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Simulation for Authentic Learning in Informal Education

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Abstract

In 2011, the Museum of Science and Industry in Chicago, Illinois embarked on the creation of a program that allows middle and high school students to explore community health issues using human patient simulation. MedLab was created to engage students in an authentic exploration of medical science, biology, and human anatomy, with a particular focus on how these fields apply to learners' lives. The program content is made relevant through an emphasis on personal health, community health, and medical science career pathways. This article explores the development, implementation, use of technology, and outcomes of MedLab.

Keywords

museum; education; field trip; medicine; medical; simulation; career; STEM

The Museum of Science and Industry (MSI) in Chicago, Illinois is located in the only remaining building from the 1893 World's Columbian Exposition and has been open since 1933. In 2008, MSI launched its Center for the Advancement of Science Education (CASE) with a strategic vision to inspire and motivate children to achieve their full potential in the fields of science, technology, medicine, and engineering. CASE was developed following the convening of a national advisory committee comprised of civic leaders, senior staff from regional non-profits serving at-risk youth, and national leaders in science education. The committee informed the identification of core priorities for CASE, with educational services for schools and community groups placed firmly at its center. CASE focuses on improving science education by: 1) facilitating high-quality science teaching and learning in and out of schools; 2) increasing awareness of, interest in, and engagement with science; and 3) encouraging students to consider STEM-related postsecondary study and careers. Associated curriculum is aligned with evidence-based best practices and with the Next Generation Science Standards in a concerted effort to support learning that happens in and out of the classroom.

In the MedLab program, students explore community health issues through a variety of authentic medical simulation activities. Students run lab tests on simulated bodily fluids, use an ultrasound imaging simulator, and perform a physical examination on a human patient simulator known as iStan™. iStan™ is a computer-driven, full-sized manikin that delivers true-to-life biomedical scenarios that swiftly change to meet the user's goals. This human patient simulator blinks, speaks and breathes, has a heartbeat and a pulse, and accurately

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mirrors human responses to procedures such as cardiopulmonary resuscitation, cardiac defibrillation, intubation, ventilation, and catheterization. Although this medical education technology has become relatively widespread in teaching hospitals and universities, it is less common outside of those settings.

MedLab Learning Theory and Audience

In 2011, MSI embarked upon the creation of a new program—MedLab—funded through a Science Education Partnership Award (SEPA) from the National Institutes of Health (NIH).¹ MedLab expands the museum's Student Experiences, which extend the educational impacts of exhibits and provide students and teachers with meaningful learning experiences that begin in the classroom, center on museum exploration, and illuminate areas for further science engagement back at school. By narrowing the scope of the field trip experience to focus on specific curriculum areas connected directly to the classroom, Student Experiences aims to:

- Increase student content knowledge in specific science subject areas.
- Engage students in the scientific process and build scientific habits of mind.
- Provide insight into real-world applications of science and introduce students to science-related careers.

MedLab was designed to address all of the above goals, with the added goal of engaging youths from underrepresented minority youth populations. These are ethnic and cultural groups that are disproportionately absent from science and engineering degree programs and professions – African Americans, Latinos, Native Americans, etc. According to recent data from the National Science Foundation, in 2012 white men constituted over 50% of the science and engineering workforce, while non-white men and women of all ethnicities made up less than 50%.² Author Gary M. Stern noted that the factors that lead to this underrepresentation are multi-pronged but include inadequate math and science training in overcrowded urban schools.³ The United States is at a critical stage in efforts to improve science education and student achievement in STEM (Science Technology Engineering and Math) fields and to meet the demands of the future job market. According to a 2013 report, projections estimate the need for 8.65 million workers in STEM-related jobs by 2018. Many sectors face an alarmingly large shortage of qualified employees.⁴

MSI's education programs, and specifically MedLab, seek to reduce this deficit and encourage young people to pursue science and health education and careers. By working closely with Chicago Public Schools (CPS), a majority minority district in which over 90%

¹"SIMLAB: Using Patient Simulation for Student Exploration of Community Health Issue," Science Education Partnership Award, last modified August 7, 2015, <http://nihsepa.org/grants/simlab-using-patient-simulation-student-exploration-community-health-issue>.

²"Women Minorities and People with Disabilities in Science and Engineering," National Science Foundation, accessed July 22, 2015, <http://www.nsf.gov/statistics/2015/nsf15311/digest/theme5.cfm#hispanics>.

³Gary Stern, "Inspiring Minorities into Health and Science Careers-Two University of Florida Programs Show Signs of Success," *Hispanic Outlook in Higher Education*, June 7, 2010, 26–27.

⁴"What is STEM education?," Live Science, last modified February 11, 2014, <http://www.livescience.com/43296-what-is-stem-education.html>.

of students are nonwhite, the museum is engaging underrepresented minority youth in both the development and delivery of the program in an effort to reduce disparities of representation in the STEM fields. Furthermore, 86% of CPS students are considered economically disadvantaged.⁵ These students are much less likely to excel academically than their peers of higher socioeconomic status⁶. By providing bus transportation and offering the MedLab program at no cost to CPS schools, the program reduces the financial barrier to participation and reaches an even greater number of students, expanding opportunities for STEM involvement. Another way the program targets economically disadvantaged students is through partnerships with under-resourced schools in Chicago. By deliberately selecting schools in communities geographically distributed across the city, MSI ensures the participation of students and educators from diverse racial, ethnic, and cultural backgrounds.

MedLab takes a constructivist approach to instruction. By presenting an immersive problem-based experience, MedLab allows students to engage in an authentic exploration of medical science, biology, and human anatomy, with a particular focus on how these fields apply to learners' lives. The on-site lessons are presented using hands-on science inquiry activities in an effort to help students develop the skills necessary for use in real-world STEM professions.⁷ Each of the on-site programs is problem-based, focusing on one disease or pathology and presented through a patient storyline. In each scenario, students are given patient charts (medical history, current symptoms, current medications, etc.) and a reason that the patient requires immediate medical attention. The students assume the roles of various medical professionals to conduct lab tests and complete a physical examination on the human patient simulator in order to diagnose and treat their patient. Studies show that when this type of inquiry-based approach is incorporated in science teaching, youth (particularly historically underserved minority students) score higher on science achievement tests, have improved science process skills, and develop more positive attitudes toward science than students taught using only a traditional approach.⁸⁹ The content is made relevant to the students through an emphasis on personal health, community health, and medical science career pathways. This holistic approach will allow the museum to investigate the degree to which the use of lifelike human patient simulation technology and authentic medical test simulation—together with community health and physiology content—creates interest in health and science careers and empowers adolescents to make positive decisions about their own health. Health education literature suggests that programs like MedLab are a viable strategy for encouraging youth to learn more about health in general and make better personal choices. For example, Brown et al notes that “programs and curricula should be designed to increase student interest in health issues and their self-

⁵“Chicago Public Schools Stats and Facts,” last modified April 17, 2015, http://cps.edu/About_CPS/At-a-glance/Pages/Stats_and_facts.aspx.

⁶Bradbury, Bruce, Miles Corak, Jane Waldfogel, and Elizabeth Washbrook. “Gaps in the School Years” in *Too Many Children Left Behind: The U.S. Achievement Gap in Comparative Perspective*, 87–110. 1st ed. New York, New York: Russell Sage Foundation (2015).

⁷NGSS Lead States, *Next Generation Science Standards: For States, By States*. Washington DC: The National Academies Press, 2013.

⁸S. Basu & A. Calabrese-Barton, “Developing a sustained interest in science among urban minority youth,” *Journal of Research in Science Teaching*, 44(2007), 466–489.

⁹H. Gibson & C. Chase, “Longitudinal impact of an inquiry-based science program on middle school students’ attitudes towards science,” *Science Education*, 86(2002), 693–705.

efficacy in controlling their own health destinies” and that “beyond age, the greatest predictor of both interest in and motivation to follow what is taught about health was a belief that kids can influence their own health.” Those who perceived that they have at least some control over future health outcomes were three to four times as likely to be interested in health and to say that they try to follow what they were taught.¹⁰

MedLab’s first year focused on developing a process for working with educators and students at a small number of Chicago Public Schools, and to identify relevant community health issues in order to begin developing storylines that would serve as the context for the simulation scenarios. Project staff conducted school site visits, field trips to the museum, and hosted a career day with school and community partners. MSI also engaged a focus group of teachers, administrators and other community members; explored the Next Generation Science Standards; and used existing CPS science and health curricula to determine how to design the program to best meet the needs of the students. The program was initially created to reach high school science and health educators and their students. As MSI program developers met with teachers and students, they recognized additional interest and need and expanded the focus to include middle schools. Ultimately, the museum created two customized medical sciences Learning Labs that were offered to 7th–12th grade classes. The lab topics – diabetes and heart disease – were chosen based on the feedback of the teachers and students involved in the early stages of development. These groups identified broad needs in health education – for curricula on adolescent health, obesity, nutrition, substance abuse, etc. Those needs fell within the Chicago Department of Public Health’s list of priority community health issues, a list identifying the health issues most relevant to the residents of Chicago.¹¹ The list was developed to set specific targets to improve the health and well-being of Chicagoans. It was also designed as a vehicle for engaging communities, partners, and other stakeholders in health improvement efforts. Each lab topic covers the needs of the teachers and students as well as multiple issues from the list. MedLab: Diabetes addresses obesity prevention, adolescent health, healthy homes, and public health infrastructure. MedLab: Heart Disease addresses tobacco use, obesity prevention, heart disease and stroke, healthy homes, and public infrastructure. A third lab, which addresses several of the priority health issues in an asthma scenario, is in its initial development phases.

Components of MedLab

The MedLab program consists of three parts: the on-site learning programs; relevant lesson plans and educator resources that are freely available for download on the museum website; and an online component. Each component of the MedLab program is vetted by museum staff and an advisory committee of health professionals and health educators before being tested by student groups selected to pilot the program through established teacher partnerships.

¹⁰S.L. Brown, J.A. Teufel, & D.A. Birch, “*Early adolescents Perceptions of Health and Health Literacy*,” *Journal of School Health*, 77(2006): 7–15.

¹¹“Chicago Department of Health: Healthy Chicago,” last modified August 16, 2011, <http://www.cityofchicago.org/content/dam/city/depts/cdph/CDPH/PublicHlthAgenda2011.pdf>

Students participating in the on-site programs experience hands-on medical science and simulation. In MedLab: Diabetes, student use urinometers, micropipettes, medical test strips, and graduated cylinders. They also examine the human patient simulator exhibiting the signs of hyperosmotic hyperglycemia. In MedLab: Heart Disease the students also use medical test strips, urinometers, and medical test strips, as well as an ultrasound simulator to view the “patient’s” heart after a recent myocardial infarction. The students compile their test and examination results and analyze them to make a differential diagnosis before making recommendations for treatment. They then discuss ways in which they can make sound health decisions themselves and how those decisions affect community health. Facilitators ask probing questions to help students recognize their personal empowerment to make positive changes in community health.

The downloadable pre and post visit lesson plans and resources enable educators taking the on-site programs to make explicit connections between what students are covering in the classroom and what they learn in the on-site programs. The lessons align with the Next Generation Science Standards upon which the CPS science framework is based and are delivered complete with background reference material, slide presentations; step-by-step instructions, materials lists for related activities; and printable student worksheets. These materials are made available freely through the museum website. Direct links are provided when teachers register for the classes as well. Covering the materials in the classroom prior to visiting is not required for participation, but teachers are encouraged to use what they find relevant to their curricula as it makes for a richer learning experience overall.

The online component, launching in summer of 2016, is currently under development. It will feature three more patient scenarios that cover multiple topics on the Chicago Department of Public Health’s list of priority community health issues. It is being developed to reach as wide an audience as possible across as many platforms as possible, so that teachers and students from all over will be able access these problem-based scenarios from any major browser on nearly any tablet device. It is being designed to be used both in tandem with an onsite visit or as a standalone activity. This virtual lab will allow students to complete simulated lab tests and perform virtual patient examinations before making differential diagnoses and recommendations for treatments.

Implementation and Evaluation

The 2014–15 school year marked the first time MedLab was available for general school group registration. Teachers registering their classes for Learning Labs through the museum’s website were given the option to choose MedLab: Diabetes (the first scenario developed) from the list education programs offered at the museum. The response was very positive, with 96 school groups participating in the program, totaling more than 2,500 students. Twenty teacher partners from the 96 groups were recruited directly by MSI and were asked to participate in the program evaluation. Evaluation strategies were twofold. An external evaluation team was engaged to assess the potential emotional risk associated with participating in the program due to the nature of working with simulated bodily fluids and a lifelike robotic patient, which can prompt a negative emotional/psychological reaction for some individuals¹². The museum’s Research and Evaluation Department also informally

assessed the perceived value of the program (downloadable lessons and the on-site experience).

The external evaluators observed 10 classes and conducted a short survey with 194 students. They reported that interactions with iStan™ posed no significant emotional risks. Of the 194 students observed during the Learning Labs, only seven reported an initial discomfort with iStan™. Of those seven, only one student declined to work directly with the human patient simulator. The other six were given the option to decline, but participated in the physical examination of iStan™ nonetheless. The seven students reporting discomfort (along with 18 other randomly selected students) were interviewed six months after participating in MedLab. All 25 of them reported having a positive overall response to the program—even the seven students who initially experienced a negative reaction. The evaluators recommended proceeding with the lab as it is designed and continuing to offer students the option to not interact with iStan™.

The museum's Research and Evaluation team interviewed fifteen of the twenty partner teachers about their participation in the on-site MedLab program and their use of the pre- and post-visit supplemental lessons. The teachers were all given a packet of paper copies and a USB thumb drive containing digital copies of the supplemental materials in addition to links to the materials on the museum website. All fifteen "strongly agreed" that they believed the Learning Lab was a good use of their students' time and that their students were engaged for the duration of the program. They all felt confident that their students understood the material presented, and they reported that their students were presented with career paths relevant to the topic. Teachers commented that students felt empowered by running the tests themselves. All of them reported that the supplemental material was easy for them to use, that their students understood the content, and that they would use the material with future classes.

The program designers were surprised and relieved to find that only a very minute number of students reported negative emotional responses to the human patient simulator robot. The biggest challenge for the external evaluation team was response rate – often the case with evaluation studies. However, NKO was able to survey the seven participants initially reporting negative reactions and the eighteen control participants after six months, given them a large enough sample size to report confidently.

Future of the Program

MedLab offers a unique opportunity to connect middle and high school students and teachers to both science and health and wellness, all while exploring related careers. Through on-site program delivery, free and easy access to lesson plans and resources, and the virtual lab online component, MSI will continue to support authentic engagement with science content and its connection to "real life" issues. This approach provides a new level

¹²M. Mathur & D. Reishling, "Navigating a social world with robot partners: a quantitative cartography of the uncanny valley," *Cognition*, 146(2016): 22–32.

of access for thousands of Chicago students traditionally underrepresented in science and health related professions.

Evaluation of the MedLab program will continue - expanding into content knowledge, effects on science attitude, and career reporting. The longitudinal study done by the external evaluation team through New Knowledge Organization will move into the final phase of evaluation during the piloting and introduction of the MedLab: Asthma scenario. This phase will consist of surveys of participants' understanding of basic health and medical science content covered in the on-site MedLab programs. They will also evaluate students' general attitudes toward health, medical science, and medical careers. Given the informal responses of the students in these areas, it is expected that the evaluation will yield positive attitudinal shifts. The internal evaluation team will also move into the final phase of active evaluation during this time. They will be conducting pre-lesson surveys and post-lesson surveys to assess student content knowledge and program engagement.

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Biographies

Jason Dupuis has experience in formal science education as a former middle school science teacher, and in informal science education as an educator and coordinator in cultural institutions in Chicago. He is the Senior Coordinator of MedLab at the Museum of Science and Industry, Chicago in charge of program development and implementation. Mr. Dupuis holds an M.S.Ed in Learning Design and Technology from Purdue University and a B.S. in Secondary Biology Education from Indiana University.

DeDee Ludwig-Palit has over 15 years of experience supporting teacher and student learning in the field of Museum Education. In her role as the Manager of Student Experiences at the Museum of Science and Industry, Chicago, she leads the team that develops and implements K-12 field trip and videoconferencing programs and she manages the development and dissemination of a suite of teacher resources. She has also served as a board member of the Museum Education Roundtable. Ms. Ludwig-Palit holds an M.Ed. in Curriculum Studies from DePaul University and a dual B.A. in Anthropology and Communications from Purdue University.

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Figure One. MedLab Model Theory of Change

The use of “lifelike” simulation technology with community health and physiology content creates a context for informing adolescents about careers in science and health and encouraging positive healthy decision-making.

Students gather around iStan™, the human patient simulator

Figure Two. Student performing lab tests

MedLab Model Theory of Change: The use of “lifelike” simulation technology with community health and physiology content creates a context for empowering adolescents toward careers in science and health and positive healthy decision-making.

Figure Three. Students gather around iStan™, the human patient simulator
iStan™'s appearance and interactivity create a unique educational experience for the middle and high school students participating in MedLab. A facilitator uploads medical scenarios or pathologies to iStan™ via proprietary software using a laptop computer and the wireless manikin responds in real time. Students actively feel and hear the simulator's heartbeat, listen to its breathing, and observe other physical changes as vitals and other information are displayed on hospital-style monitors above the "patient."

Student performing lab tests

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