Well Played

a journal on video games, value and meaning

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INTRODUCTION

Informal education on academic and attitudinal content has been part and parcel of commercialized play since the modern industry emerged at the end of the 1800's. "School subject" style games were popular with game playing families, and were often pirated by rival publishers. Published in 1809, John Harris's *Geographical Recreation or A Voyage Around the Habitable Globe* was a very early example of the "school subject" game genre. In the late 1890s Parker Brothers published *The Young People's Geographical Game* and McLoughlin Brothers published *The Game of Familiar Quotations* and *The Complete Game of Authors*. These are just a few examples of games centered around the kind of facts that were taught in contemporary schools.

Games to teach attitudinal, moral, political and ethical subjects have also been with us from the beginnings of the modern industry. Milton Bradley's well-known *Checkered Game of Life* from the 1860's sent the player ahead for "industry" and "honesty" and back for "gambling" and "idleness." Elizabeth Magie's *The Landlord's Game* was devised to convince the player that property ownership was indeed theft, despite the fact that it's descendent, Monopoly, flipped that message.

As games are being re-examined as tools for teaching in the age of the computer game, it made sense for the IGDA's Learning, Education and Games SIG to collaborate with the Well Played journal to release an issue focused on education and

learning. This resulting collection shows a diversity of topics from hard science to ethics.

Two of the papers in this volume examine the intersection of games, learning and hard science. The authors of *Medulla: A 2D Sidescrolling Platformer Game That Teaches Basic Brain Structure And Function* look at a playful approach to learning with terminology and history of biology terms for psychology students. *In Play or Science? A Study Of Learning And Framing In Crowdscience*, the authors examine the learning that happens with players of crowd science games, epitomized by Foldit, and the thought, description, and framing exhibited by players as they discuss their participation.

The next two articles look at the use of games to influence more humanistic subjects. In the first, *Barriers To Learning About Mental Illness Through Empathy Games – Results Of A User Study On Perfection,* the writers find challenges not in the design or application of games to the topic, but in the study subjects' perception of games. In the second, *Zombie-Based Critical Learning – Teaching Moral Philosophy With The Walking Dead,* the author uses a commercial-off-the-shelf horror title to reach secondary school students in Norway; an audience that proves more receptive to games.

The last two papers*, Distributed Teaching and Learning Systems in Dota 2* and *An Analysis of Plague, Inc.: Evolved for Learning* examine how teaching and learning occur within the games themselves.

Thank you to everyone who submitted articles for consideration in this issue. We received many high quality submissions, and if your work didn't make it this time, please feel free to submit again for a learning games issue in the future. My thanks also go to all the members of the Learning, Education and Games SIG for working together to move the field forward, particularly my fellow Executive Committee Members, Elena Bertozzi, PhD,

Stephen Jacobs, Guest Editor

MEDULLA: A 2D SIDESCROLLING PLATFORMER GAME THAT TEACHES BASIC BRAIN STRUCTURE AND FUNCTION

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Abstract

This article explores the design and instructional effectiveness of *Medulla*, an educational game meant to teach brain structure and function to undergraduate psychology students. Developed in the retro-style platformer genre, *Medulla* uses two-dimensional gameplay with pixel-based graphics to engage students in learning content related to the brain, information which is often pre-requisite to more rigorous psychological study. A pretest-posttest design was used in an experiment assessing *Medulla's* ability to teach psychology content. Results indicated content knowledge was significantly higher on the posttest than the pretest, with a large effect size. *Medulla* appears to be an effective learning tool. These results have important implications in the design of educational psychology games and for educational game designers and artists exploring the possibility of using a two-dimensional retro-style structure.

Introduction

Educational games that teach undergraduate psychology subject matter are rare. While countless games aim to improve cognitive function or other constructs studied by psychologists (e.g., Whitbourne, 2012; Lumosity, 2014), few focus on helping undergraduate psychology students learn the pre-requisite content that is required to succeed in their academic study. However, preliminary research on educational games and gamification in the psychology classroom shows these tools hold promise in motivating students to learn and retain course content over time (Landers & Callan, 2011).

The primary functions and locations of prominent brain areas is one example of content which is commonly required for the successful completion of introductory psychology courses—courses that are typically pre-requisite to enrollment in specialized classes. Students may be required to know, for example, that a primary function of the occipital lobe is processing visual information, and that it is located at the rear of the brain (Grill-Spector, 2003). This foundational knowledge enables students to understand more advanced psychological concepts and processes related to these areas of the brain.

To assist students in learning foundational psychology concepts, the field has engaged strategies such as active learning (Benjamin Jr., 1991; Mathie et al., 1993), collaborative learning (Johnson & Johnson, 2009), and problem-based learning (Dahlgren & Dahlgren, 2002; Reynolds, 1997). Games-based learning, such as through educational games, is one active learning strategy that builds on past research illustrating that students who receive scientific information through multimodal channels (relying on narration and animations) retain information better than students who received text alone (Mayer, 1997). Similarly, research by Moreno and Mayer (2000) indicated that students who played educational games that addressed the player using

first- and second-person speech "remembered more and used what they learned to solve new problems better" than students who played games that addressed the player using third-person speech (p. 729). These findings show promise in the psychology classroom for the use of educational games that feature multimodal affordances such as text, sound, and animation in conjunction with narrative structures that directly address the student player through first- and second-person speech.

In this study, an educational game, *Medulla*, was designed, developed, and empirically tested with undergraduate students majoring in psychology at the University of Central Florida. A pretest-posttest design was used to assess content knowledge before and after gameplay to identify learning effects. This test assessed players' knowledge of the parts of the brain – the content that *Medulla* aimed to teach. It was hypothesized that across all participants, posttest scores would be significantly higher than pretest scores. The results supported this hypothesis. The active learning featured in *Medulla* aligns with current national recommendations for undergraduate psychology curricula, which aim to "incorporate more active learning of science … to maximize the important and varied outcomes" of the undergraduate learning experience (Perlman & McCann, 2005, p. 13). It also supports previous research illustrating the benefits of multimodal educational games that use narrative to help students retain and apply scientific knowledge. *Medulla* was not only successful as a learning game because it used features previously suggested as beneficial by research, but also because of its reliance upon a fantasy-based narrative that takes potentially dry technical content and weaves it into a storyline where players can save the world.

Developing *Medulla*

Medulla (Figure 1) is a two-dimensional platformer developed using Unity3D. The aesthetic is pixel-based, reminiscent of the

retro genre and the games that inspired it. *Medulla* places the player in a world in turmoil. The evil Thor the Destroyer is wreaking havoc on the city of Medulla, inflicting maladies upon the minds of its citizens. The player must defeat him and his minions while curing the citizens' minds. *Medulla* has two primary mechanics: 1) Shooting brainwaves and 2) Curing citizens.
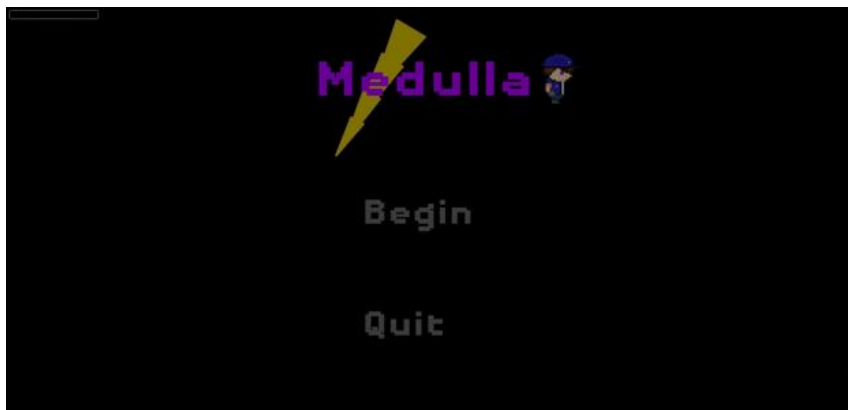
Figure 1. Medulla Title Screen

The final version of *Medulla* included between 34 and 76 minutes of gameplay (mean = 50.96) and was carefully designed (over 500 hours of development). Achievements were embedded to encourage participants' exploration of the game world; such achievements included "Pacifist," awarded to players who completed a level without killing anything; "Violent," given to players who attacked a well-meaning, friendly non-player character; and "Moonwalker," given to players who pressed both arrow keys at once (presumably to see what would happen).

While not intended as a direct teaching element, *Medulla*'s narrative incorporated domain-specific terminology to not only provide exposure and familiarity with these terms, but also to keep the names of people and places consistent with the game world. For example, various cities in the game are named after

parts of the brain (e.g., the towns of Occipital and Parietal). Similarly, some characters' names are drawn from parts of the brain as well: conjoined twins Broca and Wernicke, who appear in Level 8, are named similarly to the language-processing areas of the brain (Broca's area and Wernicke's area). Balancing humor and scientific content, *Medulla* incorporated visual and textual narrative elements in order to improve immersion in the game environment (Schneider, Lang, Shin, & Bradley, 2004).

Procedure

Participants

20 undergraduate psychology students from the University of Central Florida (11 female, 9 male), between the ages of 18 and 31 (mean = 18.75, SD = 2.9), were recruited through a participant management system. Participants were screened for recent drug use—including alcohol, tobacco, caffeine, sedatives, antipsychotics, and antidepressants—and normality of vision—normal or corrected—in order to ensure consistency in visual acuity and dissuade performance differences due to inferiority of vision or the use of performance-altering drugs.

A pretest and posttest were administered to measure participants' knowledge of the brain structure and function information taught in-game; the pretest and posttest were identical to allow for comparison, and included two parts. The first assessed knowledge of the primary functions of each major brain region. The second assessed knowledge of the location of each major brain region.

Experimental Testbed: Medulla

Participants played *Medulla* on a standard desktop computer (1920 x 1080 pixels resolution) that was controlled for volume and monitor settings (e.g., brightness, contrast, color). A mouse and keyboard were used to interact with the game.

In *Medulla*, brainwaves function as the attacking mechanism. After right-clicking, a projectile emerges from the avatar's head and travels forward for a few fractions of a second before being destroyed (Figure 2). If the projectile collides with an enemy, the enemy is defeated and despawns.

Figure 2. Shooting Brainwaves to Defeat Enemies

Throughout the levels, players encounter and must cure ill citizens. Upon approaching a citizen, the avatar stops and movement and shooting controls are disabled. Fantasy-based dialogue appears as text at the bottom of the screen that relates to the affected portion of the brain (e.g., the occipital lobe for vision). An image of the brain appears, prompting the player to click the correct section (Figure 3). Correct clicks award the player with extra health (up to a maximum of two) and additional time (a time bonus was awarded for remaining time at the end of each level; additional time meant more points). Choosing incorrectly results in a second try. Failure on the second try decreases the player's health by one (death may result from loss of health) and does not award points. After either choosing correctly, or choosing incorrectly twice (death is certain), the player regains control and may proceed through the level.
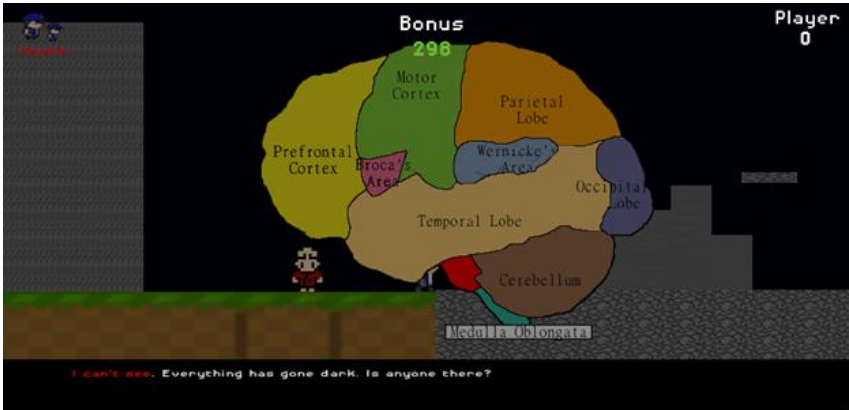
Figure 3. Clicking the Brain to Cure Ill Citizens

Medulla's gameplay feels most similar to a fusion between *Super Mario Bros.* and *Mega Man*. It includes a substantial amount of platforming-based gameplay, where the user is required to make precise jumps in order to progress through the level or collect points. However, the shooting element often requires players to slow their pace in order to avoid colliding with an enemy that must first be defeated. In this manner, enemies were used as tools to regulate the player's speed and progression to combine fast-paced gameplay with more deliberate thought-based play (Figure 4). This was done to encourage players to pause and think before responding, allowing additional time to consider the learning content before progressing.

Figure 4. Using Enemies to Control Pace of Gameplay

However, the ability of non-player agents to control pacing brought about its own challenge. The citizens that required curing placed players at an abrupt stop, forcing gameplay into the narrow constraints of a question-and-answer structure. When designing *Medulla*, the researcher realized the importance of a proper balance between this interruption of gameplay, which enabled practice of the learning content, and smoother, more continuous gameplay. While this interruption was not pervasive in the first level, where players only knew and practiced one brain area, it became an issue by the end of the game, when players needed to recall and practice nine areas within a single level. Front-loading and back-loading the learning content in each level was the solution. Evenly spacing ill citizens within a level would have resulted in interruptions every few seconds. By placing most of the ill citizens at the beginning and end of each level, with a few interspersed in between, the learning content became less of an intrusion on enjoyment (as determined from informal preliminary playtesting). As a result, more ill citizens could be placed, allowing for more time to be spent practicing the learning content while reducing the impact of interrupted gameplay. While this was an interesting effect that enabled more thorough use of a pervasive mechanic, substituting a more

engaging mechanic would have been preferable, but there was difficulty identifying such a mechanic. This seemed to be the best way to address the limitation.

Yet another challenge was revealed through early playtesting—teaching the *desired* content. In the original design of *Medulla*, dialogue instantly appeared on screen when the player approached an ill citizen. In an instant, the players moved their mouse cursors in the direction of the correct brain area. While this may at first seem testament to the game's potential ability to teach psychology-based content, the time the player spent reading the dialogue, processing it, making a decision, and beginning the action of moving the mouse cursor seemed far too short. Players appeared to easily able to guess the appropriate response based on the narrative dialogue presented to them. That is, because the text for each brain area was always the same (e.g., the ill citizens in the city of Motor Cortex always said, "You! Please help! I can't control my body!"), the player became an instrument of efficiency, *associating the first few words* with the brain area, *rather than the function*. "You! Please help!" became associated with the motor cortex, instead of "I can't control my body" – the phrase that should have been responsible for prompting the student to consider which area of the brain is connected with bodily control. This became evident during completion of the posttest when the player could not associate the brain area with the function, despite her ability to quickly select it when playing the game. The game was teaching something, but not the desired content. Previous literature (Squire, Giovanetto, Devane, & Durga, 2005) has shown that well-designed games can prompt players' ability to learn factual knowledge such as timelines, specialized vocabulary, and historical terms; as such, thinking through the most effective game design elements to teach content was crucial. Similarly, Squire, Barnett, Grant, and Higginbotham (2004) showed that bringing specialized vocabulary into the game levels themselves

and not just in cut scenes or easy-to-skip sections increases learning (p. 519).

A two-fold solution counteracted this. First, the relevant section of the dialogue, the learning content, was highlighted in red, while the remaining the text was unaltered (e.g., "You! Please help! I can't control my body!"). Highlighting is a strategy used to increase the saliency of target objects (Schultz, 1986) and facilitates attentional focus on the highlighted object (Tan & Fisher, 1987). This worked to improve the likelihood that the player, if trying to rapidly search the text and identify the relevant information, would set their focus on the learning content. The other part of the solution required implementing a waiting period before the player could select the brain. Initially, the brain and the text were displayed simultaneously, enabling the player to select before reading any text. The modification involved displaying the text immediately and waiting three seconds before displaying the brain. With this implementation, the player was forced to wait, whether or not they read the text. Three seconds was not deemed to be burdensome, but it did provide the player with free time in which reading was the only available action within the game. After incorporating these two solutions, the important information was now salient and the player had adequate time to find and read it.

Medulla concludes with a final fast-paced review in the form of a final battle against THOR THE DESTROYER (Figure 5).
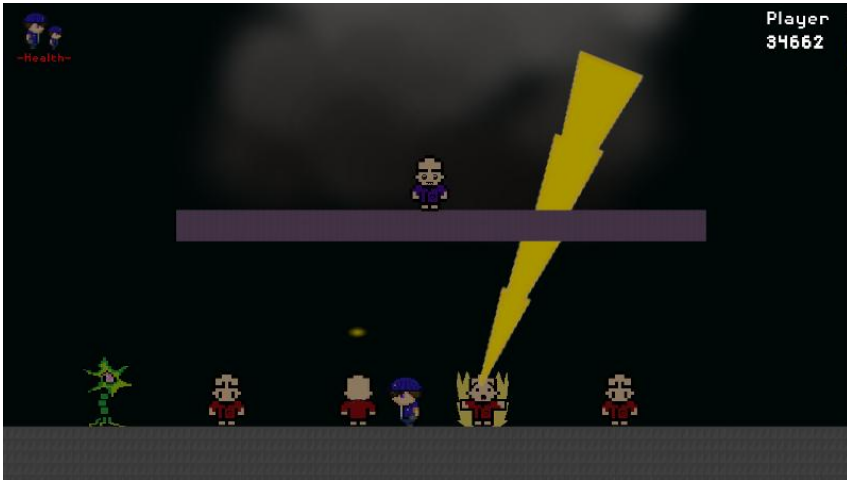
Figure 5. Final Review and Battle

In this battle, previously cured citizens assist the player. This is the in-game reason provided for their presence; the number of citizens is unaltered by the player's success. THOR stands on a platform above the player and citizens. The citizens shoot brainwaves upward at the platform in an attempt to destroy it, an act that would remove THOR's protection and force him to fall to the ground. Every few seconds, THOR inflicts illness upon one of the citizens—his sprite changes to a version of him with an evil grin and a lightning bolt strikes the citizen, forcing that citizen to face the camera and stop shooting. Clicking the ill citizen prompts the same familiar curing dialogue and process present throughout the game. Once cured, the citizen turns back around and resumes shooting the platform. The player cannot directly damage the platform; he must keep the citizens healthy so that they can continue to fight. As this process ensues, enemies walk across the screen from both sides, injuring the player if not defeated. Player death can occur, but does not reset the battle; it only delays the player's ability to cure citizens and complete the game. Once the platform receives enough damage, it disappears. THOR tumbles through the air until he hits the ground, head first. The screen goes dark as a year passes. A flash of light begins

the final cinematic in which THOR explains, from his amnesia-clouded perspective, what happened over the past year. In this final battle, over 100 citizens are cured using all brain areas taught throughout the game. In this way, it serves as a grand review of the content.

Features

Aside from the aforementioned, *Medulla* was designed with two additional features in mind, narrative and achievements. To include narrative, *Medulla* narrated a fantasy-based story to provide context and meaning to the actions occurring in-game. Without this explanation, the player might have been left with questions like *Why is the player clicking a brain that appears when approaching a person? Why is the player defeating enemies? Why are the enemies trying to hurt the player?* Additionally, Leung (2012) described how more abstract elements such as "attraction, seduction, and engagement" are difficult to embed in the game design but are crucial for successful user experience (p. 9). This approach—what she terms the art of experience design—requires designers to think through level design from the perspective of the intended user and to test the levels (ideally early in the process as a form of formative rather than summative evaluation) with an audience of intended users.

The narrative was delivered primarily through text-based dialogue and a few simple animations presented in cinematics. Cinematics occurred at the beginning of the game, introducing THOR and presenting the hero's call to action; just before the boss fight, revealing THOR's true identity and introducing the citizens that will help in the fight; and the end of the game, describing THOR's fate after being defeated by the player. A short cinematic was also present just prior to the final battle.

Additionally, dialogue was presented at the beginning and end of every level, providing information on the current city (each level

was considered a new city) and presenting new brain powers. New powers were awarded upon beginning a new level and each brain power was presented in the city of its origin (e.g., the occipital power was provided in the city of Occipital, or level 2). Below is an example of dialogue from the beginning of Level 7, Cerebellum (the cerebellum being the area of the brain that controls motor movement, balance, and posture):

-Hi friend! Welcome to Cerebellum!

-We're a little wobbly these days, but this was once the happiest place on Medulla!

– Of course, our spirits aren't down too much, but we do need some help!

– I don't think there's a person who doesn't know your name and the things you've accomplished.

– You're getting close to THOR THE DESTROYER's territory. Just push a little further.

– Before you go, take the Cerebellum power and help anybody who is having trouble with their balance.

-Thanks friend!

While inhabitants of Cerebellum were designed to be excessively friendly, each city had its defining quality. The cities and their inhabitants were named after elements related to the brain parts; this was done to increase exposure to the technical content in the narrative. For instance, Level 6, The Prefrontal Cortex Laboratory, introduced the player to one of THOR's enslaved researchers who supervised the facility that created THOR's minions. However, other cities and their inhabitants were not directly connected to the technical content; instead, these cities were written in a way that was intended to be intriguing to

the players, enhancing the fantastical feel of the narrative. For example, Temporal was home to the Sky Beards—people who spoke in rhyme, lived in the sky, and had large beards. Parietal introduced the player to The Sergeant—A sadomasochistic sergeant who flings insults, yells his dialogue, and calls the player names, like "thin mint," "scrawny toes," and "milk muffin." Other levels contained similarly developed characters. These narrative elements introduced humor to the game, encouraging players to explore the city and in some cases, as with the Prefrontal Cortex Laboratory level, increased exposure to the brain section names.

Throughout the game, players received achievements (e.g., Figure 6) for completing various goals. Unexpected achievements, or those which have requirements unknown to the player prior to earning, were used. Blair (2012) suggested unexpected achievements should be used to provide incentive to experiment or explore during gameplay as players attempt to identify their criteria. For players interested in achievements, this behavior may increase play time. Additionally, as achievements are commonly included in most modern games, their inclusion created another similarity between *Medulla* and the games the gamer participants were already playing.

Figure 6. Example of an achievement that was used in Medulla

Achievements were given for:

- Completing each level,
- Curing citizens (achievements given for first cure, three in a row, 10 in a row, and curing all citizens in a level),

- Curing a citizen that was not between the player and the end of the level (i.e., curing the citizen was optional),

- Defeating enemies (achievements for defeating one, ten, and fifty),

- Completing a level without killing enemies,

- Attacking a friendly NPC,

- Completing a level with more time than was given at the beginning of the level,

- Completing a level without dying,

- Moonwalking (pressing both left and right arrow keys at once achieved this effect),

- Killing self while a minion of Thor (in one level, the player is turned into a minion. Jumping on spikes is required to unlock this achievement).

Upon completing the requirements necessary for unlocking an achievement, a small window appeared in the bottom right of the screen, and then disappeared after a few seconds (Figure 7).

Figure 7. Achievement Award Interface.

Thereafter, pressing the escape key enabled the participant to view their list of completed achievements (Figure 8). The criteria

for unlocking the incomplete achievements were hidden from the player at all times; these achievements were displayed as "Achievement Locked."

Figure 8. Achievement List Interface

Methodology

Participants were asked to sit in front of the experimental computer and silence their mobile phones in order to reduce the potential for distraction. After drug screening, participants were provided with an IRB approved informed consent document. Following the consent process, participants completed a demographic questionnaire and took an 18-question pretest to assess prior knowledge. No feedback was provided on correctness to reduce the potential for learning effects outside of the gaming session.

Prior to playing *Medulla*, the experimenter presented a list of game controls on a sheet of paper. The controls were read aloud and participants were informed that they could refer to this list of controls at any time. Participants placed high-quality, surround-sound, noise-cancelling headphones over their ears and played *Medulla* in its entirety. If questions arose during gameplay, the experimenter provided an answer with the

minimal amount of information necessary to progress. When requested, this feedback primarily consisted of instructions such as "run to the right," "go up," or "use the right mouse button to shoot the enemy instead of the left mouse button."

After gameplay, participants completed a posttest identical to the pretest.

Results & Discussion

The hypothesis predicted that posttest scores would be significantly higher than pretest scores. Table 1 provides a list of descriptive statistics for pretest, posttest, and difference scores, as well as difference scores between pretest and posttest. Posttest scores were significantly higher than pretest scores, $t(79) = -21.643$, $p < .001$, $d = 2.980$. See Table 2.

Table 1. Descriptive Statistics for Posttest and Difference Scores

Test	Minimum	Maximum	Mean	Std. Deviation
Pretest	4	18	8.50	4.03
Posttest	13	18	17.40	1.27
Posttest – Pretest	0	14	8.90	3.74

Table 2. Pretest and Posttest Scores

	Mean	St Dev	St Error Mean	95% Conf:Upper	95% Conf:Lower	t		dif	Sig.
Pre-/Post	-8.90	3.74	.836	-10.650	-7.150	-10.642		19	.000

These results indicate the game's success in teaching the content. The effect size, d = 2.980, indicates that participants performed much better on the posttest than the pretest. In combination, these results support *Medulla*'s effectiveness as an educational game, and the strategies used in its design.

Conclusion

This study presented *Medulla,* an educational game. *Medulla* was empirically tested with undergraduate psychology students, the target population, to assess its effectiveness in teaching brain structure and function information. Results indicate that participants experienced significant and substantial learning through playing *Medulla.*

The brevity of gameplay was a choice the developer made specifically to make *Medulla* appealing to college students. That is, *Medulla* can be played quickly, appealing to students looking to rapidly study the material so that they can spend more time on advanced topics of study for which this knowledge is prerequisite. In contrast to opening a book or searching the Internet and then engaging in rote memorization, the participant can run the game, play for approximately one hour, and be able to recall the information with accuracy.

Similarly, the developer focused on offering design variety in *Medulla*. Few educational games are created in the style of pixel-

based 2D sidescrolling platformers. In an era of complex, high-fidelity, three-dimensional games, retro-style games still hold relevance. While this has been exhaustively demonstrated in the entertainment industry with the success of games like *Risk of Rain* (Chucklefish, 2013) and *BIT.TRIP Runner 2* (Gaijin Games, 2013), it has received little attention in modern educational games. This study supports its effectiveness. This is important because retro-style 2D games are simpler to create than their 3D counterparts; the z-dimension does not require consideration during programming and art development. In a domain where resources are often limited, researchers, ambitious instructors, and developers can, in good conscience, make a more economical choice. As Kayali and Schuh (2011) assert, such object-oriented level design in retro-styled games can offer "varied gameplay while at the same time saving resources" (p. 11).

Further, this style of game may be more accessible to inexperienced gamers. While those who frequently play fast-paced three-dimensional games may feel comfortable in a variety of gaming environments, controlling an avatar in environments with a third dimension can prove challenging for inexperienced players (Beckhaus, Blom, & Haringer, 2005; Fong, 2006). This is important in an educational setting where there is no guarantee that all students will have the relevant experience.

Finally, *Medulla* illustrates that educational games that incorporate engaging narratives and directly address the player, inviting them into the action, may be successful learning tools. These results reinforce earlier assessments of multimodality (Mayer, 1997) and direct player address (Moreno & Mayer, 2000). As McQuiggan et al. (2008) have argued, the motivational benefits of narrative embedded within education games has substantial benefits for learners, such as increased presence, interest, self-efficacy, and control. Similarly, Rowe et al. (2011) have shown that no matter what prior knowledge or experience with games students bring to the classroom, narrative-centered

learning environments helped students achieve improved learning outcomes and problem solving ability.

Of course, there is room for improvement. The learning mechanics used in *Medulla* are straightforward and similar to drill and practice learning. While the game was successful, and lessons were learned during its development, a need remains for better learning mechanics that do not feel intrusive to begin with. Moreover, it is difficult to isolate the specific elements which made *Medulla* successful. Future design-based research and experimentation should identify these elements, and advance the science on creating these games to maximize engagement and pedagogical effectiveness.

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PLAY OR SCIENCE? A STUDY OF LEARNING AND FRAMING IN CROWDSCIENCE

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Abstract

Crowdscience games may hold unique potentials as learning opportunities compared to games made for fun or education. They are part of an actual science problem solving process: By playing, players help scientists, and thereby interact with real continuous research processes. This mixes the two worlds of play and science in new ways. During usability testing we discovered that users of the crowdscience game Quantum Dreams tended to answer questions in game terms, even when directed explicitly to give science explanations. We then examined these competing frames of understanding through a mixed correlational and grounded theory analysis. This essay presents the core ideas of crowdscience games as learning opportunities, and reports how a group of players used "game", "science" and "conceptual" frames to interpret their experience. Our results suggest that oscillating between the frames instead of sticking to just one led to the

largest number of correct science interpretations, as players could participate legitimately and autonomously at multiple levels of understanding.

Introduction

When learning games first entered the scene, curriculum content and teaching methods shifted very little. Surface features of gameplay were added, but drills and narrative construction mirrored what was known on paper, blackboards and older media. Brenda Laurel memorably described this as 'chocolate covered broccoli' (2001): The same old stuff with a game design forced around it, such as getting to fire your gun only after completing a math problem in the *Space Invaders* clone *Math Blaster*.

As purposeful play gained momentum, however, the maturing games industry increasingly came to shape play practices outside "just for fun" contexts. The medium was increasingly shaping the message. Or rather, games are no longer seen as delivery mechanisms for content, but as ecologies of participation.

In this essay, we use the little action game *Quantum Dreams* (http://scienceathome.org/games/quantum-dreams/) to present the learning potentials in crowd science games, where participants are actually helping a scientist by playing. We then discuss the challenge of having mixed epistemic frames in the play experience: The immediate game interface on one hand, and the science process on the other. When used in a classroom setting, a third frame, learning and education, is also added.

This conundrum is unpacked through a grounded and correlational analysis of 38 players' interpretations of interface-elements in Quantum Dreams. The fact that many players seemed to place focus on either game or science surfaced during pragmatic perusing of usability test data, and was turned into a more formal analysis for the sake of this essay.

Gaming for science

Sawyer and Smith's "serious games typology" from GDC 2008 identified science and research as one of the seven major purposes that games now serve for various audiences including in healthcare, industry and government (Breuer & Bente, 2010; Klopfer et al., 2009; Sawyer & Smith, 2008).

Crowdscience games represent a tipping point, where serious game playing not just supports changes in attitudes or competences in the user, but makes an active difference for researchers trying to solve a problem – from mapping the neurons of the mouse retina, over curating archaeological artifacts, to building the controlling AI for a quantum computer.

Citizen science is not new

It could sound like the crowd science movement was a direct manifestation of the transformative power of games envisioned by utopists like Jane McGonigal (McGonigal, 2011). Its roots, however, are to be found much further back – before the internet, and even before science was segregated from leisure and craft. When Charles Darwin wrote his Origin of the Species and Gregor Mendel got curious about genes in his greenhouse, they were just taking part in the societal agenda of their day. Granted, they had time and means not available to the vast majority of rural denizens and the emerging urban populace, but they were not professional scientists contracted by a university or corporation.

These early citizen scientists were motivated by their own curiosity, needs and times, but there are also early examples of regular people being recruited into centralized efforts. Amateur bird lovers and entomologists have, for instance, long helped track the movement of species across the continents. The advent of modern communication technologies enabled this process further, allowing the Smithsonian Institution to recruit local

individuals to maintain weather stations and wire in results, creating a real-time meteorological map of the continental United States.

This was viewed as an opportunity to participate and learn as well as a civic duty.

In this sense, the telegraph foreshadowed what would become online crowd science: Some centralized organizer at e.g. a university or NGO creates and advertises an infrastructure that allows ordinary people with a little time on their hands to contribute.

Cultural psychological motives for crowd science participation

Understanding why people would want to contribute to science today must be seen in the light of the frames work and leisure. Industrialization institutionalized work, with payment based on exact measures of time and effort, contrary to the past where the largely rural population worked based on immediate seasonal needs. In essence this new "iron cage of capitalism" created a formal, psychological and cultural separation of leisure from work hours (Weber, 1905/2005).

Humans have played in all cultures that we know of (Avedon & Sutton-Smith, 1971; Huizinga, 1959; Suits, 1972), but with the new wage economy, spare earnings could be spent, and new demands for entertainment and dedicated free time was born. This became a theme in worker's rights. In 1888 hundreds of trade unionists thus paraded through Worchester Massachusetts bearing a banner that read *"eight hours for work, eight hours for rest, eight hours for what we will."* Workers wanted opportunities for recreation (Ashby, 2006). Together with the technological possibilities that first gave us dime novels, cheap sheet music and nickel theaters, this can be viewed as a cornerstone in western culture and its entertainment industry that would lead to the rise

of cinema, flow-TV and eventually computer games. As gaming progressed from niche market to mobile mass movement, a new age of casual gaming arose. In the new millennium, women over 30 would be the most rapidly expanding consumer group for years on end, and gaming moved from high-investment titles on stationary screens to little pauses in life (Juul, 2010; Software Entertainment Association (ESA), 2013; Wei & Huffaker, 2012). We are experiencing an unparalleled acceptance of play into everyday life – a ludification of culture (Raessens, 2006) and a cognitive surplus which can be put toward informal education and interesting problem solving (Shirky, 2010).

It is in this context that participation in crowd science projects must be understood. While earlier incarnations of citizen science such as the Smithsonian web of weather stations often required some level of expertise and civic sensibility, online technology places the tools needed to contribute at anyone's fingertips, and strives to shape an engaging learning curve from slight interest (Lieberoth, Kock, Marin, Planke, & Sherson, 2014) using the frame and mechanics of game play.

We now see crowd science games in numerous domains, ranging from our own work in fields like psychology (Lieberoth, 2014a) and physics (Sørensen et al., 2015; Lieberoth et al., 2014, Magnussen, Hansen, Planke & Sherson, 2014, Bjælde, Pedersen & Sherson., 2014) to astronomy (Raddick et al., 2010), protein folding (Cooper et al., 2010) and other STEM-subjects, but also spreading to new exiting areas like transcribing historical texts and fieldnotes (Chrons & Sundell, 2011). No matter the domain, players get the chance to take an active part in solving real problems or curating real materials, getting casually acquainted with the area, materials and real cutting edge problems in the process.

Crowd science games as learning opportunities

While some crowd science games mainly exist as game interfaces, most of the institutions behind the genre go to some length to inform users about the scientific project they will be contributing to, and even build educational elements into the game architecture.

This is especially important to games where a modicum of skill is needed to really contribute. For instance, our early game *Quantum Moves* required quite a bit of training before users could traverse the difficult levels that represented truly wicked problems in building our quantum computer, compared to how new users can contribute to Galaxy Zoo straight away, even if they may become more speedy and precise with practice (Lieberoth et al., 2014).

As such, crowd science games can be educational in their own right, but we believe that their true educational potential lies as part of *a game based pedagogy* rather than as a stand-alone deployment device for learning practice. There is perhaps a naïve conception in educational game design, that participation alone is enough to engender learning. Time spent on any task will bolster skills and some concepts may transfer near-automatically. However, it is nontrivial to align the activity in a way that allows the player to gain some immediate payoff while creating a sustained and meaningful learning trajectory (Dewey, 1938a; Dreier, 2003; Squire, 2006).

Game experiences with real science allows teachers to solidify teachable moments and weave cognitive hooks into their existing teaching agendas (Avery, 2008; Davis, Horn, & Sherin, 2013; Haug, 2014; Lieberoth & Hansen, 2011)

Having the game awkwardly wrangled onto the content "edutainment"-style is generally considered bad design (Charsky, 2010; Klopfer et al., 2009; Resnick, 2004). We suggest that crowd

science games supply an advantage with regard to this challenge, as there is less disjunction between the medium and the science matter – the context and the content are both scientific, and accumulating data demonstrates that this attracts people with just a casual interest in e.g. quantum physics to corresponding games. The crowd science game supplies a genuine opportunity for legitimate peripheral participation (as per Lave & Wenger, 1991) in the scientific process. User engagement may be bolstered through the gameplay itself, or as is often seen via a wider ecology of knowledge of information, interesting quizzes, social milieus, and even opportunities to co-create the game itself.

An analytical approach to these challenges would be to analyze the epistemic frames – games versus science – under which the activity is interpreted by different users, and assess if the two interpretations can coexist in parallel, as supports for one another, or not at all. When we discovered that these levels were clearly dissociable in a set of usability surveys from an educational play session, we decided to investigate further. This is the subject of the remaining parts of this paper.

Game well played or science done well? A question of framing

So what defines the play experience of a crowd science game? Viewing crowd science games through the standard motivational frameworks (Huizenga, Admiraal, Akkerman, & Ten Dam, 2009; R. M. Ryan, Rigby, & Przybylski, 2006; Wouters, van Nimwegen, van Oostendorp, & van der Spek, 2013) and player types (Hamari & Tuunanen, 2014) offers some useful design heuristics and measuring tools, but this only seems to paint half the picture. Dropout and conversion rates in *Quantum Moves* resembled most free to play games (i.e. Draganov, 2014; Fields, 2014), but deeper analyses from *Galaxy Zoo* and *The Milky Way Project* revealed that engagement profiles could be sorted into types ranging from

briefly hardworking, over moderate, to lasting categories, which cannot simply be boiled down to gameplay (Ponciano, Brasileiro, Simpson, & Smith, 2014).

Indeed, recent research has shown that framing the same activity as either game or work irrespective of the game elements used can have a measurable psychological impact in terms of interest and enjoyment in the short term (Lieberoth, 2014b).

Accordingly, interview studies have shown that while game elements attract new users to citizen science platforms, they are less of a factor in sustained engagement (Iacovides, Jennett, Cornish-Trestrail, & Cox, 2013; Lieberoth et al., 2014)

Framing thus seems to be a central issue: If players view a crowd science game only in comparison with other online games, they will often be disappointed. However, if part of their interest stems from *or* shifts to intrinsic motivation related to taking part in the science project, then play and science frames can merge into a new level of enjoyable experiences. To understand a well played citizen science game, we must thus try to understand not just the raw game play, but also the meta-motivational frame under which the activity unfolds, and how this shapes players' interpretation of the game elements.

Quantum Dreams: a play experience analysis

To put the discussion presented above under scrutiny, we examined user experiences in the crowd science game Quantum Dreams. Quantum computers offer immense computational speedup compared to conventional computers by replacing bit, which can be either 0 or 1, with qubits. These can be both 0 and 1 at the same time. Thus, a quantum computer with N qubits can represent 2N different values at the same time, allowing an exponential increase in the computing power for certain tasks (Nielsen & Chuang, 2000). Our approach is to build a quantum computer from ultra-cold atoms in an optical lattice

(Weitenberg, Kuhr, Mølmer, & Sherson, 2011). The individual atoms are transported around the lattice by optical tweezers. However, when moved the atoms begin to slosh – similar to coffee in a cup if you are not careful. Computer algorithms are only capable of solving the problem of transporting the atom without sloshing, if given enough time. To investigate whether humans given the right visual tools can form heuristic algorithms to find fast solutions to the complex quantum problem of moving a single atom without sloshing, we built the game Quantum Dreams in the Unity game engine. Quantum Dreams represents a simple 3D game loop based on the more complex levels in our less smooth game Quantum Moves (Sørensen et al., 2015; Lieberoth et al., 2014, Magnussen, Hansen, Planke & Sherson, 2014, Bjælde, Pedersen & Sherson., 2014). Contrary to most crowd science games, Quantum Dreams is not only embedded in the project homepage, but also lives its own life on online app stores with minimal background information. Our "micropayment" is scientific data rather than money. In the game, the players are asked to collect an atom with an optical tweezer and transport it to a target area. A more detailed metagameplay will supporting other play experiences and educational content follow in later iterations.
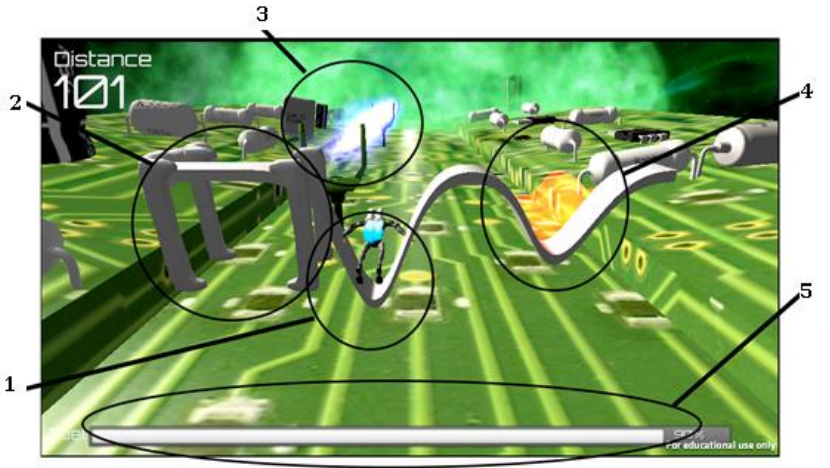
Figure 1. Quantum Dreams General User Interface (GUI). 1) The optical tweezer which is controlled by the player. The optical tweezer manipulates the atom by changing the potential energy landscape. The robot represents your cursor. 2) The target indicator, which indicates where the target area is going to appear. 3) The target area into which the atom should be moved. When the atom is in the target area, seconds are added to the timer based on the proportion of overlap with the probability distribution. 4) The probability distribution of the atom's location. 5) The timer. When the timer runs out the game is over.

The GUI resembles Guitar Hero with the player controlling a little flying robot with the mouse flying "into the screen". When a yellow shining substance (figure 1, number 4) appears, the robot can be moved to grab it and ferry it carefully across the screen to hit targets that appear further down the "road" (figure 1, number 3). The yellow substance represents a *probability distribution* of where the atom might be, and the robot controls the optical tweezer. Since atoms in the quantum computer are quite fragile, they must be moved quickly and carefully, or they might be lost due to excitations to high energy states (Sørensen et al., 2015). The game is thus one of fine motor coordination and quickly gleaning the best speed and route, before the robot reaches each target. By repeatedly moving the probability distribution into new target areas during game play, the player helps us map out

the best routes in corresponding spaces in the actual quantum computer. The game itself has a technological sciency feel, but the quantum narrative is largely left out of the core loop gameplay itself.

Frames can be understood as the shifting lenses through which we interpret social reality beyond the immediate physical givens (Deterding, 2009; Lieberoth, 2014b). In his seminal work on the subject Erving Goffman (1976) often cites game play as clear example of how people submit to rules and conventions that transform otherwise meaningless actions, such as moving a checkers piece, into significant events within the shared frame of "play". Engrossment into frames oscillates, so as conversation fluxes you might shift attention from meanings within the game, to preserving a friendly relationship with your opponent, and back again (Fine, 1983). Frameworks thus delimit mental and practical situations wherein differing "habits of mind" or "modes of thinking" (Kuhn, 2008) come to the fore. As Quantum Dreams was introduced to our test population in the context of their vocational school, and events started out with a talk on physics, the primary frame of interpretation would have been "education" or "science" for most. The introduction of the highly gamelike GUI, however, *keyed* (as per Goffman, 1976) a swing to "gaming" from which some were not able to shift back. The questions, apart from finding out if the testers enjoyed the game, were thus: Did they remember any physics information? And how do the frames of gaming and science coexist for the players in a simple game experience like this?

Participants

38 Danish students (age 14-22, M=17.27, all male) were recruited to play as part of their vocational school (HTX) training. The participants can be described as heavy gamers, with 30 of them reporting playing 10+ hours/week, with high interest in physics (M = 3.74 SD = .852, on a scale 1-5).

Procedure

The study took place during an ordinary two-lesson science class at a local vocational school. Participants were informed that they would be part of a usability test for a near-finished crowd science game. The students were first given a presentation of the game, its crowd science purpose, and the underlying physics. The abstract subject matter was adapted to the students' current science-education level. The students then played for 15 minutes on their own laptop computers. After the play session ended, students were given printed surveys as described above. The first page asked them to fill in boxes according to the circles seen in figure 1, describing what each GUI element represented in physics terms. Once done with this task, the students moved on to the likert-style survey.

Materials

Participants were given logins to an early version of Quantum Dreams, largely similar to the one launched on Wooglie January 2015. The data were collected with paper surveys. The players were presented with the image of the general user interface (GUI) seen in fig 1, and instructed to *"look at the image. Write in the boxes which physics phenomena the game element represents. If you don't remember the physics term, describe it in your own words. Leave the field empty if you don't remember at all."*

The subsequent pages consisted of a series of multiple-choice questions on a 5-point likert scale from "strongly disagree" to "strongly agree". The scales *interest/enjoyment* (7 items, α = .887), *value/usefulness* (7 items, α = .694), *competence* (6 items, α = .816) and *autonomy* (7 items, α = .760) were adapted from the Intrinsic Motivation Inventories (Intrinsic Motivation Inventory, 1994; Ryan & Deci, 2000). Here, interest/enjoyment is taken to be a main measure of intrinsic motivation stemming from the activity in and of itself, while the other scales are taken to be contributing

factors, namely how much the student finds scientific/ educational meaning in the activity, how well they feel that they can do (i.e. mastery) and the degree to which they have flexibility and choice in the participation trajectory. The shorter learning orientation measures in English *mastery* (3 items, α = .285), *performance: approach* (3 items, α = .794), and *performance: avoidance* (3 items, α = .529) were adapted from the Patterns of Adaptive Learning Scales (PALS) (Midgley et al., 2005). These scales are taken to indicate the degree to which learners prefer work that allows for growth through exploration and even constructive failures (mastery) versus just doing well by some objective measure and avoiding looking bad in the eyes of oneself and one's peers (approach/avoid). The scales were supplemented with a series of individual questions mainly used for parts of usability testing that are not reported here. Apart from the PALS-items and the game itself, all questions and instructions were in Danish.

Data analysis

Data were analyzed using SPSS 21.0. Central limits theorem assumed for populations over 30. All scales had an acceptable Cronbach's alpha score, except PALS mastery which was abbreviated for an earlier study, and came out with an unacceptable score of .285 (as per Gliem & Gliem, 2003). As a result, it was not used here. Students reported middling performance orientation (M = 3.49, SD = .71) and desire to avoid bad performances (3.12, SD = .69) in their everyday educational lives.

For the GIU-interpretation task all answers were first entered into a spreadsheet, and then, inspired by patterns gleaned by cursory examination of the original paper sheets, a grounded theory approach was used to sort each response into categories according to an open-ended scheme. "Science" and "game" were picked as a priori codes (for a more rigorous example of this

technique, see Hoare, Mills, & Francis, 2012). After coding the number of answers attempted, answers in each category, number of correct science answers and number of correct answers in total (even if the task was only to give science answers) were calculated for each participant. A large subset of the students did not attempt to describe any of the GUI-elements, while most of those who did labored to fill in all the boxes. After this exercise, a simple correlation matrix was generated to include the likert items in the analysis.

Results

17 out of the 38 students (44.74%) used at least one science explanation to describe a GUI-element. 22 students (57.89%) used at least one game explanation, and 11 students (28.95%) used at least one other kind of conceptualization. The latter conceptual types of answers included descriptions (*"guy who follows the mouse"*) or interpretations (*"helper"*). In one instance all of the student's descriptions appeared as unintelligible *1337 speek* gamer slang and abbreviations fit for fast chat channels and message boards. Obviously this kid was deeply engrossed in a gaming mindset, even to a point where he could not (or for identity-reasons opted not to) communicate his interpretations in a way that made sense not just outside the gaming frame, but also outside the culture maintained around hardcore gamer culture. Because no other singular categories emerged in the coding process, descriptive answers that were neither science or game-oriented were grouped together as "conceptual". 11 (28.95%) out of the participant pool left all boxes blank, indicating that they could not find any physics answers as per the instruction, and did not attempt cross-frame explanations in their place. Out of the interpretations given, students on average got two right regardless of category (M = 2.33, SD = 1.27), but only managed about one correct physics answer (M = 1.35, SD = 1.12). The number of correct descriptions was obviously dependent on the number of attempts made.

In response to the game experience students' answers indicate above average scores for interest/enjoyment (the main intrinsic motivation measure) (M = 3.67, SD = .55), with slightly lower scores for perceived value/usefulness (M = 3.55, SD = .49), autonomy (M = 3.37, SD = .53) and competence (M = 3.16, S.D. = .62).
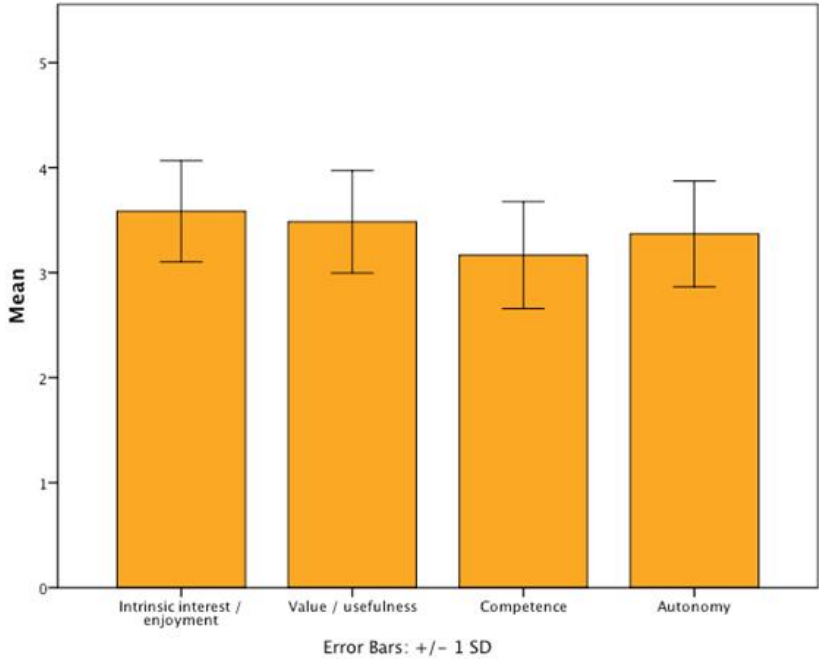
Figure 2. Intrinsic Motivation Inventory (IMI)

Quantum Dreams was however *not* perceived as "feeling like other good games" (a validation item used in Lieberoth, 2014b). This was reflected in medium correlations with both interest/enjoyment, $r = .410^{**}$, and value/usefulness, $r = .345^{*}$, and most strongly autonomy $r = .46^{**}$. Physics interest was strongly correlated with interest/enjoyment, $r = .61^{**}$, value/usefulness $r = .533^{**}$, and autonomy, $r = .68^{**}$, as well as a performance approach to learning, $r = .531^{**}$. The PALS scale did not predict any other variables.

When GUI-description categories and precision (i.e. the number of descriptions that could be regarded as accurate) were subsequently also entered into the correlation matrix, autonomy showed up as the only interesting factor: It was very highly correlated with the proportion of correct physics descriptions given, $r = .61$**, while physics interest was only correlated with the general number of correct descriptions given $r = .58$**.
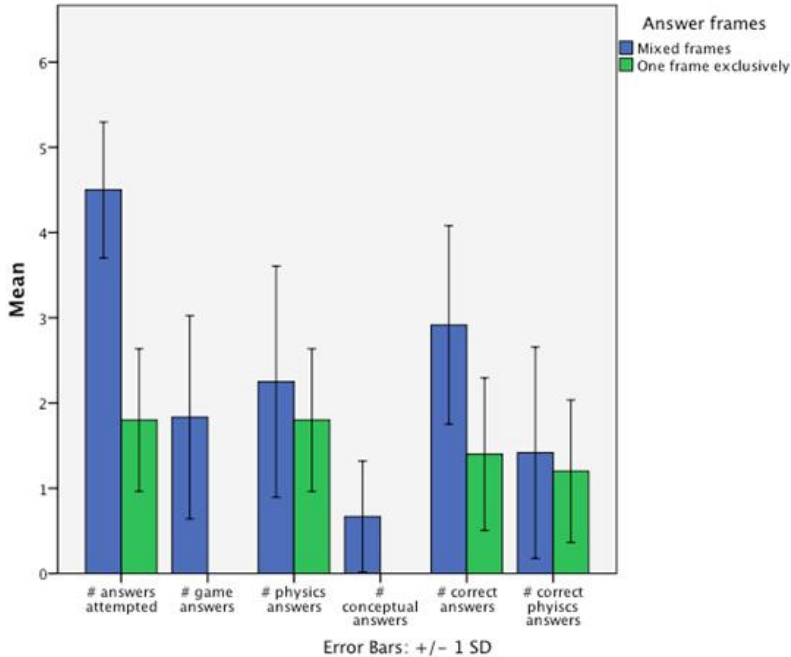
Figure 3. Answer patterns divided by interpretative frames

Many used answers from multiple categories to explain GUI-elements, sometimes crossing between them in one answer, but 11 (40.70% of those who attempted any answers) stuck exclusively to one out of the three categories – mostly either game or science. An independent-samples Mann-Whitney test revealed a significant difference between these two groups on number of correct answers** and number of answers attempted**, but not physics answers. Shifting between

categories was, however, not negatively related to the total number of correct physics answers achieved either, indicating that flexibly oscillating between frames and thus allowing oneself to give the best answer available at any one point, was an effective way of giving a stream of correct answers overall, without the science understanding suffering – even though the task was to give only science explanations.

Discussion

In this essay, we have theorized about the potentials of crowdscience games as opportunities for learning, and described the challenge of several epistemic frames co-existing in the same arena.

In the service of citizen science, a game well played is important on dual dimensions, namely 1.) the purely subjective user experience that, like in any other game, will make people come back for more and tell their friends, and 2.) the quality of data generated results directly engaged players performing at high skill levels. People must literally play the game well, or we will not get the quality of data needed to build our quantum computer.

Game-oriented descriptions were dominant in the vocational class examined here, but this understanding competed with physics thinking. This can be interpreted as a conflict or dynamic oscillation between two prevalent frameworks for interpretation, keyed by elements present in the game experience and the surrounding educational situation.

The importance of the real science subject matter was highlighted by the importance of physics interest and feeling of autonomy. Out of the intrinsic motivation subscales, autonomy stood out as a key variable: It is very possible that we have here gleaned an instance of some students picking between possible

frames of engagement, and in the end going directly for the science broccoli.

The dynamics discovered paint an interesting picture of experiences with a game, which can be well played on multiple dimensions – namely both as gaming, learning and participatory science experience. Of course, correlation is not necessarily indicative of learning, neither in the 38-person sample or more generally, and we have no formal before/after tests to show. The game was designed for intrinsically motivated crowdscience participants and not for formal educational deployment, so gains measured at a school like here, would need to be dissociated from the presentation and pedagogy enacted around the play experience. But they paint a strong picture of the mindsets activated around play with a fairly esoteric subject matter, where the main learning must necessarily take place as part of the pedagogies surrounding the experience, even if implicit understandings about the vagaries of quantum particles may be developed through the interactive experience.

It should be noted that our categorization of GUI-element descriptions was based on a rough heuristic categorization. Many of the conceptual descriptions could be argued to have some sort of overlap with the game interpretations, and analyses with more students and questions designed for this end might reveal interesting subcategories. Indeed, the research only came to be written up for publication because interesting patterns emerged from our usability data. We were not aiming to test any particular hypotheses, and did not have clear a priori criteria for data analysis, so the findings here must mainly be viewed as illustrations of relationships between engagement, personal factors (PALS, science interest) and the flux of interpretative frames that guided students' play experience and descriptions of the interface elements.

The patterns seen are encouraging to our claim that

crowdscience games hold strong learning potentials, owing to their direct, impactful and *interactive* relationship with *continual* science processes (see also Dewey, 1938b). Indeed, it appears that allowing one's mind to shift between multiple frames of understanding allowed students to come up with descriptions for the physics elements, rather than sticking solely to one mode of explanation and experiencing cognitive roadblocks when the right single-frame answer did not come to mind. But these findings are also a somber reminder that game thinking can be distracting, even when students are explicitly asked to focus on the science explanations. All things considered, many students never supplied any science descriptions, likely owing to the fact that this usability study was not run as part of a continuous educational plan for quantum physics. The pedagogies surrounding any game deployment is likely to be the main contributing factor to student learning, while a game like Quantum Dream supplies a first hand experience with the behavior of atoms in quantum space, which is very hard to grasp even for trained scientists.

Conclusions

This was an accidental study. We were looking at user experiences as part of our design process, and found an interesting image of students mixing play and science frames to answer our questions. Some of these discoveries have already been implemented in the game design process, while we are looking deeper into how people cognitively engage with the interface using eye tracking. And of course, the grand prize of implementing play data in quantum physics is an ongoing process.

We have suggested that crowdscience games offer a closer marriage between game and science, but it also looks like these two frames sometimes coexist and sometimes push each other to the side in play trajectories. Our exploration of how students in

a vocational class opted to describe different interface elements made the difference between "science", "game" and "conceptual" frameworks of interpretation visible. It appears that the special status of crowdscience games affords some cognitive freedom: An ecology of thinking-layers to oscillate within. This not only supplies multiple routes to engagement but also allows flexible students to exercise a degree of fruitful autonomy in their learning process.

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BARRIERS TO LEARNING ABOUT MENTAL ILLNESS THROUGH EMPATHY GAMES – RESULTS OF A USER STUDY ON PERFECTION

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Abstract

Video games are an expressive art form which potentially allows
players to explore someone else's inner world through first hand,
embodied experiences. This paper describes the results of an
exploratory study on the game *Perfection,* which models the
experience of anorexia nervosa. *Perfection's* first and foremost
design goal was to capture "what it's like" to struggle with the
disorder. We were hoping that exploring this struggle in
gameplay would have educational and therapeutic potential,
increase understanding of anorexia and help to fight stigma.

Fifteen therapists were observed playing *Perfection* and then
interviewed about their gameplay experience. Analysis showed
that although game's design did not negatively impact the game's
educational potential, several barriers to therapists'
understandings and positive valuations of the game as a
therapeutic or educational tool were identified. Discussing these
barriers along with suggestions for use and further study aims
to help other designers to create successful educational therapy
games and to avoid the pitfalls we encountered when making
Perfection.

Introduction

Many social problems that co-exist with or arise from mental
health issues are not well understood. Full understanding goes
beyond cognitive understanding of symptoms or physio-
psychological mechanisms and includes fullness of experience.
Lack of experiential understanding often burdens relationships
between people with mental health issues and their social
environment, including friends, family and even therapists,

which can intensify mental health issues and create barriers to recovery.

Art – be it in the form of painting, poetry, literature, theatre or film – has always been considered a powerful window into the human condition. Art can help us better understand our own and other people's experiences. It stimulates the senses, providing access to our emotions. Thus, using the potential of art as a tool for insight, self-exploration and learning about ourselves has a long tradition in therapy (Miller, n.d.).

Videogames are a new expressive art form and the experiences they provide, compared to other forms of representational media, are as close to real life in terms of vividness as one can get. Building on the "continuum of vividness" by Charles Hills, game scholar Ian Bogost argues for the inclusion of videogames above "moving images with sound" and right underneath "actual experience" (Bogost 2007, pp.34). Along those lines, Jim Gee claims that games enable embodied, first hand experiences (Gee 2003). In games, we can step into someone else's shoes; experience the world from someone else's perspective. Gee calls this "projective identities." By modeling realities through rules and mechanics – e.g. someone's *inner* world – and allowing players to explore this inner world with all of its potentials and constraints through embodied, firsthand experience, games are powerful tools to increase understanding of mental health issues.

It is thus no surprise that there is a growing body of games (and other interactive technology) that leverage this medium-specific ability to foster embodied learning in the service of mental health education and communication. By modeling salient aspects of the lived experience of various disorders (e.g. depression, ADHD, Alzheimer's disease) and allowing players to explore "what it feels like" through the interaction with the rules and mechanics, these games aim to raise awareness for, increase understanding of, improve dialogue and alleviate stigma of various issues and

create empathy for those afflicted by them (*Drawn to Distraction*: ADHD, *Elude*: Depression, *Depression Quest:* Depression).

The big question, however, is: does it work? Does the theory that games are uniquely and ideally suited to stimulate experiential learning about mental health issues translate into practice? What are the factors – apart from the design itself– that facilitate or hinder an increased understanding of the modeled experiences?

To explore this question, we conducted a user study with 15 mental health professionals on the game *Perfection* – a game modeling the experience of anorexia nervosa. *Perfection* was designed in collaboration between one of the authors (Rusch) and a subject matter expert with anorexia (to ensure authenticity of the modeled experience). The game can be considered a subjective, artistic expression of what it's like to struggle with anorexia. In this article, we give a brief description of the game design and the experiences it intended to model. We describe the study design and we present the most relevant findings with a special focus on the barriers to understanding that we identified from our target audience (therapists). We also explore potential reasons for barriers and then we provide suggestions on how to decrease these barriers in future projects.

The Game

Perfection (http://fortherecords.org/perfection.html) (see Figure 1) is a short, metaphorical game that has been designed as part of the interactive transmedia documentary project, *For the Records. For the Records* investigates the lived experiences of young adults and eating-, bipolar-, attention deficit- and obsessive-compulsive disorders. The project brings experimental film, animation, photo essays and games together on a web-platform to explore what having these disorders feels like. People with lived experience of the particular mental health issues have been strongly involved as subject matter experts and co-creators of all

media pieces (for a detailed description of the project and design process see Rana & Rusch, 2014).

Perfection is a game about the eating disorder anorexia nervosa, a disorder that is often highly incomprehensible to people without firsthand experience, and that is fraught with misconceptions (e.g. persons with anorexia do not eat because they want to look thinner). We arrived at the game's metaphors and mechanisms in collaboration with a subject matter expert with lived experience of anorexia. Key to the game's design was the subject matter expert's assertion that the eating disorder was not really about food or the body per se. The drive for what is perceived as the "perfect body" is actually a drive for a more fundamental control over one's emotional life. Emotions – both good and bad – are experienced as threatening, because they are uncontrollable. Starving oneself is a way of keeping those emotions in-check, of disengaging from a world of desires and protecting oneself from emotional harm. We chose this subjective approach to the game's design over an attempt at modeling a textbook description of anorexia because we believed that an authentic expression of someone's actual experience is more "real" and has more potential for resonance than a more objective checklist of symptoms.

The game's core metaphor is the body as garden. The game aims to align the player's mindset with that of a person with anorexia by suggesting a (false) win state (= perfection) whose pursuit has devastating side effects. The game suggests that a perfect garden is devoid of slugs and weeds. To achieve perfection, the player would need to eliminate these unwanted elements until only the pretty flower in the middle remains. The conflict of the game revolves around garden saturation. Watering the garden increases its saturation, the flower flourishes, but so do the weeds (=representations of unwanted body aspects), and the numbers of slugs (= representations of unwanted emotions). Eliminating slugs by moving the mouse over them in a scrubbing motion (=

a metaphor for exercising) decreases saturation, as does parching the garden. De-saturation further kills the weeds, enabling the player to rip them out, but it also damages the flower.

The game is structured in three stages in which an increasing number of weeds must be eradicated (= representing increasingly higher weight-loss goals). At the end of stage three, when no more weeds are left, the Perfection ending is reached. This ending, though, has come at the cost of a healthy flower and equals "starvation". Another (true win) ending – Imperfection – is hidden in the game, which encourages the player to challenge the previous assumptions and change behavior. To reach it, players have to consistently keep their garden within an ideal saturation range, learn to accept the slugs and weeds and to nurse the garden back to health. While the eating disorder may never fully be "forgotten", there are good chances to overcome it, which is why this game has a win state: "Imperfection".

Figure 1. Perfection

The game as a whole is systemic, meaning that players are not

forced down a linear path. While we aimed to seduce players to go initially towards the Perfection ending, the ending that players actually reach first is solely dependent on their actions; either path is available to them at any time. Players can also remain in perpetual limbo between Perfection and Imperfection if they try to balance watering the garden with ripping out weeds and killing slugs. This balancing act represents the struggle of a person recovering from anorexia to get healthy, while at the same time not being ready to let go of old patterns.

Description of the user study

Our main research question for this study was how playing the games impacted therapists' experiential understanding of the modeled disorder (and their empathy with and attitude towards persons with the disorder). This study was approved by our university IRB. We recruited sixteen therapists through email using a recruitment flyer. When providers contacted us to state their interest in the study, we set up a time to review the consent form. After the consent form was signed, the study began.

Therapists first completed a survey and a voice-recorded interview that touched upon demographical data, professional and gameplay experience as well as personal and professional experience with the disorders modeled in the games. Therapists were then asked to play the four *For the Records* games, including *Perfection.* Fifteen of the sixteen recruited therapists played *Perfection*. All games are web-based and were played on a computer with keyboard and mouse. Research personnel (typically working in teams of two) observed the participants as they played and took notes of their observations (e.g. where did therapists get stuck, what reactions to the game could be noted in terms of body language, facial expression and other verbal / non-verbal utterances). When therapists ran into usability problems, researchers provided only the prompts and hints needed to continue gameplay. Similarly, they trouble shot technical

problems when they arose. Researchers asked therapists to "think aloud" as they played the games. When players expressed feeling stuck as opposed to experiencing a usability issue, researchers would prompt therapists to reflect on their game behavior and what they might do differently. After playing the game, researchers debriefed the therapists about their experience, paying particular attention to the connection of their experience to their interpretation and understanding of all game elements. This debriefing interview was also voice recorded and took approximately 30 minutes.

We inductively anlayzed the voice recordings and gameplay observation notes for the therapists' responses to and understandings of *Perfection* as well as their gameplay strategy (e.g. what did therapists try to do in the game and why?). In our initial analysis, we searched for common themes about the therapists' game play experiences and attitude changes, as well as themes surrounding their understanding of anorexia, challenge of previous assumptions, their empathy and acceptance.

Well Designed? The Experience of Playing *Perfection*

The question of whether games as artistic expressions of mental disorders can promote learning and increase understanding of those disorders hinges first and foremost on the quality of the design itself. Our gameplay observations of the therapists revealed that they mostly played the game as designed and they enacted the intended modeled behavior. Some therapists (5 of 15) did choose to primarily water the garden and reached the Imperfection ending directly. However, most therapists (7 of 15) were in fact seduced into scrubbing away slugs and pulling weeds to initially reach the Perfection ending. During the post-game play interview, all of the therapists reported feeling overwhelmed, anxious, frustrated or even sad while playing *Perfection*, emotions anticipated by the game's designers. They generally connected this aspect of the game with the idea that

trying to be perfect is exhausting for individuals with anorexia. One therapist emphasized that initially it felt good to try to get rid of imperfections but then increasingly it felt hopeless.

We were surprised to observe that five therapists initially resisted letting go of scrubbing the slugs despite recognizing the importance of watering the garden after reaching the Perfection ending and even commenting that they should let go of the scrubbing and pulling behavior. Instead of letting go, these therapists tried to balance watering the garden with scrubbing away the slugs. When this occurred, they became visibly agitated and reported that they were feeling annoyed and frustrated that the game did not seem to be progressing or that they didn't know what to do next. This seemed like a type of recovery behavior, accepting that they must eat to live but not totally willing to let go of the anorexic-like behavior to eradicate and control imperfections. This may parallel an addiction-like process within the experience of anorexia where people struggle with letting go of the concrete and immediate gratification and need to adjust to living with and accepting a less controlled, less seemingly perfect way of being.

Toward the end of the debriefing interview, we asked each therapist whether *Perfection* corresponded with their idea of anorexia by requested that they select one of four options: close correspondence, mostly accurate, somewhat accurate, or missing the point completely. The therapists overall did not give *Perfection* a high correspondence level rating with anorexia — a majority (7 of 15) reported it was "somewhat accurate," the second lowest rating (see Table 1). There was no distinction in ratings between therapists that reached the imperfection ending directly and therapists that reached the perfection ending first. We found this surprising as the group generally enacted the intended game behavior or recovery behavior that was of the anorexic mindset, experienced the intended emotional reactions

and connected aspects of the modeled disorder and experienced emotions with the possible experience of anorexia.

Table 1. Therapist Correspondence Rating for *Perfection*

Correspondence to anorexia nervosa	Close Correspondence	Mostly Accurate	Somewhat Accurate	Missing the Point Completely	No response
Number of therapists	3	1	7	0	4

However, we did not anticipate how loaded games are as media and how that influences processes of understanding and interpretation of the portrayed content. Using games successfully to increase empathy hinges not only on the successful modeling of the disorder with rules and mechanics. It also depends to a large degree on a players' relationship with the medium itself. Our observations suggest that the design of *Perfection* successfully captured the salient aspects of anorexia. But, we identified several barriers to understanding the relevant mental health disorder when using games as the vehicle of communication that go beyond the design itself including therapists relationships to games and the credibility of games as artist media. Knowing about potential barriers to understanding can influence which design direction we choose for which target audience, how we determine the game's purpose and the context we envision in which a game should be played.

Barriers to Increased Understanding: Therapists' relationship to games

We observed that one barrier for increasing understanding of a modeled disorder such as anorexia is the gameplay experience of the group. Our therapist players were not gamers. Only two (2 of 15) therapists indicated they had any experience playing games beyond an occasional casual or social game or retro console during childhood. The therapists seemed to lack the gaming

language, UI conventions and control scheme knowledge to contextualize how to interpret usability issues (Hsieh, Lester, Moreno-Ger & Torrente 2012). Their lack of gaming experience may have made usability issues more severe. The version of the game that served as the basis for the user study (there exists now a final, more polished one in which the noted usability issues have been fixed) also contained a few usability issues, such as subtle or misleading interface feedback (i.e. it was hard to detect changes in the garden, the saturation meter did not draw player's attention and the weeds, which could only be pulled when turned brown returned with a brown color upon watering, suggesting they were dead, not newly sprouted). The combination of these may have contributed to frustration and anxiety during game play, which is difficult to disentangle from emotions modeled by game play (e.g. frustration).

Usability issues may also have shaped some of the game play experience. Two players who reached the imperfection ending directly appeared to pursue watering the garden to the optimal saturation level because they experienced usability issues with the weeds and slugs. One player could not operate the mouse controls to pull the weeds and then was unable to use the mouse to scrub the slugs. This person abandoned trying. Another player also could not pull the weeds, although the player was scrubbing the slugs properly. As this person didn't perceive that she was actually scrubbing away the slugs, she then also abandoned trying. Both players continued to click the watering can to reach imperfection because it was perceived as the only successful interaction. They reached Imperfection not because they failed to buy into the anorexia seduction, but because they were unable to interact with the game properly. Although frustration was an intended in-game emotion, the visually observed and reported frustration experienced by these players was due to their inability to interact with the weeds and the slugs.

Another player who reached neither game ending before the

game suddenly froze, experienced similar usability issues with operating mouse controls to pull the weeds. This player became very frustrated and confirmed that she was unsure if she was supposed to be frustrated with the game because it was the intended response or if the game just wasn't working. Those who were not seduced by the game due to usability issues do not really count here in regard to assessing the design's principle correctness. But it tells us a lot about the importance of usability and accessibility for this target audience.

The cumulative effect of usability issues was particularly problematic for our non-gamer group because it added to their pre-existing gameplay insecurities. Their insecurities seemed to get in the way of just observing what was going on in the game and being open to experience during game play. We were surprised to observe that twelve (12 of 15) therapists appeared self-conscious, insecure, without reference to whether they reached the Imperfection ending directly or the Perfection ending first. They commented that they felt insecure in their gameplay ability both while playing *Perfection* and during the post-gameplay interview. Twelve therapists repeatedly apologized and seemed anxious about "making a mistake"; if there were any game errors, they assumed it was due to an incorrect action on their part. Three players reported that the mere thought of playing a game, before they had even started, was stressful to them. Of importance, players who exhibited insecurities also doubted their initial understanding of the game's metaphor relationship to the experience of anorexia. Six therapists explicitly doubted and dismissed visceral reactions and first impressions elicited by the game, feeling that these could not be valid as they were non-gamers who could not correctly play the game.

Barriers to Increased Understanding: Credibility of Games as Artistic Media

Lack of therapists' game savvy seems related to their skepticism towards games' potential as insightful / educational artistic media. While they said in the pre-game interview they thought games could tackle serious themes, they revealed later on that they expected them to do so in an openly educational (and literal) way and that the target audience for such education was probably only children. Six out of fifteen therapist players who envisioned using games like *Perfection* with clients assumed the appropriate clients would be children or adolescents, reflective of a view of the medium as toy rather than as a therapeutic tool.

Therapists further critiqued the game's metaphorical nature (something that would no doubt be accepted about a poem or other, established art form used to express aspects of the human condition). They doubted the potential of a game about anorexia to increase understanding of the disorder, if it followed an artistic rather than a textbook approach where the body was not literally depicted. When we probed therapists to describe the reasons for their low correspondence ratings, four expressed concerns that the metaphor did not more explicitly reference the human body so they could make a more literal connection to failing health and distorted body image while playing the game. Additionally, five therapists expressed concerns that the complexity of the metaphor and overall gameplay caused them to hesitate using the game in practice. One therapist explained that they believed the game was too metaphorical to play and connect with anorexia without knowing more about anorexia; this therapist believed that they made the metaphorical leap due to their professional knowledge as a therapist. Another therapist player who gave *Perfection* the highest correspondence rating reported that she would not use the game in practice because the game and metaphor are too complicated for her to guide others through.

These comments may be reflections of the primacy of scientific method and objective ways of knowing in mental health and psychology. Professionals educated in this manner may favor traditional media over the experiential approach in games. Therapists want to *see* and *cognitively understand* the game elements, rather than interpret the game's dynamics and their emotional reactions to them as vehicles of understanding. This may be an important implication for future designs, including how to build expectations for players when using games.

An artistic, metaphorical approach can stimulate an instant emotional reaction that is in line with what the game is intended to model and it does not matter if players understand upfront what the game is about and what each element means. It is still possible to leverage the *experience* of playing the game and then dive into an interpretation of the game and connect what has been emotionally felt to a cognitive understanding. The post-reflective mind does not always need to come first. Pre-reflective, embodied experience can just as well be a gateway to understanding. However, for players not attuned to this communicative power of games (which is unique to games as media!), it may initially be a barrier to understanding. No other medium asks us to decode its meaning through its experiential structure, through the interpretation of the emotions the moment-to-moment gameplay gives rise to.

Countering Barriers to Understanding

Obviously, having a highly accessible, rigorously usability tested and bug-free game is key component to increasing the ability of players to not only play but also understand the game's content. Apart from this rather obvious lesson, we found that due to its metaphorical nature and its heavy reliance on its experiential structure as the gateway to understanding, *Perfection* requires explanation and prompting to increase players' intellectual understanding of the modeled disorder. Since it seduces players

to enact "bad" behavior, this behavior needs to be pointed out to players to reach reflection level. Just like a person with anorexia might not be aware of her or his destructive behavior, players of *Perfection* aren't either. For the game to be effective as a teaching tool, though, people need to be able to note the parallels between what they do in the game, and to how this is "typical" behavior of a person with anorexia. If the players neither notice nor reflect upon it, they cannot learn. Critical reflection is a pre-condition for true learning (Gee, 2003, 39-40; Klopfer, Osterweil & Salen, 2009).

Paras and Bizzocchi suggest the inclusion of "reflection mechanics" into the gameplay. They point out that the educational opportunities afforded by videogames are similar to 'active learning,' which emphasizes the process of reflection. (see Paras & Bizzocchi 2005). They observe that during the flow state players enter into when playing, reflection gets pushed into the background: "Though the act of gaining knowledge or skill may take place, learning is not fully realized unless the player reflects on the events that took place during the experience." By incorporating reflection into the mechanics themselves, this issue could be alleviated. Their example is a hockey game aimed at teaching players how to play safer hockey:

Players that engage in concussive activities are forced to sit for a while and consider the seriousness and the implications of concussion effects, just a [sic!] player would be forced to sit in a live hockey game. The act of reflection is incorporated into both the core mechanics of the game, and the fantasy experience of the game world. During the reflection period, it is likely that the player will not exit the magic circle, and the reflection period will encourage the player to learn how to play better, safer hockey. (see Paras & Bizzocchi 2005).

We tried to prompt reflection in *Perfection* through the ambiguous "win" state – the Perfection ending itself that was

actually a "game over". We further used messages between the different stages of the game to reinforce the theme and make players wonder about the game's deeper meaning. Only two participants in our user study actually got to play the game version that used an actual voice over in addition to the text messages text. But for those two, reflection was increased by the voice over as they wondered aloud about what it meant. For some therapists, the connection between their experience and the modeled disorder occurred during gameplay through reflective prompting, researchers encouraging "thinking aloud" – asking therapists for their interpretation of game elements as they played the game. However, the therapists mostly appeared confused when they ultimately reached the Imperfection ending. Yet, their reported ability to connect the game with the experience of anorexia later appeared to increase as they read the "what it's about" screen at the end of the game. They also began to connect game elements and their experienced emotions with the modeled disorder as our post-game play interview progressed and they were given time to reflect.

Obviously, *Perfection* does not come with a researcher that prompts reflection during or after gameplay. But taking inspiration from Gee's concept of Big G games which leverage media convergence to convey content across multiple platforms and form affinity groups (see Gee Games 4 Change keynote, 2012) – it was designed as part of a bigger project – the interactive documentary *For the Records*, which includes short films that correspond thematically to the games and aims to provide context to the individual game experiences. For time reasons, we did not specifically incorporate these other contextual components of *the For the Records* project in our user study the participants did not see the films or other materials.[1] The effect of directing players towards such contextual materials either before or after gameplay to prompt them to reflect on their playing experience should be explored. But, the issue may be best

framed as how we can best design the overall experience so to help the player develop game comprehension skills needed to be both immersed in the game and reflect on what it means/feels like for them.

One way of addressing the problem of game comprehension, particularly in regard to metaphorical, experiential games, is to include games more in media literacy education in schools. School children do not know how to interpret poems on their own, either. We cannot expect people to know how to "read" games, if they have never been taught how to do so. Admittedly, waiting for game literacy to catch up and for a new generation of game-savvy therapists to grow up might not be very practical for designers who want to leverage the expressive and educational power of the medium today.

One way to guide player expectations and to help players' make the connection between their gameplay experiences and the game's deeper meaning is to be more obvious about what the game is about. The title alone can be an important interpretative clue. We can further take inspiration from *Minority Media*, a Canadian game company who has made incredibly powerful metaphorical games about personal issues: *Papo & Yo*, a game about a boy and his experiences living with an alcoholic rather, and *Spirits of Spring*, which tackles the concept of bullying. *Minority* uses metaphor as a "magic door" to stimulate interest in serious topics. Its gameplay trailers mix metaphorical in-game action with literal live-action footage that contextualizes the metaphorical content and makes its meaning explicit. The games themselves also contain clues that connect the metaphor with its literal meaning, facilitating interpretation. *Papo & Yo* intersperses gameplay set in the metaphorical realm with cut-scenes that provide glimpses into the game's underlying, literal meaning: e.g. a little boy in a car, the drunken father who was driving and a body lying in the streets in front of the car. *Spirits of Spring* has a

narrator who speaks more and more openly about bullying as the game progresses, making it very clear what this game is about.

Conclusions

Games are usually not shipped with researchers to provide reflective prompting. Thus, a lesson to take away from this user study is that empathy games aimed at aligning the player's mindset with the inner state of another individual as modeled in the game should not solely focus on accurately modeling this inner state. Consideration should also be given to how we can elevate the immediate embodied experience of players' to the level of cognition. We added the "what it's about" page to the *Perfection* game website. Not everyone reads this page, though. It would have been more effective to prompt reflection during the course of the actual game, e.g. by way of more obvious interface feedback. The final version of *Perfection* also features voice over in addition to text inserts, drawing attention to the two competing voices of the disorder and the voice of health. When designing metaphorical empathy games, one apparently cannot be too heavy-handed in giving interpretative cues to players. Reflection is also promoted when the assumed "win state" is more openly called into question. *Perfection* is framed by the Perfection and the Imperfection ending, and while we thought that our "back to life" button on the Perfection end screen is a very direct hint that one has actually died, our therapist players usually did not understand that.

However, our observation that games are still frequently perceived as "kid's stuff" or not on par with other artistic, expressive media and thus suspect when it comes to successfully tackling serious topics such as mental health, is hard to address through an individual game's design. It requires many such games to be made and to be played by a new generation who is growing up with the medium and is thus not biased against it. Let's get to work!

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[1] The user study investigated therapists' responses to four games, not only *Perfetion* and took about 1 ½ hrs each. It would have taken over two hours to also incorporate other materials, which we found to be too much time commitment for our participants.

ZOMBIE-BASED CRITICAL LEARNING – TEACHING MORAL PHILOSOPHY WITH THE WALKING DEAD

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"Today, I'm sitting in front!"

The rain taps gently on the classroom windows, the countryside of suburban Bergen slightly distorted by the accumulated drops. "Lars" eagerly takes a seat in the front row. He is a bright young man, although his attention is pitted against the alluring opportunities of web-based procrastination, or he relies too much on his wits and too little on keeping up with the curriculum. Today, however, "Lars" is *on*. He is engaged and ready to learn, because for the next three weeks, we are going to spend time with *The Walking Dead*.

Good ideas often inspire more a sense of discovery rather than invention. Such was the case when I came up with the idea of using *The Walking Dead* by Telltale Games as a learning tool in my unit on moral philosophy. I had my intuitions confirmed after an initial trial run late on the second semester of my first year of teaching. When I later started building the curriculum for

the final unit, it was like putting together a jigsaw puzzle that assembled itself.

At its heart, *The Walking Dead* is a game about how humans cope with difficult decisions in a world where the safety of modern society is torn apart and altruism is a virtue few can afford. The game's dilemmas synergize well with teaching moral philosophy, as its setting excels at exposing the inherent differences between deontology and teleology – whether an action is good in and of itself, or if the value of an action is dependent in its outcome. It robs us of the luxury of an "easy way out" or "doing what is right"; it demands that we make deep sacrifices on order to preserve our humanity and hold on to our moral virtues.

While none but the severely deranged would kill and steal for the right to take a selfie – the epitome of self-realization in the modern world – the primal need for food, water and safety can quickly devour humankind's civil side. In the fight for survival in the lowest levels of Maslow's hierarchy of needs, the moral codes of justice and good become collateral damage.

There are no win-win scenarios in the world of *The Walking Dead*; reality is a zero-sum game at best, where one man's gain is another man's loss. The game constantly puts the player in dilemmas that inevitably have both good and bad outcomes: someone *will* starve, no matter how badly you wish there was enough food for everyone; choosing to save one person *will* result in the death of another. In a world where the walls separating good from evil are torn down, white will mix with black, and humans are left picking between different shades of grey.

The dead return

The Walking Dead by Telltale Games is a post-apocalyptic dystopian action-adventure game with a big emphasis on non-linear storytelling. The game comes in ten episodes across two

seasons, with two to three hours of gameplay per episode. Its cartoonish graphical art style has an almost euphemizing effect on the violence and brutality, where limbs are hacked off and skulls bashed. It gets its pedigree from the point-and-click adventure games of old, like the *King's Quest* and *Monkey Island* series. You control Lee Everett, the game's main protagonist, by clicking the mouse cursor on the object or person with which you want Lee to interact. You can also move Lee directly with the WASD-keys, or using a game pad. So-called quick time events sometimes interrupt gameplay, where on-screen prompts tell the player to press the indicated buttons as quickly as possible. These may appear when the player has to run away from a zombie, cave said zombie's head in with a hammer, or move a heavy object, and so on, allowing for a wide array of actions that gameplay mechanics do not necessarily support, giving the player a more cinematic experience.

Apart from these quick time events and moving around exploring an environment, the main gameplay mechanic is making various choices and decisions. These can be simple, like choosing what questions to ask, or more difficult, like choosing who to save in life-or-death situations. When the player has to make a choice, the game presents the available choices in two to four dialogue options. The variety and number of possibilities open to the player vary between situations and dilemmas, and options that will result in an action rather than a line of dialogue are marked in brackets, like [Hit him] or [Save Doug]. In certain instances, the player has limited time to make a choice, like when danger is approaching or other characters are having a conversation. A bar at the bottom of the screen indicates the time available to the player, shrinking in size as the window of opportunity closes. Failing to act within this window often results in the player, and Lee, not taking any action.

Gameplay wise, The Walking Dead is less complicated than many other games out there, although certain parts, especially the

quick time events, can prove difficult to players not used to such gameplay tropes. One of my colleagues who also teaches religion and ethics and whom I introduced to the game early last year, gave a slightly exasperated retelling of her first hours of the game, most of which consisted of her desperate efforts of running away from zombies, trying her best not to get bitten, followed by repeated failures of doing so. Fortunately, the teacher is not required to become a master zombie slayer, as students with more gaming experience can take care of most, if not all, of gameplay.

We first meet Lee, the game's main protagonist, sitting in a police car, presumably on his way to jail. A conversation with the officer at the wheel serves us bits and pieces of Lee's past – he has committed a serious crime, murder, by the sound of it. In this sequence, the game introduces us to its dialogue system, and we are given control of most of Lee's responses. As the car drives along the highway, a row of police vehicles driving in the opposite direction serve as an ill omen of what is to come, their numbers rapidly increasing, frantic messages sounding over the radio. A few minutes later, Lee's journey takes a turn for the worse – much worse.

After falling down the rabbit hole – the hole being the car colliding with a zombie and running off the road – Lee wakes up, dazed, confused and hurt in the back seat of the police car. The officer lies face down a few feet from the car, a trail of blood giving little doubt regarding his fate. The player now has more control over the protagonist, but still restrained by the handcuffs around Lee's wrists. After getting the keys from the (un)dead police officer, Lee is quickly cornered by zombies appearing from the surrounding trees. He makes a desperate dash over the forest floor, dodging zombies, rocks and branches, before clambering over a wooden fence and into a small suburb. When exploring a nearby house, Lee stumbles upon the game's second protagonist, a young girl named Clementine. Her parents are out

of town, their fate unknown, and her babysitter now among the living dead, Lee promptly takes Clementine under his wing, and they to become an inseparable pair for the most of the game's first season. From here, we follow Lee and Clem on their journey in a desperate struggle to survive in a world where the dead rapidly outnumber the living and choice always comes at a cost.

Zombie based critical learning

There are several advantages to using a game like The Walking Dead to teach a subject like ethics. These are not necessarily limited to this exact game or subject, and can with some modifications be made applicable to other educational situations. As Gee (2007) notes, critical learning requires learners to innovate and think about the domain at a "meta" level. In my experience, it is more difficult for my students to innovate and, equally important, formulate individual, original and independent solutions and answers to the tasks given to them when they have a strong conception that there is a "correct answer", or if they are working with material that simply doesn't allow or have room for individual interpretations. Enter the concept of zombie based critical learning.

We humans learn best when we learn through experiences. Stories help us remember and learn. Games let us experience the world though others' eyes, a trait that they share with other forms of media like books and films. However, video games also let us *act* through the voice, hands and feet of others, and thus creates an element of agency that other media cannot provide. Video games offer embodied experiences – through mechanics, aesthetics, dynamics, or any combination of the three – that let us ask questions that we would not be able to otherwise, or that would be less meaningful in a different contexts, and this is what makes them exciting learning tools. A tool is as interesting as what you can do with it. The premise and educational value of being able to ask "what happens if I do this?" should not be

underestimated. Of course, other learning tools and methods display similar experiences; role-playing, hypertexts, excursions and field trips, and experiments, but the wide array of different experiences that games can offer, as well as their many modalities and rich variety, enables me as a teacher to do things together with my students that would be impossible otherwise.

Learning does not come from gameplay alone. Jonas Linderoth (2012) points out that one should not assume that gameplay automatically results in new skills or knowledge. Guided instruction is important, also when using video games. In *TWD*, the player uses the same buttons to talk to people as to kill them. This vast amplification of input makes it impossible for learning to come from the mechanics alone. Rather, there is much more utility in the aesthetics: the way *TWD* simulates human interaction in complex moral dilemmas. Playing the game is therefore only part of the learning process.

"A game isn't automatically fun just because it's about pirates" (Squire, 2011), and the same goes for games about zombies. What separates the good games from bad lies in the polish of the game experience, not in the content (Squire, 2011). Games should not be substitute for guided instruction, as they are not as adaptive or sensitive to the individual student's educational needs and questions. Rather, games can provide a narrative framework aiding the construction knowledge. For games to be good learning tools, it is important for teacher and students to clarify and implement this knowledge though a debriefing, and together draw connections from the experiences from the game into genuine, real-world contexts. Nicola Whitton (2014) explains the benefits of using games as starting points for learning: "The framework of a role-playing or adventure game, for example, creates a setting in which challenges make sense and become meaningful within the context of the game". Using The Walking Dead as such a framework, learning becomes "not […] a set of abstract and unconnected tasks but as a meaningful and

purposive series of activities leading to an end goal" (Whitton, 2014). Rooting instruction and discussion in the dilemmas of TWD, learning becomes an interconnected whole, with the narrative of the game forming the framework of learning about ethical theories, as opposed to "abstract and unconnected tasks".

Furthermore, video games have a certain disarming quality about that take the "schoolness" out of school, which in turn creates a risk free, playful environment where there is not one right answer and the students are free to form and express their own hypotheses and opinions. This can be of special benefit for students normally afraid of raising their hands in class. When teaching with *The Walking Dead* (and other video games for that matter), I often find the class as a whole is more actively participating in discussions. Stig Andreassen, a master student at the University of Bergen, also reports similar findings in observing our classes play *The Walking Dead*. One of the teachers Andreassen interviewed reported that "the students had already started to use the philosophical terms within the field correctly in the first class, which she had not expected" and that "students who normally remain silent and disinterested spoke up and was engaged in the class" (Andreassen, 2015). Whether this is due to the novelty of commercial games in school, as discussed above, or the fact that *The Walking Dead* quite simply is a good game is difficult to conclude – my guess is that it is a combination of both.

Now, the key element to zombie based critical learning is this: the game provides an experience that is inherently different from what the student would expect in everyday life. This may seem counterintuitive at first, but this mismatch provides the student with acres of fertile, unbroken ground in which he or she can grow their own knowledge; it creates a wide space in which the student and innovate and become producers of new knowledge. Coming back to *The Walking Dead*, the game presents the students with dilemmas they most likely have not thought of

before, and this creates room for the innovation that is so crucial for critical learning. The game's post-apocalyptic setting lets us focus in the dilemmas and ethical theories themselves, rather than worrying about the moral implications of discussing abortion or capital punishment. Moreover, dilemmas like the latter two often come so heavily laden with baggage, having been discussed *ad absurdum* in the news media, to the point where there is little space left for innovation; the earth barren and unfertile.

In order to reach what Gee (2007) refers to as critical learning, learning how to "think about the [semiotic] domain at a "meta" level as a complex system of interrelated parts", they have to be able to abstract the core concepts of moral philosophy and apply them to other, real-world situations. In other words, they have learn how to connect the meanings of utilitarianism, relational ethics etc. from instances in the game to new instances in other contexts.

We can carry this concept over to other subjects – you do not need zombies to teach moral philosophy, or indeed other subjects – but the core if it remains. The mismatch between the contents of the game and the final learning goals of the subject is a productive mismatch, since this creates more space for the student to formulate creative and innovative solutions to a problem.

There is one final, important step to this learning process: debriefing what students learn during gameplay, and implementing this in real world scenarios. This is where critical learning comes in. Here, knowledge gained though or alongside gameplay is implemented in the real world, evaluation focusing in to what degree the student is able to abstract and implement this knowledge in contexts that are separate from the video game context.

Teaching with zombies – The Walking Dead and ethics

The basic structure of my *TWD*-class is like so:

The unit starts with a short presentation of the four ethical theories I want my students to learn: consequential ethics, ethics of virtue, relational ethics, and ethics of duty. Gameplay follows short, displayed on the classroom projector. Students do the actual gameplay, passing a wireless controller around among the class. Upon encountering a dilemma, we pause the game, and for the first four dilemmas, I give a short lecture on each theory, linked to a suitable dilemma demonstrating the nuances of the theory at hand. I then ask my students to discuss how to solve the dilemma based on the theory just introduced. I talk to the individual groups and summarize the various arguments before we put the solution to a vote. I create a poll using an online survey tool called *Kahoot* (getkahoot.com), which allows each student vote anonymously with their cell phones or laptops. Whatever alternative gets the most votes is the one we act on in the game. When we have gone through all the ethical theories and the students have "unlocked all the skills", as it were, and they are free to use any theories they find suitable for each dilemma.

It can take as much as thirty minutes from the moment the game starts to the point we encounter the first dilemma. Some teachers (and indeed some students) might object to spending this much time without any actual learning taking place. However, I find this a necessary investment for the experience to become meaningful, and to develop a close bond to Lee and Clementine. Without such a bond, relational ethics becomes all but irrelevant, and players will probably treat the two protagonists with less empathy than they would after getting to know them over the initial minutes of the game.

After a dramatic encounter with the living dead, Lee and Clementine arrive at the farm of an old man, Hershel Greene.

Hershel is immediately suspicious of Lee, and proceeds to inquire about his past. This faces the students with two options: Should Lee cloak his past in the veil of a white (grey?) lie, or come clean and confess? In this dilemma, I introduce them to ethics of duty and Kant's categorical imperative. We judge the moral value of the act based on whether the act is good in and of itself. Most of my students concluded that it is not in keeping with ethics of duty to lie, since lying in and of itself is regarded as morally wrong.

In the next dilemma, the player has to decide whether to save Duck, a young boy, or Shawn, a young adult. Here, I introduced my students to consequential ethics and utilitarianism, asking them to base their decision on this ethical theory. Here, many of my students argued that Shawn is much more useful than Duck, since Duck is a young boy who is physically weak (and, according to some of my students, really *really* annoying), while Shawn is strong and of much more use. On the other hand, other students argued that we should save Duck, since we're depending on his family to give us a ride away from our current location, thus arguing from an egotistical consequential perspective.

An important part of the unit is analyzing the overview of how the player choices look in comparison with other players worldwide, presented at the end of each episode. Consider the following figure, which is a screenshot of what my latest class of students decided to do in each dilemma of episode 1. Notice that while most players, along with my students, have chosen not to lie to Hershel and to save Carley, the three dilemmas in the middle are much more evenly balanced. What can we conclude from this? My class and I agreed that the first and last dilemmas are a bit easier than the others: we have little to gain from lying to Hershel, and Carley got chosen over Doug simply because she is more useful than him; she is a good shot and physically fit, while Dough is a tech geek who is a bit on the heavy side. The three dilemmas in the middle, however, present the player with

having to choose between different shades of grey, as the values in each dilemma are very evenly weighted. My class also noted that the different ethical theories gave widely different solutions, depending on whether the given theory was deontological or teleological in nature. This led my class to conclude that there isn't necessarily an obvious right or wrong answer to an ethical dilemma, it all depends on your moral standpoint.

Figure 1: The result of my class' latest playthrough of The Walking Dead episode 1

My students sometimes expressed frustration over the fact that some of the dilemmas in TWD results in the same outcomes no matter what you do. To this, I answer that the actual consequence is not as important as the reflection the dilemma itself provokes. As Stephen Beirne points out in discussing saving vs. harvesting Little Sisters in Bioshock: "the fact of the dilemma as a (effective) framing device establishes it as meaningful, as impactful on narrative, regardless of consequences" (Beirne, 2014).

The final element in the unit is the last part of zombie-based critical learning: the debriefing and implementation of the learning goals of the subject matter. In this part, the game is no longer a part of the learning process. Instead, I arrange the

students into groups, and ask them to pick from a list of real world dilemmas, or choose their own. Now that the core knowledge is in place, the students are prepared to tackle contemporary issues with the right toolset, like abortion, capital punishment and euthanasia, for instance. I evaluate them based on how they are able to abstract knowledge of ethical theories acquired during gameplay and apply these models and theories, how they compare and contrast the theories against each other, and how independent they are in doing so.

Too many mouths

Venturing deeper into the ethical and pedagogical possibility space of TWD, I wish to spend some paragraphs exploring one of my favorite dilemmas from the games. In this particular conundrum, taking place in the beginning of episode two of season one, Lee, Clementine and the rest of the surviors have taken shelter in an abandoned motor inn. Cars, dumpsters, bits of plywood and rusted sheet metal serve as impromptu walls, lining the perimeters of the inn. Bringing back two survivors from the episode's first encounter, Lee and his companions, Mark and Kenny, are greeted by a shocked and frustrated Lilly, scolding Lee and the others for bringing two more survivors, one badly injured, back to the safe house. The groups' supplies are already stretched thin, and they simply cannot cope with any more survivors, especially if they are dead weight that cannot contribute to the group's survival. A heated argument breaks out, and an exasperated Lilly, who until now has been in charge of handing out supplies, hands this responsibility over to Lee, refusing to bear the burden this time around.

Now it is up to Lee and us as players to decide: who gets to eat, and who has to go hungry for another day? There are nine survivors, eleven if we include the two newcomers (one who is passed out and unable to eat on his own), but only food enough to feed four. Who should get to eat, and why? Should we feed

the young and innocent kids? Should we feed Larry, the grumpy old man who carries a deep grudge against us? Larry may be old, but he's built like an ox and is responsible for maintaining the lair's defenses, and will need to keep his energy up. Or should we feed his daughter Lilly, to see if we can't get him to come around? What about the adults who are on hunting duty, shouldn't they get a bite to eat, so they'll have the energy to provide for the rest? Or should we use the food to forward our own selfish motives? Carley sure seems to have taken a liking to Lee, after all…

While most require the player to choose between two to four alternatives, this has a far greater range of solutions, and one can argue for and against feeding each survivor using all the different ethical theories. We can take the utilitarian approach and feed the ones who need energy to be the most useful to the group, such as Larry, Mark and Kenny. A common deontological norm is to provide for the women and children first – Clementine and Duck, and Katja and Carley. Relational ethics would also argue in favor of Clementine, her safety and well-being is Lee's and our responsibility, after all. Lilly has been under a lot of pressure lately; the virtue of fairness would certainly dictate that she gets to eat. Mark surely also deserves something, it was he who shared his food in the first place. It's possible for Lee to feed himself as well, although, wouldn't that be committing the vice of selfishness? "Gotta keep my strength up too…", Lee mutters, as he pockets the last piece of jerky.

The list goes on and on, and many of the survivors stand on equal ground when all the arguments and moral theories have been considered. So who did my students pick? Let's have a look at the statistics. This table displays the voting results in five of my classes. My students discussed in smaller groups, and each group voted on the four survivors they decided deserved to eat.

Table 1. The result of five classes voting on the second dilemma of TWD episode two, season one.

Who gets to eat?	Group 1	Group 2	Group 3	Group 4	Group 5
Lee	50 %	23,10 %	47,10 %	50 %	50 %
Clementine	70 %	100 %	76,50 %	80 %	88,90 %
Carley	60 %	76,90 %	41,20 %	20 %	55,60 %
Mark	40 %	69,20 %	76,50 %	50 %	38,90 %
Larry	5 %	7,70 %	0 %	10 %	5,60 %
Duck	55 %	69,20 %	47,10 %	40 %	72,20 %
Kenny (Duck's father)	40 %	23,10 %	70,60 %	50 %	22,20 %
Katja (Duck's mother)	15 %	0 %	41,20 %	30 %	27,80 %
Lilly (Larry's daughter)	20 %	23,10 %	17,60 %	50 %	55,60 %
Stranger #1 (Ben)	0 %	7,70 %	5,90 %	10 %	5,60 %
Stranger #2	15 %	0 %	0 %	10 %	0 %

One survivor stands out like zombie in a cornfield: Clementine came out on top in all five classes. Other lucky winners are Duck, Carley and Mark, but poor Larry is as unpopular as the two strangers (one who, remember, is mortally injured)!

It would seem that relational ethics takes precedence over all the other theories, even consequential ethics, which arguably is of

most utility when one's survival is at stake. Ethics of virtue and duty can explain why Carley, Mark and Duck get such a high ranking as well, while possible justifying why Larry has to go hungry for another day.

Long Road Ahead

In conclusion, I will remark that basing learning on an immersive, engaging experience that is immediate and accessible to a majority of the students is a great benefit for many types of learners. Being able to practice recent knowledge in meaningful, interactive environments is an opportunity our students get all too seldom. Having played *The Walking Dead* together gives us an experience we can always come back to, talk about and reflect upon. Moreover, the knowledge that my students have gained in tandem with a gaming experience seems to stick a bit better than facts without such an experience – it seems to promote learning retention. More research is required to conclude if my anecdotal claims have any validity.

Good video games are all about the experience, and I postulate that the same goes for good learning. Video games, when used correctly, can provide a context that makes for just that, and can be a great benefit for students and teachers alike. Preferably, the gaming experience and the learning experience should be interwoven, but one should not replace the other, and I can't stress enough the fact that learning does not end then gameplay does; rather, the gaming experience is the *beginning* of learning.

I still bump into my old students from time to time, and they all tell the same story: "keep playing The Walking Dead in your classes, that's the one thing we remember!". While I certainly hope that more of my teachings stay with them after they graduate, the stories they and the excitement they tell them with does more than warm the heart of a young teacher who's only been in the game for three years.

Good games make for good experiences, and I delight in sharing these with my students. I do not know if my students learned "better" than they would with more conventional methods, but to me that's not the point. To me it's all about creating good learning experiences for my students, and to make sure that what I teach my students stay with them for the years to come. And if zombies truly are the ultimate tool for learning about moral philosophy, then so be it.

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DISTRIBUTED TEACHING AND LEARNING SYSTEMS IN DOTA 2

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One theme that has been somewhat underdeveloped in the games and learning literature is the role of teaching in and around games. Many studies tend to focus on the rich learning that happens through gameplay without directly addressing these as teaching interactions as well. Gee's seminal *What Video Games Have to Tell Us About Learning and Literacy* (2003) is a prime example; the 36 learning principles Gee outlines, such as "designing multiple routes to participation" or the "amplification of input," are not just ways in which good learning occurs but are also key strategies for good teaching. Squire's excellent *Video Games and Learning: Teaching and Participatory Culture in the Digital Age* (2011) similarly tends to privilege the kinds of learning that happen through gameplay while underselling the specific ways these games function as teachers in their own right, though Squire does reflect on teachers as designers of learning experiences much like game designers shape the play (and learning) experiences of their games. While much maligned, the gamification literature largely captures something about the ways games teach, although it is often limited to issues of motivation and engagement rather than deep insights into

teaching practices outright. Gamification interventions such as Sheldon's *The Multiplayer Classroom* (2012) or Kapp's *The Gamification of Learning and Instruction* (2012) also tend to get tangled up in the metaphors of gaming (like levels and points and roles/classes) which can interfere with the truly meaningful insights games provide into teaching. Salen et al. (2010) perhaps address most clearly the ways games teach in their Quest to Learn program by leveraging game-like design in their instructional practices, though again the relationship between games and teaching is still left somewhat tacit. I don't doubt that these and other game-based learning theorists recognize that game design features are teaching features, though it is striking how few explicitly address the issue.

This article is meant to directly describe the ways a game—in this case, Valve's *Dota 2*—teaches and to point out what that might tell us about teaching more generally. *Dota 2* is a well-designed and well executed game, and like many other games includes features like a tutorial and in-game library which are relatively clear instances of teaching. What differentiates *Dota 2*—and what makes it so illuminating in terms of broader themes in teaching—is the way Valve has designed additional teaching "channels" which leverage the affordances of the game client and work together to teach the complexity of the game. These channels utilize other players as teachers; that is, Valve includes features which are "activated" by other players who perform the role of teacher using affordances of the game itself. For example, the game includes a "coach" mode where a player can invite another player into their game and the "coach" can mark up the player's map, control their camera, and has a dedicated chat channel. *Dota 2* is made up of multiple designed teaching systems which use the tools of the game to teach (like the tutorial) as well as other "designed-for-emergent" teaching systems which invite players to be participant teachers.

Furthermore, like many modern games, *Dota 2* has spawned a

number of emergent teaching spaces like YouTube videos or theorycrafting websites which are outside of Valve's direct designs but which still serve as vital channels for teaching and learning. The relationships between these various designed and emergent teaching systems and the way they work together are especially compelling. These different sites may use very different teaching methods (some highly didactic, some demonstrative, some interactive or based around dialogue and debate), so *where* a learner goes can deeply influence *how* they are taught. A broad view of teaching and learning that considers multiple "nodes" of learning suggests something very rich about learning and the many trajectories it may take for any learner, and about the many forms of teaching they might encounter. Perhaps most importantly, because some of these distributed teaching sites are outside of the control of the designer, the relationships between these various sites highlights a tension about who is responsible for teaching and learning—a tension many contemporary schools face with the rise of the internet and other digital media as legitimate sites for learning. Increasingly, learners can customize their experiences and have more power to arrange teaching and learning sites that suit their interests (for good or not). The ways *Dota 2* leverages many of these emergent sites—but is also subject to those it cannot control—provides an interesting model for how modern institutions (like school) can find a place in a digitally networked 21st-century world.

To deal with these complex distributed teaching and learning systems, this article extends a pair of related concepts: Gee's (2003) notion of "big 'G' Games" and Jenkins et al.'s (2006) idea of an ecology of media and communication technologies. Big G Games, for Gee, include not just the game itself (what happens on the screen) but also a range of other activities and sites like YouTube walkthroughs and tutorials, guides and FAQs, web forums, "theorycrafting," cosplay, machinima, fan fiction and many others. Together, these activities make up the Game, and by

considering the many different sites for participation we might gain a better understanding of what playing games really entails. Jenkins' idea of an ecology of media technologies follows a similar epistemological bent, where the relationships between various media forms and participants and the "cultural communities" (2006, p. 8) which negotiate practices around them serve as a more informative and meaningful way of thinking about media interactivity. Both of these views provide an interesting lens to think about the way teaching happens in and around games, especially a game like *Dota 2* where there are many sites where teaching occurs. This article looks at *designed teaching systems* in the game (such as the in-game tutorial and knowledge library), *designed-for-emergent teaching systems* (including the "coach" mode and the streaming/spectator mode), and outside-the-game *emergent teaching systems* (especially Twitch.tv and the theorycrafting site Dotafire.com) in order to show how these teaching systems are distributed across the Game (after Gee's term) and form an ecological network of teaching systems (in Jenkin's terms).

Dota 2 and teaching

Dota 2, formally known as *Defense of the Ancients 2,* is developed by Valve Corporation. It is a Multiplayer Online Battle Arena (MOBA), a sub-genre of Real-Time Strategy (RTS) games, played online in cooperation with and competition against other players. Two teams of five players each attack the opposing team's base while defending their own. There are many different strategies possible depending on the composition of each team and their plan of attack ("rushing" the opponent with all 5 players, fighting a battle of attrition, playing "hit-and-run," and so on). *Dota 2* also has a very large "professional" competitive scene, one of the most important factors in *Dota 2*'s popularity as it is both a participatory and spectator sport.

Dota 2 faces a particularly difficult challenge in that it is a very

complex game with over 100 heroes, hundreds of abilities and pieces of equipment, and countless potential strategies. The game must teach the player the basic elements (what the goals are, what success and failure look like, techniques to achieve these and so on). Players must also navigate multiple semiotic domains (the mechanics of the game as well as interface elements) so a player needs to learn how to operate both the operational and conceptual levels of the game. To play successfully, they must also learn somewhat abstract strategies for reacting on-the-fly as the game changes through the course of play. Furthermore, because of the highly social nature of the game, there are complex social practices around playing the game that players must learn in order to participate fully in the gameplay experience. These include things like terminology, team composition and strategies, trends in play styles, social conventions and others. Participating in the Game (in Gee's term) requires navigating these social realities as well as the "technical" ones of the "little 'g' game."

The in-game tutorial only covers an almost superficial amount of the actual learning necessary to master the game; it introduces some key features, ones that are absolutely necessary to playing but which hardly account for the deep and sophisticated knowledge it takes to "learn" the game. The tutorial modules are there to *begin* the learning process for the player, and to shape their initial experience and give them a frame for their continued play, but mastery requires tremendous effort by the player. Of course, it's possible to argue that the joy of gaming is in discovering rules and strategies on your own (Koster, 2007), and no tutorial will completely cover every possible concept fully. It is no surprise, perhaps, that the tutorial is only a starting place.

Valve's unique solution to deal with the complex teaching necessary for mastery beyond the tutorial is in those other teaching channels which include players as active peer- and expert teachers. For one thing, it reduces the amount of work on

Valve's part—they design systems which support peer teaching but don't necessarily have to develop all the content to teach, effectively "outsourcing" the labor to the players. Furthermore, in a game that regularly changes through patches, balance updates, and expansions, having a large group of participant player-teachers means that they can respond to these updates rapidly and without the overhead of re-designed "official" teaching interventions. Many players likely relish their role as participant teachers for a variety of reasons, such as supporting friends or other new players and the social cache it brings, showcasing their knowledge and skills, and even feeling part of the continued development and success of the game. Valve certainly benefits from having players dedicated to the game and engaged in actively introducing new players to it since they will likely continue providing revenue, so including as many teaching supports as possible (through their own designs and through designing tools for players to do their own teaching) is in Valve's financial best interests at the very least.

Designed teaching and learning systems in *Dota 2*

I use the term "designed teaching and learning system" to refer to many of the overt teaching features of the game; these are what might pass as obvious or common sites of teaching across many videogames, including tutorials, didactic showing/telling, descriptive text, and so on. Most games contain variations on these designed systems, although not all games do. These designed systems are insightful for two important reasons: first, they are intended explicitly by the game maker to perform the function of teaching the player how to play; second, the relative ubiquity of these designed systems across games points to their perceived importance by both game designers and players. *Dota 2* contains several of these designed systems; I will primarily focus on two (the in-game tutorial and the knowledge library) but recognize there are more examples within the game; these two simply provide compelling cases in their own right.

In-game tutorial

Dota 2's optional, multi-part tutorial covers various features of the game, from basic camera and character movement to complex, multi-player battles (essentially, the "real" game). It includes two special modules designed as "testing grounds," where players can play a match against the computer to work through the material they just learned in a safe, low-risk environment. Players can play any of the tutorial modules only after "unlocking" them by completing the previous module, but they can repeat previous modules as many times as they'd like. The game actively assesses the player's performance and acts as a gatekeeper to the player while providing a productive space for players to practice and develop strategies for their play.

The tutorial is broken into eight scenarios, each covering a different topic but also organized sequentially so that the scenarios build on top of what previous tutorial sections covered. This kind of scaffolding is a common teaching technique (see, for example, Bransford et al., 2000 or Pea, 2004) and is closely related to Vygotsky's (1933) concept of the Zone of Proximal Development where learners initially encounter limited affordances in order to reduce cognitive overload or early failure, have the support and guidance of a more-knowledgeable expert, and gradually have constraints removed once they can cope with increasing conceptual or physical complexity in the "real" task they are learning. For example, *Dota 2*'s first tutorial scenario is actually non-interactive, instead containing a 4-minute narrated overview of the basic mechanics and goals of the game. Subsequent tutorials introduce new concepts, from basics like movement and melee combat to advanced ranged combat and high-level knowledge like "last hit" bonuses and equipment management.

The game also scaffolds the kinds and frequency of teaching "interventions," many of which are highly didactic and rely

heavily on direct showing and telling. The game tells the player how to do something specifically and directly (such as how to move their character, and points out a spot on the map to move to) and then waits until the player completes that task. Module 2 includes 34 pop-up/dialog boxes, 22 of which include some kind of showing/telling prompt, as well as 7 times where the action "stops" until the player demonstrates competence with the new skill or feature at hand. By the fourth module, there are only 4 dialog boxes and 1 "stop" at the beginning of the module when it introduces the new concept of starting gear. Within the span of three modules, the teaching interventions drastically drop, and players are mainly practicing the skills they have learned and have demonstrated to the game that they can use them properly.

In-game knowledge library

The game also contains a great repository of information—and teaching—outside of the tutorial modules called the Library. This is another optional section of the game client where players can look up information about all of the heroes (currently 109 of them) as well as items and more (easily several hundred entries). Each character page includes detailed statistical information on their abilities (such as the amount of damage done or the duration) as well as additional narrative descriptions. These statistics provide concrete information for players to use when planning how and when to use various abilities during play (forming strategies for their play) as well as evidence when debating those strategies such as on theorycrafting websites. Players can then use the game as an exploratory space to contextualize that information (to make somewhat abstract statistics meaningful as part of their play experiences). The library is not unlike a "traditional" game manual in that it is a teaching and learning resource that provides background or contextual information that primarily makes sense only when used in conjunction with actual gameplay.

What makes the in-game Library in *Dota 2* different from a manual—and a more explicit teaching resource—is its multimodal demonstrations of character abilities in action. Each ability includes a video showing (modelling) a specific example of what the attack "should" look like in order to let the player know when the ability works and, potentially, how it should be used (in what situation, against what enemies, and so on). For example, an area-of-effect ability will show multiple enemies surrounding the hero and demonstrate the way the ability damages all enemies simultaneously. This modeling teaches players a great deal about the correct use of the ability, tied to statistical information, and creates a robust link to the actual context a player will use it during their gameplay. The Library can make abstract information contextually meaningful (by showing statistical information that then informs play) as well as make specific instances of gameplay more meaningful by providing additional background information (such as when a player consults the Library to look up how much damage their new ability does).

Designed-for-emergent teaching and learning systems in *Dota 2*

As described above, Valve has designed a number of systems with the *conditions* for teaching to occur but which rely on players to do the actual teaching. The game itself doesn't teach through any direct design by Valve but through players who "enact" the teaching on their own through affordances of the game client (including interface elements, chat and communication channels, and interactive components of the client). Players are supported (and even expected) to do some of the work in teaching, especially of the various social features like terms, strategies, and etiquette but also more basic gameplay as well. Like designed systems, *Dota 2* includes several different designed-for-emergent systems, of which I will only focus on three. These range across a spectrum of kinds of teaching, from nearly explicit teaching

(the "coach" mode) to implied teaching (the community "build" feature) to a highly emergent channel (the streaming/spectator mode).

"Coach" mode

In "coach" mode, players can invite friends or other players to help them play the game in real time using their own game clients to network together. Coaches can "take over" parts of the learner's game interface (remotely) and control aspects of it. The coach can, for example, make marks on the player's map or action bar that clearly call attention to them and make them salient or relevant, a feature not found in the "normal" game interface. This special mode also includes a separate chat channel for the coach and player to use that no other player has access to; it is a tool that they can use to interact "safely" removed from the view of others. Through this coach/player channel, the teacher (coach) can communicate concepts, terms, and the like to the leaner (player), who can use in turn use it to ask questions and so on.

This designed-for-emergent teaching system is meant to give players both access to a more-knowledgeable peer and to provide specific tools for teaching; while there is no prescribed teaching on Valve's part, they have designed tools which support the teaching performed by players. They have also identified or assumed what kinds of tools are important to perform these functions (interface control, marking and highlighting, a "protected" space for learners and teachers to communicate with less fear of calling attention to the learner's status and so on). In essence, they have created special conditions for teaching to occur, though it is up to players to complete the teaching act.

Community character builds and guides

Another way for players to share their knowledge and to teach other players is through the community character builds and

guides features. These are interrelated features; the build feature is an interactive tool found in the game client where players can "spec" heroes with different equipment and abilities. They can access these builds within a game and apply it while they play; they can also publish these to the community. Guides are written documents created by players which normally feature builds that other players can import directly into their game, and often also contain a great deal of didactic explanation, meta-level commentary, strategies and suggestions, and even debate through a comment system.

Like the coach feature, these are channels where teaching is meant to occur, though perhaps less directly or explicitly. Valve has built systems where the conditions for teaching are present and provided additional tools that might be used by players such as the interactive modules and the comment feature on guides but which require players to fill in the content and perform the teaching. The guides provide a sanctioned space to share knowledge and teach other players not unlike a forum but with the additional connectivity of interactive tool tips and the ability to "plug in" to the game client. Not all players may use them for this purpose. Some players may only use the build feature to test out various configurations on their own, and so the game allows them to "teach" themselves by interacting with the tool, although this is not a particularly deep level of learning since the tool is primarily meant to "plug in" to guides or for convenient access during the course of gameplay.

Streaming/spectator mode

Many modern games have vibrant streaming spaces, a feature popularized in part by YouTube and especially Twitch.tv (discussed below). Valve has added an in-client streaming mode which leverages the native interactivity of the client as an additional feature to a "normal" stream site. Players use their own game client to watch matches with the ability to access

running statistical information (such as the kill:death ratio and in-game economy) or to change their view to focus on an individual player (including that player's interface), a free-roaming camera, and even to a "directed" camera that is controlled by a commentator. Some streams do not include a commentator, but most professional or semi-professional tournament streams do. Stream channels also have a separate chat channel visible only to other streamers and not to the players.

Players enact teaching in several different ways. In the least direct way, they serve as demonstrations or models through their play; a player can watch the "teacher's" view and interface and follow along with one particular player (even across many different matches) in order to watch an expert make choices, alter strategies and so on. These expert players are teachers in the sense that they model these actions, though they may not even be aware that they serve this role (they may not know, for instance, that someone is watching them as they play); they are, in some sense, "unintentional" teachers. It is often up to the player to learn by watching (and, hopefully, have some strategy in their own mind as how to learn through this watching). Nevertheless, these player-teachers do a great deal of modeling expert play in action.

Another, somewhat more direct, form of teaching through the stream feature is through commentators. Much like a good sports commentator can break down, explicate, or analyze some part of the game, many *Dota 2* commentators provide a great deal of insight into the thinking of players, descriptions and explanations of the game in action, and "meta" commentary on the game in general. For example, during competitive matches teams take turn choosing and excluding heroes, and often commentators will discuss the choice one team made, options for countering it, strategic planning on what teams might do in their next pick or in their overall composition, and even trends

by a specific team or in the game community at large. Most commentators use a great deal of jargon appropriate to the player base and can create or perpetuate these lexical or thematic touchpoints, such as terms for strategies (like a "split push" or "support farming") or locations on the map. Again, these commentators may not directly recognize that they are teachers, but they do a variety of teaching acts throughout the course of their discussion at several levels (discursive, mechanical, strategic, meta). Valve has included interactive features in the client (such as the commentator's ability to direct the camera and a dedicated voice channel) to support commentators and their audience which can be used to teach players about the game in many different ways.

Emergent teaching and learning systems around Dota 2

Many contemporary games include a great deal of Game sites, from lore-based discussion sites to streams to cosplay websites and many others. *Dota 2* is no exception, and is indeed not all that remarkable in the sense that the kinds of activities happening in the Game are not terribly different from, say, *World of Warcraft* or *Minecraft* or *Pokémon*. These are important sites for teaching and learning and play a large role in creating, perpetuating, and changing the Game and the game. It is possible (though outside the scope of this article) to consider the various affordances of sites like forums or YouTube, but it is important to at least gesture that these various sites are used differently for different purposes and have different affordances and limitations which influence the kinds of teaching and learning that occur through them. There are many, but I will look briefly at Twitch.tv streams and the theorycrafting site Dotafire.com to highlight a few important threads.

Twitch.tv streams

Twitch.tv is a major site for live game streams, including *Dota*

2. Streams on Twitch.tv are similar to those within the game client except they are generally locked to one individual player's view or on a commentator's screen (it is not interactive in the way the in-client stream is). Many players also include a small webcam video of their face overlaid on the game screen and use a microphone to talk to their stream audience or to other players. Viewers also have a dedicated chat channel to communicate with each other and often with the streamer. Much like the in-client streams, these spaces serve as teaching sites through modeling, commentary, and player communication. Unlike the in-game streams, Twitch often focuses on the personalities of individual streamers and groups form around popular streamers; here a great deal of social maintenance happens, and these popular streamers often drive community practices by using particular builds, strategies, and terminology (like, names, phrases or jokes).

Dotafire.com

Dotafire.com is a forum site where players can post hero builds and discuss strategies (among other things) through threaded conversations between many members. Members often engage in a practice known as "theorycrafting" where they formulate complex models of how various abilities relate and work to maximize performance. These discussions, like many of the hero guides, are often quite didactic (take X ability, perform Y action at a given time) in the sense that these players are explicitly telling others what to do and how. Theorycrafting usually requires that the player provides concrete, demonstrable evidence that other players can then test out. It is a kind of "prove it" scenario in which other players can validate a theory to make a more reliable or accurate model. In a sense, theorycrafting is a rich scientific practice that relies on evidence and falsification as a core feature. A website like Dotafire.com also has features which enable debate and discussion as a native affordance.

Implications of distributed teaching and learning systems in *Dota 2*

Within the Game of *Dota 2* it's possible to see many different channels through which teaching happens, from explicitly designed systems to player enacted teaching outside of the game. This particular analysis is meant to describe several of these sites and to highlight the ways teaching occurs through these sites. Further research might explore how affordances at different sites change the kinds of teaching acts they use. This article is also meant to hint that it is possible to conduct traces of specific teaching and learning across various channels and stress the need for innovative research methodologies to follow players across their various learning trajectories or to make large-scale claims about such learning pathways.

Further, *Dota 2* is a complex and dynamic game, and no single event, nor even a set of teaching events can teach all of this complexity. An ecological view of these teaching systems shows that teaching is a deeply interconnected practice, and learning happens at many various sites. Such a model suggests that we may think of teaching and learning more properly as Teaching and Learning (following Gee's term). In particular, tracing a learner's journey through various teaching and learning sites could uncover important information about the relationships between the various kinds of sites and the kinds of teaching and learning found at each site; it could also demonstrate that it is the act of moving *across* sites that is the valuable part of the teaching and learning transaction.

Indeed, what makes *Dota 2* so compelling is that it shows that learners have some control over how they encounter and organize their learning within a Teaching and Learning system. It's easy enough to imagine the tutorial as a teaching intervention, where a player learns the basics of the game in a series of events designed by Valve. But that same learner may

also watch a YouTube "how to play" video instead of playing the tutorial and learn many of these same things (and others not included by Valve). They also might watch some professional competitive matches and learn a great deal about strategies and hero builds. They could follow-up on these strategies by looking at the in-game build guides. They might then try them out in a match, where they get feedback from the game and possibly from other players about their performance with that particular build, and then iterate in a series of matches to perfect their play or try alternate solutions (possibly after consulting theorycrafting guides or by posting their build and receiving feedback from other players). They might even be inspired by the game to create some artwork around their favorite character, and dive deeper into the in-game Library for more background on the story or their character's history. They could take this artwork to a fan site and connect to another fan to write a story or a comic around the game, and share not just their passion but their knowledge about *Dota 2*. Further research may validate or complicate this learning trajectory, but this is not a terribly unlikely path through *Dota 2*. It shows that players can customize their experiences across a network of distributed, interrelated teaching sites that the player can configure in a way which matches their interests and their need for more specific knowledge.

This model also suggests something profound about teaching in general beyond videogames. Through a distributed teaching and learning perspective, like the one demonstrated by *Dota 2*, it's possible to think about ways in which teachers can organize networked nodes of teaching, where learners access different teaching acts in different contexts (some didactic, some demonstrative, some hands-on "messing about"). These different nodes can serve different functions towards some Teaching goal. Admittedly, this may not be too far off of what many teachers do; a science classroom often has didactic teaching moments,

course readings, lab time and so on, each of which is serving a different function in the Teaching network. However, it's worth considering claims about the inauthenticity of these kinds of environments (that many of these activities are not meant to lead to "real" science but to fulfill some mandated competency) and contrast it with games (where generally learning is always aimed at playing the "real" game).

A distributed teaching and learning systems model also highlights a broader range of who and what might "count" as a teacher. A game like *Dota 2* shows that tools like interactive pop-up windows or customizable interface objects can be teachers. It also shows the power of peer and participant teachers, where many different people contribute some information or demonstrations of skill or knowledge, often passionately and enthusiastically. It even suggests that teachers don't necessarily have to be "formally" positioned as teachers (a player in a streaming game may never know who or what they are teaching) and yet can still serve as expert teachers if they are connected to learners who can translate watching experts in action into their own play.

That is not, however, the real power of a distributed teaching and learning model. This perspective suggests that teachers can design and organize *some* of these nodes (in the same way that Valve can design and organize *some* of the Teaching nodes in *Dota 2*) but not all of them; players/learners have some control and can organize these nodes to fit their needs as described above. For teachers, then, one opportunity is to leverage Teaching systems (which include emergent or non-sanctioned sites) in such a way as to enhance and support the learner's trajectories. In other words, teachers can plan, design, and organize some Teaching events as well as recognize (and hopefully integrate) other sites learner's may utilize in order to create a dynamic and complex system of learning. It is important to reflect here, of course, that this also implies that teachers are not alone in this process

but are integral agents networked with other teachers, learners, tools, and pathways. It is a bit of a double edged sword in this regard—if learners can customize their trajectory, especially through sites and teachers outside of the "control" of a teacher, they may learn something completely unintended by the teacher. This can be daunting to a traditional classroom teacher indeed.

This last point may be the most critical. One potential afforded by a distributed teaching and learning system—and one problem for an institution such as school—is that control is also distributed and, in many regards, is ultimately left up to the learner. Good designs (such as the kinds of teaching channels found in *Dota* 2) help shape the experience, but players can watch YouTube walkthroughs, talk to other players, and otherwise learn a great deal about the game outside of Valve's control (including things Valve may not want, such as cheats, hacks, or exploits). Distributed teaching and learning systems demonstrate that it is possible to organize all kinds of learning events outside of the control of any institution. This article is meant to emphasize that something like *Dota 2* is tantalizing in the way it might connect learners to many various knowledges, practices, people, and contexts that transcend one teaching and learning site (like school, for instance). It is just as important to think carefully about how those connections are made. On the one hand, we might rethink what a "class" is, how it is arranged, and who participates in the acts of teaching. If we consider that all kinds of people and things can teach, and these various teachers can be arranged and activated in particular configurations to support a broad array of learning needs, we might arrive at very different in-school teaching interventions than what "traditionally" passes for teaching in a classroom. On the other hand, learners who can organize and navigate complex distributed systems outside of the control of an institution like school challenge how we think about the purpose of school in the first place. Instead of a primary site of public learning, it

may become just one of many sites where people go to learn, teach, and participate civically. It also changes the relationship between teachers, learners, content, and practice. In short, *Dota 2* just might serve as a model for what 21st century Teaching could look like, in all its complexities.

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AN ANALYSIS OF PLAGUE, INC.: EVOLVED FOR LEARNING

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Do you think you can design a pathogen that will eliminate all of humanity? That question is the premise of the game *Plague, Inc.: Evolved.* Developed by *ndemic Creations* and early-released in 2014, this game is the computer version of the popular app, *Plague, Inc.* The gameplay is simple: Choose a pathogen to play, collect DNA points, mutate the pathogen, and try to kill all humans before they develop a cure. The learning potential of the game includes problem-based learning, model-based reasoning and creativity. The first two are possible because the main gameplay follows the key components of rational constructivism (Newcombe, 2011; Xu & Griffiths, 2011); the last is possible because the scenario creator embedded in the game supports all four types of creativity as described by Elliot Eisner.

Gameplay

Currently, *Plague, Inc.: Evolved* is a single-player game, although multi-player capabilities are in development (Vaughan, 2014). The primary gameplay uses "god view", where one can manipulate the pathogen and monitor the world's reactions. To begin, one either selects the type of pathogen to play, such as

bacteria, or selects a scenario to follow, such as the black plague. The game then shows a map of the world, including major ports, airports, and travel routes. Around the border of the map are information boxes which lead the player to more information about the pathogen or the global response. As the pathogen infects more people and spreads to different countries, red and orange bubbles appear on the map. Popping these bubbles allows the player to collect "DNA points" to use towards mutating the pathogen. The game provides three categories for mutation options: "Transmission" to adjust how the disease spreads to other countries, "Symptoms" to adjust how the human body reacts to the disease, and "Abilities" to adjust the disease's hardiness in various environments. Some pathogens and scenarios have additional mutations specific to their aims. For example, the "necroa virus" includes mutations for creating and controlling zombies and the "frozen virus" scenario allows the pathogen to devolve humans into Neanderthals.

Figure 1. Main game screen showing travel routes, basic game information, and opportunities to collect "DNA points."

As the player develops the pathogen into deadly proportions, there are three main challenges to overcome. The first challenge

concerns the disease spread. Countries with less-traveled ports are difficult to infect. Countries with strong healthcare systems prevent the spread of the disease once it crosses the borders. As the disease becomes more deadly, countries begin closing their borders and isolating the infected. The second challenge is having too deadly of a pathogen. If the disease kills all of its hosts before it infects every human, it burns itself out and the player loses. The third challenge is the global cure effort. As the disease infects more countries and people, these countries begin researching a cure. Once the cure is developed, it is quickly deployed throughout the world. Unless the player has zombies from the "necroa virus" or aggressive apes from the "simian flu," the cure reaches all living humans before the pathogen can kill them.

Plague, Inc.: Evolved has also incorporated "mods" into its main gameplay. Instead of choosing a pathogen or scenario to play, the main menu allows the player to create a custom scenario and modify most of the aspects of the game. Set as various "labs," players can create their own mutations and progressions for mutations, change attributes for various countries, create and modify how governments will react to the pathogen, add events that can drastically alter game play, and include alternate win conditions. Visual aspects of the game may also be modified, such as adding custom graphics. Special skills, such as programming abilities, are not required because the look and feel of the scenario creator is similar to that of the game itself. Players select or add a game attribute then adjust its corresponding variables, which are listed and include the range of possible values. Although the user-friendly interface may restrict the possibilities for player modifications, it may also increase the number of players who want to try "modding" a game. Players may then play the custom scenario and/or upload it to the game community.
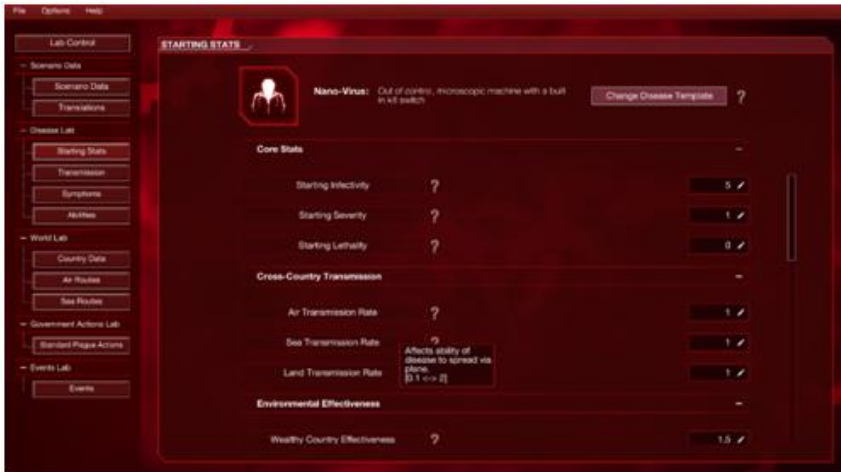
Figure 2. The scenario creator.

Community

Plague, Inc.: Evolved has two main gaming communities. The first, as mentioned above, is the community surrounding the custom scenarios. Player-created scenarios are uploaded to a common location accessible from within the game itself. These scenarios are often based on news stories, books, or movies. For example, one player-created scenario is based on the science-fiction movie, *The Day of the Triffids* (1963), where most of the population becomes blind and mobile plants attack them. Participants in this community rate each other's scenarios using a simple like/dislike system; results appear as a five-star quality rating system. No other feedback or discussion is possible in this community. In the *Steam* community, however, players engage in several discussions. The general discussions are separated into four sections, English, French, Russian and German, and typically address gameplay, questions for the developers, and the sharing of fun things players have done with the game. A separate section in the community is for discussing the scenario creator, where players share knowledge and questions about modifying the game. Participants in the discussions are identified by their

user name, but there is no designation of who is "expert" or "novice," although the game developers, who are active participants in the community, are identified as such. Also within the *Steam* community are areas where participants can share screenshots and fan-generated artwork.

Game analysis

To understand *Plague, Inc.: Evolved* in more depth, the *MDA Framework* (Hunicke et al., 2004) will now be applied to the game. The *MDA Framework* considers how games are consumed and decomposes them into three components: mechanics, dynamics, and aesthetics. The mechanics describe the rules, algorithms, and data management in the game. The dynamics describe the behavior of the game as a result of player inputs and game outputs. The aesthetics describe the player's experiences on an emotional level. Together, these three components describe the interactions between the player and the game.

The mechanics of *Plague, Inc.: Evolved* are algorithms based on real life which were then modified to create a game-like experience. Creator James Vaughan entered publicly available information on epidemiology and economics into a spreadsheet, where he determined their trends and interactions with other variables (Gera, 2013). He then modified the equations to create the game. For example, he weighted the game in favor of the pathogen. In order for the game to be playable, Vaughan adjusted the infection speeds, made every human vulnerable, and allowed simultaneous mutations (when the pathogen mutates, all infected people receive the mutation) (Rath, 2013). The most significant advantage to the pathogen that Vaughan added, however, is that the player controls the mutations rather than waiting for random events.

The dynamics of the game uses a simple real-time interface. The game shows the disease spread by plotting red dots on a map

of the world and by reporting the infection and death rates at the bottom of the screen. As the disease infects more people, red and orange bubbles appear on the map. Red indicates infection in a new country and orange indicates increased infection within a country. The player accumulates "DNA points" by clicking on these bubbles. The player may use these points to mutate the pathogen by opening a separate screen, selecting a mutation, and clicking the "Evolve" button. The global cure effort is summarized in a bar on the main screen as well. The player can find more detailed information about countries, the global cure effort, and governmental response to the plague through additional screens. This information enables the user to make educated decisions about which mutations to select. Additional information that may affect infection rates, such as a country closing its borders, or the cure effort, such as a government falling into anarchy, appear as news headlines.

Figure 3. The mutation screen for a disease named "Fred" and the world screen showing the global response.

Being a strategy game, the primary aesthetics are challenge and discovery. The challenge arises from trying to select mutations in such a way as to maximize the infection rates while remaining undetected or while retarding the cure effort. If the pathogen spreads too quickly, governments close their borders and focus on developing a cure. If the pathogen becomes too lethal before infecting everyone, it dies out. The discovery aspect develops as the player experiments with different mutation combinations. Formal discovery happens when the player chooses certain

combinations of symptoms and receives clear and immediate feedback from the game. These combinations trigger a pop-up message, affect gameplay, and can potentially unlock an achievement badge. For example, choosing the insomnia and anemia symptoms results in the "Walking Dead – Insomnia and Anemia are causing people to walk around grey with tiredness." message, slows the cure effort, and unlocks the "Brainzzz" achievement. Informal discovery happens as the player tried to find the best combination of mutations to achieve short-term goals and needs to monitor the relevant data in order to determine if a goal was reached. The emotional response of the player fluctuates between challenge and discovery throughout the game as the player tries to achieve short- and long-term goals. For example, a player may decide to try and infect Greenland (challenge), realizes that Greenland has a shipping port (discovery), theorizes which mutations increase boat transmissions (discovery), only to learn that Greenland has closed its port (challenge).

Learning potential

When playing a video game, players attempt to develop a mental model that is similar to the actual programmed model of the game (Boyan & Sherry, 2011). These mental models are dynamic representations of situations in a real or imaginary world and may include spatial relationships, systems comprehension, deductive reasoning, and/or a representation of what the situation is about (Roskos-Ewoldsen, Davies, & Roskos-Ewoldsen, 2004). Players create mental models to account for the game's challenges and use trial and error to refine their model, so when the game's challenges include educational content, players create mental models of the educational content while creating a mental model of the game itself (Boyan & Sherry, 2011).

This process of refining mental models through trial and error may help explain some of the reported educational benefits of

Plague, Inc. The Center for Disease Control supports *Plague, Inc.: Evolved* as a tool for teaching people about outbreaks and disease transmission (Khan, 2013; Tirrel, 2013). Parents report an increased interest in hand washing and geography in their children who have played the game. Educators and PhD students are using the game as a tool for investigating infectious diseases and economic models (Rath, 2013; Tirrel, 2013). To further understand how people are learning from the game, I will analyze how I and two other players have learned from playing, apply a theoretical framework to this analysis, and extend that framework to describe the learning potential of this game.

My background is in mathematics and computer science, so the first thing I noticed while playing the game was the logistical growth curves happening as people became infected, as my disease spread to other countries, and as the cure effort got underway. Repeated playing of the game found me trying to adjust those curves by selecting various combinations of mutations that I thought would give me the best chance. My decisions were based on probabilistic reasoning; I found that focusing on symptoms increased the chance of the plague burning itself out while focusing on transmission decreased the chance of a country closing its borders before I could reach it. During this process, my geography knowledge, previously a weakness of mine, increased as I tried to reach particular countries. I was asking myself, "Where is Bolivia and what kind of climate does it have?" In a similar fashion, my science knowledge increased. Knowing the geography and science helped develop my mental model and increased my probabilistic reasoning, allowing my decisions to be more sophisticated.

I observed two other people play this game. One is a retired engineer and the other is in the golf industry. Both are self-described visual learners who think aloud while they play. They each began not with mathematical mental models but with spatial models; they quickly noticed the transportation paths on

the map and chose mutations to increase the probability that these paths would carry their plagues. They also learned science and geography as they engaged in repeated play and used this knowledge in their decision making. One of them also recognized some of the economic models in the game. As a result, I was able to observe them developing their mental models and reasoning in a similar fashion as I did even though their models were dissimilar to mine.

The theory that describes the learning that the three of us experienced is rational constructivism, sometimes known as neo-constructivism. It states that humans have a natural ability to compute probabilities, which they apply to a complex world in order to select or integrate multiple cues and to draw conclusions (Newcombe, 2011; Xu & Griffiths, 2011). Learning is a form of Bayesian inference, where the learner constructs a probability distribution over a set of hypotheses and use experiences to increase or decrease confidence in each hypothesis by constructing and adjusting mental models. Because experience affects the learner's probabilistic reasoning, action is crucial to learning; it helps develop domain-general knowledge into domain-specific knowledge (Xu & Kushnir, 2012).

In strategy games such as *Plague, Inc.: Evolved*, players strive for a condition known as the Nash equilibrium, a state in which each player choses an optimal strategy based on the actions of other players (Lonbørg & Weisstein, 2014). In order to achieve equilibrium, however, players must engage in repeated play. Doing so creates information that the player then uses in probabilistic decision making (Sanchirico, 1996). *Plague, Inc.: Evolved* enables this process by providing the player with a model that represents the scenario and that the player needs to actively interact with. This model is an *idea model* in that it illustrates key concepts and allows the player to create a mental model and use game play to develop deeper understandings of that model

(Squire, 2011). As the player accumulates information, like the key characteristics of Greenland, she is able to apply strategies that take advantage of that information, such as increasing the cold tolerance of the pathogen. This domain-specific knowledge happens through active participation with the game: looking at a nation's information screen, monitoring world data, investigating possible mutation combinations. The result is that repeated play of *Plague, Inc.: Evolved* creates more sophisticated mental models which enable stronger probabilistic decision making, which is the foundation of rational constructivism. With each game taking about an hour to complete, repeated play is easy to achieve.

Plague, Inc.: Evolved supports problem-based learning. Although the game has only one win-condition, kill humanity, there are multiple paths possible for achieving that win condition. The enjoyment comes from trying to discover creative ways to reach that condition, something possible only from learning the underlying properties of the system itself (Squire, 2011). This game also supports model-based reasoning. The data produced by the underlying algorithms are easily available to the player, encouraging them to produce mental models of the system, such as the logistic growth curves, even when they do not know the formal terms for their models. Educators are already using this game for model-based reasoning in economics and biology (Khan, 2013; Tirrel, 2013); extending the applications of this game into mathematics could also help students better understand exponential and logistic growth.

The scenario creator

The potential for learning within the scenario creator for *Plague, Inc.: Evolved* is different than that found in other video games' modding environments. The modding engines provided with *Civilization, The Sims,* and *Warcraft III* have been shown to be useful tools for introducing players to introductory computer

science topics and programming (El-Nasr & Smith, 2006; Hayes & King, 2009; Squire, 2008). The scenario creator in *Plague, Inc.: Evolved* is not as useful of a tool for learning computer science. Most of the modifications allowed are simple variable adjustments; the user chooses which attribute to modify then changes the values of the variables that the scenario creator provides for that attribute. The "Events Lab" section of the scenario creator offers users more flexibility by allowing them to create events using a very simple scripting tool, but the tool is too simple to be used as a means of learning basic programming.

Kurt Squire's (2008) work with *Civilization* has also shown that modding that game allowed players to deepen their knowledge about a particular culture or event in history. In a similar fashion, the scenario creator in *Plague, Inc.: Evolved* can be used to explore biology, economics, and geography. For example, players quickly learn that Canada is a difficult country to fully infect with a pathogen. Modifying the variables associated with Canada in the game allows players to explore whether the country's climate, population, or wealth has a higher impact in preventing disease spread. The scenario creator is simple to use for anyone familiar with the game itself, which may increase the number of players who experiment with designing. The level of realism possible in a custom scenario is limited, however, because of the limited number of variables one can change. For example, a recent discussion thread on the game's *Steam* community concerned possible "work-arounds" to simulate population growth.

Although the main game play has limited opportunities for creativity, the scenario creator affords several opportunities for several types of creative expression. Elliot Eisner (1966) describes four types of creativity: boundary pushing, inventing, boundary breaking and aesthetic organizing. Boundary pushing, the process of extending or redefining the limits of a system or object, happens in the scenario creator when the player extends the effects of various symptoms or redefines the capabilities of a

particular pathogen. Inventing, the process of restructuring the known in order to create something new, happens when the player creates mutations and events that were not previously found in the game or in the real world. Boundary breaking, the rejection or reversal of accepted assumptions, can happen when the player modifies the game world, like changing the win conditions or the climate of different countries. Aesthetic organizing, the process of placing order and harmony on a system, can happen when the player designs the scenario to tell a story or recreate an event. In addition to Eisner's four types of creativity, artistic and written creativity are possible in the scenario creator; players can include their own images and text in their creation. Therefore, creative expression is likely the strongest learning potential found within *Plague, Inc.: Evolved*'s scenario creator.

Conclusion

Being a strategy game, *Plague, Inc.: Evolved* is a natural environment for problem-based learning. It allows multiple solutions for reaching the win condition. By providing a visual model in real-time as well as ample data about the plague and the world's reactions, this game also supports model-based reasoning. Like the app it was developed from, *Plague, Inc.*, this game provides a good example of rational constructivism, the use of mental models and probabilistic reasoning. By adding the scenario creator to the computer version of the game, it has extended the learning potential to include creativity. Players can develop scenarios by using any of Eisner's types of creativity. The multi-player capabilities should be released in 2015. It is to be expected that this upgrade will extend the learning potential to include aspects of social constructivism as well.

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