Becoming Butterflies: Interactive Embodiment of the Butterfly Lifecycle

Annie Kelly
University of Colorado
Boulder, CO 80309, USA
annie.kelly@colorado.edu

Danielle Albers Szafir
University of Colorado
Boulder, CO 80309, USA
danielle.szafir@colorado.edu

Matt Whitlock
University of Colorado
Boulder, CO 80309, USA
matthew.whitlock@colorado.edu

Steve Voida
University of Colorado
Boulder, CO 80309, USA
svoida@colorado.edu

Brielle Nickoloff
University of Colorado
Boulder, CO 80309, USA
brielle.nickoloff@colorado.edu

Angel Lam
University of Colorado
Boulder, CO 80309, USA
angel.lam@colorado.edu

ACM.
UbiComp/ISWC'17 Adjunct, September 11–15, 2017, Maui, HI, USA
ACM 978-1-4503-5190-4/17/09.
https://doi.org/10.1145/3123024.3123136

Abstract
Museum directors are often faced with the challenge of engaging users in the museum experience while preserving the intentions of exhibit content. Designing exhibits for children can heighten the tension between these sometimes competing goals. Working with the University of Colorado Museum of Natural History, we designed and implemented *Metamorphosis*, a system for an engaging, educational butterfly exhibit. The exhibit employs augmented reality and full-body interaction to guide users through critical phases of a butterfly's metamorphosis process. In *Metamorphosis*, we incorporated participatory design methods in order to leverage engaging ubiquitous technologies while supporting an educational narrative aligned with the museum's goals.

Author Keywords
Augmented Reality; Museum exhibits; Kinect; Metamorphosis; Embodiment; Teaching; Children; Full-body interaction.

ACM Classification Keywords
K.3.1 [Computers and Education]: Computer Uses in Education—Computer-assisted instruction.

Introduction
The University of Colorado Museum of Natural History hosts an exhibit entitled "Becoming Butterflies." The exhibit, photographed in Figure 1, is designed to educate children

Figure 1: Existing “Becoming Butterflies" exhibit, previously displayed at University of Colorado-Boulder transferred to University of Colorado’s South Denver campus

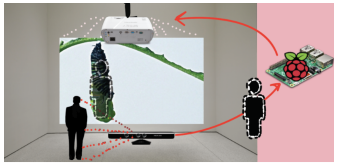

Figure 2: Proposed deployment plan for future iterations

about the lifecycle of several butterfly species, highlighting each species‘ keys to survival, such as predator evasion and food consumption. The intended experience for this exhibit is for children walk around to several “life stage" stations to learn about butterfly maturation processes and key aspects of the egg, caterpillar, chrysalis, and adult stages of four butterfly species. This information is currently displayed through static pictures and textual descriptions on posters.

Our work seeks to increase visitor engagement and learning by leveraging the affordances of augmented reality and full-body interaction while preserving the exhibit‘s educational intent. We addressed these challenges by working with the museum‘s staff throughout our design and development processes to craft an engaging exhibit that foregrounds the educational goals of the original installation.

Related Work

Augmenting museum exhibits using technology can motivate more people to visit museums [4] and improve visitor engagement, conversation, and playfulness [1]. The increasing ubiquity of consumer-grade virtual and augmented reality (AR) technologies has given developers affordable and usable tools that make it possible to quickly augment museum spaces. Museum exhibitions such as the Mejlby Stone Installation, S.O.L.A.R. System (Solar-System and Orbit Learning in Augmented Reality), and SHAPE (Situating Hybrid Assemblies in Public Environments) exemplify augmented reality‘s ability to foster better engagement [5].

More generally, context-awareness and user immersion as exemplified by these technologies allow for novel teaching methods, which resonate with the educational goals of many museum exhibits. Matuk et al. find that experiential learning is beneficial for educating museum visitors, and this can be achieved in exhibits that incorporate experience design rather than object-based design [3]. Wu et al. investigate AR in educational contexts and find that the notions of engagement, contextualization and authenticity make AR an effective teaching tool for educators [6].

Despite this, Kortbek and Grønbæk suggest that museum curators worry that installation of new technology in a museum distracts from the exhibit‘s content and therefore diminishes the museum‘s intended educational goals [2]. However, their research found that incorporating features such as audio augmentation, full-body input, and audio-visual cues actually provide visitors with a more active role in learning. These design principles make for a unique experience that does not interfere with the purpose of the existing exhibition. Effectively navigating this tension is of primary concern for technology deployments in museum environments and is core to our work with “Becoming Butterflies."

System Design

Software and Hardware

The museum staff highlighted the importance of having a lightweight and modular system installation to enable portability and extensibility. To support this goal, we used a commodity Windows laptop for processing user input and streaming output frames. A Microsoft Kinect faces outward from a wall, and, using its RGB and infrared cameras, streams users‘ skeletal information to a Windows Presentation Foundation application running on the laptop. Using Microsoft’s Kinect API, the laptop projects real-time output to the same wall that users are facing. In future iterations of this exhibit, we hope to run our Kinect processing code on a Raspberry Pi to increase exhibit portability and reduce the system‘s cost. The deployment plan is depicted in Figure 2.

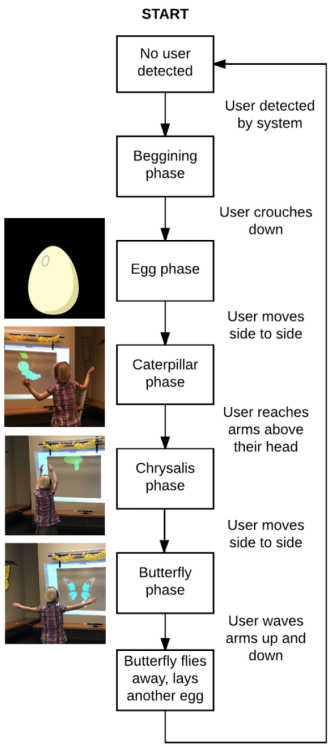

Figure 3: System flow diagram, taking the user through the metamorphosis lifecycle

Metamorphosis Narrative

Our system, *Metamorphosis* shows children key aspects of the butterfly life cycle, emphasizing four transitions that users mimic through physical interaction: the transition from an egg to a caterpillar, a caterpillar to a chrysalis, a chrysalis to a butterfly, and a butterfly laying an egg, which restarts the cycle. The system's flow is visualized in Figure 3.

The system allows children to experience this life cycle by interacting with an animated projected character, as shown in Figure 4. Children begin the interaction by entering into a space where they can be tracked by the Kinect. Once the Kinect begins tracking, the user is prompted (via text projected on the wall and audio played via overhead speakers) to crouch to become an egg. Once the user‘s tracked center of mass is sufficiently low, the projector displays an egg. The user wiggles back and forth to break free of the egg and become a caterpillar. In caterpillar form, the user moves around eating leaves by making a “chomping" gesture with his/her arms until the caterpillar is ready to become a chrysalis. At this point the user reaches his/her hand up to touch the branch overhead, forming a silk thread and becoming a chrysalis. The user holds still until the system prompts them to break free and become a butterfly by reaching his/her arms out. Finally, The user is prompted to move his/her arms up and down to fly away and lay another egg. Visual cues, verbal instructions, and a textual display help the children to find and carry out the expected poses and actions.

Evaluation

In order to evaluate our system design, we presented several video sketches and a working version of our system to the museum staff. We then conducted a semi-structured interview with the Museum Exhibit Director, Rebecca Coon, to ensure that the proposed design would align both with the content of the exhibit and the educational goals of the museum.

Supporting Educational Goals

In our initial conversations with Ms. Coon, she described the museum‘s current exhibit as a “lifecycle experience" intended for 7–10 year-old children. To facilitate this narrative, there are stations detailing each stage of the lifecycle. She mentioned that preschool-age visitors do not have currently have an experience specifically targeted toward their age group at the museum, and that “learning through play and acting out is especially appropriate for them." Ms. Coon noted that our system design incorporated these elements in a generally effective fashion and described our system as “echoing the goals of the exhibit by focusing on the life stages, but it‘s presented in a totally different format." Ms. Coon continuously reiterated the core challenge of technology integration in museums: that interactive exhibits might increase engagement but are typically “not woven into the experience." Based on feedback from our colleagues at the museum, our participatory design approach seemed to effectively mitigate some of these limitations.

Family Fun Day

We deployed *Metamorphosis* at the University of Colorado‘s South Denver campus' “Becoming Butterflies" showcase, where we deployed our system for one day. Overall, children were excited to use our system. Our deployment allowed us to identify unexpected challenges for leveraging commercial technologies in the exhibit–namely, toddlers were too small for their gestures to be tracked effectively, some of the transitions between phases were difficult for participants to trigger, and the childrens‘ desires to use the system at the same time as their parents or siblings is not yet supported. In addition, we observed some users who

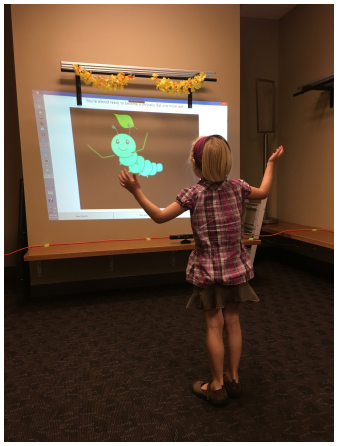

Figure 4: A child interacting with the system, using her arms to eat leaves

were nervous to use our system if others were watching them. This stage-fright could be mitigated by creating a collaborative experience in which multiple users engage with the system together, as discussed with Ms. Coon. We also found that children at different age groups needed different instructions, with younger children often needing visual as well as auditory support. These cases required intervention from a group member.

Conclusion and Future Work

Metamorphosis promotes participant interaction, both through visual feedback and embodied physical movements. The interactions are designed to facilitate learning about butterfly metamorphosis. Incorporating participatory design methods through each iteration of our design allowed the content to remain true to the intended educational message of the original exhibit. Interaction and play are great ways to engage users in educational narratives and provide the potential for young children to grasp the intended lessons of an exhibit. Our hardware setup is lightweight, making it portable and extensible for museums that may want to implement our system, and the design may serve as an example for those developing interactive exhibits for museums. Moving forward, we plan to continue making improvements to the system's user experience in collaboration with museum staff, so that it can become a standing fixture in the museum. In addition, we plan to release our framework as an open-source project to facilitate deployment of other low cost, lightweight interactive museum installations.

Acknowledgments

We would like to thank Rebecca Coon, and the staff and visitors at the CU Natural History Museum for their valuable time and feedback about our proposed exhibit designs. This work was funded in part by a CU Boulder IGP grant.

REFERENCES

1. Ditte Amund Basballe and Kim Halskov. 2010. Projections on museum exhibits: engaging visitors in the museum setting. In *Proceedings of the 22nd Conference of the Computer-Human Interaction Special Interest Group of Australia on Computer-Human Interaction*. ACM, 80–87.
2. Karen Johanne Kortbek and Kaj Grønbæk. 2008. Communicating art through interactive technology: new approaches for interaction design in art museums. In *Proceedings of the 5th Nordic conference on Human-computer interaction: building bridges*. ACM, 229–238.
3. Camillia Matuk. 2016. The Learning Affordances of Augmented Reality for Museum Exhibits on Human Health. *Museums & Social Issues* 11, 1 (2016), 73–87.
4. Takeshi Naemura, Yasuaki Kakehi, Tomoko Hashida, Daisuke Akatsuka, Takuro Wada, Takashi Nariya, Totaro Nakashima, Ryo Oshima, Takafumi Kuno, and others. 2010. Mixed reality technologies for museum experience. In *Proceedings of the 9th ACM SIGGRAPH Conference on Virtual-Reality Continuum and its Applications in Industry*. ACM, 17–20.
5. Eric Woods, Mark Billinghurst, Julian Looser, Graham Aldridge, Deidre Brown, Barbara Garrie, and Claudia Nelles. 2004. Augmenting the science centre and museum experience. In *Proceedings of the 2nd international conference on Computer graphics and interactive techniques in Australasia and South East Asia*. ACM, 230–236.
6. Hsin-Kai Wu, Silvia Wen-Yu Lee, Hsin-Yi Chang, and Jyh-Chong Liang. 2013. Current status, opportunities and challenges of augmented reality in education. *Computers & Education* 62 (2013), 41–49.