Journal of Virtual Worlds Research

jvwresearch.org ISSN: 1941-8477

Arts

June 2013
Volume 6, No. 2

Art by: Catarina Carneiro de Sousa

Volume 6, Number 2
Arts
June 2013

Journal of Virtual Worlds Research
jvwresearch.org ISSN: 1941-8477

Volume 6, Number 2
Arts
June 2013

Museum Discovery Institute: Girls Designing in Cyberspace

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Abstract

In 2007, Cornell University piloted the Museum Discovery Institute (MDI), adding a new dimension to its commitment to educational outreach. The pilot program was aligned with the Girl Scouts' National GirLink Initiative and its Museum Discovery badge requirements, in response to the organization's initiative focused on girls and technology. Students visited bricks and mortar museums on Cornell University's campus and designed and created their own 3D virtual exhibits in response to their learning experience during the museum visits. In this case study, we will describe and contextualize the framework of the educational experiences integrated into the Museum Discovery Institute as a reference resource for museum education professionals and classroom educators.

1. Introduction

Be willing to "play" with ideas, to be comfortable not knowing all the answers and joy in the process of discovery, to share experiences with others, to value different perspectives…The spirit with which the space is designed will be reflected in the final product. - Speed Art Museum

In June of 2007, the Cornell Theory Center (CTC), a high-performance computing and interdisciplinary research center at Cornell University, piloted the Museum Discovery Institute (MDI) as part of its commitment to educational outreach through its umbrella outreach program, SciCentr. MDI was a hybrid program for middle school students, combining the creation of three-dimensional exhibits in cyberspace with learning in the many traditional museums on Cornell's campus. The primary objective was to introduce the participants in a constructivist-theory based manner to multi-user virtual environments (MUVEs) (a.k.a. "virtual worlds") as a tool for learning technical design skills. Specifically, the Museum Discovery Institute provided students with opportunities to develop 3D virtual exhibit content deemed important and valuable by the students, contextualized and informed by study of how bricks and mortar museums work.

The pilot program content aligned with the Girl Scouts' National GirLink Initiative and its Museum Discovery badge requirements, in response to the organization's initiative focusing on girls and technology. The National GirLink Initiative was launched by Girl Scouts USA in the fall of 2001 to bridge the technology achievement gap between girls and boys by:

1. Creating a national dialogue on the issue;
2. Cultivating links between the high-tech community and Girl Scouts;
3. Producing leading edge research, conducted by Girl Scouts USA on girls and technology;
4. Assessing the most successful technology projects for replication across the nation (Girl Scout Leader, summer 2001).

Under the umbrella of this initiative, girl scouts of middle - and high school-age were encouraged to earn a newly designated Museum Discovery Interest Project Badge. The requirements of the badge were written to introduce young women to a technology-focused topic, to build their technical skills, and to explore career opportunities in a technology-related field. Projects satisfying this badge also were required to incorporate an element of service learning (Girls Scouts of the USA Staff, 1997).

The Museum Discovery Institute (MDI) was organized with the requirements of the Museum Discovery Interest Project Badge in mind. The structure of the institute met specific requirements necessary for the girls to receive a badge in Museum Discovery after completion of the week-long institute. The three goals of the Museum Discovery Institute were to:

1. Build fluency in technology (FITness) through a structured and supportive model;
2. Build awareness of museum design through exposure to online and local museum resources; and
3. Enhance teamwork skills through group exercises.

2. The SciFair Model

MDI replicated the model of SciCentr's SciFair program, which is grounded in K12 user-generated content (Corbit, 2005; Corbit, Kolodziej, & Bernstein, 2005; Corbit & Norton, 2007). The SciFair Model supports youth in researching, designing, building, and sharing virtual worlds of their own envisioning, usually focused on STEM (science, technology, engineering and mathematics) topics, such as global warming, Mars exploration, or the human digestive tract. The worlds, and/or individual exhibits within a world, become a student's objectified personal "knowledge space". In these knowledge spaces, students are encouraged to construct and share their own particular knowledge of a subject of their choice.

Project-based learning such as virtual world design and creation is aligned with the educational theory of constructivism, first introduced by Piaget and later developed by Lev Vygotksy (1962). Vygotsky suggests that learners depend on both individual thought and social interaction, and learning happens in a dynamic cycle of collecting, organizing and producing knowledge. Indeed, the collaborative construction by K12 students of knowledge spaces in virtual worlds is a pictorial manifestation of this socially and culturally situated learning. In this way, the SciFair model also enacts constructionist (distinct from "constructivist") pedagogies. Constructionist learning involves students drawing their own conclusions through creative experimentation and the making of social objects, in this case: digital learning artifacts (Papert, 1980). The constructionist teacher takes on a facilitator's role, supporting students' own hands-on problem solving. The SciFair Model likewise relies on "mentors," undergraduate college students engaging in service learning, rather than just certified teachers.

Virtual world programming and 3D modelling have been shown to elicit positive cognitive and affective outcomes in middle school students across STEM disciplines (McCue & James, 2008). Empirical research to date suggests that these computationally-rich educational tools have the power to be extremely effective for STEM education by accomplishing the following: improving scientific understanding (Friedman & diSessa, 1999); implementing constructivist and inquiry-based pedagogies (Barab et al., 2000); designing "authentic" opportunities for learning where students "do" science (Rosenbaum, Klopfer, & Perry, 2007); engaging young girls with scientific activities to the degree that their enthusiasm surpasses that of their male peers (Ketelhut, 2007); motivating heretofore unmotivated students (Dede, Ketelhut, & Reuss, 2004); improving scores on standardized tests (Weaver, 2000); and increasing the frequency of scientific behaviors in students (Ketelhut, 2007). Virtual world programming in particular has been shown to have a positive impact on minority and underserved students' attitudes toward science (Corbit & Norton, 2007) and has proved an effective program for accommodating cultural expression (Corbit et al., 2006). Female, as often as male teens recommend using the medium for learning (Norton et al., 2008).

In addition to a constructivist approach to building understanding of a new communication medium, the integration of the digital medium of virtual worlds offers the opportunity to enhance the participants' understanding of foundation computing skills. In general, such collaborative projects align well with the 2008 ISTE NETS for Students (International Society for Technology in Education, National Educational Technology Standards 2006). The SciFair Model was developed in the ActiveWorlds system (www.activeworlds.com). Students are provided with a sequential introduction to computing skills, including building basic scripting of "actions" for creation and implantation of interactive features. An "action" is composed of, at minimum, a trigger and a command. Students select from a variety of triggers (create, activate, or bump) then add appropriate commands and additional information as their building skills increase. These activities can be used to support the one standard –

Algorithmic Thinking – that the Computer Science Teachers Association added to the NETS for Students when they published their 8th Grade standards (CSTA, 2006).

3. A CASE STUDY: THE MUSEUM DISCOVERY INSTITUTE

Youth benefit from onsite programs at museums, especially when they are asked to conceive and create related content as a way of communicating their new understanding (Kratz & Merritt, 2011). The Museum Discovery Institute combined the value of first-hand, in-person museum visits with the new knowledge construction supported by the SciFair Model. The goal of MDI was therefore two-fold: it provided an opportunity to learn in physical museum spaces and to experience designing and building a museum exhibit in a digital space. Such reflective design presents students with the opportunity to share their responses to museum visits across broad audiences. It also makes possible the establishment of an accessible archive of this student generated content as a supplement to students' museum visits.

Each day of MDI was designed to include time at the computer learning and mastering technical design skills. Each day also included field experiences at different, physical museums. These field experiences enhanced the in-world experience of building a virtual exhibit. Participants had the opportunity to interact directly with museum professionals throughout MDI as an important component of their experiences. These experiences could then be translated into their own virtual exhibits. In this way, both elements of the design experience -- as museum visitor and as museum curator -- are woven through the program.

3.1 Framework for Design Skill and Content Development Integration

MDI's instructional sequence is designed to lead the participants through a specific learning trajectory. Students are introduced to the museum exhibit as a representation of knowledge, one that is in fact explicitly designed with an audience in mind. MDI participants are introduced concurrently to the virtual world medium. They are immediately given skills to build a visual, virtual representation of their "knowledge space" as informed by the SciFair Model. They are explicitly encouraged to take into consideration the aspects of design culled from their experiences as exhibit visitors, while they are mastering the technical skill required to build a virtual world. Finally, student learning culminates in a presentation of their own virtual exhibit, a showcase of their knowledge space and an experience of welcoming visitors to their exhibit.

The SciFair Model instructional sequence for introducing students to the technology is one that the SciFair team developed over a period of ten years, and in response to the feedback of hundreds of students as they learned to use the medium (Corbit, 2005). The process is articulated across three overlapping subject domains:

1. The Design Medium
2. The Learning Context
3. Presentation

Domain One provides the foundation skills for creating a knowledge space based on the metaphor of a simple museum exhibit that incorporates objects, images, and signage/labelling. Text can be used for orientation, identification/explanation, and integration/reflection. With the experience of creating their introductory exhibits and "homesteading spaces" (see below), participants move on to consider the user experience and interactive design of their knowledge spaces, populated with the thematic knowledge gleaned in Domain Two. Domain Three is interwoven into the entire experience, as the participants share their ongoing work and provide each other with feedback. This prepares them to plan their final presentations, where they share the interactivity of their virtual exhibit and demonstrate their knowledge space.

3.2 The Design Medium, Domain One

The first domain introduces students to the virtual world ActiveWorlds browser with support offered over-the-shoulder and in-world, and the refinement and mastery of technical skill through hands-on experimentation. The sequence of computing activities for the MDI was specifically designed to create the most content with the simplest commands. The very first day of the program provided the foundation for allowing the students to immediately become content developers. Subsequent days allowed for integration of actual museum experiences with more intricate commands supporting more creative design options. As the students learned various combinations of triggers and commands based on the level of interactivity desired, their spaces became customized. Therefore, students could select either to develop their skills in digital design technology or to dive more deeply into content.

Even before the program launched, an MDI welcome world was prepared by the mentors. This world consisted of six empty structures, one for each program participant, arranged around a central fountain. In the welcome plaza area were also sign objects linked to URLs related to MDI. These links included a user guide, resources related to the lessons presented, instructional links to textures and colors, and a teleport to an object yard to assist the students with the construction of their museum exhibit (see Figure 1). This use of an introductory space providing resource, direction, and modelling design choices is an element of the SciFair Model.

On the first morning of the institute, the six girls participating in MDI (ranging in age from eleven to thirteen) were introduced to the medium of virtual worlds. Beginning their journey at the welcome plaza, they learned the components of the ActiveWorlds browser, navigation, the web pages, chat tools, and 3D world space. Ice breakers adapted from conventional social team-building activities were used in-world to immediately involve the students in the digital space, to support encouraging familiarity with the browser components, and to introduce participants to one another in a quick and interactive manner.

Figure 1: MDI introductory plaza

After the introduction to the browser, the first virtual in-world lesson was divided into four parts: how to copy a sign object; how to change the sign's color; how to use the Object Properties Box; how to link JPEGs to Picture Objects. When learning new commands, for example, students engage in repeated experiences with a single command in order to understand the sequence necessary to complete a digital task. It is always important to repeat the steps of one command before learning the steps of additional commands. During the very first day of the MDI program, each participant created two exhibits using these simple introductory commands: a small exhibit on history or Girl Scout history; and a personal exhibit on a topic of their interest. As exercises, these two exhibits allowed the students repeated opportunities to explore the initial potential of the digital medium. This stage was analogous to the "homesteading" stage of the SciFair Model in which students refine their technical learning by building a personal exhibit in preparation for collaborative design.

After creating these exhibits to reinforce the initial building concepts, participants were introduced to still more technical knowledge. The girls returned to their history and personal exhibits and incorporated links (URLs) to Web content relevant to their research on the signs and picture objects in their exhibits. For example, after designing an exhibit on black holes with sign objects and picture objects, the student returned to the existing objects to apply the new action, (a combination of a trigger and a command) activate URL. The action, "activate *URL",* allowed the student to embed research content into the exhibit (see Figure 2).

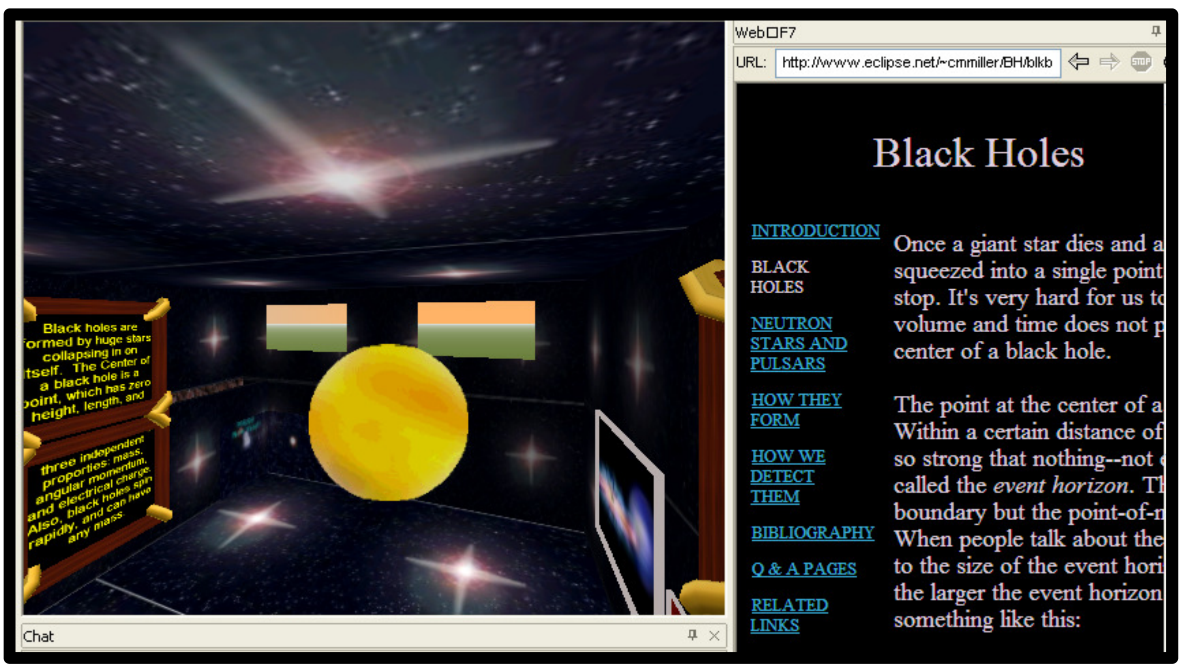

Figure 2: Screen shot of personal exhibit on black holes with embedded URL links

By the third day, after the girls had mastered the basic components of designing and building in the virtual world, the mentors moved into teaching them how to use more intricate commands, such as move and rotate. As the students learned various combinations of triggers and commands (actions), the interactivity of the museums increased in varied ways. Spinning objects, for example, were used to attract attention and/or as landmarks for navigation using the move command, which makes an object move in a certain pattern, and the rotate command, which tells an object to rotate continuously around an axis.

Creating active worlds commands such as "teleport" and "warp", and addition of the "bump" trigger were the final digital skills introduced. These were used to further control the visitor's experience. Teleports send an avatar to a new location instantly, while warps slide the avatar to a new destination location. In order to create a teleport or a warp, the student needed to learn the coordinates, altitude and facing direction of the destination location. The bump trigger is initiated when the avatar "bumps" into an object. Whatever command was written in the action box would then occur. These interactive features were especially appealing to the designer and to youthful visitors to the exhibits as they provide a game-like exploration of the content, and can have a big impact the users' experience that the student-curators would actually witness during the virtual tours on the final day of MDI. Significantly, as students were designing their own exhibits, they were also visiting exhibits and paying attention to the experience of museums from the visitor's perspective, a skill developed in Domain Two.

3.3 The Learning Context, Domain Two

The toolkit of domain two includes the development of a conceptual understanding of museum curation and exhibition through field-based experiences and museum visits. The MDI-affiliated museums that students investigated included the Museum of the Earth and the Paleontological Research Institution; geology exhibits in Cornell's Snee Hall; the Cornell Plantations; the Cornell Theory Center's three-wall CAVE (Computer Aided Virtual Environment) virtual reality environment; and the Johnson Museum of Art. Again, all three domains of the SciFair Model implemented during MDI were threaded throughout each day's activities, so MDI participants visited a physical museum space on each program day, met with a museum curator and/or educator, and discussed actual exhibit design elements, such as graphic design in signage or how to respond to various visitor disabilities.

Direct interaction and exploration for the first day of MDI featured the on-campus collections of the Museum of the Earth and the Paleontological Research Institute (PRI). The Department of Earth and Atmospheric Sciences is housed in Snee Hall, on the campus of Cornell University, and students visited its mineralogical museum, and various exhibits including dinosaur footprints, working models of geological occurrences, a seismograph station, a fossil display from the Paleontological Research Institution and Rock Park. Rock Park, a very different approach to collection design, displays specimens from New York State and surrounding regions.

The Museums Operation Manager spoke on the mastodon exhibit, presenting ideas on label design and exhibit display. The Museum Discovery Institute participants learned about the design elements of font type, font size, color and about content of information included in the exhibits at Snee Hall. The information presented at Snee Hall corresponded to the students' in-world signs and the layout of the 3D designs of their museum.

On the second day, students visited the Cornell Plantations to experience a museum of living plants in an outdoor setting, learning how to maintain living exhibits and about botanical careers in a botanical garden. The girls met with the Director of Horticulture who explained the purpose and parts of a public garden and led a tour of the Herb Garden. In addition, the girls learned about working in Plant Records, the Youth Education Program, as Gardeners and about managing the Lath House, a nursery facility at the garden.

Figure 3: Participants visited displays of 3D objects and discussed documentation of the collection in two dimensions

In the afternoon of the third day of MDI, the students visited the Cornell Theory Center CAVE. The CAVE provided a three-walled display for viewing 3D spaces and exploring scientific visualizations of data from research in fields ranging from molecular to atmospheric sciences. This extended the concept of the virtual museum and allowed the participants to experience this variation on 3D visualization first hand, using both the head mounted controls and wand and following the explorer with special 3D glasses. This provided an exciting introduction to leading-edge graphics.

During their morning at the Herbert F. Johnson Museum of Art on day four of the MDI program, the students toured the collections and were introduced to the use of technology in an art museum. They saw examples of how various types of technology are used in security, lighting, storage, temperature and humidity systems. Special attention was paid to the accessibility of the museum for people with disabilities. MDI served as a platform for students to learn how digital technology is integrated in different types of museums, as they learned about various museum careers.

3.4 Integration of Design Skill and Content Development

Immediately following their preliminary building experiences, the girls began construction of their Museum Discovery exhibits, MDI's capstone project. On the second day of MDI, the group had a brainstorming session to develop an overarching theme for the Museum Discovery Exhibits. After reviewing different themes, such as, music, writers, artists, world climates, marine life, world cultures, and famous women, the girls decided upon a history museum. Their History Museum included the history of the Aztecs, dogs, Egypt, New York State, video games, and Rome.

Prior to the construction of the exhibit the girls completed a World Design Plan. This plan addressed questions related to the exhibit design:

- What will your exhibit look like?
- Describe the particular style of exhibit.
- How will the space be used?
- How will the space be divided?
- What will visitors do in your exhibit?
- What do you want visitors to have learned when they leave?

The museum field trips and the experiential learning in the museums were planned to dovetail with the scaffolding of design technology skills. For example, the students decided upon returning from their first field trip at Snee Hall to create a specific area in Museum Discovery world where they shared with each other through their personal exhibit spaces what they had learned from the experience in an accurate reflection of their learning (see Figure 4).

Figure 4: Collaborative exhibit space reflecting content introduced during Museum of the Earth field trip

Moving beyond reflection to creative representation, mastery of the "texture" command allowed one student to add the image of an Egyptian mural to her columns, roof and ceiling in her museum on Egypt (see Figure 5). Unlike the collaborative spaces, these personal exhibit spaces allowed the students to develop within their own personal boundaries, and make design decisions autonomously.

Figures 5: Use of mural texture to support an Egyptian theme in a History of Egypt exhibit space

These skills were part of the first virtual in-world lessons. After subsequent lessons on the move and rotate commands, the designer of the Egypt Museum was able to apply these to the existing sign objects to increase the interactivity of the space. The Egypt Museum included a secret chamber underground, the creation of which involved more complex commands, acquired through one on one with a MDI mentor. Similarly, the designer of the New York State Museum not only displayed her knowledge, but also tested the knowledge of her visitors through the design and construction of a quiz game exhibit (see Figure 6).

Figure 6: A quiz appears when a visitor clicks "Click Here for New York Quiz".
A click on a sign asking a question triggers the appearance of the answer on an additional sign.

She also used the move command in a playful way, by creating an apple sprite image, a prime agricultural crop that actually falls from the virtual tree. The final projects created by the students clearly demonstrate their combined mastery of both the design medium and their chosen content, while also being attentive to domain three: the virtual knowledge space as user experience and method of presentation.

3.5 Presentation, Domain Three

The third and final domain includes the final showcase, where teams and mentors present their work to each other and members of their community, as well as special guests. The last day of the institute was devoted to completing the final design of the museum exhibit, as well as to practicing the presentation for the Showcase. The Showcase, which was the culminating event at the Museum Discovery Institute, was a series of presentations from each student. This public activity allowed each student to demonstrate her museum exhibit by conducting a virtual tour which included navigating the three dimensional space as she explained her inspirations and the challenges she encountered. In this way, the student revealed both the interactivity of her virtual exhibit space and her mastery of technical design skills to peers, families, friends and community guests.

Public presentation of virtual spaces to other participants and community members is a crucial element of the SciFair model for supporting middle and high school students' generation of virtual worlds. Presentations happen both face-to-face and inworld, so students are given organized support and structure to prepare them for public speaking, in much the same way they are provided with technical support in digital design. Presentations of current work were practiced daily beginning on the second day of MDI. The practice presentations provided an opportunity for questions and answers in an informal setting. They also functioned as design critique sessions and allowed for the students to provide their peers with constructive feedback. This feedback could then be incorporated in the museum design. The daily presentations also allowed students to demonstrate the interactivity of their spaces, thus allowing them to share their original ideas with their peers.

The practice presentations became an important part of the learning process. Not only were the presentations ideal for sharing information, displaying interactivity and incorporating feedback, the frequency of practicing the presentations allowed for the experience to become familiar. The more the students practiced the presentation, the more they were at ease with expressing their ideas and navigating a virtual space. One young woman exclaimed at the podium of her last practice presentation "I feel like a university professor!"

4. Conclusion

While the MDI program has not been integrated directly into classroom experiences, the possibility to do so exists. The SciFair program and related curricular content developed for SciCentr were adopted by the Greater Southern Tier BOCES (Boards of Cooperative Educational Services) in Elmira, NY. The Virginia Beach City Public School District in partnership with the National Institute of Aerospace in Hampton, VA, has established an Active Worlds universe for classroom projects and a NASA engineering design competition. The American Museum of Natural History ran a second pilot virtual world summer institute in 2012 using ActiveWorlds. All of these programs have benefitted from lessons learned in programs such as MDI.

One exhibit created for the Southern Tier SciFair summer program in 2007 presents a maze-like exploration of the human digestive tract created by a team of students with their science teacher and a college design technology mentor. This project now serves as a virtual field trip opportunity for her classes, a fun tool and a living legacy for the 2007 team. Also, in a related project, the New York Hall of Science supported the development of the Virtual Hall of Science, through an NSF ITEST (Innovative Technology Experiences for Students and Teachers) award and funding from Deutsche Bank. Exhibits created by youth in this project will be open for class field trips in 2013 through their partnership with SciFair.

In 2012, the Adventures in Science program at the American Museum of Natural History ran Virtual Worlds Institutes for middle school students for a second summer, having acquired a universe for ActiveWorlds. Students explored the museum collections, interacted with researchers and curators, and were challenged to develop their own research hypotheses centered on questions related to current work in Anthropology and Paleontology. As they worked, they gathered their digital references and artifacts in field camps of tents, one for each team of two students, analogous to the practice galleries described in the case study. As a final presentation, these teams designed and completed virtual dioramas within custom worlds that presented the backdrop for each program. In particular, students studying the Cretaceous Seas translated the handmade clay models of creatures that they had studied into 3D digital models. Technical support staff translated these models for the software and made them available to the students' in-world. For their final presentation the teams designed exhibits in underwater caves and set their creatures, often schools of creatures, out into an undersea environment that they had modified to fit the creatures' requirements.

In programs such as these, the focus is on content mastery and the virtual worlds are the presentation medium. MDI is unique among these programs because of its focus on user-centered design. The challenge is to balance the time requirements for mastering the focal content with that of mastering the digital design process; and to do this in such a way that the students have meaningful and satisfying experiences with both. The MDI program therefore can provide a useful model both for introducing virtual world development to K12 students in formal and informal educational settings; and for supporting K12 museum visitors in knowledge production and constructivist learning.

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