Promoting embodied learning through virtual and real world gaming experiences

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Abstract: Embodied experiences can be important for changing attitudes, deepening understanding, and increasing science process skills. The Field Museum is interested in best practices for using and combining digital and analog moments for STEM learning. Recent studies support the use of digital tools, particularly virtual worlds, for embodied learning. Other studies show that physical role-playing activities can lead to embodied learning. The choice of virtual or physical experiences to trigger embodied learning should tie directly to learning goals. Here we highlight two activities from "I Dig Tanzania" that facilitated embodied learning: one that was most effective as a role-play and the other as a virtual world activity. External analysis documents the affective and content gains made by our teen participants. These results and participant feedback will be used to initiate a conversation about the importance of embodiment in achieving learning goals, particularly those that relate to attitudes and process.

Introduction

I Dig Science (IDSci) is an intensive summer program for underserved teens that synthesizes learning in a 3D simulation of a fossil excavation with a synchronous paleontology expedition in Africa and privileged access to a natural history museum. IDSci provides an opportunity for teens to develop their problem solving skills in a rich and engaging scientific context by having the embodied experience of being a scientist and using a problem-based learning approach to investigate real scientific and social problems. Numerous studies have shown that providing opportunities for young people to participate in the scientific process is critical to their future enjoyment of, and engagement with, science (e.g. Lederman, 1992; Gibson and Chase, 2002). Through an integrated suite of virtual and real world activities, teens used digital and museum resources to generate and test hypotheses about the largest mass extinction event in Earth history and environmental and social issues confronting Tanzanian society. By encouraging teens to mimic the work of scientists and situating the learning at natural history museums, IDSci provides the kind of authentic experience that is critical to facilitating higher order learning (e.g., Brown et al, 1989).

Embodied Learning

There is a large amount of literature on the affordances of virtual worlds for learning (e.g., Rickel and Johnson, 2000; Dalgarno and Lee, 2010). Among these affordances, great importance is ascribed to the ability of virtual worlds to provide learners with embodied experiences (Taylor, 2002); embodiment being the identification of the learner with their avatar or virtual character and that character's virtual experiences. Embodiment within a virtual world is possible because the "mental representation of the body" is not necessarily located in the physical body but can, in fact, be located elsewhere (Biocca, 1997) due to the plasticity of most people's body schema. This can be seen in the physical world in phenomena like the rubber hand illusion (New Scientist, 2009), in which a participant's hand is hidden and a fake hand placed within their field of view. The two hands are then stroked simultaneously and even though it is obvious that the rubber hand is not real, about two-thirds of participants transpose a feeling of ownership to it. In virtual worlds, the avatar on the screen becomes the user's extended body such that "users do not simply roam through the space as 'mind', but find themselves grounded in the practice of the body, and thus in the world" (Taylor, 2002; p.42). However, as with the rubber hand illusion, embodiment within a virtual world only occurs in approximately two-thirds to three-quarters of participants (Heeter,1995; p.200). Why a minority do not experience embodiment is not understood, but it may stem from some participants being "so strongly situated in the real world and their real body that they have a difficult time becoming involved in the virtual world". Heeter's use of the word "situated" specifically describes the experience of being embodied within a space, rather than simply "located" within it, a distinction established by Merleau-Ponty (Smith, 2007; p.16).

Embodiment has the potential to allow learners see themselves from a different perspective and is potentially transformative. This is particularly important for the underserved urban teens targeted by IDSci, who have never thought of themselves as scientists or even problem-solvers. Additionally, virtual environments can be highly motivating for many students (Sancho et al., 2009), and underserved male teens show particular affinity for them

(Steinkuehler et al., 2012). For other learners, group role-playing exercises can be an effective way to promote embodiment and learning (McSharry and Jones, 2000). Recognizing that embodiment can have different triggers for different learners, and that it may not be possible for all learners, IDSci takes a blended approach, leveraging the affordances of 3D virtual worlds but also including real world role-playing activities and placing the learning experiences in a natural history museum.

The Program

I Dig Tanzania 2012 (IDT) was the most recent iteration of the I Dig Science series (launched as a collaboration between the Field Museum of Natural History and Global Kids in 2008). During IDT, 16 teens in Chicago participated in a 3-week program to discover the causes, effects, and implications of the end-Permian mass extinction, and to explore environmental and social issues in Tanzania. IDT made use of four complementary platforms: 1) the virtual world Second Life; 2) videos, photos and satellite calls from the expedition team and local African colleagues and students; 3) behind-the-scenes, exhibit-based and real-world activities at natural history museums; and 4) a suite of digital technologies (e.g. Google Docs, iMovie, Tumblr, Skype). These four platforms were integrated seamlessly to provide robust embodied experiences in which teens could work and learn about the larger world in which they live. The evaluation of the IDT program (Childs and Peachey, in preparation) found that Second Life and the real-world activities were particularly effective in providing teens with embodied opportunities to achieve learning goals. The affordances of Second Life that promote embodiment center around two aspects of the virtual world, the use of space and the presence of the avatar. The space within the virtual world is three-dimensional and navigable, and responds to the actions of the user through the movement of objects and responses of objects to the actions of the user. The avatar not only provides a mechanism for interaction with the environment, but is also personalizable. The sense of the reality of this space was developed through activities promoting movement and interaction, such as a soccer game. Although appearing to be purely a fun activity, this helps the learners to coordinate the movement of their avatar and interact with the soccer ball. Once the ability to move becomes natural, the technology appears less intrusive to the user, and the sense of location within the space becomes stronger. Similarly, early on in the program, the learners are given an activity which requires them to modify their avatar (to adapt to its environment). This introduces the learners to the sense of the avatar being personalizable, and through its alteration they feel ownership over it. It is then not only a means for interaction, it is an extension of their body within the space, and represents them as an individual to the other learners.

Methods

Seven methods were used as sources for research data. 1) Participants in the program were given fifteen minutes at the end of every day to update their program blogs. This was a directed activity, with questions and topics provided by the facilitators. 2) Learning activities directed the development of Googlebooks, which were created in groups and provided learning content for review. 3) Much of the physical activity within the program was filmed, creating a resource for non-participant observation of interaction that includes the capture of subtle indicators such as body language. 4) Participant interaction within the virtual world was chatlogged and many object interactions were logged, so that virtual interaction and collaboration could be tracked and coded, and 5) inworld machinima was captured for many of the SL activities. 6) A survey was administered at the beginning of the program and another shortly before the close to capture comparative reflections as data at a point in time. 7) Finally, four participants were selected for interviews to explore more detailed insights, perceptions and beliefs about their experience on the basis of their activity profiles across the program. A combination of these seven methods allowed for triangulation and some internal verification. However the quantity of data presented a significant time and resource challenge, so a pragmatic approach was taken in which the core sources (blogs, chatlogs, surveys) were the primary items analyzed, with evidence from other sources such as interviews and object interactions to used to corroborate and triangulate the key findings.

Human-Wildlife Conflict

Human-wildlife conflict “is a serious obstacle to wildlife conservation worldwide and is becoming more prevalent as human populations increase, development expands, the global climate changes and other human and environmental factors put people and wildlife in greater direct competition for a shrinking resource base” (HWCC, 2012, para. 1). Interdisciplinary collaboration and an understanding between all stakeholders is vital to address and mitigate these conflicts (HWCC, 2012). Learning objectives for the human-wildlife conflict activity included getting learners to understand negative and positive aspects of local wildlife, to understand the connections between different species (human, plant and animal), and to make observations and gather data to collaboratively find a solution to the problem. To achieve these goals, the teens participated in three complementary activities. First, participants embarked on an exhibit-based photo scavenger hunt to explore the size and scope of the African large mammal fauna, with the goal of giving all participants a common knowledge base about African wildlife. Then,

participants Skyped with students from the University of Dar es Salaam in Tanzania to discuss local human-wildlife conflict issues and how they affect life in Tanzania. Finally, IDSci participants engaged in a Second Life activity in which they became Tanzanian farmers, and had to manage their local wildlife.

In the Second Life activity, participants virtually planted and grew crops that were then trampled by a virtual elephant, mimicking the experiences of real farmers in certain parts of Tanzania. When challenged with problem of elephants trampling their crops, the participants first collectively decided to build a wall around their crops (see Figure 1a), but this had the unintended consequence of disrupting the ecosystem, resulting in their crops dying. The participants, who were now heavily invested in their farms, became increasingly frustrated in the methods that they were attempting to use to solve the elephant problem. Through close examination of their virtual environment, participants observed that some of the Acacia trees on their farms were healthy and covered in ants (see Figure 1b), but most were dying and covered with stem-boring beetles. In the group discussion that followed, participants postulated that Acacia trees were vital for crop survival (the trees keep the soil from eroding and maintain nutrient levels). They learned that when elephants graze on Acacia trees they stimulate the trees to produce more nectar which feeds the ants, and, in return, the ants protect the trees from predators. When the trees are not being grazed on by elephants, they produce less nectar and the ants depart. This leaves the trees vulnerable to predators and parasites, eventually causing the trees' death and the failure of nearby crops (Palmer et. al., 2008). Upon completion of the activities participants discussed practical and effective ways for Tanzanian farmers to keep the ecosystem intact while protecting their crops from elephants.

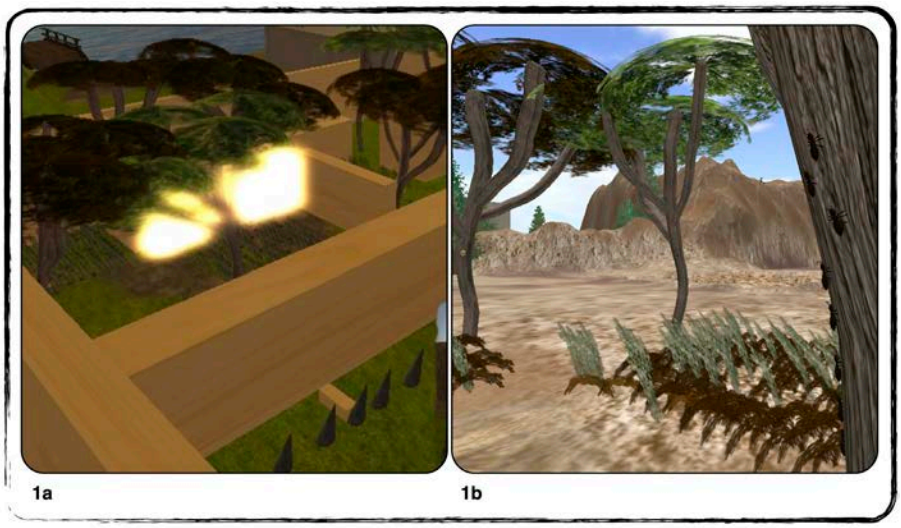

Figure 1: The human-wildlife conflict activity in Second Life a) wall built by teen participants to keep the elephant away from their crops and b) ants on healthy Acacia tree.

Evaluation of the human-wildlife conflict activities found that 13 of the 15 teen participants demonstrated an understanding of the common conflicts between humans and wild animals and 14 of the 15 participants demonstrated an understanding that all species are connected in some way. Evaluation of the teens' blogs showed that the Second Life activity had the greatest impact on their learning (Childs and Peachey, in preparation). Some examples from participants' blogs include:

Being a farmer in Second Life reveals the intricate and delicate scale on which life balances. Each species in some way helps, or hinders, another; no matter how indirectly. What we experienced on Second Life mirrored a trouble of real Tanzanian farmers.

As we planted crops in Second Life, we were attacked by an elephant. In order to combat our foe, we built a fence around our crops. After that all our plants started to die. We learned that the trees need the elephants to survive, and without them our crops died.

These statements suggest that the teens began to feel the competition between farmer and wildlife, seeing the elephant as a "foe" to be combated, as opposed to only understanding it in an abstract sense. It also provided an empathic window into the worries and troubles of a Tanzanian farmer trying to make a living in a harsh environment. The virtual world experiences provided authenticity and, to some extent, gave them a real experience upon which they could draw. This experiential component not only enabled the teens to actively utilize the principles and skills being discussed, but also incorporated an emotional component to their engagement (Childs and Peachey, in preparation).

Clean water

Access to clean water is a major problem that confronts Tanzanian society. “Only 54% of the population has access to improved water supplies...women and children spend on average over two hours a day collecting water and up to seven hours in remote areas” and “20,000 children die before the age of five each year in Tanzania due to diarrheal diseases” (WaterAid, 2012, Context section, para. 1). Given the scale of the problem in Tanzania and the impact it has on health and quality of life, it is imperative that people become engaged with this issue to find sustainable solutions. The learning objective for the clean water activity was to understand how lack of access to clean water affects Tanzanians.” To achieve this, the teens again participated in three complementary activities.

First, the teens watched a video from a Peace Corps veteran who was active in the children’s aid-focused NGO World Vision, in which she shared stories from her work helping a Maasai village access clean water. The video was intended to introduce the concept of clean water and provide a common knowledge base for all participants. Then, participants Skyped with students from the University of Dar es Salaam to discuss access to clean water in both urban and rural communities in Tanzania. Finally, participants played a real-world game in which they assumed the role of an African youth tasked with providing clean water to his/her family (see Figure 2). The game’s objective was to carry a 5-gallon bucket of water a distance of 0.5 miles around the Museum. Participants competed with one another to see who could carry their bucket of water the fastest while losing the least water in the process. During the walk, participants were approached by program facilitators who presented them with scenario cards (see Figure 3). Upon completion of the activities, participants discussed the issue of water access and brainstormed possible solutions that would be practical and effective for the Tanzanian population.

Figure 2: Teen participants competing in the water game.

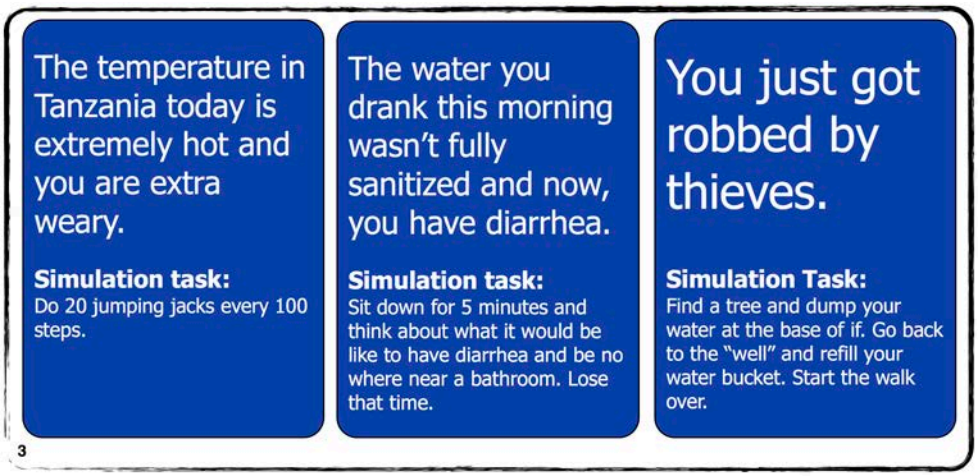

Figure 3: Water game scenario cards.

Although the learning objective from the clean water activities was not formally evaluated, it was clear that the real-world game had the greatest impact on participant learning (Childs and Peachey, in preparation). This is shown in excerpts from participant blogs and post-program interviews.

Blog excerpt: The most fun things we have done this week is carrying the water around the museum. That really opened my eyes to what people in Africa have to do. Experiencing the water carrying process impacted me much more than just seeing pictures of what other people have to do to get water.

Although physically demanding, participants felt that the activity was very instructive in that it gave them a particular insight into the experiences of Tanzanians (Childs and Peachey, in preparation). Similar to the human-wildlife conflict activity in Second Life, the real-world game provided teens with the direct experience needed to gain a deeper understanding of the problem, which resulted in them empathizing with the people that are directly affected by it.

Interview excerpt: *Kathy*: unless you actually do it, you don't really… at least I'm like "oh it's not that bad, I'm sure they're just complaining" but when we had to carry that bucket of water, 5 gallons, around, you definitely realize what…

Ray: it's a lot. Going around the museum I think it's probably a mile or two, max. And then we got robbed and we had to go all the way back and we had to go around again.

Kathy: and then we got attacked by birds that weren't even supposed to be there.

Ray: It was hard.

Discussion

As these two examples from the IDT program show, embodied experiences can be important for changing attitudes, deepening understanding and increasing science process skills. Participants embodied a Tanzanian farmer or a local seeking clean water to experience first-hand the problems these groups face. These experiences allowed participants to gain a better understanding of each problem and then use personal examples to propose logical solutions. Whether the experience that led to embodiment was a real-world role-play or took place in a virtual world did not seem to impact learning. Instead, each experience was effective at promoting embodiment because it allowed participants to gain insight into the problem by emulating the physical behavior of those whose perspective they were modeling. "Physical" is appropriate in this context, even for the virtual world activity, due to the degree of embodiment experienced by the participants.

In the case of clean water, insight about the plight of African youth came from the weight of the water and the physical challenge of the task. Those aspects were best realized through a real-world role-play, which allowed our American teen participants to embody their African peers' situation, even for just 30 minutes. At the outset, the task seemed simple: carry a bucket around the building (and, indeed, the task was far easier than the conditions and distances that some African youth deal with on a daily basis). Although the task was physically daunting on its own (carrying the water a set distance); participants grew increasingly frustrated and upset as scenario cards were dealt by facilitators. Each scenario was based on authentic accounts from African youth, but seemed random and unjust to our American participants. The combination of the task and scenarios helped participants to understand that a seemingly simple task can be a great challenge when it is undertaken by vulnerable people who are subjected to both injustices and stochastic events. The physicality of the role-play game helped us to surpass our simple learning goal of understanding how lack of access to clean water affects Tanzanians. Additionally, we were able to raise awareness about the plight of African youth who seek clean water and to change attitudes about the problem of clean water. Pre-participation, American teens thought that their African peers were "just complaining" about their task and access to clean water. But post-participation, American teens gained an understanding that, in their own words, was truly transformational for them and, for some, was the most memorable experience of their three-week program (Childs and Peachey, in preparation).

In the case of human-animal conflict, insight came from the trial and error process and a holistic understanding of the African ecosystem provided by the virtual world simulation. Those features were best realized with a digital activity in which participants could rapidly see the results of different methods for excluding elephants and make detailed observations of the simulated ecosystem. It would have been possible to design a similar activity using analog methods, such as illustrated game cards or physical role-play, but those methods would have made it more challenging for learners to see the whole picture rapidly and synchronously. In this activity, placing the learners within a virtual world scenario was a more realistic and accurate replication of the physical world environment than an alternative real-world activity would have been. The effort in typing the phrase "grow crops", although less than physically sowing them, still incurred a cost to participants. The impact of seeing the facilitator's avatar (an elephant) physically trampling those crops was less abstract than an analog method would have been, resulting in a stronger emotional reaction. Perhaps most importantly, the visual complexity of the virtual world enabled clues to

the solution to be placed subtly within the environment, requiring the participants to replicate real world scientific processes of investigation (e.g., iterative observation and problem-solving), whereas any analog method, such as activity cards, would have foregrounded the answers.

Conclusion

The effectiveness of both activities described above, whether situated in the physical or the virtual, is related to the degree to which the activity can embody the key elements of the learning goals. No proxy experience can replicate entirely the experience being modeled, but by identifying the essential aspects that need to be communicated, and by choosing the most effective platform to convey these aspects, an effective learning experience can be constructed. Because of the effects of embodiment within a virtual world, physical does not necessarily mean more real. Neither does more technological mean more engaging, even for so-called "net generation" learners. For most of these learners, and increasingly for previous generations who are becoming more adept at using these platforms, the distinction between "technology" and "not technology" has disappeared; there are simply a range of different activities in which to take part, which may appear on a screen, or may be in the physical world, depending on which is most appropriate at the time. Whether real or virtual, embodied experiences clearly have a direct impact on how youth construct knowledge and engage in meaning-making and sensemaking. Therefore, providing for embodied experiences should be considered as an instructional strategy by program designers and facilitators. Finding the right reality in which to set learning activities, without a priori assumptions about which is the most appropriate, and finding the right balance of realities, has proven to be the best approach for the IDT program.

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