

Alternate Reality Games: Platforms for Collaborative Learning

Elizabeth Bonsignore, Kari Kraus, June Ahn, Amanda Visconti, Ann Fraistat, Allison Druin, University of Maryland, College of Information Studies, 4105 Hornbake Bldg, South Wing, College Park, MD 20742

Derek Hansen, 265N CTB, Brigham Young University, Provo, UT 84602

ebonsign@umd.edu, dlhansen@byu.edu, kkraus@umd.edu, juneahn@umd.edu, visconti@umd.edu, ann.fraistat@gmail.com, allisond@umiacs.umd.edu

Abstract: We review the first iteration of an Alternate Reality Game (ARG) designed to engage middle school students in the interpretive process behind history and the mathematical roots of cryptography and cartography. Building from the core characteristic of ARGs as collaborative sense-making systems, we sought to integrate elements of effective cooperative learning environments, such as positive interdependence, into our game design. We detail how cooperative learning constructs were designed into the narrative and game mechanics, and how evidence of these features emerged during play. We found that the jigsaw puzzle design of game challenges supported collaboration between groups; daily, whole-class discussions strengthened group processing; and real-time, chat-based dialogue among students themselves and students with an in-game character enhanced promotive interaction (e.g., providing positive reinforcement). However, we did note weaknesses in positive interdependence within groups. We conclude with design implications for future iterations of the ARG.

Introduction

Well-designed games often provide situated learning contexts that support deep learning: they include rich, compelling narratives; require players to engage in individual and collaborative problem-solving activities; and offer opportunities for players to assume authentic, community-valued roles as investigators, engineers, archeologists, artists, etc. (Gee, 2008; Shaffer et al., 2005). As socially situated, interactive media experiences, Alternate Reality Games (ARGs) incorporate several of the features that promote deep learning (Gee, 2008): they provide compelling narrative contexts and require collaboration to complete.

An ARG is an immersive story-game hybrid whose core mechanics are collaborative problem-solving and participatory storytelling. The narrative context of an ARG is not bound by any one communications platform or media type: its story fragments can be scattered and hidden in websites, phone calls, text messages, or books. Because of the ways in which an ARG's narrative elements are hidden, players must collaboratively hunt for clues, solve puzzles, and synthesize disparate information to assemble and advance its ever-evolving storyline. An ARG rendition of a Sherlock Holmes mystery, for example, might involve Watson sending players a text message with GPS coordinates to the next clue, which the players must find, decode and email to Holmes before the story can continue. Just as the ARG's narrative is distributed across "real-world" platforms, players use "real-world" technologies such as blogs, chat, and online community forums to collaborate as they make sense of the unfolding story. A well-designed ARG engages learners in 21st century literacy practices, such as evaluating and sharing information across multiple media, analyzing complex problems, and using new media tools to re-interpret existing content or create new expressions (Bonsignore et al., in-press; Jenkins et al., 2006).

Although the inherent community-based, "collective intelligence" characteristic of ARGs holds potential to promote socially situated learning (Jenkins et al., 2006), player participation is often lopsided. Active players, those who find clues, solve puzzles, and synthesize information to advance the story, represent a fraction of the total players involved in an ARG (Gurzick et al., 2010; Kim et al., 2008). The majority are bystanders or "lurkers" who do not participate in the story except at a minimal level, such as passively experiencing it through the latest story updates from a player community website. To mitigate this uneven active participation ratio and to realize more fully the potential of ARGs in education-based contexts, we are investigating ways to incorporate cooperative learning constructs (e.g., Johnson et al., 1994) into their design.

In this paper, we examine the effects of cooperative learning designs on middle school students who participated in the first iteration of an ARG that engaged them in the interpretive process behind history and the mathematical roots of cryptography and cartography. Building from the core characteristic of ARGs as collaborative sense-making systems, we sought to integrate elements of effective cooperative learning environments, such as positive interdependence (**Table 1**), into our game design. Using a design narrative approach (Hoadley, 2002), we detail 1) how these cooperative learning constructs were designed into the narrative and game mechanics, and 2) how evidence of their effects emerged during game play.

Research Landscape and Related Work

Game-based learning studies over the past decade have investigated the knowledge-building activities of players in single and multiplayer videogames (Squire, 2006; Steinkuehler & Duncan, 2008); the authentic scientific

inquiry practices of players in multi-user virtual environments (MUVES) (Barab et al., 2007; Dede et al., 2004); and the ways in which role-playing activities (“playing an environmental scientist”) enable players to adopt epistemic frames, or ways of knowing and working within specific in-game contexts that can transfer to “real-world” contexts (Shaffer et al., 2005). Socially situated opportunities for learning are embedded in the narrative frameworks for all of these games (e.g., players help a civilization similar to ours to solve a critical environmental issue). However, design-based techniques that directly engineer collaboration into these games have been largely a secondary, not central design concern. Further, most of this research has been focused on games that employ 3D gaming or virtual reality environments. Research by Klopfer, Perry, Squire and Jan (2005) on augmented reality game design represents one of the few studies that 1) focused explicitly on ways to embed cooperative learning elements into play and 2) moved the game-based environment beyond the desktop. Both augmented and alternate reality games remove traditional videogame requirements to remain tethered to a desktop or to invest in specialized tools necessary in virtual environments. Although augmented reality technologies can be used within an ARG to enhance the immersive experience of game-play, ARGs do not rely on augmented reality effects in their design or play. As “real-world” collaborative sense-making systems, ARGs can take advantage of relatively low-cost social media technologies and tools, such as online community wikis, forums, and blogs. We seek to extend Klopfer et al.’s (2005) collaborative learning focus for augmented reality games by investigating the effects of integrating cooperative learning constructs into ARGs.

Alternate Reality Games (ARGs): collaborative, counterfactual learning experiences

Like their videogame counterparts, ARGs were initially developed for entertainment; however, they are garnering increasing attention as a potentially transformative vehicle for education, specifically in terms of the ways in which they promote 1) critical thinking and information literacy skills, and 2) collaborative problem-solving and sense-making (e.g., Johnson et al., 2010; Whitton, 2008). A small number of ARGs have already been developed with educational goals in mind, such as *World Without Oil*, which asked players to imagine their world in the midst of a global oil crisis, and *Black Cloud*, which engaged at-risk high school students in scientific investigations of environmental issues in their local neighborhoods (Niemeyer et al., 2009).

ARGs invite players to imagine and inhabit a past, present, or future *alternate* world, requiring that they look critically at the information they find, constantly asking “what if” questions. *Counterfactual thinking* involves imagining what might have been, or considering “what-if” alternatives to specific events (Byrne, 2007). It can be a tool that fosters investigative reasoning across multiple disciplines, including science, history, and business (Gaglio, 2004; Hawkins & Pea, 1987; Owens, 2010). By embedding game play and story seamlessly into existing, everyday technologies, ARGs neither acknowledge nor promote the fact that they are games. The lines between “what’s real” and “what’s not” are unclear, fostering “what-if” interrogation. Known as the “This is Not a Game” (TINAG) principle by ARG designers, it can be the primary apparatus for prompting critical, counterfactual thinking and information literacy practices, because players are responsible for distinguishing “truth” from fiction.

Mandatory collaboration is another primary design goal for ARG designers, who strive “to create puzzles and challenges that no single person could solve on their own” (McGonigal, 2008, p. 203). ARG designers immerse their players in hands-on experiences. Players have a central role in assembling the story world, by collecting and connecting pieces of the game’s narrative, then sharing their interpretations with each other. Through role-playing, videogames have offered similar collaborative means for players to participate as contributing members of virtual communities, such as SWAT teams or environmental research teams (Gee, 2008; Klopfer et al., 2005). In contrast, players in ARGs do not take on roles as digitally rendered avatars or specific character types. Instead, players inhabit the game space as themselves. As ARGs “present the evidence of the story, and let the players tell it” (McGonigal, 2008, p. 202), players often begin to view *themselves* as detectives, storytellers, and problem-solvers. Still, each individual player must be afforded opportunities to feel as though her existing and emergent individual skills can contribute to the community’s efforts. Else, she will remain one of the passive bystanders who watches the story unfold, but makes little effort to participate. Cooperative learning research offers techniques to help maximize the potential for ARGs to support problem-solving and critical thinking at individual as well as community levels.

Essential elements of Cooperative Learning

Cooperative learning, the strategic use of small groups working together to accomplish shared learning goals while maximizing individual learning, has been shown to be a highly effective instructional practice for over 40 years (Johnson & Johnson, 2009). Although diversity in cooperative learning methods exists – between 8 and 10 variations have been applied and studied since the 1970s – all of the methods have been found to produce higher achievement than competitive or individualistic learning approaches (Johnson & Johnson, 2009; Slavin, 1991). Improved academic performance is not the only indicator of the effectiveness of cooperative learning, however: improved psychological health, self esteem, and task-oriented and personal social support have been consistently confirmed as well (e.g., Johnson & Johnson, 2009; Slavin, 1991). As a repertoire of successful

learning techniques, cooperative learning offers an additional set of conditions that can “translate into design principles for good games” (Gee, 2008, p. 37).

Cooperative learning approaches require group members to take individual responsibility for specific aspects of interdependent tasks (*positive interdependence*), and to promote each other’s successes as they work toward the group’s shared goals (*promotive interaction*). These techniques offer ARGs a means to ensure interdependency among the game’s interactive puzzles while allowing players to contribute as individuals, based on a combination of their personal interests and their ARG community’s needs. This is the balance that we sought to achieve through both narrative and game mechanics in our ARG, the *Arcane Gallery of Gadgetry*.

The Arcane Gallery of Gadgetry (AGOG)

The *Arcane Gallery of Gadgetry*’s mythology is grounded in the history of the U. S. Patent Office. From 1836 to 1932, the Patent Office building, then located in Washington, DC, was dubbed a “Temple of Invention.” Thousands of miniature models of patent submissions were put on display, and thousands of visitors came to view first-hand the ingenuity of their fellow citizens (Robertson, 2006). A number of historically significant figures were associated with the Patent Office, including Abraham Lincoln, Walt Whitman, and Clara Barton. In 1877, a fire damaged over 100,000 patent models housed there (Robertson, 2006). The fire, whose cause has never been completely resolved, provided the *AGOG* designers with the means to traverse fiction and reality: we could use this gap in historical knowledge to create counterfactual paths, filled with documents, inventions, and personalities that players would have to investigate and resolve.

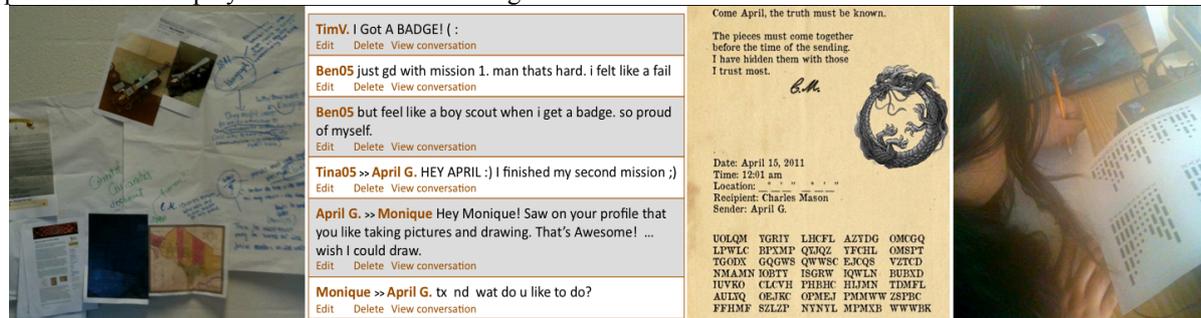


Figure 1: From left to right: **1a)** Working notes and artifacts that were posted along an "evidence" wall. **1b)** Sample chat messages. **1c)** Sample encoded document the students decoded. **1d)** A student works on Morse-encoding the final message.

Goals

Throughout the design process of *AGOG*, we applied the notion of creating designed experiences, rather than content-delivery vehicles (Squire, 2006). Our goal was to have students view historical events and artifacts as possibility spaces that can be actively interpreted and reconstructed, not inevitabilities that could simply be memorized and retold. One design goal for building the historically grounded mythology of *AGOG* was to enable students to discover fault lines that exist in extant historical records, such as the 1877 Patent Office fire. We used these gaps to focus students’ attention on unanswered questions, or questions open to interpretation (e.g., What might have caused the Patent Office fire? How do you track and restore lost records? How do ideas get patented?). In this way, we sought to subtly foster student engagement with the *National Center for History’s Historical Thinking Skills* (Lesh, 2011), such as “differentiating between historical facts and historical interpretations,” and “challenging arguments of historical inevitability” (p. 17).

Another primary design goal was to find ways that would not only encourage the collaboration typically experienced in ARGs, but also provoke interdependencies among players so that they would distribute team tasks more equally among themselves. To ensure that no one player could collect and reconstruct all the information required in the game timeframe, we distributed story content across multiple media types and tools, and embedded interdependent puzzle components within these story fragments. Historic maps contained over a hundred locations and landmarks into which we embedded several clues; several cryptographic key phrases were split across historic documents; a simple telegraph had to be reconstructed and tested; and archival data had to be evaluated to solve a logic puzzle about historical figures that were part of the game’s narrative.

Participants and Methods

AGOG is part of a larger, design-based research initiative that explores the potential of ARGs to create authentic contexts for collaborative learning and participatory design. This first iteration, *AGOG Season 1*, took place over a 2-week period in a public school in the U.S. Sixty 8th graders started the ARG, with about 55 students (13-15 years old) participating consistently. The students played during their American History class sessions (50 minutes each). To accommodate computer lab scheduling and to facilitate classroom management, the students remained in their respective class sessions (27 students in one class, 33 in the other), with only one instance of the game being played across both groups. Fewer boys participated than girls: 44% boys (26), 56%

girls (34); half the students were eligible for the school's free and reduced meal program; and six percent had limited English proficiency (LEP). Regarding ethnicity, 43% (26) of the students identified themselves as African American, 37% (22) as Caucasian, 13% (8) as Hispanic, one as Asian American, and four as mixed race. A teacher and school librarian worked with our research team throughout the game.

We followed a multi-method case study framework (Yin, 2003). The main case involves the design and effects of AGOG in a formal education setting; the embedded unit of analysis for this paper focuses on student participation and collaboration. Our investigation covered several levels of student participation in terms of data collection: 1) observation and field notes on all in-class sessions, 2) brief daily summary meetings among the researchers and teacher before and after classes; 3) online, print, and physical artifacts created by students and in-game characters as part of AGOG; and 4) a post-game survey and discussion with students. We databased all of the students' online interactions (e.g., chat interactions, wiki entries), as well as their post-game survey responses (e.g., some demographic data, free-form written responses to open-ended questions). The goals of our data analysis were to craft a design-based account of the students' interactions with AGOG, while at the same time using our findings 1) to inform the integration of cooperative learning techniques into future iterations of the game, and 2) to develop design-based theories about their integration into immersive learning experiences like ARGs (cf. Barab et al., 2007; Hoadley, 2002). The essential elements of cooperative learning (Table 1, Johnson et al., 1994) formed our initial coding frame. For example, if one student encouraged another via chat, it was coded as an instance of *promotive interaction*. We followed a constant comparative analytic approach (Boeije, 2002). Each data source (e.g., blog posts) was first analyzed as a single set. Then, coding comparisons were made across sources (e.g., survey responses, blog posts, chat interactions) as a means of data triangulation.

Implementation

The game began when the students were recruited by university researchers to help inspect a set of historical artifacts that had allegedly been discovered by staff members from the Smithsonian Museum. After receiving background on the *Junto*, an actual but secret philanthropic society established by one of America's founding fathers (Benjamin Franklin), the students accepted an invitation to be part of a modern version of the *Junto*, called *JENIUS* (*Junto of Enlightened Naturalists and Inventors for a United Society*). They discovered that *JENIUS* is an underground extension of the original *Junto*, and that its purpose is to curate a special subset of covert Patent Office designs known as the *Arcane Gallery of Gadgets*. Most of the game's narrative content and missions were presented and stored across two websites: a "rabbit hole" public site and a password-protected private community site. All students could see each other's work, both online and on a working "wall of evidence" on which students and researchers posted ongoing questions, ideas, and findings (Figure 1a).

JENIUS membership is distributed across four Orders, or community sub-groups. Each Order provides a different, but interrelated function. *Archivists* are responsible for determining the authenticity of documents and artifacts, and maintaining accurate records. *Cryptographers* are responsible for ensuring the security of *JENIUS* artifacts, through their knowledge of codes and ciphers. *Inventors* are responsible for maintaining existing *JENIUS* artifacts, as well as creating new designs. *Surveyors* are responsible for maintaining the society's maps and charts, along with other location-based data, such as the geographic coordinates of *JENIUS* artifacts that must remain distributed to ensure they do not fall into unsuspecting, non-*JENIUS* hands. *JENIUS* Orders provided the game-based means for students to band into interdependent groups. Students self-selected into Orders, based on an online "Orders Quiz" developed to help them decide which specialty was the best fit.

The game was staged in two phases: a training phase and the final mission. During training, students worked to acquire various Order skills, such as using geographic tools like gazetteers and Google Maps™ (surveyors), searching patent and biographical databases (archivists), making an electric circuit (inventors), and learning about cryptographic keys, Morse code, and encryption using mono- and poly-alphabetic substitution (cryptographers). Students earned badges for every mission they completed, and a final certification badge when they completed all three missions for a specific Order. Badges for completed missions were posted on their profile pages. The training phase was intended to promote collaboration within groups and emphasize individual accountability (public posting of badges, encouraging and helping fellow Order members).

The *JENIUS* students' final mission required the skills of members from each Order, and entailed decoding, decrypting, and reassembling a message that had been scattered across documents they uncovered through their research. Surveyors pinpointed the locations of clues, cryptographers decrypted the clues, archivists validated and reassembled the contents of the decrypted message, and inventors repaired a notional telegraph and created a Morse-encoded recording of the message. The students would complete the game successfully only by collaborating across Orders as they applied the individual skills they had acquired.

The game narrative was shared with students via two in-game characters: the *JENIUS* Ambassador and April Gravure. The fictional *JENIUS* Ambassador, a mysterious, omniscient leader in the society, provided information to players at key, pre-scripted stages in the game narrative (e.g., Introduction; Final Mission Orders; end-game congratulations). April was a fictional 21-year old college student who needed the students' help to send the message that would successfully end the game. April was the game's "*protagonist by proxy*", a phrase

used to describe a character who seems to discover the story in tandem with the players (Anderson, 2008). The “protagonist by proxy” is a staple interactive dynamic in ARGs. During game-play, the player is presented with the same artifacts and information – such as URLs, copies of documents, email – as the in-game protagonist. Players have the chance to unearth secrets that this character may not have, but needs, and s/he has the means to communicate new information to the players. Moreover, the protagonist often models productive information-seeking and problem-solving behaviors that the players can emulate. Players often see the in-game protagonists as people “just like them,” and are motivated to regard them as both mentors and investigative partners. These characters were not avatars: members of the *AGOG* design team played the *JENIUS* Ambassador and April.

We used the following media channels to deliver story fragments over the course of the game (see http://www.arcanegalleryofgadgetry.org/time_files/slide0003.htm for a visualization):

- *Videos* and *text-/image-based blog posts* were used by April G. to reveal secrets about the *JENIUS* Academy and clues to the final mission, as the students advanced through the game.
- *Podcasts* were the only communications used by the *JENIUS* Ambassador. As a stereotypical authority figure, his communications were one-way only; he did not engage in dialogue with the students.
- *Facebook-like Status Wall* updates were used as an informal, live *chat* mechanism. These updates were visible to all students, and posted in a prominent place on the *JENIUS* community website.
- *Incomplete Wiki entries* were seeded on the *JENIUS* website, providing hints and clues. The community wiki also included copies of *JENIUS* documents (e.g., historic maps, community ledgers) and images of artifacts (e.g., the Kairograph, an *AGOG* invention fashioned after the telegraph). April created some of the wiki entries, modeling ways to compose informative archival documents and accurate geographic data.

The students could use any of these media during game-play. For example, in their first mission, all students created and posted videos of themselves taking the same “oath” to scientific and moral inquiry that Benjamin Franklin’s original *Junto* members used. Throughout the game, they also used the Status Wall updates to chat with April and each other, created blog posts, and edited wiki entries to complete missions and share information with their classmates. The research team, participating as fellow *JENIUS* members with the students, also used these media to help point players toward clues, and to model information literacy practices.

At the beginning of class sessions each day, we would gather as a community to summarize events and activities of the day before, and introduce new plot points (via videos/blog posts by April G. or podcasts from the Ambassador). Students could ask for help or share information during these *group processing* sessions (**Table 1**), which lasted 10-15 minutes. Just before the final mission, and also in the post-game debrief, we allotted extra group processing time for the students to share burning questions or concerns that they had (~30 minutes). Throughout the game, students also posted any questions, concerns, or evidence they felt they should share with the community on “big paper” that became our “wall of evidence” (**Figure 1a**).

Table 1: Elements of Cooperative Learning mapped to *AGOG* design features.

Essential elements of Cooperative Learning	How each was designed into <i>AGOG</i> Season 1
Individual Accountability Individual performance is assessed and shared with both the individual and group. Individuals are held responsible for contributing to the group success.	Each student was required to complete a series of increasingly complex problem-solving missions to become certified in a specific Order. Badges were awarded and posted on individual member profiles for each mission completed.
Positive Interdependence Group members believe they are linked with each other so that the success of one depends on the success of all (and vice versa).	Members from each <i>JENIUS</i> Order had to solve individual clues that, taken together, form the end-game solution.
Promotive Interaction Individuals encourage each other’s efforts to achieve the group goals by sharing resources and providing positive, constructive feedback to each other.	Students were encouraged to share information via the community chat feature, blogs and wiki, as well as on the “big-paper” posted on a community “wall of evidence” in the lab (Figure 1a-1b).
Group Processing (and associated <i>constructive controversies</i>) Groups periodically reflect on how well they are functioning and how they may improve their processes. These sessions often reveal intellectual controversies, which, when managed constructively, can promote active searches for more information, and a reconceptualization of knowledge/reasoning.	Daily whole group “circle time” was built into the beginning of class to discuss individual mission status and to review plot updates. During class, researchers worked with small groups. An extensive session was held midway through the game, just before the final community mission was revealed to players.

Findings

Table 1 summarizes the cooperative learning elements that we sought to design into *AGOG*. Key examples of the ways in which we saw these elements emerge during game-play are detailed in this section. We provide

evidence of the target behaviors that cooperative learning structures promote, such as providing mutual support when difficulties are encountered, awareness of one's interdependence with the larger community, sharing resources, and celebrating individual and joint successes. All student names are pseudonyms.

Individual Accountability. We found that the training mission format worked well to support individual accountability. The training missions allowed us to embed content-based and information literacy lessons into the game in an authentic way, and enabled individual assessment and feedback. All students were very proud of their badge accomplishments, as evidenced by their Status Wall updates to each other and April (**Figure 1b**). In the post-game survey, almost half of the students noted that the missions and badges were the most fun, challenging, or surprising aspects of *AGOG*. Of these, 20% mentioned that the missions were both challenging and fun. One student let his colleagues know how he was doing in training via this short blog post:

Anton (Day 4): Wheww!!! Just finished two of the missions of cryptographer. Very happy {kinda gettin into this game}.

Another student shared both her frustration and success with April via chat as she decrypted an excerpt from the 14th Amendment, on due process (an American History content requirement):

Myra (at the start of a class session, Day 3): ... i Got A 67% i Dont Get It.

April G >> Myra: Hey, that's not bad, though—you're almost there. Ask the *JENIUS* people for help on that last question.

Myra >> April G (toward the end of the class session): i Got 100% (:

April G >> April: 100% --That's cool! You get a new badge!!! :)

Myra >> April G: I Know, Right

Positive Interdependence was most visible across groups during the final mission, because the interdependence of the Order tasks was strong (e.g., cryptographers decrypt a clue that surveyors pinpoint as the next clue's location). One student captured her analysis of *AGOG*'s increasingly interlocking parts as follows: "There were 3 [missions] you played and then a master level that you have to use the skills you learned from the first 3. The last level is a group level where you put all of your skills together." Our "wall of evidence" proved particularly useful for students during daily group discussions, as they made visual cross-Order connections from individual Order discoveries (e.g., the same Ouroboros symbol imprinted on both surveyors' maps and cryptographers' clues). Cross-Order collaboration also occurred online, as students created blog posts to share information, or posted status updates asking for help from members outside their own Orders (samples below). A few students also logged in from home, or otherwise outside of their regular class sessions.

Ben05 (Day 5, decoding April's notebook): Who is a cryptographer? I NEED UR HELP!

Ginny >> Claire746 (over the weekend): hey i have to tell you some clues i have found out

Claire746 (over the weekend, after she had decoded a critical clue and wanted to solve more before class resumed Monday/Day 6): haha...im going solo! im trying to figure other things that i dont even know... can someone help? Surveyors!!!! help!!!!

Individual accountability and positive interdependence *within* groups was more problematic due to the Order self-selection process coupled with the individual-only (versus group) badge awards. We allowed students to choose their *JENIUS* Orders because 1) in most ARGs, players self-organize into teams based on skills they feel they can contribute, and 2) we wanted the students to identify personally with their Order. To encourage the formation of informal, interrelated sub-groups *within* Orders, participating members of the design team encouraged students who had completed missions quickly to work with members of their Order who were struggling. This worked well in one class, because the distribution of students across Orders was fairly even (7 archivists, 7 cryptographers, 6 inventors, 7 surveyors). In the other class, an overwhelming number chose to be cryptographers (17), and only one was a surveyor. Consequently, training could be difficult to manage since students worked at different paces, and several students did not feel accountable to earn badges for their Order.

Promotive interaction, in which students share resources and highlight each other's success, appeared strongest during the final mission. During the training phase, in-game characters modeled promotive interaction for students. For example, April posted encouraging status updates (**Figure 1b**) and shared clues via videos, the Ambassador congratulated students on their progress in his podcasts, and participating members of the research team encouraged students. By the final mission, students were engaging in their own promotive interaction efforts, as shown in the Status updates (above) and in the blog posts shown below. In the post-game survey, over half the students commented that they had to "work together and share information" to complete the game.

The stories of *Ben05* and *Claire746* offer evidence for both positive interdependence and promotive interaction. Early in the game, the teacher relayed to us that *Claire746* typically did not participate much in class, yet her blog posts, status updates, badge certifications and efforts in class to find and decrypt clues tell a different story. In her post-game survey, she responded that she enjoyed "how real [the game] felt" and that the most fun and challenging part to her was "when we felt like a detective figuring out things." During the final mission, she posted several blogs to share information she had found with her classmates. She also relayed her knowledge about navigating and working with the media on the site and her desire to collaborate via chat:

Claire746 (Day 7): If you go under collaborate-->wiki-->unsolved questions-->message to charles mason (CM) to see the message... or to -->cabinet of curiosities document to find the hidden key phase: "YOU DELAY BUT TIME WILL NOT." i dont know what "A PLACE FOR EVERYTHNG" means... can anybody help?

Ben05, another quiet student, initially shared his frustration at the difficulty of his first mission and his elation at finally completing it (**Figure 1b**). By the final mission, he was one of the game's most prolific bloggers:

Ben05 (Day 6): As you know, last week we observed April G's notes on her phone recording. The morse code translated out to be: Messages Across Time. This is obviously linked to the Kairograph, which can send messages in the past, present, and future. SCAR is obviously on the hunt for this. We need April to write that message on the 15th!!!! We need to work together for clues & find why SCAR wants April. You can talk to me about my blog at Ben05.

Ben05 (Day 7): Me and Anton just got done decoding Walt Whitman message. It states: Time Lost is never found again. This is obviously leading to something, but what? We need more clues!!!!!!!

Group processing. Questions about TINAG dominated interactions between the design team and the players during group processing discussions, highlighting the responsibility that educators have to balance the drama of uncovering new nuggets of history with the academic imperative to remain trustworthy models. Still, these TINAG talks also gave players an opportunity to debate and share insights with their peers. One student related *AGOG*'s mechanics to the interlocking layers of fiction and reality in the film *Inception*, while another explained to her classmates that what they were doing was "imaginary real." Yet another suggested that some of the information we were working with was "like beliefs" (i.e., opinions, and not always factual or grounded in evidence). We viewed our community TINAG discussions as opportunities for *constructive controversy* (Johnson et al., 1994), not as conflicts to be avoided or suppressed. As described by Johnson et al. (1994), constructively managed conflicts promote: "an active search for more information, a reconceptualization of one's knowledge and conclusions, and, consequently...higher-level reasoning strategies" (p. 29).

Design Implications and Conclusions

To help foster positive interdependence and accountability within groups (Orders) in future iterations of *AGOG*, we plan to design at least one training mission that requires two to three players to work together, with opportunities to earn Order-level badges (i.e., each member receives both an individual and "team" award for completing a training mission). To help students get a sense that their individual training efforts will contribute to the overall story and final community mission, we also plan to include more narrative information from in-game characters during the training phase. Finally, a long-term ARG design goal is to mitigate inherent re-playability and scalability issues (Bonsignore et al., in-press). One option we are investigating involves the development of a repertoire of design patterns (Alexander, 1977) that can be used to create counterfactual, playable extensions from gaps in existing historical records or scientific knowledge (Bonsignore et al., 2012). Counterfactual design patterns could also be used as a participatory cultures' design strategy (Jenkins et al., 2006) for developing in-game challenges that invite players to craft historically grounded extensions to the existing *AGOG* story world.

Our data analysis reflected that we made strides toward more balanced participation from several students whose class interaction was typically underrepresented. We also believe that *AGOG* made an impact on the students' perceptions of history, and their efforts to interpret information. We found that the points at which the game's mythology blurred the lines between fact and fiction prompted them to move beyond rote memorization of content. Instead, they began to question, analyze, and make hypotheses about the data presented. In their post-game surveys, several players (~15%) mentioned that they felt like spies or detectives, helping to "save the world," and "saving the past." The ARG's dynamic, puzzle-quest nature engendered engagement as well as collaboration. Students noted that they felt *AGOG* made history interactive, and gave them opportunities to choose what to study: "it let you learn more of the past and interacts with you and is fun"; "there were many jobs we could choose from. It was really fun"; and "we learned about codes, map reading, and old inventions. I invented things." Others observed that history was not just a facts-only or events-only endeavor, but required inter-disciplinary work: "I was surprised we had to do a little math". A few students expressed frustration at being asked to move beyond regurgitating answers from textbooks they had previously been taught never to question. However, many expressed newfound awareness of historical thinking as an investigative process, involving "detective" work and interpretation. In particular, the porous boundary between the fictional game world and the "real world" (TINAG) provoked students to engage in *constructive controversies* with each other. As one student summarized in her post-game survey, "It was cool. It was a strategizing game that keeps you thinking."

References

Alexander, C. (1977). *A pattern language: towns, buildings, construction*. New York: Oxford Univ. Press.

- Anderson, M. (2008, Nov 12). An Interview with JC Hutchins: Personal Effects. *ARGNet: Alternate Reality Gaming Network*. http://www.argn.com/2008/11/an_interview_with_jc_hutchins_personal_effects/
- Barab, S., Sadler, T., Heiselt, C., Hickey, D., & Zuiker, S. (2007). Relating Narrative, Inquiry, and Inscriptions: Supporting Consequential Play. *Journal of Science Education & Technology*, 16(1), 59-82.
- Boeije, H. (2002). A Purposeful Approach to the Constant Comparative Method in the Analysis of Qualitative Interviews. *Quality and Quantity*, 36(4), 391-409.
- Bonsignore, E., Kraus, K., Visconti, A., Hansen, D., Fraistat, A., & Druin, A. (2012). Game Design for Promoting Counterfactual Thinking. In *Proc. CHI 2012*. ACM Press.
- Bonsignore, E., Hansen, D., Kraus, K. M., & Ruppel, M. (in-press). *Alternate Reality Games as Platforms for Practicing 21st Century Literacies*. *International Journal of Learning and Media (IJLM)*.
- Byrne, R. (2007). *The Rational Imagination: How People Create Alternatives to Reality*. Cambridge, MA: MIT.
- Dede, C., Nelson, B., Ketelhut, D. J., Clarke, J., & Bowman, C. (2004). Design-based research strategies for studying situated learning in a multi-user virtual environment. In *Proc. ICLS 2004*, 158-165.
- Gaglio, C. M. (2004). The Role of Mental Simulations and Counterfactual Thinking in the Opportunity Identification Process. *Entrepreneurship Theory and Practice*, 28(6), 533-552.
- Gee, J. (2008). Learning and Games. In K. Salen (Ed.), *The Ecology of Games: Connecting Youth, Games, and Learning*, 21-40. Cambridge, MA: MIT Press.
- Gurzick, D., White, K. F., Lutters, W. G., Landry, B. M., Dombrowski, C., & Kim, J. Y. (2011). Designing the future of collaborative workplace systems: lessons learned from a comparison with alternate reality games. In *Proc. iConference 2011*, 174-180.
- Hawkins, J., & Pea, R. D. (1987). Tools for bridging the cultures of everyday and scientific thinking. *Journal of Research in Science Teaching*, 24(4), 291-307.
- Hoadley, C. P. (2002). Creating context: design-based research in creating and understanding CSCL. In *Proc. CSCL 2002*, 453-462.
- Jenkins, H., Clinton, K., Purushotma, R., Robinson, A. J., & Weigel, M. (2006). *Confronting the Challenges of Participatory Culture: Media Education for the 21st Century*. Chicago, IL: MacArthur Foundation.
- Johnson, D., Johnson, R. T., & Holubec, E. J. (1994). *The New Circles of Learning: Cooperation in the Classroom and School*. Alexandria, VA: Association for Supervision and Curriculum Development.
- Johnson, D. W., & Johnson, R. T. (2009). An Educational Psychology Success Story: Social Interdependence Theory and Cooperative Learning. *Educational Researcher*, 38, 365-379.
- Johnson, M., Buhler, A. G., & Hillman, C. (2010). The Library is Undead: Information Seeking During the Zombie Apocalypse. *Journal of Library Innovation*, 1(2), 29-43.
- Kim, J. Y., Allen, J. P., & Lee, E. (2008). Alternate reality gaming. *Commun. ACM*, 51(2), 36-42.
- Klopfer, E., Perry, J., Squire, K., & Jan, M-F. (2005). Collaborative learning through augmented reality role playing. In *Proc. CSCL 2005*, 311-315.
- Lesh, B. (2011). "Why won't you just tell us the answer?" Teaching historical thinking in grades 7-12. Portland, ME: Stenhouse Publishers.
- McGonigal, J. (2008). Why I Love Bees: A Case Study in Collective Intelligence Gaming. In K. Salen (Ed.), *The Ecology of Games: Connecting Youth, Games, and Learning*, 199-227. Cambridge, MA: MIT.
- Niemeyer, G., Garcia, A., & Naima, R. (2009). Black cloud: patterns towards da future. In *Proc. Multimedia (MM 2009)*, 1073-1082.
- Owens, T. (2010). Modding the History of Science: Values at Play in Modder Discussions of Sid Meier's CIVILIZATION. *Simulation & Gaming*, 42, 481-495.
- Robertson, C. (2006). *Temple of invention: history of a national landmark*. London: Smithsonian American Art Museum National Portrait Gallery in association with Scala Publishers.
- Shaffer, D. W., Squire, K. R., Halverson, R., & Gee, J. P. (2005). Video Games and the Future of Learning. *The Phi Delta Kappan*, 87(2), 104-111.
- Slavin, R. E. (1991). Synthesis of Research of Cooperative Learning. *Educational Leadership*, 48(5), 71-82.
- Squire, K. (2006). From Content to Context: Videogames as Designed Experience. *Educational Researcher*, 35(8), 19-29.
- Steinkuehler, C., & Duncan, S. (2008). Scientific Habits of Mind in Virtual Worlds. *Journal of Science Education and Technology*, 17, 530-543.
- Whitton, N. (2008). Alternate reality games for developing student autonomy and peer learning. In *Proc. Learners in the Co-creation of Knowledge (LICK) 2008*, 32-40.
- Yin, R. K. (2003). Designing Case Studies. *Case Study Research: Design and Methods* (3rd ed., pp. 19-56). Thousand Oaks, CA: Sage Publications.

Acknowledgments

We thank the students, teachers, and librarians who participated in, and provided feedback on the first season of the Arcane Gallery of Gadgets (*AGOG*). We also thank the National Science Foundation (NSF IIS-0952567).