Scaffolding Science Inquiry in Museums with Zydeco

Alex Kuhn
University of Michigan
2260 Hayward Street
Ann Arbor, MI 48109 USA
kuhnalex@umich.edu

Clara Cahill
University of Michigan
610 East University Avenue
Ann Arbor, MI 48109 USA
claracah@umich.edu

Chris Quintana
University of Michigan
610 East University Avenue
Ann Arbor, MI 48109 USA
quintana@umich.edu

Elliot Soloway
University of Michigan
2260 Hayward Street
Ann Arbor, MI 48109 USA
soloway@umich.edu

CHI 2010, April 10–15, 2010, Atlanta, Georgia, USA.
ACM 978-1-60558-930-5/10/04.

Abstract
One of the educational goals in science is to not only learn content but also to learn the scientific process. While there is a range of settings for this, such as classrooms and museums, they are not always well connected in educationally viable ways. We are designing Zydeco to bridge the classroom and museum environment and address the following goals: (1) To scaffold science inquiry in a mobile context and (2) to facilitate collaboration among peers. In this paper we will be focusing on the mobile design of Zydeco, which will scaffold structured investigation, data collection and analysis while students are in the museum.

Keywords
Learner-centered design, science inquiry learning, collaboration, adaptive scaffolding, context-aware, mobile computing

ACM Classification Keywords
H.5.2 Information Interfaces and Presentation: User Interfaces. K.3.1 Computers and Education: Computer Uses in Education - Collaborative learning.

General Terms
Design

Introduction

Museums can provide rich opportunities for inquiry-based learning outside of the classroom. Indeed, twenty-first century skills require students to be able to capture data, information, and observations; analyze these collections of data; and evaluate claims outside of the walls of the classroom [7]. However, such structured inquiry away from the classroom (or as we will call it *nomadic inquiry* [4]) is difficult for novice learners to perform and hard for teachers to facilitate [1]. A learner needs to determine what data must be observed or collected, understand how to meaningfully interpret the data and then combine different elements to create and refine a hypothesis [2]. Although positive effects of connecting classroom work to museum field trips has been shown, most teachers encourage broad, survey-based exploration rather than in-depth connections when the students are outside the classroom [5].

Our strategy is to provide computer-based support for learners to carry out in-depth inquiry in a museum setting, and thus assist teachers in creating a richer curriculum. The emergence of affordable, powerful, mobile, Internet-connected computing devices (e.g., smartphones) can support a new type of learning opportunity for students in museums. To take advantage of this we created Zydeco, a mobile system for facilitating scaffolded and structured investigation, data collection, and interpretation in a museum. Zydeco uses an overarching strategy (role playing) for supporting learners that has been shown to encourage collaborative inquiry in classrooms [3]. Role-dependent guidance and hints are provided to help the students through the science inquiry process, which was shown to be beneficial by other researchers on the *Mystery at the Museum* project [6]. Additionally, Zydeco is a context-aware system as it keeps track of information about the student, such as what exhibit they are at and their role. Learners answer questions at each exhibit to enable the system to monitor their progression and understanding, and are aided by dynamic prompts and questions if they appear to be struggling. Zydeco also provides the tools needed to collect data: taking pictures, recording audio notes, and gathering additional data about an exhibit.

Thus, Zydeco provides a new way to utilize museums. It is different than the standard exploration based museum trip as the group has a defined learning goal. This structured experience enables students to have a defined learning outcome, integrating it as part of a classroom experience, while utilizing the rich environment of the museum. Additionally, Zydeco enables exhibits to become multipurpose by providing new learning experiences with some computing setup.

We designed Zydeco using learner-centered design (LCD) to bridge the museum and classroom environments and address two educational goals: (1) helping students gather and interpret evidence to solve complex problems, for example, "How do populations respond to the changing environment?" and (2) encouraging collaboration among the students as they perform scientific inquiry [9]. The LCD approach helped us focus on supporting the learners through the scientific inquiry process while thinking about how to remove this scaffolding as the students gain proficiency. Zydeco is being iteratively designed and tested on children who are 12-14 years old.

figure 1: Initial Zydeco screen.

Here we describe the initial design and benefits of Zydeco, a mobile-computer based system that supports collaborative science inquiry in a museum.

Prior Work

Several other researchers have used mobile tools to scaffold the museum experience for learners. *Mystery at the Museum* encouraged collaboration and cooperation among visitors by providing a game where people assumed roles and interacted with the exhibits and virtual pieces to solve a mystery [6].

The *Ambient Wood* project designed a mobile system to enable students to collect observations and gather data in the woods [8]. They explored how to promote collaboration and reflection among the students with a colocated and a remote adult. This project utilized location awareness with GPS and radio frequency transceivers as beacons to provide feedback in the program and also from the environment.

Lastly, the *Myartspace* project had students use a mobile device to capture text, pictures, and audio in a museum and brought this captured knowledge back to the classroom through a website [10]. This system allowed students to bring the collected data back to the classroom, though it had some issues with students taking too many pictures and also not having a way to provide captions on their audio and images.

While we are building on the concepts of this previous research, we are looking at a broader range of tools and scaffolding strategies to support a greater range of collaborative science inquiry practices.

Zydeco Overview

Zydeco is a system designed to support students' inquiry using three features. These are:

- Context-awareness
- Static and dynamic questions and prompts
- Data collection and analysis tools

The system is context-aware in that it keeps track of the role of the student, the exhibit they are interacting with, their previous activity history and current task, and how much time has been spent on the different tasks. This enables the system to provide contextual questions and prompts for the students, which can be in the form of: process management prompts, reflective prompts, content specific prompts, and assessment questions. Zydeco is also a platform for data collection, enabling students to take pictures, record audio, and utilize virtual tools to generate data.

Below is an example scenario showing how Zydeco, using the above principles, supports learners. While the scenario is hypothetical, it illustrates how the testing of Zydeco with students in the University of Michigan's Exhibit Museum of Natural History will be conducted.

A class of middle school students arrives at the museum and is split into groups of three. Each student is given a mobile device (i.e., smartphone such as Apple's iPhone) loaded with the Zydeco system and is presented with the driving question that they are trying to solve (Figure 1): "What effect does life have on the environment?" The question is aligned with the curriculum that the students have been studying in the classroom, and the teacher has already had them form

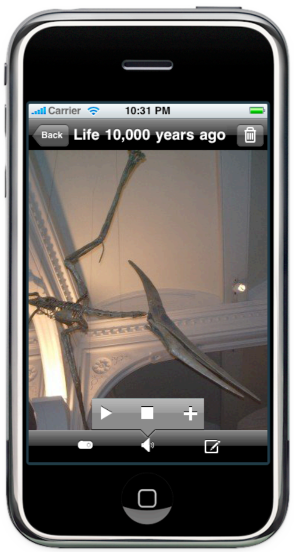

figure 2: Data collection screen with linked photo and audio.

an initial hypothesis to the question based on what they have learned so far in class. Zydeco now gives them an opportunity to investigate the topic further, and at the end to present what they learned to the class.

Each student in the group is given a role by Zydeco (Figure 1). In this case, the group has a Paleontologist, a Paleobotanist, and a Meteorologist. Everyone must be an active participant and collaborate, as the different roles need to work together in sharing and analyzing knowledge to be successful.

The Zydeco system provides the students with a list of exhibits it suggests they visit. The students are instructed to interact with five different exhibits in order to gather enough information to investigate their hypothesis. This is different than the standard exploration based museum trip as the group has a defined learning goal. This structured experience enables students to have a defined learning outcome, similar to a classroom experience, while utilizing the rich environment of the museum.

The group of students picks out the first exhibit they want to visit, a diorama titled *Life 10,000 Years Ago*, and walks up to it. The exhibit has a Bluetooth beacon on it, which the Zydeco system picks up as they approach. The group chooses to connect with the exhibit to interact with it. After the group connects, Zydeco presents them with a question to think about at the exhibit, relating to their main driving question. In this case, they are asked, "How did these plants become extinct?"

Zydeco is aware of the context of each group member: what exhibit they are at, their role, and the question they are trying to solve. Using this information it provides each student with a different prompt to consider in order to answer the question. The Meteorologist, presented with a graph displaying the average temperature and rainfall over the years, receives a hint to consider what temperature conditions were present at the time and what has changed since then. The Paleobotanist is given a hint to consider what characteristics the plants have and required for survival. He or she has a graph showing the temperature and rainfall conditions that different plants thrive in. These prompts are always given to the students in each specific role, and are an example of static prompts.

The group begins reasoning out what plants died off due to temperature and rainfall changes. Using Zydeco on their mobile device, the students record audio notes describing which plants died off due to these changes. This is one form of data collection that Zydeco supports.

The Paleontologist is provided a hint to consider what animals eat the plants. He or she is given a flow chart of the food chain of animals in the diorama's region. The group discusses the food chain, however they are unable to reason out why some plants went extinct. Because of the context-aware nature of Zydeco, after two minutes have elapsed without any progress, the program will provide a dynamic prompt to the Paleontologist; this time it suggests they consider who are the predators of the herbivores. The students revisit the chart, and notice that some herbivores did not have a natural predator and so they ate several plants to extinction.

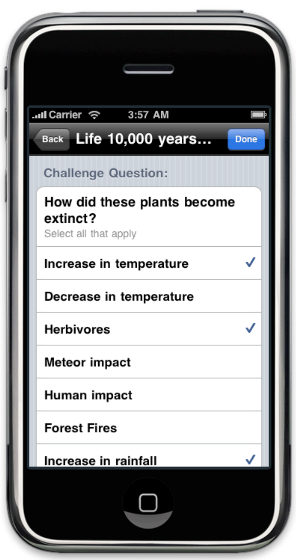

figure 3: Challenge question screen with answer choices.

Using Zydeco's data collection capabilities, the Paleontologist takes a picture of the animals that ate plants to extinction, then records an audio note linked to it describing why this happened (Figure 2). This data will be used to help support their hypothesis when they present what they learned to their peers.

Now that the group has investigated the exhibit, they are ready to answer a challenge question in Zydeco test their knowledge. They select answers from a list of difference choices on how these plants became extinct (Figure 3). The group selects temperature changes, rainfall changes, and herbivores without a predator from a list of possibilities. After answering this question, they disconnect from the exhibit and the overview page on Zydeco is updated to reflect that they finished the exhibit.

After the group has visited all the exhibits, they need to refine their hypothesis before they present it to the class. Zydeco organizes the data that was collected by which exhibit it was taken at (Figure 4), which can be reviewed to help think on the hypothesis. This data can also be uploaded to a web server to later create a simple PowerPoint style presentation, play back the data they collected, and inform the class on the significance of each exhibit and how they tie together.

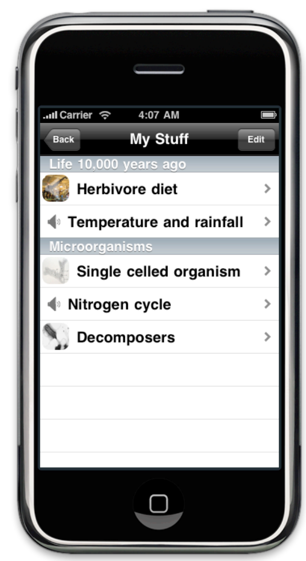

figure 4: Reviewing the data that was collected.

Design Assessment Methodology

We will be testing and iteratively designing the application on a group of 12-14 year old students in the University of Michigan's Exhibit Museum of Natural History. We will be analyzing their usage of the Zydeco system within the museum through logging their actions and audio recording.

After the group finishes, the students will be interviewed on their experience with Zydeco and rate the usability of different parts of the system. They will be asked to go through their museum trip and explain what they learned from each exhibit and how it led them to their final hypothesis. This will be analyzed to learn more about how the students are using Zydeco to perform scientific inquiry.

Contributions of Work

Zydeco is a work-in-progress to create a system that bridges the classroom and museum experience and enable students to perform collaborative, scientific inquiry in a museum aided by a mobile device. This is made possible by the availability of affordable, feature-rich smartphones, whose small profile allows visitors to carry the device throughout the museum.

Our work on Zydeco is exploring how to create technology-embedded spaces for education. Using Zydeco, current exhibits at a museum can be enhanced to provide a structured learning experience with defined learning goals by using mobile devices to provide educational content and procedural support. This enables a museum to make existing exhibits multi-purpose with an inexpensive technological setup.

This research is helping to uncover information about providing educational scaffolding on smaller, mobile devices. We are striving to learn how to determine when a student is struggling through various mobile assessment mechanisms and use this information to provide dynamic supports.

Acknowledgements

This project was supported by a GROCS grant from the University of Michigan's Duderstadt Center. We would also like to thank the University of Michigan's Exhibit Museum of Natural History, which provided advice and support throughout the project.

Citations

[1] Allen, S. and Gutwill, J. P. Creating a program to deepen family inquiry at interactive science exhibits. *Curator*, 52, 3 (July 2009), 289-306.

[2] Hofstein, A. and Rosenfeld, S. Bridging the gap between formal and informal science learning. *Studies in Science Education*, 28, 1 (1996), 87-112.

[3] Howes, E. and Cruz, B. C. Role-playing in science education: An effective strategy for developing multiple perspectives. *Journal of Elementary Science Education*, 21, 3 (April 2009), 33-46.

[4] Hsi, S. A study of user experiences mediated by nomadic web content in a museum. *Journal of Computer Assisted Learning*, 19, 3 (September 2003), 308-319.

[5] Kisiel, J.F. Revealing agendas: An examination of teacher motivations and strategies for conducting museum field trips. Doctoral dissertation thesis. University of Southern California. (2003).

[6] Klopfer, E., Perry, J., Squire, K., Jan, M., and Steinkuehler, C. Mystery at the museum: a collaborative game for museum education. In *Proceedings of the 2005 Conference on Computer Support For Collaborative Learning: Learning 2005: the Next 10 Years!* (Taipei, Taiwan, 2005). Computer Support for Collaborative Learning. International Society of the Learning Sciences, 316-320.

[7] National Research Council *Learning science in informal environments: People, places, and pursuits*. The National Academies Press, Washington, D. C., 2009.

[8] Price, S., Rogers, Y., Stanton, D. and Smith, H. A. *New Conceptual Framework for CSCL: Supporting diverse forms of reflection through multiple interactions*. Kluwer Academic Publishers, 2003.

[9] Quintana, C., Krajcik, J., and Soloway, E. Issues and approaches for developing learner-centered technology. *Advances in Computers* 57 (San Diego CA, 2003), Academic Press, 272-321.

[10] Vavoula, G., Sharples, M., Rudman, P., Meek, J. and Lonsdale, P. Myartspace: Design and evaluation of support for learning with multimedia phones between classrooms and museums. *Computers & Education*, 53, 2 (September 2009), 286-299.