig Sites – Overhead display says “To Science Center”. Only one button is available, to return to the Center. You’re returned to the Booth #2.

▪ Status Reports
  ○ Project Status – Overall status of the project; # of theories and artifacts, etc.
  ○ Leaderboards – Allows players to see how their efforts compare to others
TRIANGULATION

Overview

Triangulation is subsurface imaging that requires three people to pull off. (NOTE: We should consider a better name for this; there are terms out there like subsurface imaging, etc.) The general idea is to make it moderately challenging and require cooperation. Here’s an overview of the steps required.

**Step 1 - Detect an object.** The PDA emits a pulse that searches directly under the player in a radius of about 10 feet. The player moves around the site emitting this pulse until they detect something.

**Step 2 - Locate the Object.** Keep sending out pulses to find the precise location. A small icon points the player in the correct general direction, but doesn’t indicate distance. The player has succeeded when they’re standing directly over the object.

**Step 3 – Create a Scan Group** – Invite 2 other players to join you to scan for the object.

**Step 4 – Determine Scan Locations.** The PDA analyzes the object and determines 3 scan locations that can be used to get the best 3D scan of the object.

**Step 5 - Find Scan Locations.** Three players roam outward looking for the scan locations. This is a “hot/cold” game with a monitor that updates every second or so to tell you if you’re moving towards or away from the nearest hotspot. (Note that two players may end up at the same location and one will have to look for another spot).

**Step 6 – Scan Item.** Players must face the artifact and Scan it. After one minute and some fancy pyrotechnics, the artifact appears in each participant’s PDA.

**Triangulation UI**

**Detecting and Locating an Object**

1. A Triangulation Icon (TI) appears onscreen below the Scan Icon if the player (a) has bought the upgrade AND (b) is standing at the dig site.

2. Push **TI** to send out a pulse
   a. The TI becomes unusable and receives a brief counting-clock overlay to indicate how long you need to wait for it to succeed or fail.
   b. After the TI is cleared, it becomes usable again.

3. If the pulse finds nothing, you get a tiny “negative” sound. Return to 1.

4. If the pulse finds something…
   a. A Directional Icon (DI) briefly shows up next to the Triangulation Icon, pointing toward the artifact’s location, then fades.
   b. The player can move closer and return to 2.

5. If the pulse happens when the player is directly over the object
a. The TI becomes unusable
b. The DI indicates that the artifact is directly downward
c. A success sound plays
d. The **Underground Scanning** widget pops up.

**Creating a Scan Group**

1. The **Underground Scanning** (US) widget remains on the interface as long as you’re standing over an underground artifact you just located. This is a slightly complex looking widget that contains:
   a. 3 **Name Slots** to hold the names of the scan group
      i. One of these slots contains the players name and is unusable
      ii. A **Kick** button appears next to each slot
   b. **Invite Scanners** button
   c. **Generate Scan Locations** button
   d. **Proximity Indicator** bar
   e. **Start Scan** button with 3 **LED Indicators**
   f. **Instructions Prompt** (this updates with new instructions as play proceeds)
   g. **Help** button

2. The player has two choices for creating a scan group:
   a. **Specific invites** - Enter the names of any players they want to invite to scan
      i. If the player is TERC territory, they receive an **Invitation Dialog** telling who needs help and which dig site to visit, and two buttons to Accept or Decline the invitation.
         1. If the Invitee declines
            a. Inviting player receives an overlay message
            b. The invite field goes blank
         2. If the Invitee accept the invite
            a. Inviting player receives an overlay message
            b. The Invite field goes gray, keeps the player’s name, and becomes unusable
      ii. If the player isn’t in TERC territory, the Inviting player receives a message that the invitee isn’t in range.
   b. **General invite** – Push the **Invite Scanners** button
      i. An overlay message appears to anyone at the dig site that Player X needs help with triangulation
      ii. Player X receives a Triangulation indicator over their head so players can identify who needs help.
      iii. After a general invite, anyone who walks within 2 feet of the inviting player automatically becomes part of the scanning group

3. Anyone in the Scan group receives their own widget containing
   a. **Name slots** (without invite functionality or Kick buttons)
   b. **Proximity Indicator** bar
   c. **Start Scan** button with 3 **LED Indicators**
   d. **Exit Group** button
4. At any time, the player can use the **Kick** button to remove one of the group members. This frees up the slot to be filled again.
   a. A player kicked from a group must be re-invited by name to rejoin

**Determining Scan Locations**

1. When there are three players in the group, the **Generate Scan Locations** button lights up.
2. The group leader (who originally found the artifact) pushes the **GSL** button
3. After a bit of thinking, three scan locations are determined, and players need to hunt for them.

**Finding Scan Locations**

4. When the last step is over, Every group member’s **Proximity Indicator** lights up, indicating how far the nearest scan location is to that player. In addition, lights on the **Start Scan** button indicate how each group member is doing.
5. As players move around, their Proximity Indicator strengthens or weakens as they get closer or farther away. Their **Start Scan** button is also affected.
   a. Note that only the closest scan location is being tested at any given time, so players may end up converging on the same point, or a player may move closer to one while searching for another and receive some puzzling changes in the readings.
6. When all players have reached their spots, they turn to face the artifact.
7. When all players are situated and oriented correctly, the **Start Scan** button will be brightly outlined

**Scanning the Artifact**

7. Each group member pushes their own **Scan Artifact** button.
8. A mild pyrotechnic display accompanies the scan.
9. When the scan is done, a 3d holographic version of the artifact appears over its location underground, then vanishes.
10. The **Underground Scanning** widget disappears
11. The PDA UI appears to each members, set to the Artifact Display screen with the just-scanned object.
12. Kaching! Research Credits all around!

When any member of the group uploads data from their PDA to the Science Center, it is registered with the SC databanks. If it’s a 1st find, every member of the group is listed.
Progression Elements provide the player with a sense of accomplishment and status, and provide the game designers with a lock and key mechanism to unveil game components at a particular pace. They also provide the player with a number of near-term to focus on as they play.

Here are the progression elements to be found in the Wildlife game, in brief:

- **Player** – As players perform various tasks in the game, they gain status in those skills and in the game generally.
- **PDA** – As players gain in status, they receive PDA points with which to upgrade their PDA
- **Project** – This is a community goal for everyone to work toward. As artifacts are discovered and analyzed, they inch closer to unlocking the next dig site area.

These elements are interrelated, and sometimes fueled by the same components.

**Implementation Concerns**

**Data Location** - All progression status will be contained on the server. When a player first consents to the monitoring agreements (see Project Research & Data Capture doc), a record is created for that user in the game database.

**Progress Visibility:**

- **Player** – A player’s personal progress will be visible through their PDA. Other players’ progress will be visible through leaderboards in the Science Center.
- **PDA** – All of the PDAs possible functions will be listed in an “app store” of the PDA; if they player has them they’re grayed out as “bought”, otherwise the points required to buy them are displayed.
- **Project** – The status of the project will be visible within the Science Center. The same display will feature both progress toward the next stage, and of the project as a whole.

**Balance & Course correction** – It’s a truism of virtual world experiences that you can test the basic mechanics before launching on a wide scale, but you’ll always get the balance wrong. We may discover within a week that people have found a trick to gain experience points too quickly, etc. We’ll need to be able to tweak numbers on the fly, through a hidden game interface available only to certain avatars, or ideally through uploading new XML data.

**Mechanism transparency** – With the almost certain need to tweak and balance gameplay numbers on the fly, we run the risk of people becoming aware of those tweaks and complaining about the ones they dislike. We have a couple options to consider:

- **Full Transparency** – Many MMOs are upfront about balance changes, going so far as to present a list of recent changes that the player has to
click through before they can play (“Casting costs for the Tome of Power have increased slightly.”) Some more casual games maintain a list of changes but make players search them out if needed.

- **Obscure the Data** – If we assume that the players won’t really care much about balance changes, we can present the numbers in a more subjective fashion, in progress bar format. Some games present percentages in place of hard numbers for a similar effect.

**Player Progression**

**Relationship to Blue Mars avatar**

For the prototype, the player’s development in the TERC game has no relationship to their status (Exploration points or whatnot) in Blue Mars game. Items like the PDA or rewarded clothing will continue to exist in the main game world, but may not share the function they have in the context of the game.

**Player Skill Set**

Within the context of the game, the player will develop points in these disciplines. Note that points can be gained and lost over time, depending on what they were rewarded for, and whether it still applies.

- **Discovery** - The player’s success at personally finding any artifact and capturing it with their PDA, including discovery of underground artifacts.

- **Measurement** – The number of measurements the player takes that are within 95% of the mean. This figure can change over time as the mean is refined.

- **Analysis** – This number is calculated from up to three values, each representing a desirable attribute in the process.
  1. Number of Tags (represents Participation; max 3 tags per artifact)
  2. Being among the first 20 to use a given tag (represents Leadership; max 2 tags per specimen, points can be lost if you change tags)
  3. Having a tag assignment in a given category be among the most popular assignment (this works in tandem with #2; #2 keeps people interested in precision and unique observation, while this one counters gaming of the system. The ideal for any player is to be among the first with an eventually popular tag).

  NOTE: We might normally want to assign points for Accuracy or Perception, but they would have to be judged against a “correct” answer, which isn’t quite in keeping with rules of the game.

- **Interpretation** – Like Analysis (and for similar reasons) interpretation is calculated from multiple sources.
  1. Number of Published Theories (represents Participation)
2. Acceptance/Rejection of Published Theories (represents Credibility; a theory will be worth points only as long as the player base supports it)

3. Number of Theories used to support other theories (represents Foundational Thinking; this is a relatively rare bonus, which doesn’t apply if the original theory doesn’t have support)

**Player Titles**

Players receive titles as they advance in their skill sets in a given discipline. Using the Analyst discipline as an example, players will proceed through these titles: Associate Analyst, Analyst, Senior Analyst. The top 2% of players in a given discipline automatically become Principals for that discipline (i.e. Principal Analyst). This is a status ranking system, but also gives players a sense of who may need help, and who can provide it.

In addition, the overall title of Researcher will be available, reflecting a user’s skill in all disciplines. Like the disciplines, players can move from lower to higher ranking Researchers. The Principal Researcher at any given time will be the person at the Science Center with the highest overall ranking.

Titles will be appended to player names (for example Lead Analyst Herve) while they’re in the Science Center or at one of the sites. Players with multiple titles can choose which to display, or players can choose to display none at all.

**Player Apparel**

When players enter the science center, they can go to a set of lockers and choose one piece of apparel (TBD, probably a hat or jacket) to wear. The apparel will reflect the discipline of their choice, and their ranking within that discipline, or their overall Researcher status. They can take this apparel with them out to the rest of Blue Mars to help advertise the game. At any time, they can return to the Science Center to select a different piece of apparel. For one week after the endgame, players can return to the Science Center and select which piece of apparel they want to keep.

**Player Trophies**

As part of the endgame, players will receive two Trophies for participating, to be used in their apartment:

1. A generic trophy for participating (Golden Femur, etc)
2. A trophy reflect the player’s Researcher status at the endgame.

**Update Frequency**

The frequency with which player scores update is primarily a technical question, but also a matter of research. On the technical side, it’s probably best to calculate and assign scores once a day. However, if TERC research would benefit from seeing how play patterns react to score values, we may want to try more consistent updates. But the first answers need to come from engineering; what is possible?
PDA Development

Overview
The PDA is a tool that the player uses for several functions in the field and in the Science Center. PDA is our generic name for the tool, and hopefully we’ll come up with a more memorable acronym (for example: Martian Archaeological Reconnaissance and Tagging Assistant, aka MARTA).

The PDA is first given to the player when they get to the science center. It initially contains the most basic functions, but can be upgraded as the player gains experience. This upgrade path enables us to teach PDA functions more gradually, but also gives players interesting new goodies to anticipate, and a reason to return to the site when they’ve got new tools to play with.

NOTE: UI details for the PDA are contained in the UI Elements document.

First PDA
The first steps with the PDA are meant to provide the player with the following training:
1. Scan artifacts
2. Upload data from PDA to the Science Center
3. Use Researcher Credits to upgrade your PDA

The first PDA is a throwaway item initially found in a bin in the Foyer. It’s a kind of dented, funky thing given to people who haven’t proven their mettle. All you can do with it is go to the dig site and capture specimens, then browse pictures without seeing any metadata. Once you capture 8 specimens, the PDA is “full” and you have to bring it back to the Science Center.

Interacting with the Upload Console will upload your specimens to the main computer. Some kind of fooforah will result, announcing your ascendance to the ranks of Associate Researcher. The player receives 25 Researcher Credits and instructions to go to the Science Center Equipment Bank.

The Equipment Bank is essentially a vending machine. The player activates it to get a menu of items they can buy with a price attached to each. Initially, the only item available is a shiny new PDA, for a cost of 25 credits. The original PDA and credits disappear, and the player learns what new functions are available.

PDA Function List
Here is a list of functions we can potentially make available to the player. Many of these functions are broken out as a way to make the learning curve more gradual, but others are just to give players an RPG-ladder to enjoy. In the end, we should determine which functions we want in the PDA, then just hide buttons until the player upgrades.

A ‘price list’ will be maintained in a separate document, but functions are listed here roughly in terms of value. Functions can generally be purchased out of order, although a few will be available only when dependent functions have been purchased. NOTE:
Functions in *italics* are available at the Science Center if the player doesn’t have them on PDA.

- Capture & Browse (included by default) – ‘Photograph’ a specimen and make it available for analysis functions. Player can browse through all personally captured specimens.
- Player Stats (included by default) – Players progress in various disciplines, number of finds, 1st finds, verifications, etc.
- Desktop Theme – Purely for customization, these are the visuals that the player sees when they first bring up the PDA.
- Extra Data – Saves extra data on finds, such as date and time of find, personal notes.
- *Player Notes* – A simple notepad that the player can call up and type into for any purpose.
- *Project News* – Updates on the project will be accessible directly on the PDA
- Associate Tracker – Allows player to track progress and online status of specific other players.
- *Tagging* – Assign tags to any artifacts saved to your PDA (this can be done at the Science Center before you purchase the upgrade)
- *Measure* – Measure bones and footprints from onscreen images
- PerfectSync – PDA stays in sync with the science center. No need for Uploads anymore!
- *Advanced Tagging* (requires PerfectSync) – Allows the PDA to function exactly like the Tagging Tables in the Science Center.
- Triangulate – With help from other players, find and scan underground artifacts

**Earning Research Credits**

The player earns research credits for the following activities:

- # of days in which player has visited a dig site
- # of dig site stages visited
- Above-ground artifact Capture
- Below-ground artifact Capture
- Specimen Upload
- Non-trivial Artifact Measurement (i.e. not slapdash clicking)
At some point, the player will reach the maximum number of Research Credits available, which is the equivalent of what it will take to max out their PDA. It shouldn’t be a huge challenge to reach this number. Reasonably diligent players will probably have every function about 3/4ths of the way through the time span of the project.

NOTE: Figure out *when* credits are awarded
Project Stages

Overview
For reasons discussed in the Game Flow Overview document, we will reveal different areas for players to explore as the project progresses. For purposes of discussion, this document assumes four stages will be made available.

Staging Conceit
The reasons we’ll present to the player for staging the dig sites are twofold.

First, the dig site needs to be examined and prepared for the stampede of researchers, by removing rubble from the entrance, blowing away loose soil, testing for live organisms or flora that need to be relocated, etc.

Second, the project can’t continue without funding, and the best way to get it is to prove through previous results that it deserves funding. Player activities and discoveries will be the means to secure funding to continue on the next site.

Stage delineation
We can delineate one stage from the next in two ways. Either or both of these methods is available to us; the work required for each is probably roughly similar.

Visible Barrier - We can draw a dividing barrier, like a police tape, between a current, explorable stage and the next one. The next stage is visible, just beyond the tape, and players can see some potential finds and look forward to grabbing them.

Ideally, the next area will be only partially visible, due to terrain considerations or darkness, like looking into the mouth of a tunnel through a small opening. Standing spotlights could be set up but only flicked on when the area is opened for research.

To add to immersion and anticipation, we can show a little robot (like the robots in the docks area of New Venice), roving in a semi-random pattern, stopping, starting, blinking, and occasionally blasting away a puff of martian dust.

Separate Site - We can designate Dig Site A, Dig Site B, etc in the Travel booth from the Science Center.

We can use some of the above methods for building anticipation about the new site, but visible through a video screen (technically a portal) onto the new site featured in the science center

One drawback of the Separate Site method is that players may be confused as to how the two sites are connected, if at all. If we want the details to cohere into a kind of story, it may be better to stick to the Visible Barrier method entirely.
Alternately, we can start with the Separate Site method but have these sites cohere with a stage that links to both of these sites.

**Governing and Unlocking Stages**

Player discoveries and analysis should play a direct part in gaining access to further stages. As more spots on the map are filled in and verified, and players measure and tag more items and introduce theories, their efforts will prove more persuasive toward untying the purse strings of whoever is theoretically funding this dig.

The method of setting and achieving the goals toward the next step is one of the few things in this project that will be primarily non-mechanical; a good analog might be a the completion of a dissertation by a student, under the guidance of a number of advisors.

**TERC representatives will set goals for each stage**, represented by the amount of fieldwork, analysis, and interpretation they feel is necessary. As progress in each of those goals continues, TERC will weigh in on both the quantity and the quality of the work accomplished.

Visually, players should be able to see a chart representing the requirements needed to unlock the next stage; for instance, thermometer bars representing each aspect of the research that needs to be worked on.

Here’s a Chronology of how it might work:

- **Day 1:** Stage 1 opens up, researchers start exploring it
- **Day 4:** TERC announces that after talks with MarsDevCorp, they’ve determined the goals to meet to open the next stage. The display is unveiled showing progress requirements, including progress made thus far.
- **Day 5, 6, 7 –** Progress is updated every morning by a TERC representative. Players crowd around to watch the numbers jump to the new figures.
- **Day 8 –** TERC announces that artifact measurement is falling behind, which is weighing on the overall fieldwork numbers.
- **Day 9, 10 –** Updates Continue
- **Day 11 –** The update reveals that goals are very close to 100%, TERC announces that they are bringing data to MarsDevCorp at the end of the day.
- **Day 12 –** TERC announces that MarsDevCorp has funded the next stage, which will open in 2 days.
- **Day 14 –** Stage 2 opens for business
Not everything in a given site needs to be found, measured, tagged, or interpreted before the next site will open. Here’s is a sample chronology of where progress on each site may stand as other sites open up, or even as the project ends:

<table>
<thead>
<tr>
<th></th>
<th>Site 1 Opens</th>
<th>Site 2 Opens</th>
<th>Site 3 Opens</th>
<th>Site 4 Opens</th>
<th>Project Ends</th>
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<td>Overall</td>
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<td>18%</td>
<td>43%</td>
<td>54%</td>
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<tr>
<td>Completed</td>
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**Other Staging Considerations**

- We should find a way to let people know ahead of time how many stages we’ve got planned, so they can sense when the endgame is approaching. One way may be to label them Dig Site W, X, Y, and Z, so players can anticipate the finale without being specifically told.

- Players should be informed via e-mail of new stages opening, so those who have drifted away can get excited again.

- We may want to use Stages as a place to posit new Guiding Questions (see Interpretation doc), prodded by discoveries from the previous stage. The Questions may be answerable by the end of the stage, but it’s more important that they’re answerable by the end of the game.
Notes and Brainstorming
Point PDA at other players to see their progress? To “capture” them as friends?

Can we afford jackets for each discipline? What if it’s the same jacket with different logos?

TERC Wildlife Game Design Doc
External Media (10)

This document contains discussion and options for possible external media tie-ins to the game. In deciding which to use, a few things need to be considered.

It’s very possible that people will prefer homebrew solutions for whatever we present, or even develop better solutions than we can. We should think about the effect of any media we provide and whether (especially if they’re tools and reference sources) we risk splitting the player base between two different solutions, diluting both.

We may be better off offering to help establish external tools and reference as soon as we hear people mentioning “I wish there was a _____”.

The types of external media we can offer fall generally into these categories:

- **Discussion:** For players to talk about the game informally. Typically includes freeform and off-topic chatter, as well as homebrew versions of all the other categories listed here.

- **Story:** Anything that expands or introduces the storyline, usually in-character in various media. (One warning: Story media are often the first abandoned when schedules get tight, a source of confusion and grumbling. We might want to stick to ‘cooked’ media, like a blog from a dead character, that nobody expects to be updated.

- **Reference:** External information designed to be used by players. For instance, detailed skeletons of a given hominid type, how to determine information from footprint measurements, etc. Reference is, for the most part, a non-interactive medium.

- **Tools:** Any interactive medium usable by the player base that’s helpful but not necessary to play the game. A wiki is an example here; it may seem to appear in the reference category, but the fact that players can edit it makes it more of a tool than straight reference.

- **Advertising:** Whatever informs people that the game is there and persuades them how awesome it is

Some combinations of the above might be possible as well.
Discussion

- **Forums** – This should probably be something we set up instead of waiting for someone else to do it. We could use the existing Blue Mars forums or make our own (linked to from those forums.)
- **Project Podcast/Shoutcast** – A periodic discussion by anyone involved in the project. These can be interactive, taking phone calls or discussion questions from a simultaneous chat forum.
- **Chat Rooms** – Live chat. This may be kind of silly given the existence of chat in the world, but who knows.
- **E-mail discussion group or listserv**

Story Media

- **Blog examples** – These would generally be in-character affairs, along these lines:
  - The diary of someone working strenuously to debunk Yeti rumors on Mars
  - The blog of someone who looks for living specimens of species considered extinct on Earth, and is now shifting their attention to Mars
- **False media examples**
  - Fortean Times style website discussing Mars myths
  - Flash animation joking derisively about Bigfoot on Mars.
  - Twitter posts from a dedicated Mars fossil hunter.
Reference

- Links – From a wiki or an official webpage, links to pre-existing sites, images, or videos that we consider useful for understanding the process and the particulars. Could include “Further Reference” links for people who want to explore the overall subject further.

- Cheat Sheets – Reference sites obviously designed by us to help users in the game. The expectation for sites like this is that they contain all that is needed, even if it’s buried in extraneous data. The authors of these sites can be TERC, or some fictional entity like MarsDevCorp, depending on how we want to feed the

- False Reference – Designed by us that appear as if they’re general purpose sites. These are typical in ARGs, and generally contain the needed information in cloud of extraneous information to mask their utilitarian nature. Hints pointing to these sites can be fed to one or two users, dropped by TERC reps, or linked mysteriously on a forum.

Tools

- Wiki – This can be the nexus of everything, as anyone who’s seen, say, Wookieepedia can attest.

- Assembly tool – I add this because I suspect someone might make one on their own. Bones images will likely be Photoshopped into proposed assemblies and posted on the wiki or whatnot. There are “make your own puzzle” apps out there that may also be used for this.

Advertising

Ads can be implemented “in character” or as just straight-up pointers to the experience.

- Videos/Slideshows on YouTube and the like
- Pop-up ads over existing videos on YouTube
- Banner/Sidebar Ads
- Mentions on the official blog
- Request/notification for a mention at Virtual World News, Anthropology Today, and other sites
- Search Engine promotions
- Descriptive pinpoint on Google Mars
- Pre-game ad on Kongregate or other gaming sites
Appendix 4: Scientist Review Rubric

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<th>EdGE Research</th>
<th>Martian Boneyards</th>
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<tbody>
<tr>
<td><strong>Science Review of Player-Generated Artifacts</strong></td>
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<tr>
<td>Instructions: Please review all the provided materials generated by players during the 4-month implementation of Martian Boneyards. These include posts from the Arcadia Theory-building board, posts from the Blue Mars Arcadia Forum, and selected excerpts from in-game chat—gathered into two distinct sets for separate review. You will have a chance to adjust your ratings during our subsequent discussion, so just give your best first impression for now. <strong>Please note—this form has 3 pages.</strong></td>
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<tr>
<td>1. Please rate the overall quality of the players' scientific inquiry as demonstrated by the materials. Please give the highest rating that you feel applies to the overall set of content postings.</td>
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<tr>
<td>Scientific inquiry as defined here focuses on activities related to evidence-based theory building. For example, inquiry activities include generating relevant and testable questions, using observations and valid scientific resources for evidence to support claims, and using evidence from others to confirm or counter your own claims. Examples of non-scientific thinking include opinions stated without substantiation, persisting in a thought with disregard to countering evidence, or generating questions or hypotheses that are irrelevant or untestable. The four phases of inquiry scaffolded by the game are Exploration, Data-Gathering, Analysis, and Evidence-Based Theory-Building.</td>
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<tr>
<td>When rating the scientific inquiry please consider all the user-generated discussion (all sources) together and give an overall rating. In this case -DO consider an average rating for all of the posts - NOT the maximum rating we discussed on the phone. Also as we discussed on the phone, measurement is now considered part of analysis (inquiry) so it is not broken out as a separate learning outcome.</td>
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<td><strong>POOR</strong></td>
<td><strong>FAIR</strong></td>
<td><strong>GOOD</strong></td>
</tr>
<tr>
<td><strong>Extent of Overall Scientific Inquiry (please select one)</strong></td>
<td>Nearly all the discussion is non-scientific thinking</td>
<td>Majority of the discussion is non-scientific thinking</td>
</tr>
<tr>
<td><strong>Sophistication of Scientific Inquiry (please select one)</strong></td>
<td>No scientific inquiry demonstrated</td>
<td>An attempt at inquiry is present, but very little accurate, relevant evidence is presented</td>
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</tbody>
</table>

2. Please itemize the core science concepts for which you saw evidence of learning in the materials. For each concept, rate the quality of the content along the following dimensions:

When rating the scientific content please record the maximum rating observed anywhere in the discussion. I want to be sure we capture the limit that players were able to go in their learning, but in response to our conversation I have also added a column for you to record the amount of the sample that is represented by this rating. Please do this in decades (<10%, 10-20%, ... 90-100%).

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<tr>
<th><strong>POOR</strong></th>
<th><strong>FAIR</strong></th>
<th><strong>GOOD</strong></th>
<th><strong>VERY GOOD</strong></th>
<th><strong>EXCELLENT</strong></th>
<th>Percentage of postings on this topic that are represented by this rating</th>
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<tbody>
<tr>
<td><strong>Comparative Anatomy</strong></td>
<td>Sub-ideas that are particularly well represented by this rating: Please add here</td>
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<td><strong>accuracy</strong></td>
<td>Nearly all information related to this core idea is inaccurate</td>
<td>Most information is inaccurate</td>
<td>About half of information is inaccurate</td>
<td>Most information is accurate</td>
<td>Nearly all information is accurate</td>
</tr>
<tr>
<td><strong>depth</strong></td>
<td>Players show a very superficial understanding of this core idea</td>
<td>Players show basic (high school level) understanding of this core idea</td>
<td>Players show understanding typical of an introductory undergraduate student</td>
<td>Players show understanding typical of a university or graduate student, focusing in this area</td>
<td>Players show understanding of typical of a professional researcher in this area</td>
</tr>
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</table>
Appendix 5: Sample Player-Generated Artifacts

8/10/10 13:18 SKULLY SKULL 1764239 Author: Jespau

source Wiki: Subject : SKULL
An adult skull is 21-22 cm long (8.6 in) (from forehead to occiput) and 17-18 cm (7.08 in) wide. Average circumference is 54-57 cms.

Our Skullly has a skull length forehead to rear of 16.91 cms (6.65 in) *** and a skull width of 14.55 cms (5.72 in)
This indicates Skullly is not an adult male with a skull 2 inches shorter than a normal male human. It is also shorter than any male child.

Female skulls are length 19 cms (7.5 in) and width 12 cms (4.7 in)
Female skull AGED 63 = 6.7 in long. Skulls shrink with age.

I propose this skeleton is from an OLDER FEMALE.

8/19/10 7:58 Tailbones (Coc) jamt

The bone in the middle is the tailbone, there has been 2 tailbones found in the cave, one in the upper cave by Skullly1 and the second one found in the lower cave in the stream across from Skullly2. The measurements by me of the 2 tailbones tells me this that Skullly1 has a larger tailbone (10.09, 9.45), than skullly 2, (9.09,8.44) these measurements are in cm. As of this time we need 12 more people to load this into the work station. Both tailbones are of adults, for the tailbone is fused together as in most humans or primates. Skullly1s tailbone has old hairline type fractures to it were as skullly2s tailbone has no visible fractures to the bone. As I believe if skullly1 fell from any great distant there may have been a significant fracture of the tailbone or pelvis.

8/19/10 8:31 Skulls jamt

of Skullly1 is of a humanoid, where as the eye socket of Skullly 2 has a more pronounced upper eye socket, more of a type from a primate! I only measured the top part for the jaw is missing in Skullly2s picture. Skullly1 has the measurements of view 1 A=17.73, B=14.64 views 2 A=16.28, B=15.91, where as skullly2 in view 1 A=19.46, B=14.73, View 2 (A=22.74, B=16.20), the side view of skullly2 is B=11.19, B=9.64. The frontal view of the jaw found in the lower cave, found above where Skullly2 (by the ramp of the missing teleporter) is wider in the frontal view measurements of A=13.55, B=10.61 and longer, both with no physical damage

8/19/10 9:28 Jaws (not the) jamt

many of them and not one) are also Grey Wolf. Wolves hunt in packs...so there were many of them and maybe more to find.
See picture in BM Forum post 19th August.
Mammalia - Carnivora - Canidae - Grey Wolf (Canis lupus)

8/19/10 12:12 TRACKS IDEN] 1764239


Captured Chat from In-Game Event. The team has just found the new area open that contains a huge baobab tree. Inside the tree are more skeletal remains.

Notone (Notone): there are large green leaves on top of the baobab
KalaW (KalaW): one looks sawed off
laurel laterne (laurellaterne): any new evidence?
KalaW (KalaW): ty Notone
Notone (Notone): hummm
fischerlawrence: where did you find that one KalaW?
laurel laterne (laurellaterne): what do you think about the green leaves Notone?
Notone (Notone): level of water was up there
laurel laterne (laurellaterne): ahhh. so you think the water level was once higher than it is now?
Notone (Notone): maybe
Notone (Notone): could be
Evo Maner (EvoMan): Yes I think so
KalaW (KalaW): does have dark beach
fischerlawrence: What kind of environment do Baobabs need?
laurél laterne (laurellaterne): :)
EcoDude (nano): Cold Kebab in new new boneyard tastesc ok"
Toyboy (toy): lol
KalaW (KalaW): no frost they can take most any enviroment
fischerlawrence: Dore, you found us!
Notone (Notone): hi dore
KalaW (KalaW): leave the bones alone bro
KalaW (KalaW): sis
dore_s (dore): look at that tree
KalaW (KalaW): on the bone hunt there she goe
dore_s (dore): omg
Toyboy (toy): is this the pond of youth.. ^^
EcoDude (nano): i first saw them in The Rift Valley Kenya
EcoDude (nano): They have no rings
Notone (Notone): baobab ont besoin d'un sol sec
KalaW (KalaW): nope no ring
laurel laterne (laurellaterne): is that the tree KalaW?
KalaW (KalaW): no in rl
KalaW (KalaW): was trying to figure out which one
dore_s (dore): com inside the big treee king
fischerlawrence: 8 species of baobab, ah.
EcoDude (nano): baobabs are all over lower below equator africa
KalaW (KalaW): lemurs and fruit bats polinate them
fischerlawrence: any species in swampy areas?
laurél laterne (laurellaterne): are they used for anything?
EcoDude (nano): humanitlys birth place
fischerlawrence: lemurs!
KalaW (KalaW): omg a least of things
KalaW (KalaW): i have web site
EcoDude (nano): cannot tell the age of a baobab
EcoDude (nano): no rings
laurel laterne (laurellaterne): what do we know about lemurs and baobabs?
Notone (Notone): this must be a baobab from madagascar, we found a skeleton of rufed lemur living in madagascar
Toyboy (toy): its a million years old tree..
KalaW (KalaW): carbon dating tells their ages
Toyboy (toy): look at the size of that thing..
KalaW (KalaW): at least i think 6000
laurel laterne (laurellaterne): cool - king how do you know the age of that one?
Toyboy (toy): from the looks of its size..
Toyboy (toy): XD
Toyboy (toy): just a hunch though
laurel laterne (laurellaterne): ah - I wonder if we can get a better estimate
Evo Maner (EvoMan): maybe diameter is an estimater
Evo Maner (EvoMan): ?
Notone (Notone): a baobab lives only 3000 years
laurel laterne (laurellaterne): cool how could we measure the diameter?
Toyboy (toy): w8.. how old is the petrified forest..?
Evo Maner (EvoMan): so measure by feet maybe
Evo Maner (EvoMan): or footsteps
EcoDude (nano): my original vid may help
http://www.youtube.com/watch?v=uTLfeCCEzB4
http://www.youtube.com/watch?v=uTLfeCCEzB4
EcoDude (nano): it mentions stone arches too
Toyboy (toy): but like KalaW said,, we can measure its age with a carbon dating..
Toyboy (toy): method..
Evo Maner (EvoMan): Pda>carbon dating not functioning
laurel laterne (laurellaterne): how can we do that king?
Toyboy (toy): this looks like a job for... GOOGLE..!!
Toyboy (toy): brb..
Evo Maner (EvoMan): my Pda been replaced with pokedex
Toyboy (toy): haha lol.. and that tree is sudo
Toyboy (toy): woodo
fischerlawrence: Dore, did you collect the bones in the tree?
fischerlawrence: how many sets?
dore_s (dore): yes
dore_s (dore): 8 i thing
laurel laterne (laurellaterne): there are bones in the tree?
dore_s (dore): yes and very nice one
Notone (Notone): The ring counts of wood used to calculate the age of the tree (if the measurement is made at the base of the trunk)
Evo Maner (EvoMan): oh we can use human height to estimate tree diameter from pic
laurel laterne (laurellaterne): what does it look like? any evidence of anything we should
know about?
Notone (Notone): so we have to cut this tree
dore_s (dore): cut the tree??
EcoDude (nano): cutting
EcoDude (nano): no
Evo Maner (EvoMan): take a pic of laurel with entire tree base
fischerlawrence: I like the idea of using human height...
EcoDude (nano):
http://www.youtube.com/watch?v=uTLfeCCEzB4
EcoDude (nano): oops
Notone (Notone): I'll get my hatchet
fischerlawrence: nice shot Nano!
laurel laterne (laurellaterne): I ran around that side and got stuck
Evo Maner (EvoMan): you need to be next to it though
fischerlawrence: whoa, that tree is talllllllll.
Toyboy (toy): from the looks of it.. this tree is the 1st tree in arcadia..
KalaW (KalaW): and we girls can deck ya
laurel laterne (laurellaterne): I am about 5' 8"
Evo Maner (EvoMan): some1 up against base of tree
fischerlawrence: whoa, that tree is tallllllllll.
Toyboy (toy): your very small grom here mic..
Toyboy (toy): from
laurel laterne (laurellaterne): 173 cm
KalaW (KalaW): i dont see leaves on the baobab
Toyboy (toy): coz its dead
Evo Maner (EvoMan): ok laurel thx 4 that
Evo Maner (EvoMan): I wonder how tall "EcoDude" is
KalaW (KalaW): hahhaa
Evo Maner (EvoMan): its ok now fool Igot yr photo
Notone (Notone): to measure the height of the tree could measure the length of its
shadow and the angle of the sun
laurel laterne (laurellaterne): cool Notone - does that fit in with what you are doing Evo?
dore_s (dore): sun in arcadia?
Evo Maner (EvoMan): can do if physical simmulation is accurate
Toyboy (toy): fron the looks of it.. this tree is the 1st tree in arcadia..
KalaW (KalaW): yes maybe
laurel laterne (laurellaterne): it certainly seems like the biggest in Arcadia
fischerlawrence: Wonder if this is the tree in cave painting?
EcoDude (nano): i9 did a x width shot
EcoDude (nano): http://itsonlygod.com/bm/baobabwidth.jpg
KalaW (KalaW): we can look at the branches
Toyboy (toy): bone in here
KalaW (KalaW): ohh i see a leaf or some thing
KalaW (KalaW): coming out of dormancy maybe
EcoDude (nano): nope
EcoDude (nano): baobabs are like that
Evo Maner (EvoMan): brb, going to forums
fischerlawrence: do you think this could be alive with the trunk hollowed out as it is?
KalaW (KalaW): look up over here maybe treehouse
KalaW (KalaW): as long as the bark is intact
Toyboy (toy): can someone stand at the tree's entrance
Toyboy (toy): please
EcoDude (nano): never seen a baobab with a hole
Toyboy (toy): im gonna take a picture
EcoDude (nano): not
Toyboy (toy): there lau
Toyboy (toy): ok stop
Toyboy (toy): w8
laurel laterne (laurellaterne): Am I near where you want us toy?
Toyboy (toy): ok got it
KalaW (KalaW): and there is no known pests
laurel laterne (laurellaterne): known pests?
KalaW (KalaW): but it hosts to a number of crop pests
fischerlawrence: This tree is significant.
laurel laterne (laurellaterne): what makes you say that fish?
fischerlawrence: I'm wondering if this is the tree in the cave painting and>
KalaW (KalaW): the pests destroy other trees around it
laurel laterne (laurellaterne): can someone take a sshot of picture and compare to shot of
cave painting?
Toyboy (toy): termite
Toyboy (toy): s..?
KalaW (KalaW): but wasnt there a ladder looking thing in that pest
KalaW (KalaW): in that painting geez
laurel laterne (laurellaterne): a ladder?
fischerlawrence: not sure, I'll have to look at the pic on forum.
KalaW (KalaW): lemurs cant make it up the truly tall or slippery baobab trees
fischerlawrence: as I remember it, there was the tree, a human, and what people thought
was, I think a chimp.
people were trying to figure out (calculate, don't you know) how tall it is!
Josie Blue (JosieBlue): can you find a shadow/
KalaW (KalaW): yes
Josie Blue (JosieBlue): well you can measure shadow
Evo Maner (EvoMan): so what do the leaves actually mean? Is it just because its near
water and not needing to be in storage mode?
KalaW (KalaW): i know makes u think so
laurel laterne (laurellaterne): it is also hard to say anything for sure in a terraformed
climate
dore_s (dore): door for under someting?
laurel laterne (laurellaterne): who knows what was natural and what was engineered
KalaW (KalaW): true true
KalaW (KalaW): baobab getting rare in some areas
Excerpt From Web-based Discussion Forum

My guess: 25 years of lab = 1800 years old tree (with devo enhancing)
ref forum viewtopic.php?f=28&t=1057&start=120
Idtei 😊
Blue Mars Volunteer

Re: Mystery: Size of the Largest Baobab Tree

by Intox » Thu Sep 30, 2010 11:55 am

The genus Adansonia includes 8 species, one is from the African continent, one is endemic in Australia and
6 in Madagascar.

Its name comes from Arabic hibah, fruit with many seeds. Indeed, each of its oval fruit often contains
hundreds of seeds
This tree is exceptionally long-lived slow growing, you can meet old specimens of nearly 2000 years.
The baobab tree rings do not produce every year because of recurrent droughts that affect the African
savannah, it is difficult to determine their age by methods of dendrochronology.

A growth model distinguishes 4 phases has been developed based on data collected on trees in South Africa.
The first phase called "sapling", lasts 10-15 years and at the end of this period, the trunk diameter at breast
height of 7-25 cm, height of 3-6 m and the width of the crest of 2-4 m. The second phase called "conical",
lasts until the tree reaches the age of 60-70 years. During this phase, growth is rapid and the trunk reached
its maximum height. At the end of the conical phase, the trunk diameter of 0.8 to 2.2 meters, height is 5-15
m and the width of the crown of 8-20 m. During the third phase, called "bottle", the trunk thickens and the
peak widens with long ascending branches. This phase ends when the tree has reached the age of 200-300
years, while its trunk is 2.8 to 5.5 m in diameter, the height is 10-20 m wide and reaches its peak 15-35 m.
In the last phase of "old age", the trunk is more volume, the branches hang heavy and sometimes the lower
break from time to time. The peak broadens and flattens, the hollow trunk and the tree eventually dies at the
age of 500-800 (-1000) years. Under conditions of exceptional growth and through a secondary growth trees
Appendix 6: Scientist Review Summary Report

The quality of the scientific knowledge building was measured through a review of player-generated artifacts by a panel of three scientists in paleo-anthropology and biology. The artifacts reviewed include all claims posted on the theory-building board (with supporting evidence) along with postings on the Blue Mars web forum that players used for supplemental discussion and one excerpt from one in-game chat on a topic not well represented in archived postings (over 200 text entries in total). Researchers selected all the artifacts that were relevant to scientific content of any kind—removing posts that were purely social, or purely about the storyline (e.g., sightings of characters, or translations of posters without scientific discussion).

The panel of scientists used a rubric to rate the extent and depth of the scientific inquiry in the artifacts, as well as the accuracy and depth of core ideas they identified within the content. They rated the quality of each on a 5-point scale (poor, fair, good, very good, excellent) discussion related to a project conducted in an introductory undergraduate class for non-science majors. Because scientific inquiry in Martian Boneyards is collaborative, the quality of the science knowledge generated is evaluated at the group level (for the entire community) as opposed to the level of the individual player. The scientists came together twice by telecon with researchers, once to review the instruments and rating procedures, and then again to compare the ratings that they each had done independently. The review team achieved consensus on ratings very
quickly on the both core ideas addressed in the players’ postings and the ratings for both content and inquiry.

The team of three scientists concluded that substantive scientific inquiry took place in the game. The player community engaged in knowledge building – questions, making claims, substantiating claims with evidence – to an extent that would be considered very good in an undergraduate introductory science course. The content generated in comparative anatomy was rated very good on accuracy and good on depth. Reviewers noted that the game motivated a level of inquiry among some players that was similar to top students in a class who took a lesson much farther than required out of self interest.

Reviewers also noted that players most, if not all, Internet resources used by players were from reasonable scientific websites (including Wikipedia, as well as university and national labs). There were no personal blogs or websites from non-scientific interest groups found. Players had a grasp of how to use the material found, the only criticism in the reviewers’ minds was that many of related topics were dealt with superficially (players did not dig deeply into evolution or functional morphology, thought there was conversation leading in those directions). Reviewers agreed that the content in comparative anatomy was mostly accurate and players’ arguments in these areas were scientifically valid.
# Appendix 7: Sample Avatar Tool Interaction Log Data

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Appendix 8: Interview Transcripts

Interviewer: Sherry Soares (aka mintchip)  
Participant: Jespau  
Date: Aug. 11, 2010  
Time: 2:00-3:30 pm EDT

mintchip: Hi Jespau! Thanks again for meeting me for the interview.
mintchip: So, I'll just recap a little bit about some things we talked about when we made the appointment.
mintchip: I'm with the EdGE research team as you know, and today I'd like to ask you a few questions about your experience in Arcadia.
Jespau: ok
mintchip: First, I'll tell you a little bit about the research and just need you to agree that you understand, OK?
Jespau: ye
mintchip: OK, here we go!
mintchip: Do you understand that this interview is for the purpose of research and that your responses, while kept anonymous, may be excerpted for use in research publications?
Jespau: yes
mintchip: OK, and Do you also understand that you may refuse to answer any questions or end this interview at any time?
Jespau: ok thats fine
mintchip: And last question before we begin...do you have any other questions? ;)
Jespau: No
mintchip: OK, so let's start. I'll ask you a series of question, and please take as much time as you need to answer. If there's anything you'd like me to explain or rephrase, just let me know.
Jespau: ok thats clear
mintchip: First question: How did you find out about Blue Mars?
Jespau: I heard about it on Second Life from one of my builder groups, from a person who was very impressed by the graphics.
Jespau: Do you want me to expand?
mintchip: And was the person talking about Blue Mars in general, or had /shehe been to Arcadia?
mintchip: Oh yes, if you'd like.
Jespau: I joined the Blue Mars group on Second Life and then went and applied for Blue Mars Beta membership.
mintchip: So, you came to Blue Mars first and then came across Arcadia?
Jespau: Just one moment I am replying to your previous question. Arcadia then. I am not sure. I was just gripped by the opportunity to try out something new and exciting with better graphics and avatars.
Jespau: ecuse the lag
Jespau: I will post the last answer again due to lkag and interruptions.

mintchip: no problem!

Jespau: I do not remember if the person mentioned any of the worlds. I do not think I had heard of Arcadia then. I am not sure. I was just gripped by the opportunity to try out something new and exciting with better graphics and avatars. Arcadia then. I am not sure. I was just gripped by the opportunity to try out something new and exciting with better graphics and avatars.

Jespau: (the chat paste is not working properly)

mintchip: ok

Jespau: I am typing in word processor to help speed it up and pasting it back in

mintchip: take your time, I don't want you to feel rushed at all :)  

Jespau: Ok ready

Jespau: gettig IMs now just a sec

Jespau: Ok freee

mintchip: Wow, you are very popular!

Jespau: hehehe

mintchip: OK, so you heard about Blue Mars via Second Life, and then you noticed Arcadia, is that correct?

Jespau: I came into Blue Mars and actually do not remember seeing Arcadia in October 2009. I did not visit the World before the boneyards unfortunately. I noticed Arcadia more when people were talking about bone hunting and how many they had found. World before the boneyards unfortunately. I noticed Arcadia more when people were talking about bone hunting and how many they had found.

Jespau: (I think I will have to type direct its not working sorry)

mintchip: that's ok

Jespau: Shall I retype my last answer as it in two pieces?

mintchip: Where was it that you heard people talking about Arcadia?

mintchip: no that's ok

Jespau: In the Welcome Area of Blue Mars

Jespau: And there were posts I think from Avatar Reality about the game.

mintchip: Do you remember your impressions when you first entered Arcadia?

Jespau: Amazed. The architecture is fabulous like New Venice and was obviously VSE work. Very realistic. I especially liked the boneyard.

Jespau: There was an atmosphere here.

mintchip: Was there anything about the boneyards that particularly interested you or made you curious?

Jespau: Well the obvious draw of searching for bones that I could not at first see, the layout with barriers, the strangeness of it all.

Jespau: To expand that I was also starting to see that there was more to it with a lab and work tools.

mintchip: When you discovered those other things, did you play around with them, learning on your own, or did others help you along?

Jespau: I firstly clicked everything in sight - as a gamer thats my first reaction. When some of the tools were not responding, I spoke to other people around and we all tried the workstations, the boards and tried to click the teleporters. Some things did not work then
- it was a long time ago.

**Jespau:** Later we worked as groups to get things going by reporting fails to fischer.

**Jespau:** As the workstations and boards began to be responsive we all tried them as a group.

**Jespau:** It was quite a steep learning curve.

**Jespau:** Sophisticated software.

**mintchip:** Given that there were some challenges along the way (technical and otherwise), what made you decide to persist and continue in Arcadia?

**Jespau:** I am a gamer. We never give up!

**mintchip:** Haha, well said!

**Jespau:** I was also fascinated by the interface.

**Jespau:** At that time I suppose I was not really aware that this was a pure science project.

**mintchip:** Do you think you'd still have persisted if you hadn't had other folks to comiserate with?

**Jespau:** I would have persisted.

**Jespau:** But it helps and is more fun in groups.

**mintchip:** So, when you realized this was a science game, what did you think about that?

**mintchip:** Did you have any ideas about what a game like that would be?

**Jespau:** I have played Myst, Riven and other similar games and I quite like a challenge. It was a matter of getting to the conclusion by whatever means.

**Jespau:** If it be science then that's fine.

**Jespau:** I did not know what I had to do in this game for quite some time.

**mintchip:** Can you tell me a bit about the activities that you've been involved with here? (for example, what things you've done in the center and in the boneyards)

**Jespau:** Research, bone identification, picture research, science research, group searching, group discussions, forum posting, theory building.

**mintchip:** Any favorites?

**Jespau:** I particularly like exploring with a group of fellow players and discussing what we find and what we think.

**mintchip:** Do you arrange to meet up with some of these folks at certain times, or just whoever is around by chance?

**Jespau:** Yes we meet sometimes by prior arrangement like - see you tomorrow at the given event time - or we talk by PM and get together - or we meet in the Welcome Area and decide to come here.

**Jespau:** (please correct typing errors!)

**mintchip:** I've noticed that you're very active on the theory board! What do you think about this feature, and have you used anything similar before?

**Jespau:** Oh sorry wrong answer

**Jespau:** The Theory board did not work for quite a while and we were all champing at the bit to get our ideas in print. That's why we started the Forum.

**Jespau:** Then when I could eventually use the Theory Board I was one of only a couple of people who were using it so I felt I had to keep it going.

**mintchip:** Is this a Forum through Blue Mars' discussion lists, or elsewhere?

**Jespau:** The BM Forum has a section for Blue Mars World.

**Jespau:** After discussion with laurel and fischer we decided to use it to put our thoughts
across rather than use the rather complicated Wiki on the EDGe site.

**mintchip:** ok. And have you ever gone to other resources outside of Arcadia/Blue Mars to help research your theories, etc.?

**Jespau:** It as a group decision.

**Jespau:** Are you kiding?

**Jespau:** I do not know how many hours I have spent on the internet, on Wikipedia, and on science relatd sites to find information. I have a folder with over 200 things in it!

**mintchip:** Wow

**Jespau:** But it is clear that there is a lot here in Arcadia that reveals many clues and I have been unravelling them slowlly.

**Jespau:** Even to the point of learning esperanto!

**mintchip:** I've heard rumors about that. :)

**mintchip:** Can you tell me about the types of experiences you've had so far that make you feel like you're learning science?

**Jespau:** Well it is not enough to just find bones although that is fun. We have to identify them, measure them and then decide what type of bone they belong to. We also have to unravel the reasons for the disappearance of the scientists and their research. This means we all have to learn a lot about science but it is fun and part of the game.

**Jespau:** I have actually learned a lot through this

**mintchip:** have you learned things that make you feel more confident in your science skills?

**Jespau:** I am not a science student and so the answer would be no. But I do know how to research anyway as it is part of of rl world. This does give me confidence I suppose.

**mintchip:** Are there particular areas of science, or even computer science, that you have become more interested in as a result of your experience in Arcadia?

**Jespau:** I would like to say that it has enlightened me and thats great.

**Jespau:** I am aleady pretty good with computers but this is an add on. Science wise I quite like anything to do with environment, spatetrael, ecosystems, plant life. Thats interesting to me.

**Jespau:** Arcadia allows me to learn and play.

**mintchip:** Have there been times when you thought about leaving Arcadia and not coming back? And if so, could you tell me why you decided to keep on going?

**Jespau:** Yes there were times when I was actually scared! Not by the science based game but by the amazing atmosphere here. I did not come alone very mtch. Later when I joined up with people I decided to stick with it. As I said we gamers keep going.

**Jespau:** All of that. The atmosphere is fairly foreboding to me, the bones and skeletons, the storyline I have translated in esperanto (Only I know it all) is gruesome, and the layout of the caves are frightening with bends and curves and black areas.

**Jespau:** I am a prettyu nervous gamer though and not typical.

**Jespau:** (pretty)

**mintchip:** So having companions was important to you

**Jespau:** Definitely! I wont go in the cave alone!

**mintchip:** :P

**Jespau:** Its veery cleverly designed as a game.

**mintchip:** Have you ever mentioned it to people you know, or wrote/blogged about it?
**Jespau:** My computer struggles a bit to play it though and it is probably est on a very high spec machine.

**mintchip:** ok

**Jespau:** The Flash interface has caused some problems.

**mintchip:** Have you spoken to Fischer or anyone about the issues?

**Jespau:** We all have.

**mintchip:** ok, just wanted to make sure it is on our radar screen ;)

**Jespau:** :)

**mintchip:** Would you recommend visiting Arcadia? If so, who do you think would enjoy it?

**Jespau:** I have thought about this a lot actually. I would recommend it but in certain ways.

**Jespau:** It has two or three levels.

**Jespau:** Young gamer boys like running around and finding bones. So I would direct them here for that purpose.

**Jespau:** Other players enjoy the more in depth work and I would tell them about that part of it.

**Jespau:** Just to say come here is OK but I like to tell them why they should come.

**Jespau:** Im bossy..

**mintchip:** oh dear! LOL

**Jespau:** only jokin.

**mintchip:** Why should they come?

**Jespau:** Who?

**Jespau:** Oh well its exciting.

**mintchip:** Folks that enjoy more in-depth gaming...what would you say to them?

**Jespau:** But it has, to be honest been a bit slow to develop.

**Jespau:** The other folks like the challenge anyway. One mention of workstations and research and they come anyway.

**mintchip:** Was that a hook for you personally?

**Jespau:** Exploring a mystery.

**mintchip:** ok

**Jespau:** with friends..

**mintchip:** Well, just one final bit and I'll turn you loose to explore the cave, OK?

**Jespau:** ok

**mintchip:** When we spoke previously, I know you expressed not wanting to reveal things about your real-life self, and that is perfectly OK.

**mintchip:** But I wonder if you'd be willing to tell us very general demographic-type info, for example

**mintchip:** are you a student? A full or part-time worker? Retired? etc

**Jespau:** Pas

**mintchip:** ok

**mintchip:** would you be able to tell me why you enjoy gaming and virtual worlds?

**mintchip:** in general...not just in Arcadia?

**Jespau:** It has been my passion for a while. Its interactive gaming I like. But also bought games. I dont know really. I am a computer fan.

**mintchip:** Well, we are very happy you are enjoying Arcadia!
Jespau: I am!
mintchip: Thank you so much for taking the time to speak to me. I'll be sure that you receive your 1000 BLU by the end of next week
Jespau: Your welcome. I hope it was helpful. Nice to talk to you. :)
mintchip: It was very helpful, actually! Thanks again. :)
mintchip: Now have fun in the cave!
Jespau: yayyyy
mintchip: :(
KalW: hi
mintchip: So I'm happy I get to speak more to you. I'm the researcher who doesn't get in-world that much. :)  
KalW: aww ty and wish u could  
KalW: wish  
KalW: omg wish  
mintchip: I know. But paperwork calls! :P  
KalW: true true  
KalW: :)  
mintchip: So, what I'd like to do is just start by giving you a little info about the purpose of the research, and about how the interview is planned, ok?  
KalW: darn stuff  
KalW: ok  
mintchip: Great. So first let me tell you that this interview is for the purpose of research and that your responses, while anonymous, may be excerpted for use in research publications. Is that OK with you?  
KalW: yes  
mintchip: OK, and do you understand that you may choose to pass on any questions or end the interview at any time?  
KalW: ok np :)  
mintchip: Then we're ready to begin, unless you have any questions first?  
KalW: no I am fine  
mintchip: Here we go!  
KalW: :))))  
mintchip: So first off, could you tell me how you heard about Blue Mars?  
KalW: Well when There was closing my hubby looked up worlds, he found There for me and nows what I like  
KalW: so here i am  
mintchip: Could you tell me what There is?  
KalW: It was a virtual world that started in 02 /03  
KalW: and closed this past March 2010  
mintchip: ok, and so it was closing and a search by your husband turned up Blue Mars?  
KalW: Yes  
KalW: he is a geologist and knows good graphics  
mintchip: OK. And when you came to Blue Mars, did you find Arcadia yourself, or did someone mention it to you?  
mintchip: cool  
KalW: I found it myself
KalW: :)  
mintchip: did it catch your eye for a particular reason, or were you just checking out all the Blue Mars worlds and came upon it accidentally?

KalW: I saw what was written and just had to check it out, it intrigued me! The idea is amazing!  
KalW: Oh and love the place :)  
mintchip: When you first arrived, did you have an idea of what Arcadia or the boneyards would be like?

KalW: No, and didnt even know what a PDA was I soon learned, got lost of course  
mintchip: you mentioned that you were intrigued when you first came in...now that you've been here a while, do you still find it intriguig?  
KalW: Omg yes i love it, it is my Favorite place on Mars now! :)  
mintchip: :)  
mintchip: Can you tell me about some of the things that "hooked" you?  
KalW: Hmmmm, the layout, the idea, the learning, I love mysterys, the need to look further into things(nosey) :P  
mintchip: You mentioned your husband is a geologist...are you also interested in that topic?

KalW: Oh yes, and plants, and weather(no wind in the caves hmm), actually if I knew how much fun it was to look up bones and artifacts I would have become a archeologist!  
KalW: love history  
mintchip: Would you say that you've learned a bit of science that you didn't know before? And if so, could you give me an example?

KalW: Ohhh a big yes, well the bones are the main thing, now I can reconize a few, and there sizes, what a difference! The paw prints coyote vs. say dog , and also to be aware of the details surrounding the enviroment! :)  
KalW: their  
mintchip: How did you become able to understand these details...with the help of other players, independent research outside if Arcadia, or a mix of both?

KalW: A mix of both.  
mintchip: Could you tell me a bit more about both of them?

KalW: Well some ideas are brought up, and I have to go look at them in world or in rl, or I just have to see for myself then tell others what I think.  
mintchip: OK. So, complete this sentence: "If I made a discovery but wasn't sure what it meant, the first thing I would do is...."

KalW: Take a really good look from all angles, then go research it, and sometimes walk away or give it a day to think about it or longer, but others may give differant ideas on the subject! Does that make sense  
mintchip: Absolutely.  
KalW: ty
mintchip: In cases where you research on your own, what are some resources you might use to get information

KalW: lol Usually the internet, but I like books maybe old fashion that way, so if i can i will do both!
mintchip: :
mintchip: :)  
KalW: :P  
mintchip: And when you're in world, what tools do you find helpful??

KalW: the work stations and the theory board, I tend to forget the forums  
mintchip: How comfortable are you using the Theory Board, for example?

KalW: actually I like it, i check it everyday!  
mintchip: That's nice to hear! Were you always as comfortable about sharing your theories, or have you gained confidence over time?

KalW: Well, I felt kinda shy(rare event) at first, but now I love it, and may get a bit cared away on it! :P  
mintchip: LOL 
mintchip: Do you feel the same about sharing your ideas when you're in Arcadia, for example, during a scheduled event like the Tuesday/Thursday meet-ups?

KalW: lol now I may to many idea, afraid that I am over doing it, still have many ideas!  
KalW: have  
mintchip: OK. Now to switch gears a little, have there ever been times when you thought about leaving Arcadia and not coming back?

KalW: No, not , nada!!!  
mintchip: Interesting! So not even little bumps that frustrated you?

KalW: Oh I figured it was me. or the beta, orrrr I had to learn! :P  
KalW: stubborn is the key wors.  
KalW: word  
mintchip: So what would you say were the top things that kept you interested and willing to persist? (besides being stubborn ;)

KalW: Rofl, hmmm, the newness of the idea of how to learn a many varied concept!!! Just the idea is fascinating to and future people, I drive a school bus and cant wait to tell the kids about this!!!! It is up their alley so to speak!  
KalW: hmm worded that goofy  
mintchip: LOL  
mintchip: no worries  
KalW: u sure  
mintchip: well, up to you if you feel you want to reword of course  
mintchip: :)  
KalW: haha omg  
KalW: Ok, a concept that is going to be very far reaching!
mintchip: In your opinion, who might enjoy or benefit from playing in Arcadia?

mintchip: oops, benefit

KalW: haha :p! Omg yes already have tenfold! :)
KalW: Hi vanity
KalW: oops
mintchip: I know it's almost time for the Thursday event, so just a quick few questions and we can wrap up, OK?
KalW: np
KalW: or make it longer or another time no rush
mintchip: OK, and this is the optional part! You've told me a little about your real life, that you're married and are a mom. Would you be willing to share anything else about your real life? For example, your profession, or age bracket?

(there was a long pause here, other avatars were entering and speaking to KalW)

mintchip: KalW, do you need a min? Or would you like to pass on this one? Either way OK. :)

KalW: Ok I am 51 years old, have 2 kids one 25 (prego one) the other he is 23, I drive a school bus have since 1998. My mom-in-law who has demnetia lives with my hubby and I! Gonna be a grandma in Feb of 2011! Love gardening, nascar, and of course Blue Mars, and especially Arcadia. My parents are still alive and live in Fla. and take care of a grandchild!
KalW: i live in Pittsburgh Pa.!
mintchip: Wow! Thank you! And congratulations again on your first grandchild.
mintchip: How long have you been involved in virtual gaming?

KalW: aww and ty on ur sister child u r gonna be an Aunt!
mintchip: YAY
KalW: Oh since 2003
KalW: hahahaha
KalW: This was exciting I must say tyvm
mintchip: What's kept you playing in general?
mintchip: thank you
KalW: The friends i met and now the new ones, and look what I have learned now!!! :)
mintchip: And final question!
KalW: okies
mintchip: Do you have any other comments you'd like to share about Arcadia in general?

KalW: Hmmm, only thing I can think of would be make it, easy for non techy people like me! I have trouble getting some things but I figure it out or call HUBBY!! haha , but no I love the way it is heading for the future! :)))
mintchip: I'm (We) are really glad to hear that!
mintchip: And now for the best part!
KalW: :(
KalW: okies
mintchip: I'll make sure that 1000BLU is credited to you for helping us out with the interview. :)
KalW: omg u realy dont have to do that
KalW: truly, I enjoyed this
mintchip: LOL, we're happy to. Speaking to our gamers is very valueable to us.
KalW: awwww ok :)
mintchip: So thanks again, and now you can catch up with everyone!
KalW: save it for fisch to get some shoes
mintchip: hahahaha
KalW: awww ty
KalW: and u play also
mintchip: ok Jammy, see you soon
mintchip: bye!
KalW: okies /wave
mintchip: ok, shall we get started then?
EcoDude: ok
mintchip: Great. So as you know, I work with the EdGE research team. What I'd like to do is ask you some questions about your experiences here.
EcoDude: sure
mintchip: OK. Now before we begin, I'll just tell you a couple of things. First off, do you understand that this interview is for the purpose of research and that your responses, although kept anonymous, may be excerpted for use in research publications?
EcoDude: yes thats fine
mintchip: Great. And that you may refuse to answer any questions or end our interview at any time?
EcoDude: ok
mintchip: OK, that was the serious part! Do you have any questions before we begin with the interview?
EcoDude: no
mintchip: OK, then we can begin. And remember if at any time you need an explanation, or more time to answer, just let me know.
EcoDude: :)  
mintchip: OK, first question
mintchip: How did you first find out about Blue Mars and Arcadia?
EcoDude: Blue Mars I think it was on a blog about virtual worlds
EcoDude: Arcadia I was invited to come
mintchip: Do you remember which blog mentioned Blue Mars?
EcoDude: May have been New World Notes, but linked to another
mintchip: OK. And you said that someone invited you to check out Arcadia?
EcoDude: yes
EcoDude: It may have been ilko, but not sure
mintchip: Did you meet the person while in another Blue Mars city? mintchip: or did you know each other somehow else?

EcoDude: I was in the meeting area
EcoDude: I had just met them as they helped we with bowling [bowling] event
EcoDude: that was definitely ilko at bowling
mintchip: was there anything about what she said that sounded particularly interesting to you about Arcadia? Or were you just checking out everywhere at the time?

EcoDude: Just came to check it out
EcoDude: I didn't know anything about it
mintchip: do you remember your first impressions when you visited the first time(s)?

EcoDude: well I had a good and friendly intro into what it was about mintchip: from ilko?
EcoDude: mainly Fisch, sorry I don't have name right
mintchip: that's ok. I know Fisch
mintchip: how much did he explain

EcoDude: Quite a bit, what was going on here, how to use the bone table, the claims board
EcoDude: sent me out with some1 else who taught me the bone scanner
mintchip: did you feel pretty comfortable learning about the tools here? Do you think you'd have figured out how things worked without someone to get you started?

EcoDude: It would have been difficult I think
mintchip: do you think you'd have stayed if you hadn't met guides here?
EcoDude: probably not, the social and teamwork part is fun
EcoDude: I wouldn't have stayed long enough to get into it without that
mintchip: Can you tell me what sort of group activities you've done while you've been here? Also, could you tell me about how many times you've come to Arcadia so far?
EcoDude: 1 bowling event, 3 trivia events so far. Tried golf multi but it was down.

EcoDude: Arcadia I have been here lots

EcoDude: I am not sure, how many hours

mintchip: Have you ever come to the Tuesday/Thursday groups in Arcadia?

EcoDude: yes, I started when one was happening....I think this helped a lot

EcoDude: I have been to both meetings since I started

mintchip: when you think about the social interaction in Arcadia on one hand, and the story/mystery of the Boneyards on the other, how do they compare in terms of what keeps you interested in returning?

EcoDude: Well the mystery would have to be interesting to me. And on the other hand I wouldn't be interested without other people being involved. So I guess they are both equally vital

mintchip: That's nice to hear!

mintchip: Have you used the theory board?

EcoDude: Yes LOL, but that was a weird 1

mintchip: Oh dear, why was that?

EcoDude: Some avatar was running around in a caveman costume

mintchip: hahaha

mintchip: a bit distracting

EcoDude: and I thought he maybe part of the mystery

EcoDude: well it was exciting at the time

mintchip: did you ever finish using the theory board?

EcoDude: Finish, I am not sure what this means?

mintchip: oh, i meant were you posting something when the caveman came by?

EcoDude: I posted something about him LOL

mintchip: aha

mintchip: right, and do you feel comfortable discussing theories of yours with the other players through chat?

mintchip: some people can be shy about putting their ideas out there
**EcoDude:** I am comfortable saying mine, but I sometimes here other peoples and I feel a bit mean telling them I don't think the evidence supports it.

**mintchip:** I understand.

**mintchip:** How do you feel about your own ability to recognize bones or other things you find?

**mintchip:** are things obvious? do you ever look up information outside of Arcadia to figure out what something might be?

**EcoDude:** you mean actually spotting them or ID them?

**mintchip:** ID mostly

**EcoDude:** I have to google for bones, but its not that difficult....and its part of the fun

**mintchip:** do you have an interest in science outside of this game at all?

**EcoDude:** Yes I have a Bachelor of Science in Ecology

**EcoDude:** I am interested in all science though

**mintchip:** background, what do you think of what you've seen here?

**mintchip:** oops, i think my last message was cut off

**mintchip:** i meant to ask, as someone with a science background, what do you think of the landscape and the artifacts here?

**EcoDude:** I think its pretty well done, I got really excited by the Poster titles as they had titles relevant to Ecology. But then got disappointed when the translations had nothing to do with it

**EcoDude:** But the enviroments are well done i think, must have been heaps of work

**EcoDude:** I am impressed

**mintchip:** thank you!

**mintchip:** do you think you personally have learned any science here? Also, do you feel like the average person could learn something about science here?

**EcoDude:** Well yes, no major concepts..but lots of interesting facts

**mintchip:** Could you give me an example or two?

**EcoDude:** The boab tree was used as a source of vitamin C

**EcoDude:** baobab
**mintchip**: And how did you learn that?

**EcoDude**: I saw the tree in the environment and had a clue what it was...looked it up and ld the tree as the baobab tree...read about it-lots of little facts

**EcoDude**: Used as a marker by some societies

**mintchip**: That is interesting!

**EcoDude**: Oh and I relearted a little organic chem trying to name a molecule

**EcoDude**: still working on that 1 though

**mintchip**: really! And what got you thinking about molecules?

**EcoDude**: 1 of the posters had a molecule on it

**mintchip**: ok.

**mintchip**: have you ever been or are you a teacher by any chance?

**EcoDude**: No I am not a teacher

**mintchip**: ok. any thoughts on whether kids could benefit from a game like this?

**EcoDude**: Yes I think so, it is a good way of getting and keeping their attention. But I wonder whether the effort creating the place is worth it. I gues

**mintchip**: I'd like you to imagine for a minute that you are in charge of Arcadia.

**EcoDude**: ok

**mintchip**: Anything you would change, add, or take away?

**EcoDude**: The bones, maybe there is too many. I started late though, so a bit overwhelming. I would add a few more specilised science puzzles, but make them not vital.

**EcoDude**: sorry about spelling

**mintchip**: could you explain more about what you mean by specialized science puzzles?

**mintchip**: no problem :)  

**EcoDude**: Well ones that are abit harder and would require abit of background in a science field to recognize

**mintchip**: perhaps we should take you on as a consultant, eh? ;)

**EcoDude**: could be a disaster lol, I was the one chasing caveman avatars
mintchip: haha

mintchip: Well, the deep question portion of our interview is now over. This next part is completely optional.

EcoDude: ok well I am prepared to have a see at the questions at least

mintchip: We like to give our interviewees the opportunity to talk a little about their real lives, if they like.

mintchip: For example, would you mind talking about why you like virtual gaming?

EcoDude: yes sure

EcoDude: I have always liked video games since I was a kid. That partly led to me being interested in 3d as well. Creating 3d things is why I first visited 3d worlds.

mintchip: May I ask you what type of job you do currently?

EcoDude: I am a lab technician for a concrete company

EcoDude: concrete

mintchip: thank you. And do you feel OK telling me anything about your age range, and whether you are a parent?

EcoDude: I am not a parent and am 26

mintchip: OK, thank you for being open to sharing that personal information. :) 

EcoDude: no probs :)

mintchip: OK, so at this point, I only want to ask if you have any other general comments or if you have any questions for the EdGE team?

EcoDude: Umm EDGE are they part of Blue Mars company?

EcoDude: I mean employed by them?

EcoDude: or is this a University project?

mintchip: nope, we work for an educational not-for-profit organization. we supply the science content, not the artwork or programming :)

mintchip: our organization specializes in math and science

mintchip: Blue Mars' folks are our partners

mintchip: Any other questions?

EcoDude: ?

EcoDude: sorry
EcoDude: mistake
mintchip: :0
mintchip: no worries.
EcoDude: Outside blue mars, edge does not work on other projects?
mintchip: we are pursuing other gaming projects via BlueMars, yes. But they
will depend on funding
EcoDude: ok, I should have worded it as are you specific to Blue mars
EcoDude: but got answer
EcoDude: ok thats all I have to ask
mintchip: well, EdGE is at the moment. But EdGE is one of several teams at a
larger not-for-profit where we work
EcoDude: Ok sounds interesting
mintchip: it definitely has been
mintchip: Well, thank you once again for spending the hour talking with me. I'll
tell you about the BLU stipend.
mintchip: I will put in the request for you to receive 1000 BLU, and usually you
will see it in 1 or 1.5 weeks in your account
EcoDude: ok
mintchip: thank you very much again
mintchip: have a lovely weekend
EcoDude: Ok you 2