

DISCUSSION

We feel that our results demonstrate that it is possible to achieve APE-like engagement with a tabletop exhibit in a natural history museum. However, Build-a-Tree offers visitors a different kind of learning experience than the APE exhibits described in [1,9,16]. In particular, APE exhibits tend to foster activities such as exploration, investigation, observation, and construction [16]. BAT, on the other hand, is a multi-level puzzle game and lacks the open-ended nature of APE exhibits. BAT also lacks the hands-on access to scientific phenomena that characterizes APE activities. Given this, one way to interpret the success of BAT, is that it offers visitors the opportunity to play a *real* game in the sense proposed by Salen and Zimmerman: a “system in which players engage in artificial conflict, defined by rules, that results in a quantifiable outcome” [32]. As such, visitors were able to apply existing social practices of game play to manage and coordinate their interaction with the table and with one another.

Stevens, Satwicz, and McCarthy conducted an ethnographic study of children playing video games in homes [36]. Their account of video game play is less concerned with what makes video games successful learning environments (e.g. [6,18]) and more concerned with what makes kids successful learners. As such, they relate the diverse ways in which kids organize themselves to support learning while playing video games in homes. These *learning arrangements* include instances of coaching, active apprenticeships, peripheral observations and participation, and inner and outer circles of play [36].

Similar to observations of Stevens et al. [36], participants in our study exhibited a variety of successful learning arrangements around the tabletop. To help understand this, we explore the role of game talk in more detail.

Game Talk

Figure 7 shows that participants devoted a large portion of their total conversation to game talk (48.8%) with an average of 6.37 utterances related to game play per minute (SD = 3.17). While this may seem high, this type of conversation seemed to play a critical role in helping visitors maintain social engagement with the exhibit. Four sub-categories of game talk emerged from our analysis: *turn-taking, narration and coaching, reflection, and pacing* (Figure 8).

Turn Taking

Talk related to turn taking was common for groups with multiple children. It included negotiations for sharing the game play experience (e.g. “you can have a turn in a minute” or “let me try”) as well as negotiation for physical orientation around the tabletop surface. This sort of talk seemed to help visitors to move between inner and outer circles of play while remaining engaged in the activity at some level of peripheral participation. It also gave them the opportunity to complain if they felt that the balance of

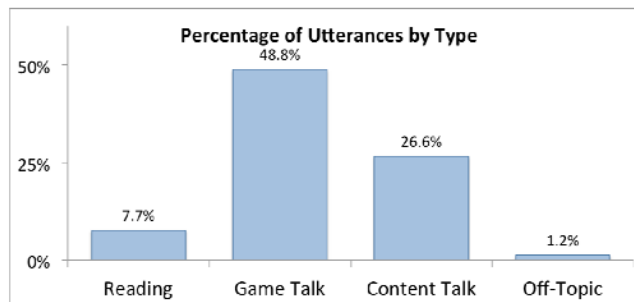


Figure 7. Percentage of visitor utterances by category type.

participation was unfair. For example, this transcript involves two boys playing with our exhibit, each six years old:

B1: No, no. There. That goes there.

B1: No, there.

B2: Can I stand in the middle?

B1: Yeah, sure. In a minute.

B2: This time can I stand in the middle?

B1: Alright, sure.

In this example, B2 successfully negotiates for a central position in the game play in preparation for his turn on the next level. His brother accepts this new arrangement while maintaining a running commentary (or narration) of game play.

Narration and Coaching

Game talk related to narration and coaching included comments on game achievement and progress, play-by-play commentary, and coaching and advice for other players. Both narration and coaching appear to be common aspects of video game play in homes. Stevens et al. [36] provide several examples in which children coach each other on video game play, offering both solicited and unsolicited advice. In these cases, siblings and friends serve as *just-in-time resources* to scaffold learning around game play [36]. In our observations, we saw parents filling a similar role. The following transcript is from a family with two boys (age 8 and 6) and their mother. The older boy is playing the game while his mother and brother narrate play and offer advice:

Mom: Flying. Put flying ones.

Mom: They're not flying.

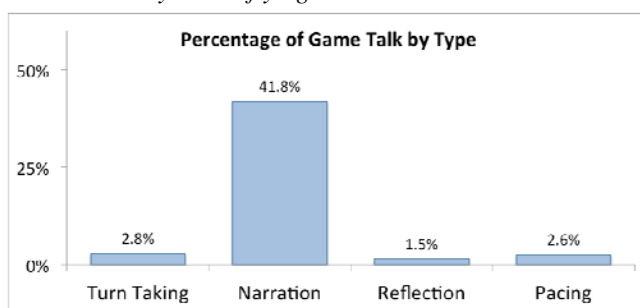


Figure 8. Percentage of game talk by families as a portion of overall utterances.

Brother: Then stick them together.

Mom: When you have a star you've got it right... at the moment it's not...

Mom: So maybe split a little bit.

Brother: I'm gonna have a little peek at the answer. Don't look.

Brother: Don't look! (player tries to look at the answer)

Brother: (??) (looks at the solution again)

Mom: It's maybe something more than just flying not flying.

Player: Giraffe

Mom: Maybe something about how they give the baby...

Mom: Do they have an egg or not.

The younger brother, while not playing this level, is actively engaged in the game's progress and participates in ways that don't directly affect his older brother's play. The mother, meanwhile, provides active coaching on both the mechanisms of game play and on the evolution content. Interestingly, although only the older boy is actively playing the game, the other members of the group use coaching and narration as a way to stay involved in the game play.

Pacing

Talk related to game pacing seemed to serve three purposes. First it helped group members make sure they were all focused on the activity and ready to proceed (e.g. saying "OK, ready?") before starting the next level. Second, pacing was used as a way to control the progress of the game when multiple visitors were playing at the same time. For example, saying, "wait, stop." Often this involved proposing ideas for how to assemble the tree on more difficult levels, or proposing new player arrangements. For example, this transcript involves four girls playing together (ages 8, 9, 11, and 13):

Put the butterfly with giraffes.

Put it over right...

That's not right.

Wait. Stop, stop, stop.

It's not right.

The final role of pacing talk tended to come from parents and was used to try to impose points of reflection during game play. In other words, trying to get kids to stop and think. For example: "Wait, wait let's stop and think here." or "Wait. You have to read that [did you know text] out loud." This kind of participation is common for parents in museums (e.g. [37]). We suspect that it is also useful for keeping parents engaged in the activity because it provides an opportunity to integrate explanatory and interpretive content into the game play.

DESIGN IMPLICATIONS

Our research highlights potential advantages of tabletop games for learning in museums. Not only are games motivational, but they also cue a repertoire of social

practices of game play that facilitate productive collaboration around the tabletop. There are, however, several pitfalls inherent in this approach that we discuss briefly in this section.

A first pitfall relates to the use of multi-level games in museums. In informal learning environments of museums, it is accepted practice not to constrain visitors to experience exhibit content in a fixed order. Tabletops (as well as other exhibits) can facilitate a variety of group interaction patterns [20] that can confound designs relying on one-group-at-a-time assumptions. The potential pitfall with multi-level games is that earlier levels are often used to scaffold game play in more advanced levels [6]. This was the case with our Build-a-Tree design. As a result we observed groups play the game for four or five levels and then wander away to make room for new visitors who, in turn, were confused by starting the game on an advanced level of play. To mitigate these problems, we recommend having only a few levels in a game (six seemed to be a good number for us). This also helped keep the amount of time that any one group spent with the exhibit at an acceptable level. Likewise, there should be easy and obvious ways for visitors to start the game over from the beginning. The trick is make sure that this mechanism is not too easy to trigger in order to avoid individual visitors accidentally (or even intentionally) restarting the game while other people are playing. Finally, as is common practice with many interactive exhibits, games should have a built-in timeout that automatically restarts the activity after around 30 seconds of non-use.

A second pitfall relates to our observation that many visitors (especially adults) are averse to the idea of playing video games in a natural history museum. While we were observing the Build-a-Tree exhibit, we overheard many parents and chaperones making comments along the lines of "we're not here to play games" in an effort to discourage children from playing. We suspect that this attitude is more common in natural history museums than in science museums because there are rare and authentic artifacts on display that can only be seen first-hand in galleries. Given this, we think that it is critical for tabletop games in museums to communicate their educational value to parents. Some ways to achieve this might be to make the content of the game directly related to the artifacts in the immediate vicinity of the tabletop. Or, as long as it is not required for game play, include explanatory labels like the *did-you-know* text in our game. This provides parents with a productive role to play in the activity: reading and interpreting the text for children [37].

Finally, designers should be cautious about relying on games at the expense of more open-ended inquiry activities in which visitors explore and answer their own questions by interacting with exhibit elements. At the heart of this design tradeoff is a question of pedagogical values. Why do we

want visitors to interact? Is it for the fun of playing a video game, for personal interest, or for the curiosity and sense of wonder invoked when encountering something new and unexpected? Or can it be some combination of these? Even though this version of the Build-a-Tree design was successful in terms of its ability to engage visitors and support group interaction, we feel that we did not succeed in creating an activity that fully aligned with our own pedagogical values. Specifically, the game affords little opportunity for open-ended exploration, and the motivation to play the game seems to have less to do with personal interest in the topic of evolution and more to do with the challenge of solving the puzzles provided on each level. We are currently working on redesigns for this activity to address this.

CONCLUSION AND FUTURE WORK

In this paper we presented the design and evaluation of a tabletop game to help natural history museum visitors learn about evolution. To evaluate the success of our exhibit, we borrowed the concept of Active Prolonged Engagement from the science museum literature. Our results showed that visitors were engaged in focused, on-topic interaction with our exhibit for prolonged periods of time. We argue that this was due in large part to existing social practices of game play that visitors brought with them into the museum.

In the future we hope to explore ways to make Build-a-Tree more open-ended in the sense of APE exhibits. One way to accomplish this might be to include levels in which there is no known right answer or where there is still active debate among scientists. Another option is to allow visitors to manipulate both organisms and traits and to focus attention more on the tree structure itself. We also hope to conduct research on learning outcomes related to evolution and tree thinking.

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