Programs for Retaining Middle School Students’ Interest in Science

Getting Involved in K-12 Outreach and Informal Science Education
Larry Bell, Museum of Science, Boston
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Decline between 4th and 8th grades

Report: Older students lose interest in math, science

Children losing interest in science through their education, report claims

Children are losing interest in science as they progress through school, new research suggests.
By Daily Telegraph reporter
"We have learned from attitude surveys that when students are younger they have great interest in science. As they get older, however, science is seen more as 'complicated' and 'difficult,' as one survey said, versus 'fun' or 'inspiring.'

Surveys also tell us that as they get older, an increasing number of students not only abandon the idea of STEM-related careers, but fail to see how this education will be relevant at all to any future job the report says.

A poll of 4,000 children aged nine to 14 found that youngsters find the subject less inspiring and relevant to their lives as they move from primary to secondary school.
Students with a high cognitive potential for science do not pursue careers as scientists or engineers because they lost their interest during school. (Krapp and Prenzel, 2011)

Because self-efficacy influences academic achievement, a drop in confidence during the middle school years can have a negative influence on students’ high school and college achievement. Of particular concern to science educators is that failure to take science and mathematics courses because of low self-efficacy can block the pursuit of careers in mathematics and science (Zeldin & Pajares, 2000).
Degrees in life science (light green), physical science/engineering (dark green), and nonscience fields (gray). Students who in eighth grade expected a science degree are shown on the left (n = 337); those who did not expect a science degree are shown on the right (n = 3022).

Robert H. Tai1,*, Christine Qi Liu1, Adam V. Maltese1, Xitao Fan1
8th graders expecting a science degree
8th graders not expecting a science degree

Degrees in life science (light green), physical science/engineering (dark green), and non-science fields (gray). Students who in eighth grade expected a science degree are shown on the left (n = 337); those who did not expect a science degree are shown on the right (n = 3022).

Robert H. Tai1,* Christine Qi Liu1 Adam V. Maltese1 Xitao Fan1
We also saw that declines in interest, motivation, and attitudes were linked to many variables, including self-efficacy, and that cumulated positive experiences in S&T might prevent such declines, like summer camps and other out-of-school experiences, but also within schools, where all sorts of initiatives could be intensified.

When efforts are well targeted and based on reasonably well-documented sources, it is usually possible to increase interest, motivation, and attitudes. In short, effort usually produces results.

Educators need knowledge that will allow them to professionally select, apply and optimize the most promising interventions.

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Nanoscale Science and Engineering Education (NSEE)

Program Solicitation
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National Science Foundation
 Directorate for Education and Human Resources
 Directorate for Biological Sciences
 Directorate for Computer and Information Science and Engineering
 Directorate for Engineering
 Directorate for Geosciences
 Office of International Science and Engineering
 Directorate for Mathematical and Physical Sciences
 Directorate for Social, Behavioral, and Economic Sciences

Letter of Intent Due Date(s) (required):

[A] Nanoscale Informal Science Education (NISE): This effort is intended to foster public awareness, engagement, and understanding of nanoscale science, engineering, and technology through establishment of a Network, a national infrastructure that links science museums and other informal science education organizations with nanoscale science and engineering research organizations.
As my colleague Bert Halperin and I began work on a proposal for an NSF-funded Nanoscale Science and Engineering Center (NSEC) at Harvard, it was clear that we must actively engage the public. Many academic researchers would like to inform the public about nanoscience, but don’t know how to do it. Science museums, on the other hand, are keen to get people’s attention, show them what is happening, and invite them to think about the big ideas. A collaboration with a science museum would be an excellent way to involve the public with our research work.
Led to a 10-year collaboration which has been renewed for another 5-10 years with the recently awarded:

[CIQM CENTER for INTEGRATED QUANTUM MATERIALS]
Museum of Science
Exploratorium
Science Museum of Minnesota
Oregon Museum of Science & Industry
New York Hall of Science
Fort Worth Museum of Science & History
Museum of Life and Science, North Carolina
Sciencenter, Ithaca

Cornell University
UWisc-Madison
Purdue University
Harvard University
Northeastern University

Inverness Associates
Multimedia Research

Association of Science-Technology Centers
Materials Research Society

NISE Net’s initial working group
Something Strange is Happening at SciWorks

Strange MATTER

Explore the fascinating world of Materials Science and uncover the surprising science behind Everyday Stuff!

Aimed at middle school audiences and their families
Developed in partnership between MRS and Ontario Science Center in 2003
Seen by 3,052,372 visitors at 46 science centers in 4 countries
6,790,372 served including related online resources
Created host ISE and MRS researcher collaborations

Presented by: MRS Materials Research Society
This local presentation is made possible in part by: Vulcan Materials Company

This exhibition and its tour are made possible by the generous support of these sponsors:

Dow, Ford Motor Company Fund, intel, Rio Tinto Alcan, 3M

400 W. Hanes Mill Rd. | Winston-Salem | (336) 767-6730 | www.sciworks.org
Catalog of educational products at www.nisenet.org

Catalog
- Programs
- Exhibits
- Tools and guides
- Media
- Image Gallery
- Evaluation & Research

318 products
1. **Nano is small and different**

   - Emerging field: Nano is an emerging field.
   - Nanometer: A nanometer is a billionth of a meter.
   - Novel properties: Nano properties can lead to new materials and devices.

2. **Nano is studying and making tiny things**

   - Atoms and molecules: The arrangement of atoms and molecules helps determine a material's properties.
   - Manipulating matter: Researchers have new ways to manipulate matter at the nanoscale.
   - Nature and technology: Nano is found in nature and in technology.
   - New tools: New tools make the field of nano possible.

3. **Nano is new technologies**

   - Interdisciplinary field: The interdisciplinary nature of nano leads to new solutions and innovations.
   - Consumer products: Nano may improve existing products.
   - Innovative applications: Nano may lead to new materials and applications.

4. **Nano is part of our society and our future**

   - Consumer influence: Our choices as consumers and citizens influence nano.
   - Gov’t and corporate guidance: Governments and companies promote and regulate nano.
   - Risks and benefits: Nano involves costs, risks, and benefits.
   - Technology and change: Nano will affect our economy, environment, and personal lives.
Understanding

• Science seen as complicated and difficult
• How science and technology is taught might be more important that what is taught\(^1\)
• Students’ perception of science weakened by their perception of “school science”\(^1\)
• Explanations too hard to understand reduce trust – nobody likes to be told they are stupid\(^2\)
• ISE works toward making science understandable

1. Potvin & Hasni, 2014  2. Fiske
Engaging

- Big gap between what school concentrates on and offers and children’s preferences
- Students prefer collaborative work, hands-on, inquiry-based, meaningful learning linking science and technology to reality
- ISE/classroom interventions can provide this

1. Potvin & Hasni, 2014  2. Fiske
A week of Public Educational Activities about Nanoscale Science and Technology at Science Museums and Research Centers across the Nation

March 29 - April 6, 2008
NanoDays Kit

downloadable version
at www.nisenet.org
1400 NanoDays Kits Distributed to date to over 400 unique sites including every state+

- 2008: 100
- 2009: 200
- 2010: 200
- 2011: 200
- 2012: 225
- 2013: 225
- 2014: 250
Belonging

How does a middle school student identify a community of scientists to which they aspire to belong?

• Physics and technology preferred by boys\(^1\)
• Biology often preferred by girls\(^1\)
• Differences more acute as students grew older\(^1\)
• Social stereotypes have influence\(^1\)
• Female, Latina and African American role models and mentors show changed attitudes and confidence for science and science careers\(^1,2\)

1. Potvin & Hasni, 2014  
2. NRC, 2009
Most Americans Can’t Name a Living Scientist

Can you name a living scientist? (first volunteered responses)

- Yes: 66%
- No: 34%

- Stephen Hawking: 15%
- James Watson: 1%
- Jane Goodall: 1%
- Bill Nye: 1%
- Michio Kaku: 1%
- Neil Degrasse Tyson: 1%
- Other: 14%

Source: Your Congress - Your Health Survey, March 2011
Charlton Research Company for Research!America
34. In which of the following settings do you personally use NISE Net materials outside of NanoDays?

<table>
<thead>
<tr>
<th>Settings</th>
<th>Count</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cart demonstrations/ brief table top activities</td>
<td>193</td>
<td>77%</td>
</tr>
<tr>
<td>K-12 school outreach activities (e.g. classes, after school programs,</td>
<td>175</td>
<td>70%</td>
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<tr>
<td>field trips, science fair)</td>
<td></td>
<td></td>
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<tr>
<td>Special events (e.g. family events, chemistry events, nano-related</td>
<td>170</td>
<td>68%</td>
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<tr>
<td>events other than NanoDays, family nights, festivals)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Science camps (daily, weekly, seasonal)</td>
<td>131</td>
<td>52%</td>
</tr>
<tr>
<td>Outreach activities with ongoing community partners (e.g. libraries,</td>
<td>117</td>
<td>47%</td>
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<tr>
<td>scouts, Boys &amp; Girls club...)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Professional development (for museum staff, school teachers, college</td>
<td>115</td>
<td>46%</td>
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<tr>
<td>students)</td>
<td></td>
<td></td>
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<tr>
<td>Longer museum programs (e.g. forums, classes, labs, science club)</td>
<td>111</td>
<td>44%</td>
</tr>
<tr>
<td>Longer term display of materials in public spaces (e.g. within exhibits,</td>
<td>97</td>
<td>39%</td>
</tr>
<tr>
<td>on the museum floor, on a table)</td>
<td></td>
<td></td>
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<tr>
<td>Lesson activities within college courses</td>
<td>45</td>
<td>18%</td>
</tr>
<tr>
<td>Other</td>
<td>6</td>
<td>2%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>251</td>
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</tbody>
</table>
Motivation

• NISE Net has helped facilitate these partnerships by giving them the “idea of doing some event for the public.”

• there’s something really motivating about getting the new kits …you get that kit and it’s like, ‘Oh man! I can’t let these guys down! I have to do something great with the kit!’
New perspectives on outreach

• I had never actually seen a physical kit before. And when I opened it up—it was like, ‘holy mackerel, everything’s here to do everything!’ And it was sort of that “ah-ha” moment... so that all of a sudden became...instead of doing the presentations to go and talk about things, it now became...now you can have kids come and do things.

• So it was that surprise of how amazing those kits really are and how easy it is and how easy they make it to do presentations.
Broader content and use

• My background is in physics. You have very nice demos that are more chemistry related. I didn’t know before. It kind of opened my eyes to things where before I was limited to things related with the physical properties of material.
• It has made me recognize more of the applications in biology and some other fields that my background isn’t in.
• NISE Net makes it easy if somebody wants to just go into a [K-12] school, or do something on campus, or do something in a [college] classroom...It’s formatted in a way that both teachers and scientists and engineers can easily get what they need from it, which I’m increasingly learning is hard to do.
MOS and MRS provide a range of science communication professional development
Nano and Society

NISE Net – CNS collaboration introduced nano and society content, new catalog activities, and improvisational training techniques, while building new connections between people in the network.
Connecting scientists and the public

The questions asked by the participants forced me to think about aspects of my research that are typically an afterthought. I'm usually preoccupied with the daily grind of performing experiments and analyzing data. Engaging with the public at this forum reminded me that the goal of my work is to improve their lives (at some point in the distant future).

Ghidewon Arefe, speaker at the Science Museum of Minnesota
April 26, 2007 Forum
Contextualizing

- Boys described as more ‘performance-goal oriented’ and girls as more often driven by social concerns
- Learning science in school to abstract or detached from real-life existence
- STS approach, ethical issues, case studies of real-life problems show positive effects on interest, motivation, and attitude

Potvin & Hasni, 2014
PD: Inclusive Audiences

Strategies to better engage Spanish speakers by building capacity, using techniques like:

- sheltered instruction
- team-based inquiry
- marketing strategies

Hands-on opportunity to apply Universal Design guidelines:

- Gathered feedback on NanoDays activities from experts with disabilities
- Used Team-Based Inquiry (TBI) approach
- Identified barriers & modified activities

Online PD Events:
- Nano for School Groups
- Nano in Food
- Nano for Summer Camps
- Bilingual NanoDays
- Science Behind NanoDays 2014
- Sheltered Instruction
Evaluation reports (118) in the catalog, mostly formative evaluation reports, but also including key summative reports

Multi-institutional evaluation team and COV

Current strands of work:

• Public Impacts
• Professional Impacts
• Logic Model
• Survey & Data Mining
PD: Team-Based Inquiry

Team-based inquiry is about building our capacity to gather and use the information we need, when we need it, in order to improve our educational products and practices.

**QUESTION**
Identify the questions you need to answer in order to develop a successful educational experience.

**INVESTIGATE**
As part of your work, collect the data and information you need to answer your TBI questions.

**REFLECT**
Discuss and analyze the data you've collected and identify key findings and lessons learned.

**IMPROVE**
Prioritize and implement improvements based on your findings and document and share your inquiry.
Enhancing self

- People want to feel good about themselves\(^2\)
- Students who intend to pursue science studies and careers are the ones who have good self-esteem or perceive themselves as being good achievers\(^1\)
- Assured early success
- Identity equated with a sense of belonging to a community, setting or activity related to science\(^3\)

Partner Reach

Core Partners: 14
Nano Infused: 188
Broad Reach: 309
Total Partners: 511
Trust

- Enthusiastic, encouraging, and close-to-students teachers are factors strongly linked to interest, motivation, and attitudes\(^1\)
- Trust strongly linked with belonging\(^2\)
- No one flunks informal education
- Trust associated with warmth\(^2\)
- Teachers perceived as warmer than scientists\(^2\)

1. Potvin & Hasni, 2014  
2. Fiske
Americans Trust Scientific Community Less Today

Compared to five years ago, would you say you trust the scientific community more, less, or about the same amount?

- More: 61%
- Same amount: 25%
- Less: 14%

Source: Your Congress - Your Health Survey, March 2011
Charlton Research Company for Research!America
Congressman C.A. Dutch Ruppersberger at NanoFabulous opening, April 2012

A few of 150 mini-grant projects

University of Vermont and ECHO run Café Scientifique on nano

Network of six sites in Arkansas providing PD and sharing exhibits

Senator Mike Enzi at the August 2012 opening of Nano exhibition in Casper, Wyoming

Outreach to four locations with no access to science museums.
Nano Mini-exhibition (93 copies by 2015)
What all this suggests to me that scientists and professional organizations can do (perhaps in collaboration with informal educators)

- Be present, be visible, be role models
- Be warm, caring, trustworthy mentors
- Work had to make things understandable
- Find out what has meaning for your audience
- Give away control—put it in their hands & minds
- Reinforce and reward your audience’s capabilities - treat them as insiders