

Let's get hands on! An evaluation of the Natural World Investigate Lab at the North Carolina Museum of Natural Sciences

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Introduction

Most children begin their school careers with a love and passion for science and math. However, from late elementary school to high school, there is a marked decline in interest toward science and math careers (Murphy & Beggs, 2003; VanLeuvan, 2004). Low interest contributes to lower science and math self-efficacy, which may result in fewer future scientists and mathematicians (e.g., Lent, Lopez, & Biescke, 1991; Plant, Baylor, Doerr, & Rosenberg-Kima, 2009).

Science, Technology, Engineering, and Math (STEM) out-of-school time (OST) initiatives could help to reverse these trends. Studies show that middle school and urban high school participation in STEM-based OST activities is associated with increased interest in STEM courses and careers. Students also demonstrate increases in STEM knowledge and understanding from participation in OST activities (Dabney, 2012; Duran, Höft, Lawson, Medjahed, & Orady, 2013). When educators provide additional time for STEM, students can positively benefit.

In response to the trends, the North Carolina Museum of Natural Sciences built the Nature Research Center (NRC) wing to provide the public with free, hands-on opportunities to directly engage in STEM experiences. At the Natural World Investigate Lab within the NRC, students and visitors engage in a variety of immersive, hands-on labs and exhibits offering a window into the sciences.

The North Carolina Museum of Natural Sciences contracted with Magnolia Consulting to provide a formative and summative evaluation of Natural World Investigate Lab programming, as part of a grant provided by the Institute of Museum and Library Services (IMLS). This final report provides an overview of the study design, detailed information on project findings, a summary of results, and recommendations for improvement.

Study Design

The purpose of this evaluation was to determine public perceptions of the utility and quality of two labs/exhibits within the Natural World Investigate Lab, Biofuels, and Science of Scent. Key evaluation questions included the following:

1. How many students did Natural World Investigate Lab programs reach between July 2012 and June 2013?
2. Do the labs and exhibits help middle school students and public visitors to develop a greater understanding of the scientific inquiry process?
3. Do the labs and exhibits contribute to an increase in middle school students' and public visitors' interest, knowledge, and skills regarding biological science?
4. Do the labs and exhibits contribute to an increase in middle school students' and public visitors' appreciation for scientific research?

5. Do the labs and exhibits contribute to an increase in middle school students' and public visitors' motivation to pursue future opportunities to learn more?
6. What did public visitors and students like most about the labs and exhibits? Did visitors see the program as an enjoyable hands-on experience?
7. What, if anything, did middle school students and public visitors dislike and what are their suggestions for improvement?

Procedure

The Natural World Investigate lab offers a variety of hands-on labs and exhibits as part of their programming for student groups and the public.

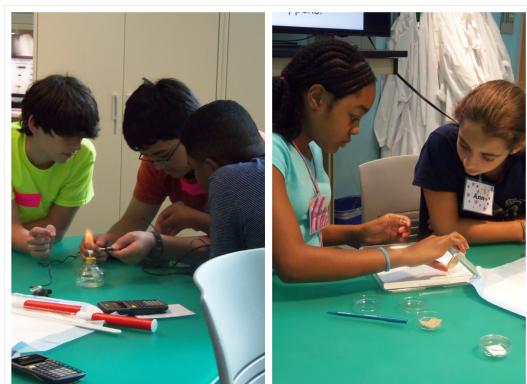


Figure 1. Students examine ethanol properties in Biofuels (left) and create termite trails in Science of Scent (right).

Student groups and labs

Student groups signed up with the museum to participate in the labs, which provided 60–90 minutes of hands-on learning in Biofuels or Science of Scent. The Biofuels lab gave students opportunities to use pipettes, measure algae density, and examine properties of ethanol, while learning about the process of converting algae to ethanol. The Science of Scent lab provided students with hands-on opportunities to use smell to find their species (e.g., all students who had the pine smell were grouped together), create and observe termite trails using a pen that mimics termite pheromones, and create their own room spray, all while learning about the process of scent in humans and other animals.

Public visitors and exhibits

Exhibits for public visitors offered the same learning opportunities as the labs in a condensed format. The Biofuels exhibit provided information on converting algae to ethanol using short videos and PowerPoint slides. Public visitors also had the opportunity to measure algae density. The Science of Scent exhibit provided information on how the brain experiences different scents through PowerPoint slides. Visitors also had the opportunity to smell three different scents and test their knowledge of smells using a short iPad-based quiz. Both exhibits were designed to last five minutes.

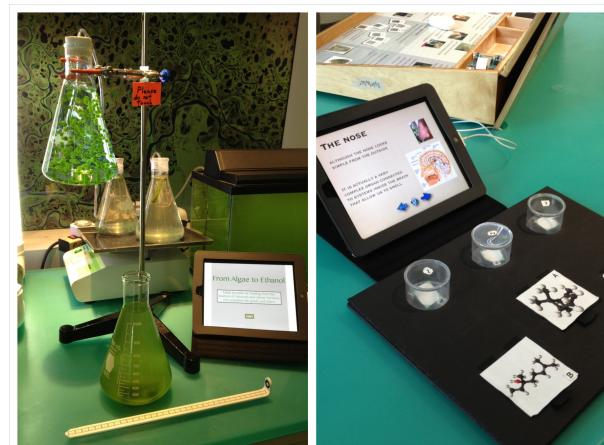


Figure 2. Biofuels (left) and Science of Scent (right) exhibits.

Guiding lab and exhibit improvements

Throughout this study, there were several procedures in place to guide ongoing lab and exhibit improvements for student groups and the public. First, evaluators held a focus group with high school students from the Museum's Teen Advisory Board on December 13, 2012. These students were the first to participate in the Biofuels and Science of Scent labs and provided constructive program feedback with suggested improvements for the labs (Appendix A). Second, evaluators met with museum staff on a monthly basis to review survey findings and offer recommendations for improvement. Based on these recommendations, museum staff increased the number of scents in the Science of Scent exhibit from three to five scents midway through the study.

Measures

As part of the study, evaluators worked with museum staff to develop two surveys, one for student groups and one for public visitors. The surveys assessed understanding of scientific inquiry; biological science interest, knowledge, and skills; appreciation for scientific research; motivation to pursue future opportunities in biological science; what students and visitors enjoyed; and dislikes and suggestions for improvement (Appendix B and C).

Participants

Study participants included Teen Advisory Board members, visiting student groups, and public visitors (Table 1).

Teen Advisory Board

Ten high school students from the Museum's Teen Advisory Board provided feedback in one December focus group (see Appendix A for focus group feedback). All students participated in the Biofuels and Science of Scent labs.

As an incentive for participating in the focus groups, evaluators gave participating students \$25 Amazon.com gift certificates.

Student Groups

A total of 246 students (52% female, 48% male) who attended the lab from various groups (e.g., school, afterschool, camp) provided survey data for the Biofuels (76%) or Science of Scent (24%) labs (Table 1). Of these 246 students, 44% came from underserved populations. Most participants were in late elementary or middle school (98%) and ranged in age from 9 to 15 (see Table 1).

Visiting student groups did not receive a monetary incentive for completing surveys.

Public Visitors

A total of 107 public visitors (71% female, 29% male) completed surveys for this study. Seventy-seven visitors were PreK–12 students, with 88% in elementary or middle school. Most

of the thirty adults had a bachelor's degree (47%), followed by master's (23%), doctorate (13%), associate's (7%), or high school degree (7%).¹ Public visitors who completed a survey ranged in age from 5 to 68 years old (Table 1).

Of the 107 public visitors, the majority participated in both exhibits (59%), with 6% participating in Biofuels only, and 36% participating in the Science of Scent only.

Public visitors spent an average of eight minutes in Science of Scent and six minutes in Biofuels with 94–99% reporting that they finished the exhibits, respectively.² One visitor did not finish the Science of Scent lab because he did not understand it. Three visitors did not finish the Biofuels lab because of difficulty understanding the lab or perceiving it as geared to children.

Evaluators offered two Amazon.com \$25 gift certificates as an incentive to public visitors for completing surveys. In mid-July, evaluators randomly selected two surveys to receive the \$25 gift certificates and contacted winners by email.

Table 1. Study participants

	Teen Advisory Board (n = 10)	Student Groups (n = 246)	Public Visitors (n = 107)
Age Range	*	9 to 15	5 to 68
Gender	Male: * Female: *	Male: 48% Female: 52%	Male: 29% Female: 71%
Grade (students)			PreK/K: 3% Early Elementary (1–3): 13% Late Elementary (4–5): 21% Middle School (6–8): 55% High School (9–12): 9% Total: (n = 77) 100%
Highest degree (adults)		Late Elementary (4–5): 40% Middle School (6–8): 58% High School (9–12): 2%	High School: 7% Associate: 7% Bachelors: 47% Masters: 23% Doctorate: 13%
Labs/Exhibits	n/a	n/a	Both labs: 59% Biofuels only: 6% Science of Scent only: 36%

*Information not disclosed because of small sample size.

¹ One 30-year old visitor (3%) did not provide highest degree information.

² Public visitors spent an average of 31 minutes in the Natural World Investigate lab.

Findings

The following section provides study results related to lab attendance; understanding of scientific inquiry; gains related to interest, knowledge, and skill related to biological science; developing appreciation for scientific research; interest in pursuing future opportunities to learn more about biological science; and what visitors enjoyed, disliked, and suggested for improvement.

KEY QUESTION:

How many students and visitors did Natural World Investigate Lab programs reach between July 2012 to June 2013?

The museum provided 60-to-90-minute Biofuels and Science of Scent labs to 246 students between January and June 2013.

Attendance records indicate that 28,463 public members visited the Natural World Investigate lab between July 2012 to June 2013, which was the duration of the IMLS grant. Of these, 12,557 visited the lab from January 2013 to June 2013, the time when the Biofuels and Science of Scent labs/exhibits were available to student groups and the public.

KEY QUESTION:

Do the labs and exhibits help middle school students and public visitors to develop a greater understanding of the scientific inquiry process?

On a 5-point scale ranging from *strongly agree* (5) to *strongly disagree* (1), students and public visitors rated their agreement with the statement that the labs/exhibits promoted a greater understanding of scientific inquiry. Overall, 80% of students and 87% of public visitors *agreed or strongly agreed* that the labs and exhibits promoted a greater understanding of the scientific inquiry process (Figure 3).

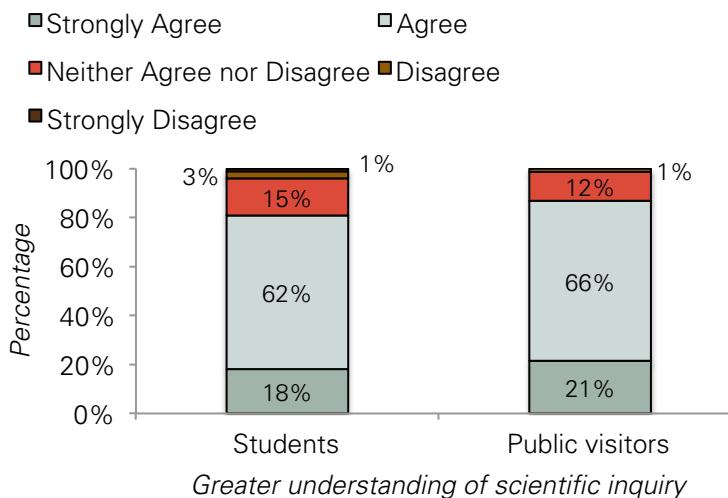


Figure 3. Agreement that labs promote greater understanding of scientific inquiry amongst students ($n = 241$) and public visitors ($n = 84$).

KEY QUESTION:

Do the labs and exhibits contribute to an increase in middle school students' and public visitors' interest, knowledge, and skills regarding biological science?

After conducting the lab/exhibit, students and public visitors rated how much more they learned about Biofuels and Science of Scent on a 5-point scale ranging from *very much more* (5) to *nothing* (1). After participating in the lab/exhibit, 96% of students and 91% of public visitors shared that, they learned at least *somewhat more* about biofuels or the science of scent (Figure 4).³

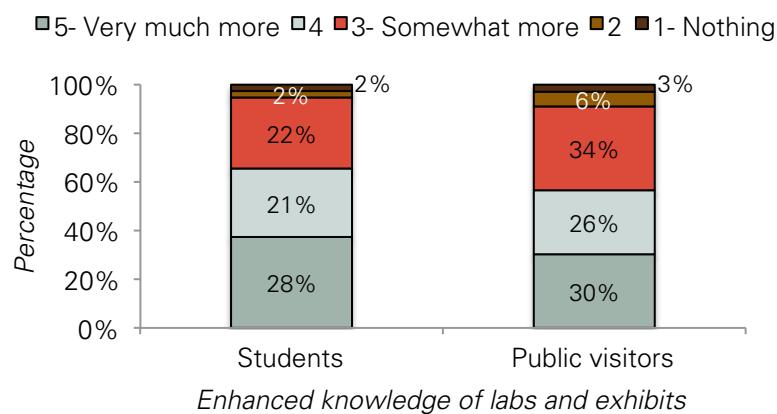


Figure 4. Enhanced knowledge about Biofuels and Science of Scent labs/exhibits amongst students (n = 242) and public visitors (n = 163).

Survey respondents also rated the extent to which they agreed that participating in the labs increased their interest, knowledge, and skills regarding biological science on a 5-point scale ranging from *strongly agree* (5) to *strongly disagree* (1) (Table 2). Overall, 77% of students and 88% of public visitors *agreed* or *strongly agreed* that they had more knowledge about biological science after participating in the lab/exhibit. Additionally, 58% of students and 87% of public visitors *agreed* or *strongly agreed* that they had more interest in biological science. Finally, 62% of students and 71% of public visitors *agreed* or *strongly agreed* that they had more skills related to biological science after participating in the lab/exhibit.

Table 2. Gains in knowledge, interest, and skills amongst students and public visitors

After participating in the labs...	Neither Agree nor Disagree					
	Strongly Agree	Agree	Disagree	Disagree	Strongly Disagree	
<i>I have more knowledge about biological science.</i>						
Students (n = 243)	28%	49%	17%	6%	1 %	
Public visitors (n = 82)	29%	59%	12%	--	--	

³ This is an aggregated figure. Because 56% of public visitors completed both labs, this same percentage answered the question twice, one time for each exhibit.

After participating in the labs...	Neither Agree nor Disagree					
	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree	
<i>I have more interest in biological science.</i>						
Students (n = 240)	22%	36%	33%	8%	2%	
Public visitors (n = 83)	41%	46%	11%	2%	--	
<i>I have more skills related to biological science.</i>						
Students (n = 241)	18%	44%	27%	9%	3%	
Public visitors (n = 81)	24%	47%	26%	4%	--	

KEY QUESTION:

Do the labs and exhibits contribute to an increase in middle school students' and public visitors' appreciation for scientific research?

Students and public visitors rated the extent to which they agreed that participation in the labs/exhibits promoted a greater appreciation for scientific research on a 5-point scale ranging from *strongly agree* (5) to *strongly disagree* (1). Overall, 72% of students and 88% of public visitors *agreed* or *strongly agreed* that the labs instilled a greater appreciation for this attribute (Figure 5).

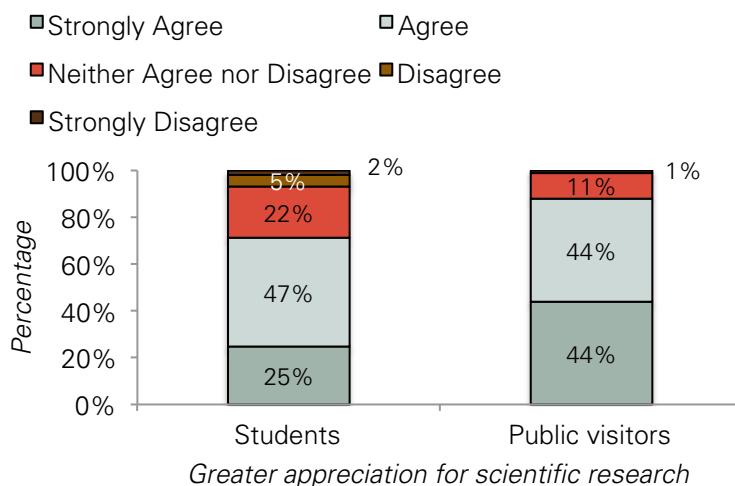


Figure 5. Agreement that labs promote greater appreciation for scientific research amongst students (n = 239) and public visitors (n = 82).

KEY QUESTION:

Do the labs and exhibits contribute to an increase in middle school students and public visitors motivation to pursue future opportunities to learn more?

Students and public visitors rated the extent to which they agreed that the labs/exhibits would lead to pursuing future opportunities on a 5-point agreement scale. Overall, 52% of students and 72% of public visitors *agreed* or *strongly agreed* that they had an enhanced motivation to pursue future biological science opportunities (Figure 6). When students indicated that they *disagreed* or *strongly disagreed*, most (63%) attributed their ratings to a lack of interest in science.

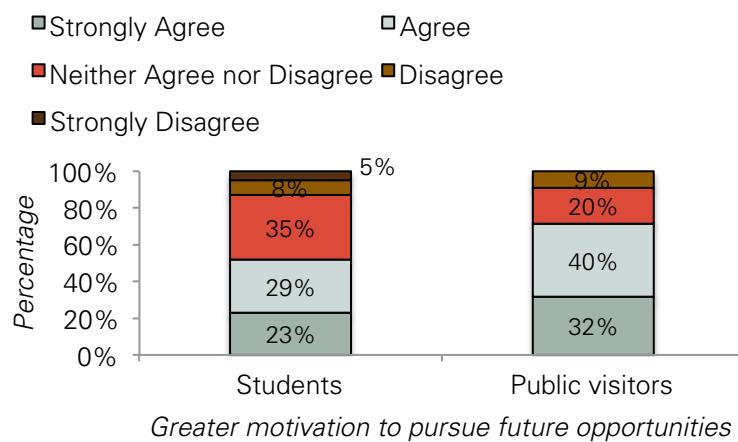


Figure 6. Agreement that labs promote greater motivation to pursue future opportunities in biological science amongst students (n = 239) and public visitors (n = 82).

As part of the survey, both groups rated the likelihood of attending future labs and seeking additional information on a 5-point scale ranging from *very likely* (5) to *very unlikely* (1) (Table 3). Overall, 73% of students and 96% of public visitors indicated they were *likely* or *very likely* to attend other labs offered by the museum. Additionally, 66% of students and 85% of public visitors indicated they were *likely* or *very likely* to search for additional information on science, technology, and math subject areas. Finally, 64% of students and 78% of public visitors indicated they were *likely* or *very likely* to seek additional information related to science, technology, and math careers.

Table 3. Likelihood of future activities amongst students and public visitors

As a result of participating in the labs, how likely are you to do the following?	Very Likely	Likely	Neither Likely nor Unlikely	Unlikely	Very Unlikely
<i>Attend other labs offered by the museum.</i>					
Students (n = 235)	28%	45%	19%	6%	2%
Public visitors (n = 84)	66%	30%	1%	2%	1%
<i>Search for additional information on science, technology, and math subject areas.</i>					
Students (n = 222)	28%	38%	21%	10%	4%
Public visitors (n = 80)	49%	36%	14%	1%	--

As a result of participating in the labs, how likely are you to do the following?	Very Likely	Likely	Neither Likely nor Unlikely	Unlikely	Very Unlikely
<i>Search for additional information related to science, technology, and math careers.</i>					
Students (n = 232)	28%	36%	26%	8%	2%
Public visitors (n = 82)	45%	33%	18%	4%	--

KEY QUESTION:

What did visitors and students like most about the labs and exhibits? Did visitors and students see the program as an enjoyable, hands-on experience?

In open-ended feedback about what they liked, 73% of students and 53% of public visitors referenced the hands-on, interactive components in the labs/exhibits (Table 4). Students mentioned enjoying hands-on activities, testing the properties of ethanol with fire, creating room spray, making termite trails, using pipettes, measuring the density of algae, working with algae in different experiments, and using scent to find their species. Public visitors mentioned being able to interact and do hands-on learning as well as smelling for different scents.

During observations of two student groups and discussions with museum staff, it was evident that students and visitors greatly enjoy the hands-on components. Students exhibited higher levels of engagement during hands-on time compared to the lecture portion of the lab, and museum staff shared in informal conversations that public visitors appeared to enjoy the interactive exhibits. Because museum staff noticed consistent Science of Scent exhibit popularity, they made the exhibit a permanent part of the Natural World Investigate lab.



Figure 7. Students creating termite trails (top left), making room spray (top right), using a spectrophotometer to test for ethanol (bottom left), and measuring algae density (bottom right).

Students and public visitors also shared several other aspects that they enjoyed about the labs/exhibits (see Table 4). Students mentioned learning about, algae, biofuels, different scents, and new information. Public visitors also referenced learning about converting algae to ethanol, the relationship between taste and scent, and the molecular structure of scents. Finally, students mentioned an appreciation for the algae-part of the Biofuels lab and “everything.” Public visitors also shared that the exhibits were clear and easy to understand and that the overall experience was positive.

Table 4. What students and public visitors enjoyed about the labs/exhibits

Recurring Themes	Students: Percentage of 214 open-ended responses	Public visitors: Percentage of 69 open-ended responses
Hands-on/Interactive Learning	73% (19%)	54% (33%)
	<i>Ethanol test</i> (16%)	n/a
	<i>Room spray</i> (12%)	n/a
	<i>Termite trails</i> (7%)	n/a
	<i>Using pipettes</i> (7%)	n/a
	<i>Algae density</i> (7%)	(1%)
	<i>Working with algae</i> (4%)	n/a
	<i>Find your species</i> (1%)	n/a
	<i>Guessing scents</i> —	(19%)
Learning	12%	25%
Algae	9%	
Clear/Easy to understand	—	13%
Everything/It was fun	6%	9%

WHAT DID YOU LIKE MOST?

I liked the fact that we used ethanol and set it on fire. The fact that we used a spectrophotometer was also very interesting. [7th grade student, Biofuels Lab, June 2013]

I loved watching the termites go on the drawn track and make[sic] the room spray. [6th grade student, Science of Scent Lab, June 2013]

The interactiveness[sic] of the experiments. It's very hands on, and that's how I learn best. [11th grade visitor, Science of Scent exhibit, March 2013]

Get to learn via hands on activities [3rd grade visitor, Biofuels and Science of Scent exhibits, April 2013]



Figure 8. Guessing scents at the Science of Scent exhibit (left) and measuring density at the Biofuels exhibit (right).

KEY QUESTION:

What, if anything, did middle school students and public visitors dislike and what are their suggestions for improvement?

Students and public visitors provided open-ended feedback on what, if anything, they disliked and how the labs/exhibits could be improved.

Overall, the majority of students (68%) and most public visitors (53%) indicated that liked everything about the labs and exhibits (Table 5). Students mentioned a variety of "other" topic areas that could not be combined into a common theme (14% of responses), including the lab being too long, not enjoying the lab, and so on. Additionally, some students mentioned there was not enough hands-on time (6%), not enjoying the lecture portion (6%), not liking the algae (4%), or not liking the Science of Scent smells (2%).

Public visitors also mentioned several "other" themes, including the labs being difficult for elementary-aged children to comprehend and the Biofuels lab not working correctly.⁴ Public visitors also wanted more information on various topics (16%), did not like the smells in the exhibit (11%), believed there was not enough hands-on time (7%), or did not like the Biofuels exhibit algae (2%).

Table 5. Student and public visitor feedback on what they disliked in the labs/exhibits

Common Themes	Students: Percentage of 189 open-ended responses	Public visitors: Percentage of 55 open-ended responses
No dislikes	68%	53%
Other	14%	11%
Make it longer/Provide more information	---	16%
Smells in Science of Scent exhibit	2%	11%
Not enough hands-on activities	6%	7%
Lecture portion	6%	---
Algae	4%	2%

Both groups had a few suggestions for improvement. The only recurring request amongst students was for more hands-on learning time ($n = 46$) (e.g., more experimenting with algae, making ethanol). Public visitors had a few common suggestions. First, 14 visitors requested more hands-on experiments, particularly for the Biofuels exhibit. Second, nine visitors requested more scents to smell for the Science of Scent exhibit.⁵ Third, six visitors requested longer experiments with more details (e.g., showing all the steps in converting algae to ethanol). Finally, four visitors requested that the PowerPoint slides have an accompanying audio or video component that walks visitors through each slide so there is no need to read each slide.

⁴ Museum staff shared that the measuring density portion of the Biofuels exhibit worked "incorrectly" if visitors did not follow instructions explicitly provided on the iPad.

⁵ Based on ongoing feedback throughout the project period, lab scientists added more scents to the Science of Scent exhibit.

Summary and Recommendations

As part of the study, the North Carolina Museum set indicators/benchmarks for levels of expected performance related to key evaluation questions. The evidence indicators and associated survey results are in Table 6. Overall, the Natural World Investigate lab met four of seven performance indicators for student groups and seven of eight performance indicators for public visitors.

Student Groups

Students had positive attendance at the labs, and survey results suggest they developed a greater understanding of scientific inquiry, gained knowledge about biological science, and had a greater appreciation for research. Overall, the lab appears important for building knowledge and instilling appreciation for biological science.

Most students (i.e., greater than 50%) indicated agreement with the four unmet indicators. Specifically, the following categories did not reach the benchmark of 70–75% agreement:

- student interest in biological science
- student skills in biological science
- student motivation to pursue future opportunities
- perception that the lab is hands on and enjoyable

Observations suggested students responded more positively to the hands-on compared to the lecture portion of the labs. When museum staff lectured on the topic, interest and engagement appeared lower, with several students looking down or around the room. Student comments supported these observations, as students frequently requested more hands on time during the labs. If there were more hands on time or interactive components during the labs, these four benchmarks might have been met.

Public Visitors

The public exhibits in the Natural World Investigate lab were well attended, with participant gains in multiple areas:

- understanding of scientific inquiry
- knowledge related to biological science
- interest related to biological science
- skills related to biological science
- appreciation for scientific research
- motivation to pursue future opportunities to learn more

Table 6. Evidence of meeting indicators

Evidence indicator set by museum	Number of visiting students within student groups	Number of public visitors (e.g., students, parents, and so on)
1) 16,000 public visitors will participate in programs from July 2012 to June 2013.	n/a	28,463
	Percentage of student responses indicating agreement	Percentage of visitor responses indicating agreement
2) 70% will gain a greater understanding of the scientific inquiry process.	80%	87%
	Labs/Exhibits 96%	91%
3) 70% will gain knowledge related to biological science that they attribute to program participation.	Biological Science: 77%	88%
4) 70% will gain interest related to biological science that they attribute to program participation.	58%	87%
5) 70% will gain skills related to biological science that they attribute to program participation.	62%	71%
6) 70% will gain a greater appreciation for research that they attribute to program participation.	72%	88%
	Pursue future opportunities: 52%	72%
	Attend other labs: 73%	96%
	Search for additional information on STEM areas: 66%	85%
7) 70% will gain a greater motivation to pursue future opportunities to learn more about biological science.	Search for additional information on STEM careers: 64%	78%
8) 75% will report the program was a hands-on, enjoyable experience.	73%	55%

Note. Red numbers indicate a particular indicator was not met.

Public visitor feedback suggests that the exhibits provided a multitude of knowledge, understanding, appreciation, and interest benefits for public visitors.

One area that did not meet the indicator was for the hands-on aspect of the lab exhibits. Visitors frequently commented that the Science of Scent exhibit was more hands-on and interactive than Biofuels.

Recommendations

Based on the study findings, evaluators suggest the following recommendations for improving the Biofuels and Science of Scent labs and exhibits:

- Continue offering the labs/exhibits for student groups and the public. Students, particularly those from underserved groups, could benefit from greater exposure to hands-on and knowledge-rich labs. Public visitors might also benefit from the opportunity to learn and develop interest through informative exhibits.
- Include the original YouTube videos on flocculation and cell lysis in the Biofuels presentation or find similar videos that illustrate these concepts. Videos might help students to visualize the algae-to-ethanol conversion process.
- Consider finding ways to invite underserved student groups back for multiple visits. By participating in multiple opportunities, students might experience additional gains in biological science interest, motivation, skills, and overall enjoyment in science.
- Try scheduling labs for 90–120 minutes and provide more structured inquiry opportunities for students. For example, consider setting up the termite trails portion of the lab to have students hypothesize why termites follow different shapes and then review hypotheses with different shapes and pens.
- When working with underserved groups, schedule a day of science at the museum. Students should have multiple opportunities in these visits to interact with scientific tools, learn about current research findings, and conduct their own research.
- Provide student groups with examples of biological science careers and places to search for more information. A handout with this information would be helpful.
- Look into possibilities for making the museum exhibits more interactive and hands on. Visitors thought the Biofuels exhibit, in particular, could have more interactive components. Museum staff could modify this exhibit to have more of a quiz-type nature, similar to the Science of Scent exhibit.
- Continue reviewing ways for public visitors to participate in audiovisual exhibits on the iPad. For example, having scientists describe the exhibit on video would provide an immersive and interactive experience.
- Consider including links to more information on the iPad exhibits for public visitors who want a greater level of detail about the topic areas.

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Appendix A. Summary of Student Focus Group Findings

As part of the project, Magnolia Consulting evaluators worked with staff from the North Carolina Museum of Natural Sciences to develop a set of focus group questions to address two Natural World Investigate Lab programs: one on Biofuels and one on the Science of Scent. Members of the Museum's Teen Advisory Committee participated in these two programs on December 8, 2012 and participated in a focus group to share feedback about these programs on December 13, 2012.

The purpose of the focus group with the Teen Advisory Committee was to gauge the quality of the Biofuels and Science of Scent Investigate Labs and provide the museum with information they could use for refining and developing future programs. During the focus group, Magnolia Consulting evaluators asked a series of questions about the workshops, and the Teen Advisory Committee shared feedback in a discussion-based format. Each question, as well as a summary of participant responses, is provided below. General recommendations for future labs are provided at the end of this summary.

Focus Group Questions and Participant Responses

What was one thing you liked best about the Biofuels Investigate Lab?

Participants said they enjoyed many things about the lab. One of the first things mentioned was being able to use the same equipment used by professionals to make biofuels. Participants noted that most schools do not have resources to use the type of technology used in the field, but this workshop provided participants access to those resources. Participants really appreciated the teaching styles and techniques used by the presenters, noting that they were open about the biofuels processes and broke complex concepts down into straightforward, step-by-step pieces. Participants also enjoyed seeing the biofuels process in action and liked having the opportunity to do participate in a hands-on way. Several participants commented that they had fun growing their own algae.

What was one thing you liked best from the Science of Scent Investigate Lab?

Like the Biofuels lab, participants reported enjoying many things about the Science of Scent lab. One participant mentioned the spray bottle as a favorite, and others praised the interactive nature of the lab, noting that the smells opened up their minds regarding how the senses and brain work together. Several participants especially liked the petri dish activity and trying to find others with the same scent. Some participants remarked that they were impressed with how animals can smell distinct differences. Similar to the Biofuels lab, participants noted that they appreciated how presenters broke down the complex topic, and they also noted that the presenters' analogies used while teaching helped make the content clearer and easier to understand.

What was one thing you liked least about the Biofuels Investigate Lab or the Science of Scent Investigate Lab?

Participants liked most aspects of both labs and did not report disliking anything. One participant referred to the experience as “perfect,” and another participant appreciated that even though s/he missed the beginning, s/he still was able to follow along. Participants thought the instructors were effective, and one participant noted that it was so much fun they forgot to check the time.

If you could change one thing about the materials for the Biofuels Investigate Lab, what would it be?

Overall, participants expressed that they would change very little about the labs or materials. Some participants noted that it would have been helpful if it had been easier to zoom in and see the differences in the pictures and graphs, noting that the computer and TV were too far away. Thus, for the next lab, it would be helpful to have closer TVs or larger text. Another participant thought that for the Biofuels lab, the table was too far away and that although it was nice being close to the algae, it would have been helpful if the students’ tables and the presentation were closer together. Finally, some participants agreed that it would have been interesting to see the concentrate form of chemicals rather than the diluted samples.

If you could change one thing about the materials for the Science of Scent Investigate Lab, what would it be?

Participants suggested a few things that could be improved regarding the materials for the Science of Scent Investigate lab. They specifically mentioned some confusion during labeling and bottling. Additionally, some would have liked more scents because they only had orange and cinnamon for spraying (for example, one participant suggested including lavender).

What should be continued and kept the same in the Biofuels Investigate Lab?

Participants agreed that the lab should continue to run experiments in the background because they liked seeing how professionals do the experiments and being able to see different stages of experiments. Participants would also like to see the labs remain interactive and continue to have instructors explain things clearly. They appreciated the way instructors taught all levels and depths of a topic, from easy to complex, which made the lessons easy to follow. They also liked how instructors explained problems in a way that encouraged participants to think about how they might be able to overcome that type of problem. In addition, participants appreciated the real-world applications and problems addressed by the lab and thought future labs should continue this aspect. Additionally, some participants suggested that some of the activities could be made into a game (for example, water molecules running through dirt, having kids watch water outside of the algae cell). Finally, participants appreciated being able to keep their own algae after the activity concluded.

What should be continued and kept the same in the Science of Scent Investigate Lab?

Participants appreciated the hands-on experience and liked the activity with the termites, noting that it was neat to see how they followed the pheromones. Participants said they still felt excited about the lab even after it was over. Although this was a much harder topic to

explain without going into detail with how brain and scents work together, they felt that the instructors did a good job of splitting it up into steps and simplifying it, keeping in mind ways to make things easier for the students.

What impact do you believe these labs will have on understanding scientific inquiry?

Participants expressed that these labs will likely have a big impact on understanding scientific inquiry, noting that when faced with questions, especially about relevant and current topics, people start thinking and becoming interested in generating potential solutions. They also indicated that the labs illustrate how younger generations can come up with new and better ideas (compared to previous generations) and that if you can get students involved in labs, it will open their minds to new topics and careers in this area. Participants conveyed the importance of doing actual experiments to increase understanding of scientific inquiry, commenting that in a school setting, labs are generally not really experimental. Several participants made other connections to school, as well, suggesting that these labs can help highlight the significance of what students learn in biology class (similarly noting that many people do not think about where to use knowledge gained from school). A few expressed concern over the current disconnect in schools, noting that students are not applying what they learn. They appreciated that these types of labs can help students see the importance and applications of science. One participant also thought these types of labs could help change perceptions of science, showing that it is not "nerdy." Finally, participants said that these types of labs can help change the mindset that what is known now is all that is correct (for example, people used to think the planets revolved around the Earth).

What impact do you believe the Biofuels Investigate Lab and Science of Scent Lab will have on interest, knowledge, and scientific skills?

Participants indicated that the Biofuels lab addressed a very relevant topic and increased their understanding of how to advance science and contribute to progress. They noted that these labs will likely increase interest in science and technology and make people feel like they could do more by showing how they can contribute to the future. Some suggested that the Biofuels lab will really affect teenagers as they start driving because they will be concerned about the price of gas. Additionally, some participants shared that with these types of labs, if you pull people from different backgrounds, and show them the problems, they might come up with a diverse array of ideas on how to solve the problems. Thus, they appreciated that you could get very interesting views and ideas of how to innovate technologies that may lead to solutions to real-world problems. Participants agreed that the best classes are when teachers tell you to figure it out yourself rather than doing it for you, and they appreciated having this opportunity with the labs. They said it is more fun this way, and also allows you to learn more.

Participants mentioned that the lab on scents really opened them up to how their nose worked and that because they were able to get a better understanding, they could spread that knowledge to others. Participants appreciated that they could take the results from these labs and use them to explain things to their friends and that this can spark more of an interest in how things work (for example, they enjoyed learning how the brain works with the senses).

What impact do you think these labs will have on scientific appreciation?

Participants shared that they liked being able to see people actually doing the science. They appreciated learning about how scientists had not been able to get the information they needed from ethanol companies, so they came up with their own way and were willing to share. This showed them that scientists were nice people who are willing to work together come up with good solutions and are able to go far with it. Some participants also noted that sometimes it seems like there is nothing left to be discovered, but by learning that scientists just figured out they can make ethanol from algae growth, they realize there is still a lot to be discovered. Participants indicated that there is a lot to learn in bioenergy and you need all of the sciences out there to come up with a feasible solution to the problems. One participant also noted that “scientist are not just crazy people but are actually doing things to solve problems, not just creating problems,” and others agreed.

Participants also noted that these labs might generate a greater appreciation for qualitative data, rather than just numbers and graphs, and highlight that science is not all based on quantitative data. The Science of Scent lab showed them that science can be fun and that no matter what people find interesting, there is probably a topic in science that addresses that area.

What are other topics that you might like to see in future labs or that would be relevant to a middle/high school student?

Participants shared a number of ideas for potential future labs including the following topics (noting the importance of keeping future labs interactive):

- global warming, how CO₂ collects in atmosphere
- emotions and chemical reactions
- bugs or live animals
- anatomy and how muscles work (sports player interested in the anatomy of athletes)
- muscle memory (how muscles remember certain tasks)
- memory class (scents bring back memories, what else does?)
- how we interpret facial expressions such as when is someone lying or having a “fake smile” (We use different muscles to fake smile. It is Interesting to see how to identify those people)
- sociology (social behaviors of animals and how they relate to humans)
- brain (exposing to neurology, how your brain interacts with you)
- how to make your body healthier/become in shape (Explain so that people don't just have to follow guidelines or what not eat, but not in a cheesy way)
- what you would do to condition your body for certain things (sports, dance, how to grow strengths you want)
- understand how to work out properly (how to not do damage to your body or get results in an easier way)
- old age (what will happen to you when you get older based on what you do now, what injuries/back/knee problems)
- different mental diseases (schizophrenia disorder).
- ADHD (People don't know what it is or what it does and the different levels. It is a very common disease; we want to learn more about common diseases.)
- model the anatomy of animals or people

- microorganisms (algae was cool, so something more like that)

Preliminary Recommendations based on Focus Group

Overall, the Teen Advisory Committee shared very positive feedback about the Biofuels and Science of Scent Investigate Labs. They appreciated the relevant and interesting topics as well as the opportunity to use equipment used by professionals. In addition, they enjoyed seeing science in action and learning more about the multiple experiments going on in addition to the labs. They spoke positively about the format of the labs and the instructors, noting that they were able to make complex topics clear and understandable. Participants said that they learned a lot from the labs and were able to retain the information they learned. They also thought these types of labs could increase future participants' understanding of the scientific inquiry process as well as their scientific interest, knowledge, skills, and appreciation for science. In addition to positive feedback, participants shared a few suggestions for improvement such as making it easier to see the materials and moving tables closer together. Additionally, they would have liked to explore more scents in the Science of Scent lab.

Based on the feedback shared during the focus group, evaluators recommend the following for future labs:

- Maintain the basic structure and interactive format of the labs in which students participate in hands-on activities and actively "do" science rather than just watch.
- Keep the break between sessions to provide a time for student to digest material and interact with others.
- Continue to provide the opportunity for participants to use the equipment used by professionals.
- Involve effective instructors who enjoy what they are doing, engage students, and are willing to answer questions.
- Keep running other experiments in the background so lab participants will have the opportunity to learn about other areas of interest, as well as what is being taught in the lab.
- Continue to hold labs that address current, relevant issues with real-world applications that can help foster connections with what students learn at school.
- Consider incorporating more games into the labs.
- Consider showing participants the concentrate forms of chemicals rather than the diluted samples.
- Consider ways to improve the setup in the labs (such as ensuring that the text on computer screens is large enough and making sure tables are placed in optimal locations).

Appendix B. Student Group Survey

Thank you for visiting the Natural World Investigate Lab at the North Carolina Museum of Natural Sciences. To learn more about the effectiveness of museum activities, Magnolia Consulting, LLC, an independent evaluation firm, is working with the museum to conduct a survey of the Natural World Investigate Lab. Your feedback on this brief survey is greatly appreciated!

Age: _____ Grade: _____
Gender: _____

1) Which Investigate Lab(s) did you participate in today? (Please check all that apply.)

- Science of Scent
- Biofuels

2) After participating in the experiment, how much more do you know about the science of scent?

- 1- Nothing
- 2
- 3- Somewhat more
- 4
- 5-Very much more
- N/A- Not applicable

3) After participating in the experiment, how much more do you know about biofuels?

- 1- Nothing
- 2
- 3- Somewhat more
- 4
- 5-Very much more
- N/A- Not applicable

4) Please indicate your level of agreement with the following statements.

After participating in the Science of Scent and/or Biofuels experiments...

	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
...I have a greater understanding of scientific inquiry.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
...I have more <u>interest</u> in biological science.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
...I have more <u>knowledge</u> about biological science.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
...I have more <u>skills</u> related to biological science.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
...I have a greater appreciation for scientific research.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
...I have more motivation to pursue future opportunities in biological science.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

5) If you selected “Disagree” or “Strongly Disagree” to any of the above, please explain why.

6) As a result of participating in the Science of Scent and/or Biofuels experiments, how likely are you to do the following?

Program Impacts	Very Likely	Likely	Neither Likely or Unlikely	Unlikely	Very Unlikely
Attend other labs offered by the museum	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Search for additional information on science, technology, and math subject areas	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Search for additional information related to science, technology, and math careers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

7) What did you like most about the Science of Scent and/or Biofuels experiments?

8) What, if anything, did you dislike about the Science of Scent and/or Biofuels experiments?

9) What suggestions do you have for improving the Science of Scent and/or Biofuels experiments?

10) Do you have anything else you would like to share with us?

Thank you for your time!

Appendix C. Public Visitor Survey

Thank you for visiting the Natural World Investigate Lab at the North Carolina Museum of Natural Sciences. To learn more about the effectiveness of museum activities, Magnolia Consulting, LLC, an independent evaluation firm, is working with the museum to conduct a survey of the Natural World Investigate Lab. As a token of our appreciation, two survey respondents will be selected in June 2013 to receive a \$25 Amazon.com gift card. Your feedback on this brief survey is greatly appreciated!

Age: _____
Gender: _____

Grade or Highest Degree: _____

I. Science of Scent Questions (only complete if you participated in this experiment)

1) How much time did you spend in the Science of Scent experiment? _____ minutes

2) Did you finish the Science of Scent experiment?

- Yes
- No

3) If no, please explain why you did not finish the experiment.

4) After participating in the experiment, how much more do you know about the science of scent?

- 1- Nothing
- 2
- 3- Somewhat more
- 4
- 5-Very much more
- N/A- Not applicable

II. Biofuels Questions (only complete if you participated in this activity)

5) How much time did you spend in the Biofuels experiment? _____ minutes

6) Did you finish the Biofuels experiment?

- Yes
- No

7) If no, please explain why you did not finish the experiment.

8) After participating in the experiments, how much more do you know about biofuels?

- 1- Nothing
- 2
- 3- Somewhat more
- 4
- 5-Very much more
- N/A- Not applicable

III. General Questions

9) Approximately how much time did you spend in the Natural World Investigate Lab? _____ minutes

10) Please indicate your level of agreement with the following statements.

After participating in the Science of Scent and/or Biofuels experiments...

	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
...I have a greater understanding of scientific inquiry.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
...I have more <u>interest</u> in biological science.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
...I have more <u>knowledge</u> about biological science.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
...I have more <u>skills</u> related to biological science.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
...I have a greater appreciation for scientific research.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
...I have more motivation to pursue future opportunities in biological science.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

11) If you selected “Disagree” or “Strongly Disagree” to any of the above, please explain why.

12) As a result of participating in the Science of Scent and/or Biofuels experiments, how likely are you to do the following?

Program Impacts	Very Likely	Likely	Neither Likely or Unlikely	Unlikely	Very Unlikely
Attend other labs offered by the museum	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Search for additional information on science, technology, and math subject areas	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Search for additional information related to science, technology, and math careers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

13) What did you like most about the Science of Scent and/or Biofuels experiments?

14) What, if anything, did you dislike about the Science of Scent and/or Biofuels experiments?

15) What suggestions do you have for improving the Science of Scent and/or Biofuels experiments?

16) Do you have anything else you would like to share with us?

17) If you would like to be entered to win an Amazon.com \$25 gift card, please write your email address here. (Note. We will only use your email address to contact you if your survey is chosen. Your email address will not be shared with anyone else.) Email: _____

Thank you for your time!