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An “Open-campus Museum” for Sharing Science with the Public

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Abstract: Only a small percent of the general population encounters ideas generated at research universities. At the Hebrew University’s science campus in Jerusalem, the Nature Park & Galleries (NPG), the unique “open-campus museum,” presents science to the public. NPG uses the entire campus, indoors and out, for communicating its messages, via signage, brochures, guide books, smart phone audio-guides, and student guides. In one of NPG’s programs, high school groups spend most of a day visiting two forefront biology research labs. They are guided by a graduate student in each of these labs. The high school students prepare for the visit by studying an in-class program of several lessons created by NPG staff in coordination with, and taught by, the school teachers. Following the lab visits, a similarly created and delivered in-class program crystallizes the learning experience. Our evaluation of the effects of this program show significant improvements in attitudes toward science and in understanding of the nature of science.

Keywords: University Museum, Academic Museum, University Outreach, Science Outreach, Nature of Science, NOS, Ideas, Attitudes Toward Science, Public Science, Educational Field Trips, Learning Environments

The Problem

America’s leading research universities spawn a great bounty of ideas, mainly through scholarly research. Although many other organizations such as corporations, research institutes, think tanks, branches of government, and foundations also generate ideas, most of these are confined to restricted subject areas.

Two studies indicate, however, that only a very small percentage of the public encounters ideas from academia. One study determined the number of “public intellectuals” inhabiting the halls of academe (Posner, 2001). After compiling a list of 546 intellectuals who received the most frequent website or blog visits and media mentions (via TV, radio, newspapers, and magazines) just 100 of these were found to receive over two thirds of these visits and mentions. Moreover, of the top 50 on this list, hardly any are academics; most are journalists, freelance authors, politicians, and others. This, in spite of the huge number—over 720,000—of full-time faculty, and a further 710,000 part-time faculty, in America’s degree granting colleges and universities (National Center for Education Statistics, 2009).

The second study measured the number of adult U.S. citizens who are exposed directly to ideas from academia by various university and college outreach efforts (Camhi, 2013). For instance, although many universities are increasing their online course offerings for adults (Walsh, 2011), most of these courses are designed specifically for career development in business and/or technical areas, or are “how to” courses, subjects less rich in ideas than many humanities, arts and sciences courses. Fewer than 1% of adult Americans (over age 25) are currently enrolled in online continuing education courses of a type rich in ideas, and fewer than 2% take such courses in-class. Other potential means of sharing university ideas with the adult public—through campus visits, civic engagement programs, public history and public science programs, extension programs of land grant universities, sale of university press books, public radio or TV broadcasts, written articles or videos of academic lectures or debates on the Internet—were all shown to address a similarly small percentage of the population. Many of those engaging in any one of these activities also are thought to be engaged in others. Thus, the overall access to the public of university ideas by all these means together is minimal (Camhi,

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2013). The notion, expressed by some outreach and engagement enthusiasts, that universities are impacting broadly on the American public, is not supported by these findings.

The writings of major university presidents partially supports the finding of minimal academic impact on the general public. For instance, Harvard's Derek Bok (1982), Cornell's Frank Rhodes (2001), and MIT's Charles Vest (2007), although claiming that academia is strongly connected to society, mostly stress the ways the campus relates to industry, government, and foundations, not to the general public. The University of California's Clark Kerr stated in his landmark 1963 book, *The Uses of the University*, "The university has come to have a new centrality for all of us, as much for those who never see the ivied halls as for those who pass through them or reside there," (Kerr, 1963). However, in a 2001 revision of the book, he stated, "Many state universities, in more recent times, have concentrated mostly on the cultivation of governors and legislators, rather than on the public as a whole". The University of Pennsylvania's Judith Rodin (Rodin and Steinberg, 2003), and Princeton's Harold Shapiro lean toward Kerr's latter opinion. For instance, Shapiro, on universities sharing their knowledge with the public, writes, "To my regret, this is one of those ideas that, while applauded in principle, is easily lost in the challenge of meeting one's day-to-day responsibilities" (Shapiro, 2005).

A Proposed Solution: The Open-Campus Museum Concept

This paper describes one attempt to increase public access to academic ideas, especially in science and nature, though it holds potential for all fields of knowledge. We describe here the efforts of the *Nature Park & Galleries* (NPG), the "open-campus museum" on The Hebrew University's science campus in Jerusalem, to achieve these goals. This being a remarkably inexpensive type of museum to create and maintain, NPG provides a model of a very cost-effective way of for academia to expand its contact with the general public.

Many university campuses are graced with excellent museums, some housed in architecturally resplendent buildings. NPG, by contrast, has no building. Rather, the boundaries of the Hebrew University's science campus are the boundaries of the museum, with the campus buildings being among the museum "objects" that may well be worthy of "display" and interpretation of architectural, historical, educational, engineering or other ideas.

NPG opened to the public in 2003, based on the notion that all the display objects needed to open a museum were already in place on campus, some indoors, some outdoors. The objects were, in a sense, waiting to have their underlying ideas and meanings interpreted for the public. These objects, some contained in the National Library or the National Collections of Natural History, both situated on campus, became the basis for ten (later fifteen) different museum presentations. Subjects included ecology, evolution, botany, cell biology, animal structure and function, history of science, cartography, architecture and design. The presentation formats were guided tours, sit-down demonstrations, behind-the scenes visits, and workshops, each lasting approximately one hour. The presenters were mostly graduate students whom we trained in best guiding practices via a rigorous MA course (e.g. Ham, 1992; Levy et. al., 2001; Knudsen et al., 2003; Camhi, 2008; Tsybulskaya and Camhi, 2009).

By no means was this the first museum without a building, as indicated by this definition from the International Commission on Museums of UNESCO: "A museum is a non-profit, permanent institution in the service of society and its development, open to the public, which acquires, conserves, researches, communicates and exhibits the tangible and intangible heritage of humanity and its environment for the purposes of education, study and enjoyment" (ICOM, 2007). With no mention of a building in the definition, botanical gardens, arboreta, and many other visitor attractions not usually housed indoors are considered museums. Surely, then, if the elements of the above definition are fulfilled, a university campus also can become a museum.

Thus, in creating NPG, no physical changes were made on campus. During its first decade, however, NPG has implemented several new, permanent, campus installations (e.g. Plant

Evolution Garden, Ecology Boardwalk, Bird Migration Trail, Discovery Tree Walk), as well as explanatory signage for these four installations, and several new seating areas. There is also a campus guide brochure, a guide book to the campus trees (Avishai and Camhi, 2007), a smart-phone audio-guide and additional NPG projects in the pipeline. Funds for all such projects, for the museum's small annual budget, and for all other outlays have been raised by NPG, through admission fees and donations. The museum receives no financial support from the University.

Testing the Solution: A Case Study Program at NPG

We present here an evaluation of one educational unit of NPG, called *Students Meet Authentic Science*, based on the notion that one of the important types of "object" a research university can show to the public is its research laboratories. This unit is intended to enhance both the understanding of the nature of science, and attitudes toward science, of 11th grade students taking the core Israeli high-school curriculum of human biology, cell biology and ecology.

We studied 14 experimental student groups (n=234) from eight schools and 15 control student groups (n=263) from ten schools, all in the Jerusalem area. For each school, our unit lasted 3-5 weeks. During this period, the experimental student groups replaced their regular biology curriculum with our unit. The control groups instead spent those weeks on their regular school curriculum, without experiencing our unit.

The unit is composed of three parts, a model of proven success in school field trips (Orion, 1993):

In-Class Preparation

This includes: (a) Students viewing a multimedia presentation about the two labs to be visited and their personnel; (b) Students reading and discussing with their teacher brief writings about the research carried out in these labs, and about the broader subject areas within which these labs work; (c) Students preparing questions to ask their guides during the lab visits. These questions focus on different aspects of both the nature of science and the biological subjects researched in the labs visited. NPG prepared all the above materials in coordination with the teachers, and guided the teachers in ways of presenting them.

The in-class preparation reduces the distracting novelty effect of visiting a wholly unfamiliar place, provides the background necessary for the students to understand what they will experience in the labs, and leads them to ask their own questions in a dialog with the guide. Thus, the students are "up and running" when they arrive for the lab visits.

The Lab Visits

Following an introductory guided tour of the science campus presented by a biology professor, each student group visits one cell biology and one ecology lab. (A total of 4 cell biology and 3 ecology labs are available for us to choose from for this project.) Each of these two 1 ½ hour lab visits is guided by a graduate student in the lab. We train these graduate students in guiding techniques, including speaking at the students' background level. The visiting students interact with scientific equipment, and engage in a dialogue with the guide about the research of the lab and how it reflects the nature of science.

In-Class Summary

Students share their lab visit experiences, analyze historical research narratives that broaden their experience into neighboring research fields, and write reflective journal entries summarizing their experiences during the entire program.

Evaluating the Program

We evaluated the effects of the unit *Students Meet Authentic Science* on the students' understanding of the nature of science (Tsybulskiy et. al., 2012) and on their attitudes about science (Tsybulskiy et. al., 2013) using a pre-post control design that included several methods:

1) A two-part questionnaire, with both Likert-based and open questions, administered at the beginning of the in-class preparation phase of the study ("pre"), and again during the summary phase ("post"). A subset of the students again responded to the questionnaire six months after the unit's conclusion ("6 mo. post") to test for long-term retention of the materials.
2) Semi-structured interviews of the students, within a week after completing the unit, and subsequent interviews of their teachers and of the university lab guides.
3) Video-taped observations, used as a check on student learning and to identify classroom and lab-visit episodes critical for designing our interview protocols (e.g. "I noticed that during the visit to the cell biology lab, you took particular interest in ______. What was going through your mind at that time?").
4) Analysis of students' reflective journals about the unit.
5) Analysis of teachers' and guides' journals about the unit.

This use of multiple data sources added both reliability and validity to the complex picture of students' understanding and attitudes. The Likert questions were analyzed with both parametric (t-test) and non-parametric (sign test and Wilcoxon) statistical tests. The open questions, interviews, reflective journals and the teachers' diaries were analyzed by Shkedi's (2004) constructivist (ethnographic) method of qualitative research, which is based on grounded theory. Results presented here are based primarily on items 1 and 2 above—questionnaires and student interviews.

Evaluation of the students' understanding focused on five separate categories of the nature of science. The questionnaire probed the degree of development of their understanding. Here we review the results of just two of these categories:

1) Are both basic and applied research valid and justifiable activities?
2) Are the same, or somewhat different, scientific methods and research strategies employed in studies on different scientific subjects (in this case, ecology versus cell biology)?

Items 1 and 2 in the table below show the differences (post minus pre results) in the Likert questions; higher scores indicate more developed understanding post versus pre. For the two categories of nature of science reviewed here (#1—both basic and applied are justified; #2—somewhat different research methods and strategies are used), the post – pre scores were significantly greater for the experimental groups than for the control groups, as shown in the last two columns. This was also the case for the other three nature of science categories that we studied but do not present here. Thus, the students came away from the unit with significantly enhanced understanding of the nature of science over the students in the control groups. Corroborating these results, the pre-unit questionnaire's open questions revealed that only 22% of the students recognized the value of basic research, whereas post-unit this jumped to 85%. Moreover, in the pre-unit questionnaire, 59% of the students recognized a diversity of scientific methods and research strategies employed in different research areas, whereas post-unit, this jumped to 83%.

Evaluation of the students' attitudes toward science included 16 different categories of attitude about interest and motivation. Here we review the results of just four of these categories:

1) Students' impression that scientific research is an interesting subject.
2) Students' motivation to choose a career in science.
3) Students' motivation to watch science TV programs.
4) Students' motivation to browse science-related websites.

Items 3-6 in the table show the post - pre differences in the relevant Likert questions. For these four attitude categories, the post - pre scores were highly significantly greater, as shown in the last two columns, for the experimental groups than for the control groups ($p \leq 0.01$). For 10 of the other 12 categories of attitudes toward science that we studied, the experimental group scores were significantly greater than those of the control groups ($p \leq 0.05$).

For all six categories of the nature of science and attitudes shown in the table, the 6 months post - pre scores were significantly greater for the experimental groups than for the control groups ($p \leq 0.05$). This was also the case for the three remaining nature of science categories and 9 of the 12 remaining attitude categories studied but not presented here. Thus, the students in the experimental groups came away from the unit with lasting, significantly improved understanding of the nature of science and lasting, enhanced attitudes about science, relative to the students in the control groups. We also found that factors such as a student’s gender, school type, preference for humanities versus sciences, and the subject of a student’s particular interest did not significantly affect these results.

Table 1: Data for the two nature of science categories (numbers 1 and 2 in the left column), and the four science attitude categories (numbers 3-6) addressed in this paper. Data shown for both the control and the experimental group are the mean post minus pre scores, and standard deviations. The elevated scores of the Exper. versus the Control groups, indicate improved student performance. As shown, these score improvements were significant for category 2, and highly significant for all five other categories, by the two statistical tests we employed.

Category	Control group mean & s.d. post - pre	Exper. group mean & s.d. post - pre	t-test p	Sign test p
1) Basic/Applied Research	0.9 (1.70)	3.69 (2.61)	.01	.01
2) Same/Different Research Methods, Strategies	0.5 (2.35)	3.20 (2.50)	.03	.02
3) Scientific Research Interests Me	-0.25 (1.31)	2.03 (1.40)	.01	.01
4) Motivation for a Career in Science	0.21 (2.10)	2.35 (1.45)	0.1	0.1
5) Motivation to Watch Science TV Programs	0.23 (1.04)	2.25 (1.63)	.01	.01
6) Motivation to Browse Science Websites	0.25 (1.39)	2.13 (1.23)	.01	.01

Conclusions and Discussion

University research labs that carry out forefront research dot the map in many nations. All around them are high schools in which students learn about research results, but seldom see how that research is carried out. Many universities have mentoring programs in which select students spend prolonged periods after school or during vacations assisting in a laboratory’s research. Positive as this experience often is, these programs usually can accommodate only very small numbers of students, and hardly any from economically challenged families, where the children have to contribute to the family’s income.

Throughout Israel, only about 200 high school students per year are mentored in university labs. By contrast, a unit such as *Students Meet Authentic Science* can readily accommodate many hundreds of high school biology students per year on a single university campus, and if fields other than biology were included, probably thousands of students could take part. How to ramp up a program such as *Students Meet Authentic Science* to serve large student populations in different subject areas is a subject of continuing study.

Our educational unit, *Students Meet Authentic Science*, appears to succeed in sharing ideas of several types with high school students, as follows:

Category 1 in the Table, "Basic/Applied Research" focuses largely on significance of basic research, since the value of applied research is rarely questioned. Many students interested in biology see careers in medicine or industrial bio-med research as the entire world of biological science. Many have never thought about exploring the world of science to discover new truths which, whether or not they lead to practical implementations, can change our conceptions of ourselves and our universe.

Category 2, "Same/Different Research Methods, Strategies" probes the misconception of many students that a single "Scientific Method" is the rule book for research, followed in all areas of science (Dodick, Argamon, and Cases, 2009). They discover that science is much more varied and flexible than they had thought, drawing on multiple contexts and approaches.

Category 3, "Scientific Research Interests Me," provided a straightforward conclusion that the educational unit left students with a greater interest in scientific investigation.

Categories 4, 5 and 6, all motivational categories, reveal that the education unit led students to think anew about ways they could continue their interest in science.

We suggest that our unit has positively affected the students in the experimental groups in ways that their schools could not have achieved. We believe that a significant part of the student appeal of this educational unit is the subjective experience of witnessing "the real thing," authentic research laboratories and their scientists, and sensing the sights, sounds and smells of these labs and their activities. It had not been clear to us at the outset that a single day's visit to the university labs and meeting the scientists would be adequate to produce a positive and lasting effect. Our results indicate that, together with the pre- and post-visit components, there was indeed such an effect.

The limited flow of university ideas to the public, mentioned above, amounts to a tragic waste of a vital resource, not only for high school students, but for all. Ideas can broaden our horizons, connect us to new areas of knowledge, and lead us to new insights and interests. Seeing the laboratories and other university venues from which ideas spring can enhance our understanding of, and perhaps our facility with, analytical thinking and complex reasoning. Ideas can stimulate us to test our points of view and beliefs. They can expand our sense of wonder, enrich our spirit, and bring us pleasure. Ideas can benefit not only individuals, but whole societies. They can lead to a more enlightened public, an elevated and more nuanced discourse on complex issues, and improved decision-making on matters of national and global significance.

An open-campus museum, as described here, appears a suitable means to contribute in some measure to the above (admittedly grandiose) goals. The engagement of the public with real laboratories and collections, with researchers who spawn new ideas, and with campus life and campus objects rich in meaning, help visitors understand what universities and their research consist of and the value they can offer society. Although most visitors respond very positively to their visits, we believe that the effect can be particularly positive for those school students or adults who have never before set foot on a university campus. How exactly to apply the open-campus concept to varied university campuses around the world is an area open to further study (Camhi, 2013).

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