The Bone Wars: Design and Development, Social Media and Community

Paul Gestwicki and Charlie Ecenbarger
Ball State University

Abstract

The Bone Wars is an original educational video game about the historic 19th-century feud between rival paleontologists, Othniel C. Marsh and Edward D. Cope. This two-player game explores their race to claim dig sites and discover new species, but its only by publishing their results that the players earn the fame that delivers victory. Just as their historic characters did, a successful player will end the game with little money, few friends, many publications, and crates of unanalyzed fossils. The game was designed and developed in a student-centered, faculty-mentored studio experience by a team of ten undergraduates and one graduate student. The team followed established practices of game design and agile software development, making effective use of a dedicated lab environment. The incremental and iterative development process was publicly shared on the team's blog and on Twitter, and we describe the impact that this had on the team and on the community of potential players.

Keywords: Game design, serious games, educational games, Othniel Charles Marsh, Edward Drinker Cope, The Bone Wars, paleontology, immersive learning, studio

Introduction

The Bone Wars is an original educational video game based on the 19th-century feud between rival paleontologists Othniel Charles Marsh and Edward Drinker Cope. It is a two-player turn-based strategy game set in the Gilded Age of American History, and the players compete to earn the most fame in eight rounds of play. The game was designed for upper-elementary or middle school students, although adult playtesters and some in lower-elementary grades enjoyed it as well.

Much has been written about the history of these two scientists, and we recommend Wallace (1999) and Davis (2011) to the interested reader. For the purpose of

this paper, it is sufficient to know that Marsh and Cope made an important impact on the history of American science. With the discovery of fossils in the American West, the two men described over one hundred new species of dinosaurs. Their work brought paleontology into the public eye, in part because of interest in the dinosaurs themselves and in part because of their willingness to engage in underhanded methods to compete with each other. They were prolific, and Cope alone had over 1400 publications—publications that were often riddled with errors. Both men exhausted their wealth, devastated relationships, and damaged their own health in their single-minded fossil obsession.

The game was designed to introduce the player to Marsh and Cope and their paleontological processes. The design team chose to emphasize the systematic nature of paleontology, yet to also permit the kind of risky, unorthodox behavior that made Marsh and Cope noteworthy. Just as the historical Marsh and Cope competed for scientific recognition and public acclaim, victory in the game is earned by accumulating Fame points. Furthermore, the systems of the game encourage the player to focus on Fame exclusively, expending all other resources in the quest for more and better fossils.

The Bone Wars was designed and developed by a team of ten undergraduate students, one graduate student, and a faculty mentor in cooperation with The Children's Museum of Indianapolis. The team engaged the wider community of paleontologists, educators, and game designers through blogging, Twitter, game conventions, and other public events. These interactions promoted the team's work and were crucial to the team's identity formation.

This paper describes the design, development, and dissemination of *The Bone Wars*. We begin with a description of the team demographics and the design history of the game. We then discuss how the team used social media and the impact this had on the team. This is followed by a broader discussion of the project's results, and we conclude with preliminary research notes from a formal qualitative study of the team itself. The complete rules of *The Bone Wars* are presented in Appendix A.

Design and Development

Team and Environment

The project was conducted at Ball State University in Muncie, Indiana. The team consisted of ten undergraduate students, one graduate student, and a faculty mentor. This team worked together for the fifteen weeks of the Spring 2014 semester in a studio environment, and so we refer to them as "the Spring Studio." The undergraduates earned six credit-hours for their participation, and the graduate student, three. Accordingly, the undergraduates were expected to devote 18 hours of attention per week to the project, and the graduate student, twelve, following the standard ratio of credit hours to work hours. The team met in an undergraduate research lab space, to which they had almost exclusive access. This space included three large

whiteboards, one movable whiteboard, and several tables with wheeled task chairs; the team reconfigured the room several times during the semester to suit their needs. Formal team meetings were held three hours per week, in the mornings on Mondays, Wednesdays, and Fridays, and the remainder of each team member's time was up to him or her to manage. Within a few weeks, the team had settled into ad hoc schedules for collocated work.

Seven of the undergraduates were Computer Science majors, including sophomores, juniors, and seniors. Two undergraduates were Animation majors, both sophomores within their program—that is, they had completed a significant amount of traditional fine arts coursework but had not taken many animation-specific courses. One freshman was recruited as a Music Media Production major, and although a talented musician, changed his major to Philosophy and Religious Studies just before the start of the Spring semester. The graduate student was in a masters program in Digital Storytelling and had a background in Communication Studies. The team was predominantly male, with only one computer scientist and one animator being female. All the students were U.S. citizens except for one Computer Science major who was an international scholar from China. The team was mentored by an Associate Professor of Computer Science with a background in games and education; the community partners included an exhibit developer and the director of interactive technology.

The members of the Spring Studio team were recruited in Fall 2013 to create an original, educational video game in collaboration with The Children's Museum of Indianapolis. The theme of the game was not yet determined at the time of recruitment, and hence, it was neither interest in history nor paleontology that encouraged students to apply to the Spring Studio. The students' application essays reveal broader interests in games, design, teamwork, and museums. Some team members had previously worked with the faculty mentor on game development projects, or were friends of such students, and they recognized this unique form of university coursework as being interesting, engaging, and rewarding—explicitly when compared to lecture-based courses.

Methodology in software development generally refers to the formal and informal practices, values, and principles that describe how a team operates (Cockburn, 2006). The mentor provided a "starter methodology" based on past project experience as well as the seven properties of successful projects articulated by Cockburn (2004): frequent delivery, reflective improvement, osmotic communication, personal safety, focus, easy access to expert users, and a technical environment with automated tests, configuration management, and frequent integration. Design and development efforts proceeded following *Scrum*, a project management framework for incremental and iterative development (Schwaber & Sutherland, 2013), and source code was held to the standards of *Clean Code* (Martin, 2008).

Table 1 summarizes how the aforementioned seven properties were enacted through the team's methodology; many of these come directly from Scrum (Schwaber

Property	**Practice**
Frequent delivery	Three-week sprints
Reflective improvement	Sprint retrospective meeting; reflective essays
Osmotic communication	Collocated studio work; task board; burndown chart
Personal safety	Conflict resolution protocol in methodology document
Focus	Studio conversations kept on-task
Easy access to expert users	Playtesting partners, museum partnership
Technical environment	Tools included JUnit, Apache Maven, Mercurial, and Jenkins

Table 1
Summary of how the seven properties of successful projects were enacted through team practice

& Sutherland, 2013) and its conventional implementation in game development, including a physical task board, art production swimlane, and sprint burn-down chart (Keith, 2010). The team used three-week sprints, and the faculty mentor acted as Scrum Master. Each sprint began with a sprint planning meeting, using user stories (Cohn, 2004) that were negotiated between the faculty mentor and team members interested in game design. Stand-up meetings were held on the Monday, Wednesday, and Friday mornings during the sprint, and during these meetings, students reported on what they had accomplished, what they had planned for next time, and any impediments to these plans. Each three-week sprint ended with a sprint review, during which the team reviewed all artifacts created during the sprint, followed by a sprint retrospective. The retrospective meeting served to promote metacognition and learning as the team improved its practices and reflectively modified its methodology—a deliberate implementation of reflective practice (Schon, 1984). This meeting followed a format recommended by Kua (2012), in which the team members addressed four questions: (a) What did we do well, that if we do not write down, we might forget? (b) What did we learn? (c) What should we do differently? (d) What still puzzles us? Following Kua (2012), the faculty mentor wrote a formal report summarizing each retrospective meeting. Additionally, after the retrospective meeting, each student participate individually wrote a reflective essay that related their three-week experience to one of the following essential questions (McTighe & Wiggins, 2013) of the course: (a) What is the relationship between games, fun, and learning? (b) How do multidisciplinary teams coordinate activity to create original software products? (c) What is the relationship between playing a serious game and a player's sense of identity? (d) What is the relationship between serious game development, individuals' sense of identity, and the team's identity?

Each three-week iteration was designed to produce a potentially shippable product—a playable prototype that embodies all the features and values of the sprint, whose testing results can be fed back into the iterative design process (Cockburn,

2006). Early iterations emphasized exploration of core mechanics and aesthetics, while later iterations were more heavily invested in production tasks. During this time, the team became aware of the card game *BONE WARS* (Cambias & Kelly, 2005), which explores the same historic themes as this work; a few members of the team played this game, but it was after their own core gameplay had been designed, and it appears to have had little or no impact on the digital game.

It is important to note that none of the Spring Studio students had previous formal game design experience such as a game design course or curriculum. The studio environment was modeled as a community of practice (Wenger, 2000) centered around the faculty mentor. That is, the mentor was actively involved in design decisions, programming, and asset production. Less experienced students early interactions were those of legitimate peripheral participation (Lave & Wenger, 1991), but as they developed more expertise, more freedom, control, and agency was offered to the students. The mentor provided social modeling of expert behavior and, when necessary, direct instruction—two methods that are known to have demonstrably higher effect sizes than if the students had been left to their own devices (Alfieri et al., 2011; Hattie & Yates, 2014).

Game Design History

In Summer 2013, a set of potential game themes was negotiated between the project mentor and The Children's Museum of Indianapolis. The exploration of potential themes was integrated into a colloquium on serious game design taught by the project mentor in Fall 2013. Eleven students from a variety of majors participated in this colloquium, which culminated in their creating prototypical serious games. One of these was a two-player card game themed around Marsh and Cope called *Bone Wars* (Jones, 2013), the game being based primarily on the Yale Peabody Museum of Natural History's online biography of Marsh (*Othniel Charles Marsh*, 2014) and the Osborn (1930) biography of Cope. In this game, players competed for victory points by excavating prestigious fossils using worker-placement mechanics—elements that are also present in the final, digital game (see Appendix A). The board game also encouraged players to sabotage each others' sites and have their laborers fight each other. The prototype itself was never played by the Spring Studio team, although it was discussed with them.

The Spring Studio team adopted several critical design constraints early in their work. The team agreed to pursue a competitive two-player game in which one player was Marsh and the other, Cope. To simplify the deployment of the game and contain technical complexity, both players would compete on the same physical device in "hot-seat" gameplay. Having both players at one device led to the further design constraint that there would be no hidden information between players: to have hidden information would require awkward device-passing or turning away from the game, but by eliding hidden information, both players can be continuously engaged in the game. Finally, the team agreed to focus on game mechanics that emphasized

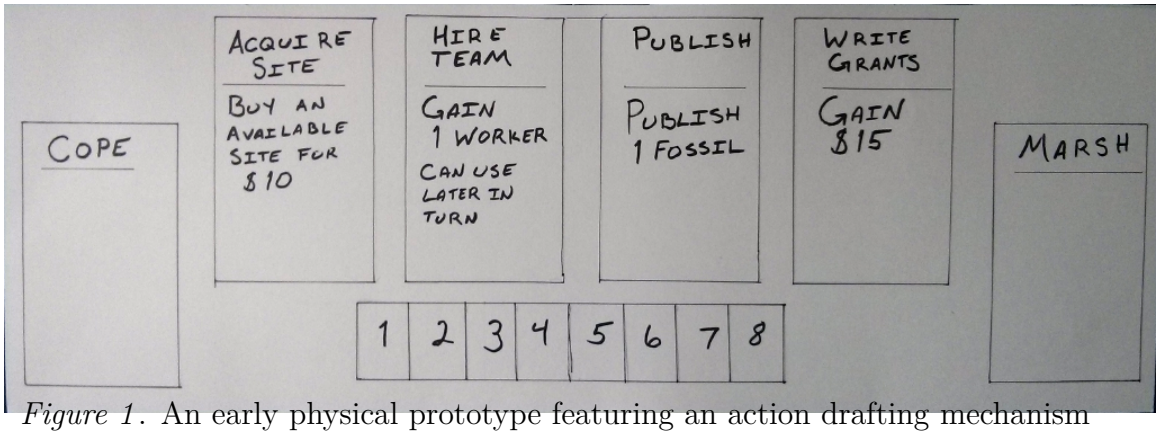

Figure 1. An early physical prototype featuring an action drafting mechanism

Marsh's and Cope's paleontological processes rather than, for example, political or media-focused machinations. The scientific processes represent clearly quantifiable systems such as site boundaries, number of fossils discovered, species naming, and scholarly publications, and hence they were conducive to representation in the formal systems of a game. This is an example of what Klopfer et al. (2009) call "finding the game in the content." These are certainly not the *only* design constraints that emerge from the story of Marsh and Cope, but they are authentic ones.

These constraints contributed to the development of a user-interface with a strong left-right orientation, with the left side being Marsh's and the right, Cope's. This orientation can be seen in the earliest physical prototypes (Figures 1 and 2) and carries through the digital prototypes to the final game (Figures 3, 4, and 5). Playtesting results later confirmed the anticipated player behavior that two players, upon receiving a tablet on which the game was running, would intuitively adopt the convention that the left player controlled Marsh and the right controlled Cope. Player identification with user-interface elements was further enhanced through color coding, Marsh being red-brown and Cope being light blue.

Given the constraint against player hidden information, the most viable prototypes centered around action drafting. This approach, known as "worker placement" among board game enthusiasts, can be found in many popular board games such as *Agricola* (Rosenberg, 2007) and *Caylus* (Attia, 2005); players take turns choosing an action from among those available until all actions or workers are exhausted. During the first two sprints, the team developed prototypes in which there were a fixed set of actions, and each player could choose one primary and one secondary action each round of play (Figure 1). These actions included writing grants, acquiring sites, prospecting for fossils, excavating sites, analyzing fossils, and publishing results, as well as a destiny action that revealed a random "story card" which could help or harm the player. Taking an action as primary conferred a benefit, and both players could not take the same primary actions. A player could earn fame by collecting several fossils of one type and then publishing the results, with more fame being earned for

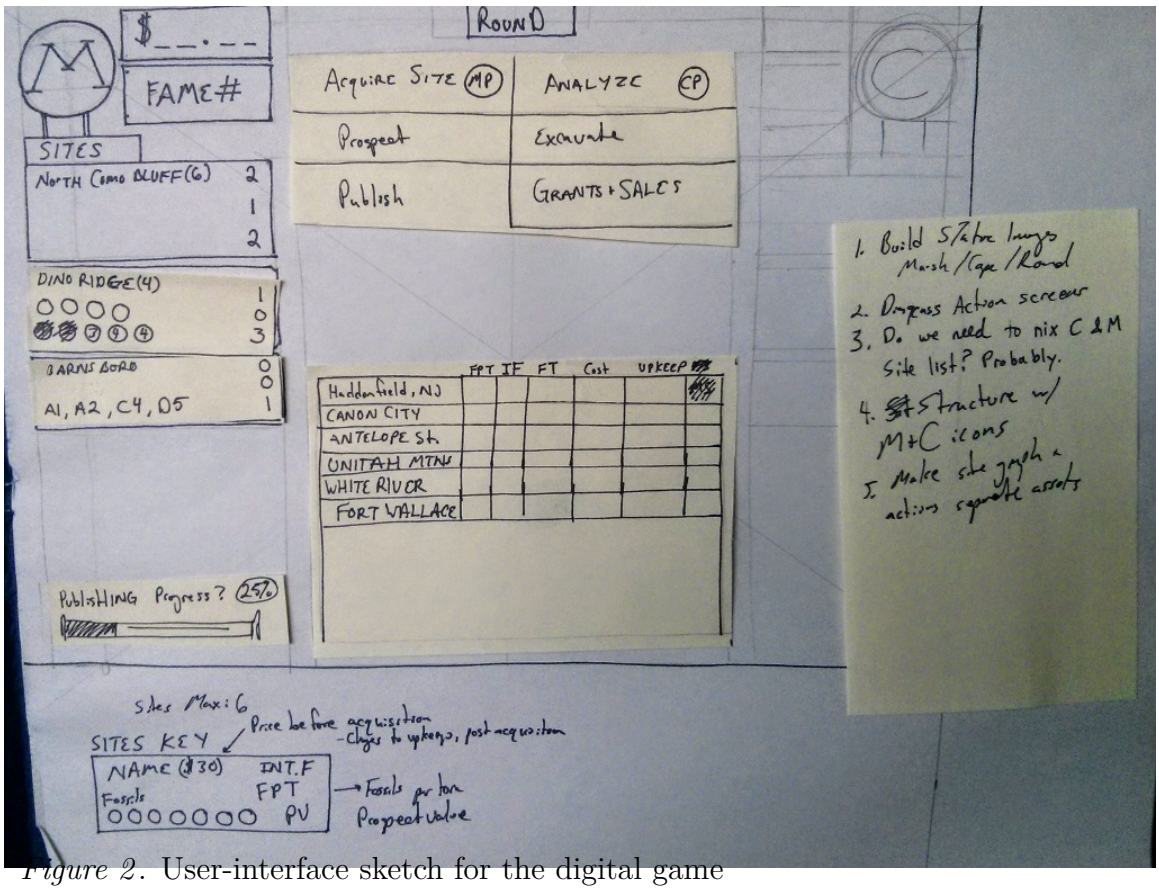

Figure 2. User-interface sketch for the digital game

having more evidence and higher quality fossils.

Playtesting revealed several problems with this design. The most significant problem was that the game was slow without being strategically deep: it was tedious to collect ample evidence to earn significant fame. Perhaps this tedium matches the work of graduate students in paleontology, but it did not make for engaging gameplay. Playtesting showed that this problem was most pronounced among players with low academic achievement, who would quickly become distracted by the game components. Another problem with this design was that it did not represent an important historical fact that Marsh and Cope did not personally perform every step of the process: they delegated responsibilities in order to meet their goals.

A revision to the core gameplay took place at the end of Sprint 2, keeping action drafting but removing action exclusivity. In the revised game, the player had direct control of a Marsh or Cope avatar as well as two hired workers, with the option to hire more. Some actions could only be taken by the Marsh or Cope workers, representing the special privilege of these men: hiring more workers, acquiring new sites, publishing results, and raising funds. The other two actions—excavating fossils and analyzing them—could be taken by any worker, including Marsh or Cope. Prospect-

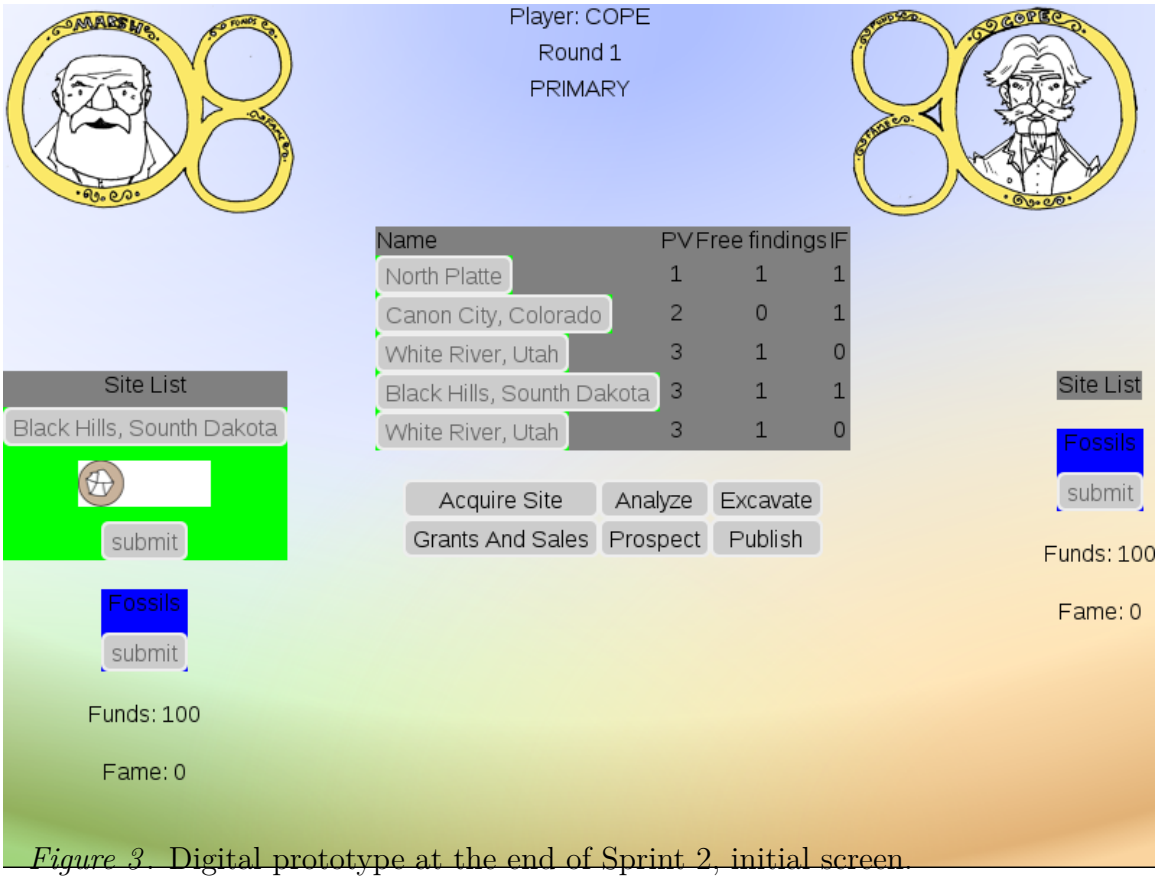

Figure 3. Digital prototype at the end of Sprint 2, initial screen.

ing was removed entirely as it did not represent an interesting choice or meaningful decision (Burgun, 2012; Rollings & Morris, 2000). The fact that players can know the type of a fossil (stegosaurus, pterenadon, etc.) is an idealized view of paleteontology, but this concession was made in order to improve gameplay.

The revised game mechanics represent a simplified but authentic view of paleontology, and with some minor modifications, these became the rules of the final digital game (Appendix A). The game demonstrates that paleontology is not simply a matter of digging up dinosaurs, but that this excavation is part of a larger scientific process. A player excavates fossils from a site and can infer what kind of dinosaur is found from these; however, the quality of the fossils is not known until laboratory analysis is complete. Once a player knows the quality of the find, he or she may publish to earn fame. However, the game also allows players to take the more unorthodox approach of publishing prior to rigorous analysis. This comes with significant risk, since fame penalties are enacted for publishing fossils whose quality is less than what has already been published. This element was added to the game based on two historic phenomena: Marsh and Cope would regularly publish "new discoveries" of species the other had already named, and they would verbally attack

Figure 4. Digital prototype at the end of the Spring semester (end of Sprint 4), initial screen

each other for perceived errors in publications. Perhaps the most well-known example of this was an early publication of Cope's in which he placed the head of a plesiosaur on the wrong end—a story that inspired the logo for the team's blog (Figure 6).

The original prototype's destiny action, which revealed random story events, was replaced by a system whereby random events happened between rounds. The possible events include: (a) a new site becomes available for acquisition; (b) a fossil hunter offers to sell a fossil to the highest bidder; (c) a *story event* occurs. The story events take historic occurrences and put them into the game context. At the time of this writing, only three events are included in the game, although the software infrastructure is in place to facilitate the addition of more (see Appendix A).

The visual aesthetics of the game are meant to evoke Art Nouveau as well as the grit of the dig site. The imagery used in Davis (2011) was particularly inspirational to the artists. The original soundtrack was inspired by period instrumentation and musical structures.

Figure 5. Final game, initial screen

Figure 6. Banner for the project blog

Community

In order to raise awareness of the project, the team employed the use of Twitter and Blogger to disseminate information to the public. The team's Twitter handle (`@bonewarsproject`) was used to engage users of similar interests to *The Bone Wars* and game development. This was achieved by posting relevant information to appropriate hashtags such as: `#gamedesign`, `#videogames` or `#gamedev`, and then engaging others who are participating in those same hashtags. The content of our tweets was varied and based upon our interests and the interests of the wider community with which we were engaging. The content included links to our blog posts, photos from the studio, play testing sessions, conferences attendance, game artwork, and the sharing of game design related resources. Furthermore, Twitter provides quick and direct access to a wide range of people who are able to find conversations and content through hashtags. Our most common hashtags were `#gamedev` and `#videogames`. At any given point throughout the day Twitter users can be found participating in conversations about game design and video games while using either of those hashtags. From the creation of the Twitter account on January 27 to the final Tweet of the semester on April 29, we had obtained 369 followers while following 358. Original artwork and links to game design resources were our most popular tweets. Twitter was monitored and active seven days a week.

Blogger was used to host the team's Website[1] and carried the bulk of our information which we would share through Twitter. The blog contained several static Webpages, including team member information, ways to contact us, and a mission statement. The blog was updated on a semi-regular basis with Monday, Wednesday, and Friday being target days for updates, though there would frequently be posts on Tuesday and Thursdays provided there was information to share. The content of the blog acted, chiefly, as a game development log. Theoretical essays on game design, reflections on the studio environment, concept artwork, UI progression, and so forth were the primary source of content. Other content was pulled from our Twitter interactions and posted in a comprehensive fashion dubbed "Twitter Round-Up" which aggregated game design resources, blog posts from other developers, or miscellaneous links found on Twitter into one entry. A historical podcast written and produced by one team member and narrated by student at the university was released during the last seven weeks of the project. The podcast focused on the history and relationship between Othniel Marsh and Edward Cope. The first blog post was on February 2, and the last post—the fiftieth—was on April 29. As of writing the blog has generated 1,862 views, the majority coming from the United States, France, Germany, and Canada. Redirects from Twitter accounted for the majority of views, while RSS feeds, Facebook, and Google searches accounted for a smaller amount.

[1] `http://bonewarsproject.blogspot.com`

Social Media Theory

In this day in age it would be unheard of for a video game to be released without a web presence, particularly on social media websites. In 2012, 83% of adults 18–29 years old, and 77% of adults 30–49 were participating on social media websites (Pew Research Center, 2013). According to research by the Electronic Software Association, this is very much the same demographic of video game players (Entertainment Software Association, 2014). Not only do social media websites and the game industry share crossover in their demographics, Harris Interactive (2009) released a report stating that gamers are "technology savvy" and "use [the Internet] heavily." There is little doubt that video game players are active on social media websites, thus the question becomes *how* are video game players using social media rather than *if* they are using social media.

We started by looking toward the game development industry, specifically independent game studios, to see how the studios and their fans were using social media. There is a reoccurring use of blogs employed as the main website for the studio; for examples, see `supermeatboy.com`, `2dboy.com`, and `thechineseroom.co.uk`. The studios use the blogs to release updates about their game, pictures of concept or development art, or just posting pictures of their everyday lives. A usual entry on their blog consists of anywhere from 100–1,000 words and are speaking directly to their audience; that is to say, they are engaging a preexisting audience rather than attempting to grow an audience. The frequency of entries is sporadic, sometimes months passing without an update. The use of Twitter, however, is a more constant stream of connectivity between developers and gamers. Members of the development team have their own Twitter accounts as well as a project specific account that releases information on a more regular basis. Furthermore, Twitter is used to engage directly with their audience—answering questions, engaging in conversations taking place on certain hashtags, or even the act of sharing links that a team member found interesting yet has no connection to their project.

These observations illuminated two themes: sharing and participation. Studios were sharing items which elicited participation from their audience, or they were participating with others' shared objects. Commonly these items are marked by hashtags, a means of classifying information so it may be found easily. Users can search hashtags that are of interest to them and begin associating with other users whose content they find interesting. This type of interaction is indicative of object-oriented sociality. This concept maintains that the objects being shared are the catalyst for people meet and associate with others online (Cetina, 2005; Engeström, 2005; Kietzmann et al., 2011). In terms of Twitter and blogs, these associations are often based on information exchange rather than personal relationships (Huberman et al., 2009). This is exemplified by the type of information being exchanged by the game studios and their audience. Information dissemination (game artwork, progress updates, blog entries, cat videos) are the center of the engagements, not social exchanges meant to build personal relationships. This does not mean to suggest that divergent personal

interactions do not take place, but is an aberrant use of the platform. Therefore, we derived that users of these platforms are more content oriented rather than relationship oriented.

Understanding our chosen platforms as content exchange mediums engendered a social media strategy that was accepted by the audience we attempted to reach. Our goal was not only to share content related to our project but contingent content that our potential audience would find valuable.

Discussion

The Game

The game balance encourages the player to exhaust all of his or her funds to acquire fossils: in a competitive game, players will end with very little money and many unanalyzed, unpublished fossils. We consider this a design success since it matches the dynamic of both Marsh's and Cope's lives.

We observed an unexpected phenomenon when testing the physical prototype. All the physical prototypes used actual currency—coins—to represent the funds that Marsh and Cope had available. The decision to use coins was made due to familiarity with the demoninations: any player savvy with American currency should be able to quickly manipulate or reason with these. Even though each player was given only one dollar's worth of coins, all the elemenatary school playtesters from low socio-economic backgrounds were distracted by the coins. Indeed, one even stole a few quarters during the session—an act that was observed and not reported, in order to see what the child would do. This anecdote points to two suggestions for future efforts. First, using artificial currency would circumvent this problem while potentially including more historical theme. Second, the cultural gulf between our design team and these playtesters was much deeper than expected, suggesting that more time must be spent building empathy for a wider variety of player. Implications toward income inequality within the United States are beyond the scope of this work.

The art team decided to use historic rather than modern depictions of the various fossils (Figure 7). For example, the *Tyrannosaurus* is shown erect, with its tail on the ground, rather than in the modern, bird-like posture, and the sauropod is a depiction of the *Brontosaurus*, which was "discovered" by Marsh but later determined to be a juvenile *Apatosaurus* (Gould, 1991). No playtesters commented on this decision, although several were self-proclaimed dinosaur enthusiasts. The extent to which these depictions contributed to the historical visual theme—together with the palette and screen decorations—is an area for future work.

Figure 7 also demonstrates the inclusion of non-dinosaur fossils, specifically the *Eohippus*. One of Marsh's major scientific contributions was an evolutionary path from the *Eohippus* to the modern horse—an illustration of evolution lauded by none other than Charles Darwin (Davis, 2011). The design team hesitated to include a non-dinosaur fossil, concerned that players hoping to find dinosaurs would be upset at the

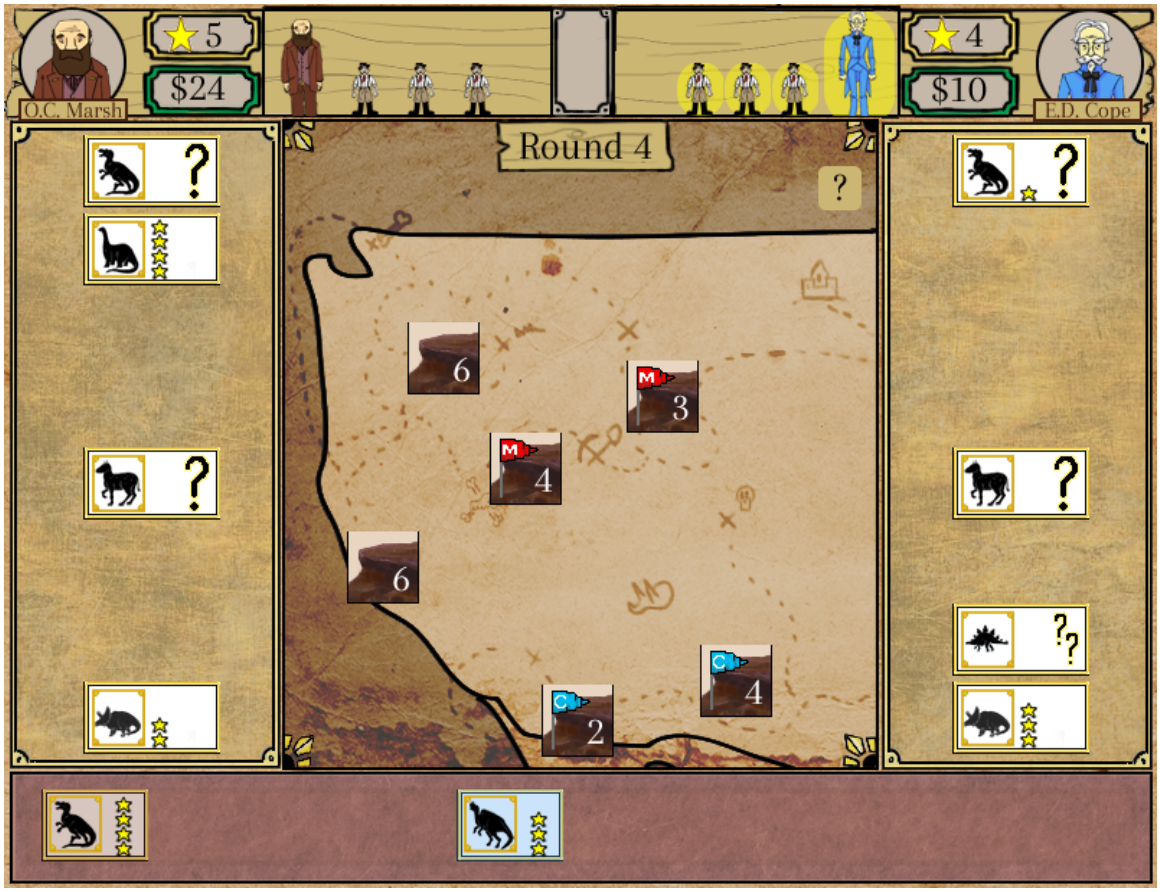

Figure 7. A sample game after three rounds of play.

discovery of a mammal. However, no playtesters ever commented on this without being asked explicitly. This suggests that either they did not care or they did not notice, neither of which encourages critical thinking. In an educational environment, curriculum surrounding *The Bone Wars* would need to scaffold players' experience here, potentially using post-play debriefing (Nicholson, n.d.; Quinsland & Van Ginkel, 1984).

In *The Bone Wars*, a site always has three types of fossils, randomly chosen but with fixed distribution, and the fossil quality is rigidly quantified on a four-point scale. The distribution and quality of fossils in reality is, of course, not so deterministic. This is an example of the reductionist nature of games, the abstraction of nature into discrete and internalizable pieces (Koster, 2004). We consider this an example of thinking with metaphor (Lakoff & Johnson, 1980), where the pieces of the game are representative of the concepts of paleontology. Playtesting did not reveal any indication that players assumed our game sites were directly analogous to historic dig sites, neither in terms of content nor location. Future formal evaluation could explore this relationship in more detail.

Having nigh-exclusive access to an undergraduate research lab was critical to the

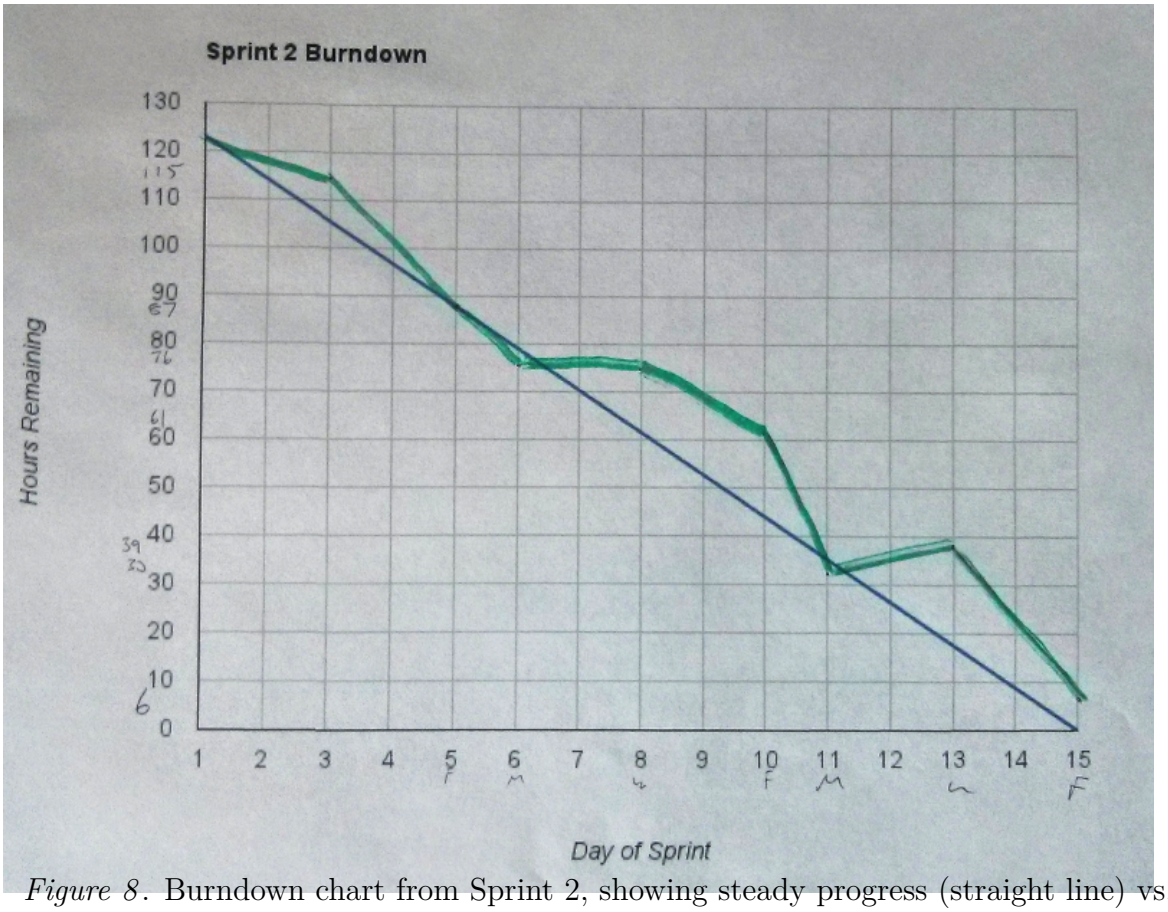

Figure 8. Burndown chart from Sprint 2, showing steady progress (straight line) vs. actual daily progress (hand-drawn line).

team's success. The lab featured four large whiteboards. One of these was reserved for a task board and Sprint Backlog (Schwaber & Sutherland, 2013). Tasks were identified on sticky notes which were physically moved across columns in one of two swimlanes: one for technical work, one for art production. The physical task board promoted the principle of osmotic communication (Cockburn, 2004) mentioned earlier, as anyone working within the lab could intuit progress by the physical arrangement of task notes. A burndown chart—tracking estimated hours of work remaining in the sprint—further contributed to this osmotic communication (Figure 8). This stands in contrast to digital project management tools, which lack the capacity for osmotic communication, which stands at the heart of situated learning theory (Lave & Wenger, 1991).

However, despite appropriately deploying these industry-standard tools, the team was not successful in completing any sprint as planned: that is, there as no sprint during which all commitments were met, all tasks were complete, and a potentially shippable product was produced. It was not until the final sprint of the semester that the team produced a game that was playable, but it was still unpolished, lacking the feedback necessary for the game to be learnable by new players. The final product

(Figure 5) is the result of a few students and the faculty mentor spending approximately three additional working days after the semester's end. The retrospective notes indicate that the team was aware of this problem and, generally, the actions necessary to address them. This phenomenon is currently among those being studied as part of a qualitative evaluation of this immersive learning environment. This study takes an ethnographic perspective, employing techniques from the Writing, Activity Theory, and Genre Research (WAGR) tradition (Russell, 1997; Spinuzzi, 2003)—an approach that specifically looks at the roles of artifacts such as the aforementioned burndown charts and task board.

The Community

The objective of The Bone Wars social media campaign was to reach as wide of an audience as possible by providing relevant and interesting content through a blog and Twitter; the blog hosted our content, while Twitter interacted with and redirected users back to the blog. During the early stages of the campaign, there was a disconnect between the content provided and the audience we were providing the content to. Many of our early blog posts were centered on game design and our process as it was happening. Meanwhile on Twitter, we were interacting with and engaging not only in game design centered hashtags, but also paleontologists and paleontology centered hashtags. Based on the infrequency of interaction with the paleontology focused users, we were able to infer that they were either not interested or not as active on Twitter as the users interested in gaming. Thus, our focus shifted to integrating ourselves into game development specific conversations and hashtags. This shift allowed for a more authentic approach to our social media identity, that is to say, we were game developers, not fossil hunters.

One common understanding of identity is that it manifests itself in two ways: identity and role. In short, this theory suggests that identity is an internal understanding of self, while role is the projection of that identity in the context of social structures (Stryker & Burke, 2000). This becomes quite intricate when thinking in terms of the role of social media. The role of each team member directly influenced the identity of the team, which in turn affected the role of social media: that is, the team affected and was affected by social media. On Twitter, where the majority of our audience derived from, our identity was projected as a collective unit and not as one individual. Our Twitter username reflected a project and tweets were not followed by a signature or any indication of which team member was sending them. This was an attempt to create an online identity that accurately reflected the team dynamic in and out of the studio setting. The identity that was projected through Twitter and our blog was one that was serious about game development, but also jovial and lighthearted in our approach. We were creating a game for younger children while reaching out to a more mature audience for exposure. Therefore, focusing on the technical and aesthetics (reflections from programmers, game artwork and music) of our process while interjecting entertaining quips (amusing links, satirical artwork,

The Bone Wars podcast) became the standard message we would send.

While our team identity influenced how we would convey ourselves on social media, we also adapted to the way other users shared information. Aside from revealing information about the projects being worked on there would also be conversations about the difficulties of game development, interesting links being passed around, or general comments on the day-to-day affairs of the users. By interacting (commenting, retweeting, or "favoriting" tweets) and sharing our own information, `@bonewarsproject` was able to associate with a community of fellow game designers and gamers on Twitter. Many of these practices fall in line with widely accepted "best practices" of Twitter (Twitter, n.d.). By participating in a community, offering relevant and interesting information to those involved in the community, we were able to drive traffic to The Bone Wars blog and increase awareness of our project.

These social media interactions had little effect on the outcome of the game; much of the feedback received was positive or supportive and offered little by way of criticism. The team identity was reinforced by the positive engagements online. It is important to note that most, if not all, of the blog entries and tweets were of a positive nature and did not reflect any of the hardships or missteps that the team endured. By failing to reveal missed deadlines, technical hiccups, or rejected artwork our online identity projected an idealized view of our game. Although our campaign reached its objective by raising awareness, we may have missed the opportunity for valuable feedback and insight from other developers regarding the game development process.

Conclusions and Future Work

We have described an approach for creating educational games by using a multidisciplinary, primarily-undergraduate studio, in which students earned credit for creating a game with a community partner. Although the team was primarily comprised of amateurs and game enthusiasts, they were able—with significant mentorship—produce an original educational game, *The Bone Wars*. The team required some pedagogic scaffolding, due primarily to their inexperience, and much of this was provided by industry-standard techniques of rapid prototyping and agile software development. This method of creating educational games within a university setting is a subject of continued active research and merits further attention and reporting of experience.

The Bone Wars features rules and aesthetics inspired by an important part of scientific history: the feud between Othniel Marsh and Edward Cope during the dawn of modern paleontology. The formal systems were developed over multiple physical and digital iterations and are inspired by both the scientific process and the historic rivalry. The aesthetics draw the player into the late 19th century, using period artistic themes in both the decorative and gameplay elements. The game therefore presents a good example of finding the game in the content (Klopfer et al., 2009). Not all of the metaphors of the game have one-to-one correspondence to history or systems, but this

may be inevitable due to the abstract and reductionist nature of games (Crawford, 1984; Koster, 2004).

The team affected and was affected by social media. Twitter, a development blog, and public events provided opportunities for the team to represent themselves to the outside world; the identity protrayed by the team was authentic although incomplete, and this portrayal became actualized within the team. Reaching out to the wider community allowed the team to get feedback on several aspects of the game's development; however, as only successes were shared, only positive feedback was received, which was not necessarily helpful in times of private team conflict. The relationship between the team's openness on social media and unresolved team conflict is subtle: one inference is that the perceived candidness of our social media may illuminate incongruity within the team, thus instead of addressing problematic situations they were not given proper attention in order to, metaphorically, sweep them under the rug. Future work may include more candid representations of team struggles in order to contrast against this experience. Regardless, we found that the amount of external attention and the contribution to team identity formation made the social media efforts worthwhile.

Acknowledgments

The authors gratefully acknowledge the contributions of the 2014 Spring Studio team and the Children's Museum of Indianapolis to the project. This project was supported by the Department of Computer Science and the Office of the Provost at Ball State University.

Appendix A: Game Rules

This appendix contains the rules for *The Bone Wars*. Metaphors from physical games are employed for clarity, rather than programming implementation details; for example, we use "shuffle a deck" rather than "randomize the order of elements in a linked list."

Components

- Eight sets of fossil cards—allosaurus, apatosaurus, ceratasaurus, hadrosaurus, eohippus, pterodactyl, stegosaurus, and triceratops—each of which has one four-star fossil, one three-star fossil, two two-star fossils, and four one-star fossils. The number of stars is the *quality* of the fossil.
- Three destiny cards:
  - Story Destiny: Reveal one story card
  - Fossil Hunter Destiny: Auction a new three- or four-star fossil of a random type.
  - New Site Destiny: Add a new site
- Three story cards:
  - Marsh chased by Sioux; he loses $10.
  - Cope invests in a failed silver mine; he loses $10.
  - Marsh and Cope raise public interest in paleontology, both gain $4.
- Eight sites
- Marsh worker, Cope worker, and hired workers
- Currency and Fame indicators

Set up

1. Populate each site with fossils by randomly choosing one fossil of one type, two of a second type, and three of a third type.
2. Bring four sites into play, shuffling their fossils and revealing the type of the top fossil.

3. Give each player the corresponding Marsh or Copeworker, $50, two hired workers, and control over one site.

Victory Conditions
The game proceeds for eight rounds, and whoever has the most Fame after eight rounds is the victor. In the case of a tie, Cope wins.

Gameplay
Players alternate actions, with Marsh going first on odd rounds and Cope on even. Actions can be taken with the Marsh/Cope worker or a hired worker, and each worker gets only one action per round. A player who has no more workers must pass, and the round is over when both players pass.

Any worker may take the following actions:

- *Excavate*: Move the top fossil from a site to the player's inventory.
- *Analyze*: Reveal the quality of a fossil in a player's inventory.

Marsh and Cope workers may additionally take the following actions:

- *Hire a Worker*: Gain a worker, who may be used this round.
- *Acquire a Site*: Pay $10 to gain control of a site.
- *Raise Funds and Write Grants*: Gain $15.
- *Publish*: Publish an analyzed or unanalyzed fossil.

An analyzed fossil can be published if there is not a published fossil of higher quality in play. The publishing player gains Fame equal to the quality of the fossil, and the first player to publish a fossil of a type gains a one Fame bonus. If the quality is higher than that of an opponent's published fossil of the same type, gain a bonus Fame and subtract one Fame (minimum of zero) from the opponent.

To attempt to publish an unanalyzed fossil, first reveal its quality. If it is equal to or greater than the quality of any published fossil of that type in play, publish it as above. If not, discard the fossil and lose one Fame (minimum of zero).

At the end of a round, each player must pay $2 for each hired worker or choose to dismiss that worker. Then, reveal and resolve one Destiny Card, shuffling the deck first if it was exhausted.

References

Alfieri, L., Brooks, P. J., Aldrich, N. J., & Tenenbaum, H. R. (2011). Does discovery-based instruction enhance learning? *Journal of Educational Psychology*, *103*(1), 1–18.

Attia, W. (2005). *Caylus.* Paris: Ystari Games. (Board game)

Burgun, K. (2012). *Game design theory: A new philosophy for understanding games.* Boca Raton, Florida: CRC Press.

Cambias, J. L., & Kelly, D. A. (2005). *BONE WARS: The game of ruthless paleontology.* North Amherst, MA: Zygote Games. (Card game)

Cetina, K. (2005). Objectual practice. In T. Schatzki, K. Cetina, & E. Savigny (Eds.), *The practice turn in contemporary theory* (pp. 184–197). London: Routledge.

Cockburn, A. (2004). *Crystal clear: A human-powered methodology for small teams.* Boston: Addison-Wesley.

Cockburn, A. (2006). *Agile software development: The cooperative game* (second ed.). Boston: Addison-Wesley.

Cohn, M. (2004). *User stories applied: For agile software development.* Boston: Addison-Wesley.

Crawford, C. (1984). *The art of computer game design.* Berkeley, CA: McGraw-Hill/Osborne.

Davis, M. (2011). *Dinosaur Wars [American Experience].* Boston: WGBH.

Engeström, J. (2005). *Why some social network services work and others don't—or: the case for object-centered sociality.* (Retrieved June 6, 2014 from `http://www.zengestrom.com/blog/2005/04/why-some-social-network-services-work-and-others-dont-or-the-case-for-object-centered-sociality.html`)

Entertainment Software Association. (2014). *Essential facts about the computer and video game industry.* Washington, D.C.: Entertainment Software Association.

Gould, S. J. (1991). *Bully for brontosaurus.* New York: W. W. Norton.

Harris Interactive. (2009). *Moments of influence.* Rochester: Harris Interactive.

Hattie, J., & Yates, G. (2014). *Visible learning and the science of how we learn.* London: Routledge.

Huberman, B., Romero, D., & Wu, F. (2009, January). *Social networks that matter: Twitter under the microscope* (Vol. 14) (No. 1-5).

Jones, E. (2013). *Bone Wars.* Unpublished. (Card game)

Keith, C. (2010). *Agile game development with scrum.* Boston: Addison-Wesley.

Kietzmann, J., Kermkens, K., McCarthy, I., & Silverstre, B. (2011). Social media? get serious! understanding the functional building blocks of social media. *Business Horizons*, *54*(3), 241–251.

Klopfer, E., Osterweil, S., & Salen, K. (2009). *Moving learning games forward: Obstacles, opportunities, & openness* (Tech. Rep.). Cambridge, MA: The Education Arcade, MIT. (Retrieved from `http://education.mit.edu/papers/MovingLearningGamesForward_EdArcade.pdf`)

Koster, R. (2004). *A theory of fun for game design.* Phoenix, Arizona: Paraglyph Press.

Kua, P. (2012). *The retrospective handbook: A guide for agile teams* (August 2012 ed.). LeanPub.

Lakoff, G., & Johnson, M. (1980). *Metaphors we live by.* Chicago, Illinois: University of Chicago Press.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation.* Cambridge: Cambridge University Press.

Martin, R. C. (2008). *Clean code: A handbook of agile software craftsmanship.* Upper Saddle River, NJ: Prentice Hall.

McTighe, J., & Wiggins, G. (2013). *Essential questions: Opening doors to student understanding.* Alexandria, Virginia: ACSD.

Nicholson, S. (n.d.). Completing the experience: Debriefing in experiential educational games. In *Proceedings of the 3rd international conference on society and information technologies* (pp. 117–121). International Institute of Informatics and Systematics.

Osborn, H. F. (1930). Edward Drinker Cope 1840–1897. *Biographical Memoirs National Academy of Sciences*, *13*(3), 125–317.

Othniel Charles Marsh. (2014). Retrieved May 26, 2014, from `http://peabody.yale.edu/collections/archives/biography/othniel-charles-marsh`. New Haven, CT: Yale Peabody Museum of Natural History.

Pew Research Center. (2013). *The demographics of social media users.* Washington, D.C.: Pew.

Quinsland, L. K., & Van Ginkel, A. (1984). How to process experience. *Journal of Experiential Education*, *7*(2), 8–13.

Rollings, A., & Morris, D. (2000). *Game architecture and design.* Scottsdale, Arizona: Coriolis.

Rosenberg, U. (2007). *Agricola.* Mahopac, NY: Z-Man Games. (Board game)

Russell, D. (1997). Rethinking genre in school and society: an activity theory analysis. *Written Communication*, *14*(4), 504–54.

Schon, D. A. (1984). *The reflective practitioner: How professionals think in action.* New York: Basic Books.

Schwaber, K., & Sutherland, J. (2013). *The scrum guide* (July 2013 ed.). Scrum.org.

Spinuzzi, C. (2003). *Tracing genres through organizations: a socio-cultural approach to information design.* Cambridge, MA: MIT Press.

Stryker, S., & Burke, P. (2000). The past, present, and future of an identity theory. *Psychology Quarterly*, *63*(4), 284–297.

Twitter. (n.d.). *Best practices.* (Retrieved from `https://business.twitter.com/best-practices`)

Wallace, D. R. (1999). *The bonehunters' revenge: dinosaurs, greed, and the greatest scientific feud of the gilded age.* Boston: Houghton Mifflin.

Wenger, E. (2000). *Communities of practice: Learning, meaning, and identity.* Cambridge: Cambridge University Press.