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14. ABSTRACT

The New York Hall of Science is closing out its ONR-funded project entitled the "Center for Design-Based STEM Education." A new ONR grant, entitled "Design Lab" (N00014-13-1-0893), will enable us to complete the remaining portions of the project over the next 18 months. The Center for Design-Based STEM Education (now formally called Design Lab) is a part of a ground-breaking STEM education initiative that will result in model museum activities, in-class curriculum projects, teacher professional development workshops, and an exhibition that all incorporate the use of design-based STEM learning, an education strategy that has been proven to effectively engage a broad constituency in STEM.

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New York Hall of Science

Center for Design-Based Education

Final Report to Office of Naval Research

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New York Hall of Science

FINAL REPORT
to the Office of Naval Research
Center for Design-Based STEM Education
Contract Number: N00014-11-1-0957
October, 2013

PROJECT SUMMARY

The New York Hall of Science (NYSCI) is pleased to report that it has successfully completed the first two years of its three-year ONR-funded project entitled the "Center for Design-Based STEM Education" (N00014-11-1-0957). A new ONR grant, entitled "Design Lab" (N00014-13-1-0893), will enable us to complete the remaining portions of the project over the next eighteen months. The Center for Design-Based STEM Education (now formally called Design Lab) is a part of a ground-breaking STEM education initiative that will result in an exhibition, field trip activities, in-class curriculum projects, and teacher professional development workshops that all incorporate the use of design-based learning, an education strategy that has been proven to effectively engage a broad constituency in STEM, including groups that have been traditionally underserved in science education. Funding from ONR is underwriting the teacher and student programming associated with the initiative.

Design, a problem-solving process central to engineering and technology, is a powerful vehicle for teaching essential inquiry skills and STEM content in an integrated and inspiring way. It is a process by which people from diverse fields make decisions about the form, function, and use of materials to create artifacts, systems, and tools that solve a range of problems, large and small. Through the design process, one learns how to identify a problem or need, how to consider design options and constraints, and how to plan, model, test, and iterate solutions to problems, making higher-order thinking skills tangible and visible. Design activities can be intrinsically motivating to students because they engage the desire to make things and learn how things work, embrace "failure" as a necessary part of the innovation and discovery process, and offer a low barrier to entry for reluctant learners and a high ceiling for achievement among active STEM learners.

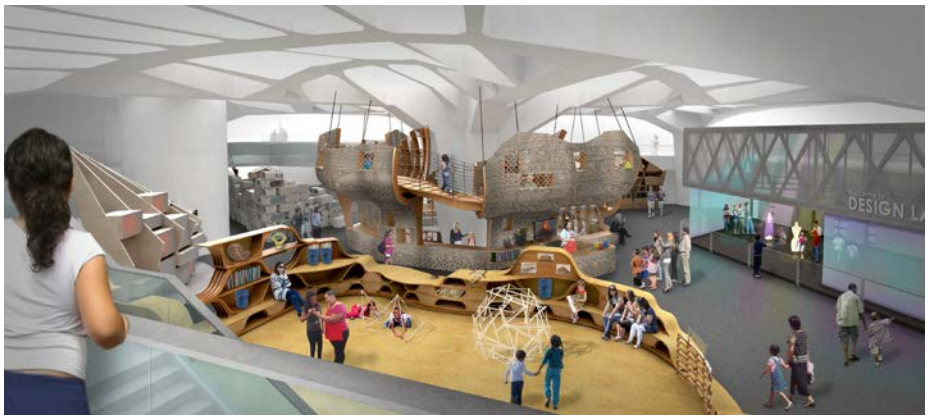
Through Design Lab, NYSCI is playing a leading role as an early adopter and innovator in design-based STEM learning. The programming we are developing through the ONR-funded project, much of which will be based in a new 10,000 square foot space at NYSCI that will be entirely devoted to design-based learning, will build on contemporary STEM-related issues and -- through a growing interest in designing and making in education, the planned dissemination of the project results, and NYSCI's leadership position in the science education field -- will serve as a catalyst for broader education reform.

ACTIVITIES COMPLETED

Over the past two years, a team of NYSCI instructors, researchers, educational specialists, along with a core advisory group of teachers, developed much of the core programming for Design Lab. The programming that was created, tested, and reiterated is both in keeping with ONR's focus on "game changing" solutions for STEM education and aligned with the new Next Generation Science Standards (NGSS), especially in the programming's focus on self-guided inquiry and real-world problem-solving, approaches that are stressed in the very first of the "conceptual shifts" outlined

by the NGSS (i.e., "Science education should reflect the real world interconnections in science" and "seek to illustrate how knowledge and practice must be intertwined…"). Working with the teacher advisory group, NYSC completed the following project tasks:

Design Lab Activity Development



A rendering of the Design Lab exhibition slated to open in 2014. The space will consist of activity areas that support facilitated design activities for students and families.

The project team developed and prototyped ten learning modules that in addition to museum-based starter activities, feature pre- and post-visit classroom activities and extensions. All of the modules were carefully evaluated to ascertain their effectiveness and usefulness with a variety of audiences. The prototype activities (the evaluation results for which are outlined below) engaged more than 9,000 individuals.

A sample activity is "Happy City," which presents NYSCI's visitors with a simple challenge: "What would you add to the museum's miniature 'city' to make it happier?" In the prototyping sessions, the participating students created inventions ranging from a musical crosswalk to a "vacation home" equipped with a propeller that enables you to take your home with you on vacation. Through their exploring and tinkering, the participants were thinking in ways that came from their own imaginations and interests and, as a result, they were more absorbed and motivated. In fact, through its focus on solving problems that are personally relevant or purposeful, the design-based approach has been shown to be effective at reaching underrepresented groups who are not always motivated by more traditional STEM activities

Teacher Professional Development

NYSCI worked intensively with thirty-nine teachers in two Summer Design Institutes through which our professional development specialists provided the participants with a variety of design-based learning strategies, showed them how to effectively employ the pre-post design lessons, and equipped them to develop their own extension activities for use in the classroom. Over the course of their involvement, each of the teachers provided valuable feedback that has enabled project staff to refine the design-based activities as well as the professional development programming. Ultimately, we hope to scale these PD experiences to many more teachers. All told, the participating teachers have used the learning modules with over 1600 middle- and high-school students.

Design Facilitation

Facilitation is essential to design-based learning. It is also a tricky process, requiring the careful observation of participants and an understanding of when and how to assist individual learners.

Too much facilitation can take program participants out of the "zone" in which they may be engaged, while for some learners, too little can leave them uncertain and frustrated about how to move forward. Through the project, NYSCI staff worked with forty-five Explainers (museum floor staff) to uncover and experiment with strategies for effectively facilitating design-based learning. As part of this work, our staff provided the Explainers with more than 90 hours of training, studied their facilitation of the activities on the museum floor, obtained the Explainers' ongoing feedback on the process, created a blog through which the Explainers can reflect on their work and exchange ideas, and initiated the development of a formal set of best practices for the design facilitation process.

Teacher Design Nights

In October 2013, NYSCI held a Teacher Design Night for the teacher participants, their colleagues and administrators. The event, which in addition to selected design activities featured refreshments and stimulating conversation, served to solidify the community of practice that the teachers developed during their trainings, get their school administrators excited about their efforts, and introduce additional teachers to the museum's resources and the power of design-based instruction. In the next grant, we plan to hold two additional Teacher Design Nights as prototypes for what we hope is an ongoing museum practice.

Evaluation

Rockman et al (REA) has served as the external evaluator for Design Lab since the project's inception. They employed a mixed-method approach (including surveys, focus groups, observations, and interviews) to obtain an appropriate range of input and feedback from the project's primary stakeholders. Some of their key conclusions are as follows:

- Teachers unanimously found that design-based learning to be a useful tool for engaging students, including those with special needs and those who sometimes have trouble focusing in the classroom.

- Teachers were surprised by the degree to which their students were engaged with project activities and how quickly they adopted design-based learning practices.

- Teachers observed that students gained confidence in their abilities the more familiar they became with design-based learning principles.

- Teachers observed high levels of collaboration and cooperation in student groups, even among students not normally exhibiting these kinds of behaviors.

- As they progressed deeper into each lesson, students began to connect the process of "failure" as a necessary means for improving comprehension and understanding.

- Participating in design learning activities motivated students to learn.

- By applying design activities to real world issues, students could more easily relate scientific content and principles to their own lives.

- The intensity and amount of daily reflection on the part of the Explainers was "very impressive."

- The Explainer training and daily blogging have been valuable tools for tracking what works and doesn't work in the facilitation process and for identifying the key issues that arise.

Publication and Dissemination

To disseminate the results of Design Lab, project staff has developed a web page that outlines the project's goals, outcomes, and benefits (http://designlab.nysci.org/). They regularly blog about the project (http://designlab-nysci.tumblr.com/). They presented the project to conferences of the Association of Science andTechnology Centers (ASTC), the American Alliance of Museum (AAM), and Interaction Design and Children (IDC). Peggy Monahan, NYSCI's Exhibits Projects Creative Director and the Project PI, and Dorothy Bennett, our Director of Design-Based Learning in Schools, wrote a chapter, "NYSCI Design Lab: No Bored Kids!" for a newly published book entitled *Design Make Play: Growing the Next Generation of STEM Innovators.* They highlighted the project work at a symposium on design-based learning, which was presented by NYCI in conjunction with MakerFaire (makerfaire.com) and the White House Office of Science and Technology Policy. And perhaps most significantly, they have shared their work through a newly established network of museums that are interested in building new avenues to STEM learning through design.

Summer Design Institute 2012: Teachers prototyped design projects and then presented their work and ideas to NYSCI staff and each other.

The network, called the Museum Design Collaborative (MDeC), includes large and small science centers throughout North America, including the Museum of Science in Boston, the Tech Museum of Innovation in San Jose; the Science Museum of Minnesota in St. Paul; Explora in Albuquerque; and TELUS Spark in Calgary. Funded by a grant from the Noyce Foundation, the group meets regularly to discuss new strategies for engagement. By collaborating to identify common criteria for assessment and creating resources such as a design-based learning "playbook," a video library of sample activities, and an online professional development course, the partners will be extending the reach of design-based learning into a range of informal science institutions. The results of Design Lab will be folded into these resources, enabling the project to impact the museum field in deep and substantial ways. In view of the growing interest among museums and other science centers in making and design-based learning, Design Lab stands to make a tremendous contribution to the field of museum education and to STEM education, more broadly. It is through

this active network that the work being created in our ONR-funded project will have its greatest national impact.

ACTIVITIES IN SECOND ONR GRANT PERIOD

Over the next eighteen months and under the new ONR grant, NYSCI will conclude its Design Lab work. Among other things, we will (1) engage another 36 middle- and elementary-school teachers in our Summer Design Institutes; (2) finalize the Design Lab modules (which will ultimately feature 12 sets of museum, pre-post, and extension activities); (3) continue the refinement of our design facilitation training; and with the opening of the Design Lab exhibition in the spring of 2014, (4) begin to serve thousands of teachers, students, and families through the programming we are developing.


Student exploring the properties of plastic in a prototype workshop.

National trends in the reform of science education tie learning to motivation. Stimulating students' interests, engaging them in problem solving, and demonstrating relevance are the recommended strategies for creating stronger attractions to STEM. Design Lab is utilizing each of these approaches. It is helping teachers and museum educators to more effectively use the natural inclinations of young people to make and discover how things work to actively engage them in STEM learning, and it is promoting the use of design-based approaches to STEM instruction that actively encourage students to work out solutions to design problems of their own choosing, enabling them to find relevance and pursue interests that are completely their own. It is only with the generous support of ONR that we making these essential strides forward.