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Waldron Educational
Consulting

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[SUMMATIVE REPORT FOR THE NANOOZE PROJECT]

This report is intended to inform the project PI, Dr. Carl Batt, and the National Science Foundation of the impacts of this NSF-funded project. The exhibit was evaluated at INNOVENTIONS at *Epcot*® in Lake Buena Vista, Florida.

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SUMMARY

The purpose of this summative report is to document the project outcomes in relation to the proposed goals. The Nanooze exhibit installation project achieved all four goals and continues to inform the public about nanotechnology in its installation at *Epcot*[®]. Surveys of visitors show acquisition of content related to the exhibits, as detailed in this summative report.

PROJECT GOALS

The following table shows how each aspect of the project mapped to the goals outlined in the original proposal. As evidenced, all four project goals were met. Goal 1 and 2 were met through the high quality, interactive exhibits that are installed at *Epcot*[®]. Each exhibit is accessible to those with disabilities, those with language barriers, and non-readers. Signage features both English and Spanish translations. Goal 3 was met through several mechanisms. First, exhibits feature everyday objects (e.g., Zoom, RopeScope), and signage connects the everyday objects to the nanoscale through constructive use of images and simple text. Translations available in both English and Spanish increase accessibility. Scientists featured on signage and in video segments connect the audience to the ‘real world’ of scientists and those who advance nanotechnology as part of their work. Goal 4 was met through the interactive web site and the publication of 100,000 issues of Nanooze, the magazine.

GOAL	INDICATORS	PROJECT OUTCOMES
1) Design and fabricate a 3,000 square foot exhibition on nanotechnology for post-atomic visitors that will have a long term presence in a theme park in the United States.	Exhibits constructed, refined, and installed <i>Epcot</i> [®]	Very high quality exhibit installed.
2) Immerse post-atomic visitors in inquiry based nanotechnology experiences.	Interactive exhibits developed and fabricated.	All exhibit components installed and functional.
3) Provide visitors tangible connections between nanotechnology and their daily lives.	Inclusion of translation of nanotechnology into everyday applications.	Several exhibits make explicit the connection between lab research and everyday applications. Scientists are featured.

4) Integrate and leverage a web site and a print magazine under the same name that will extend learning beyond the venue.	Creation of web site; Publication of magazines; distribution of magazines.	Web site is online and interactive. 100,000 magazines have been printed and distributed.
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MAP TO TIMELINE

The entire project is on track based on the timeline in the original proposal. Fabrication began within 30 days of the award and was completed within one year of project commencement. Evaluation was completed in step with this timeline, and the summative report was prepared in 2012.

METHODS

Formative data for this project was collected through previous NSF award 0426378. The current summative evaluation documented visitor learning outcomes during a site visit at *Epcot*®. During this two-day visit, 70 visitors were interviewed about their learning after interacting with the exhibits. The survey was administered after visitors had interacted with at least two exhibits and had a dwell time of five minutes or greater. The questionnaire was as follows:

Gender: M / F	Age: 5-17	18-24	25-64	65+
Race/ethnicity: White Hispanic/Latino Black/African American Asian Other				
1. What is the smallest thing you can see with just your eyes?				
2. What is the smallest thing you can think of?				
3. What is this exhibit about?				
4. What do you think nano means?				
5. What are molecules? What do they do?				
Ropescope				
1. What are these tools used for?				
2. Why do scientists use tools like this?				
3. Can you see nanometer size objects with these tools? YES NO				
Zoom				
1. What are you seeing in this zoom?				

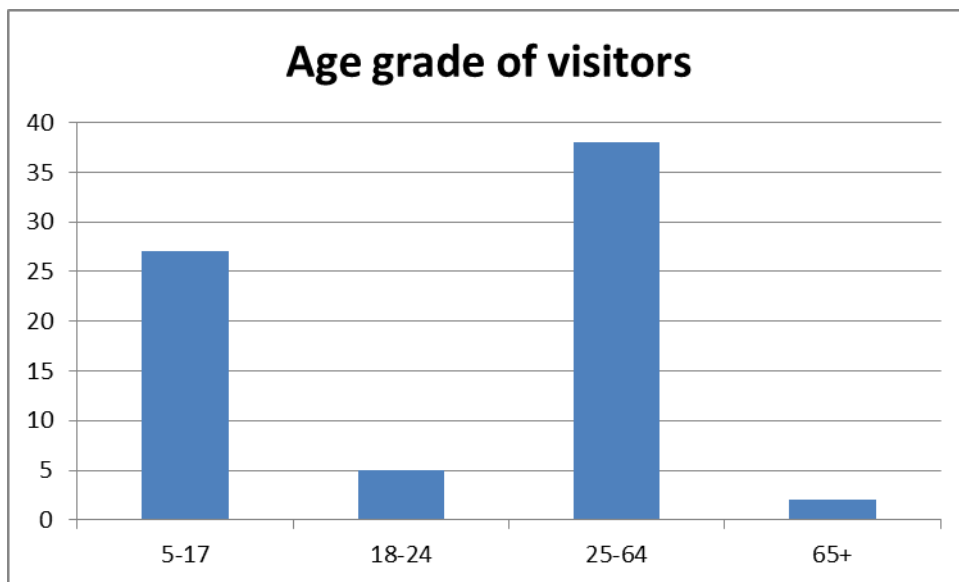
2. How big are the objects?
Touch a Molecule
1. What are you doing with this molecule?
2. What is the molecule made of?
3. How do molecules move?

Visitors were approached and asked to participate in the survey. Parents/guardians of minors under 18 filled out parental consent forms prior to interviews with visitors of that age range. Nine people declined interview. All data was entered and analyzed via cluster analysis.

SUMMARY OF RESULTS

DEMOGRAPHICS

The survey was implemented with 70 visitors. The demographic breakdown was as follows: 36 male, 34 female. Predominant audience was Caucasian (59), with 4 Hispanic/Latino(a), 4 Black/African-American, 2 Asian and 1 Other ethnic background. Age grade is represented in the following table.



SURVEY RESPONSES

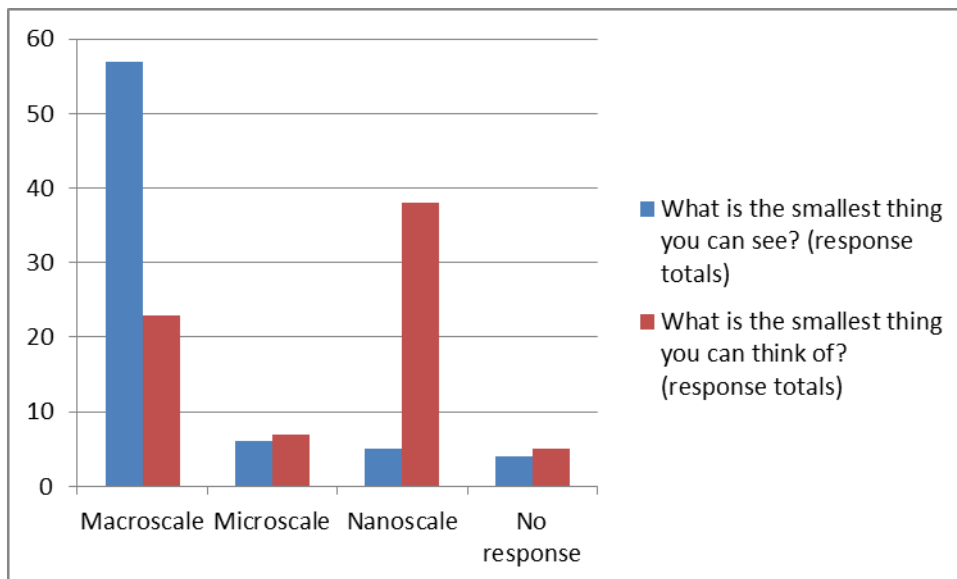
COMMON QUESTIONS (ASKED OF ALL VISITORS)

Each question on the survey is represented below with the number of responses per category. Each of these is followed by a graphical representation of responses.

1. What is the smallest thing you can see with just your eyes? What is the smallest thing you can think of?

As seen in previous work, the smallest thing that people described being able to see was something macroscopic. The smallest thing respondents could think of was dominated by items at the nanoscale (38 responses), showing that the exhibit had an influence on responses.

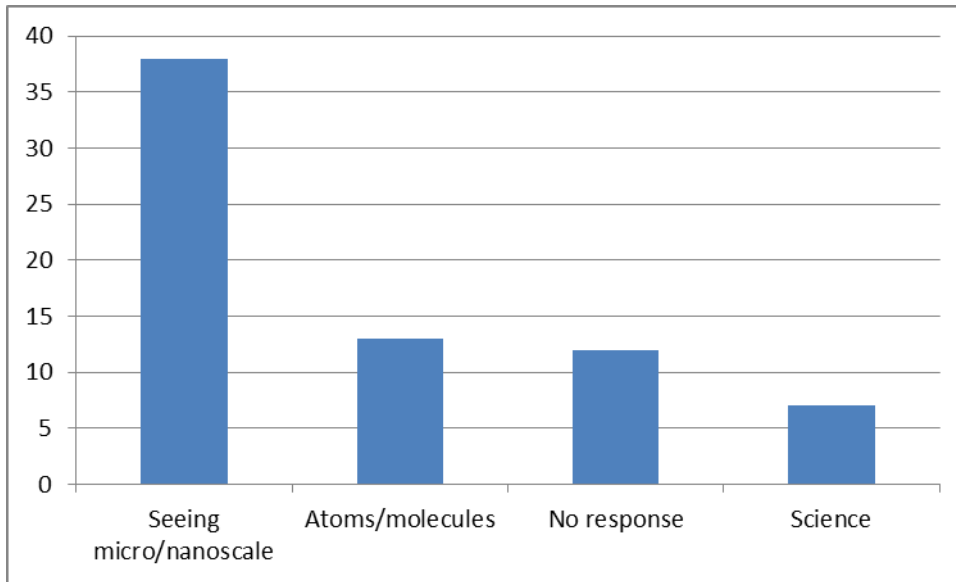
Scale	What is the smallest thing you can see? (response totals)	What is the smallest thing you can think of? (response totals)
Macroscale	57	23
Microscale	6	7
Nanoscale	5	38
No response	4	5



2. What is this exhibit about?

The majority of visitors felt the exhibit was about seeing things at the macro and nanoscales. Next most common responses were those related to atoms and molecules. An almost equivalent number of visitors had no response (see table below). Another group responded with the general term, “science”.

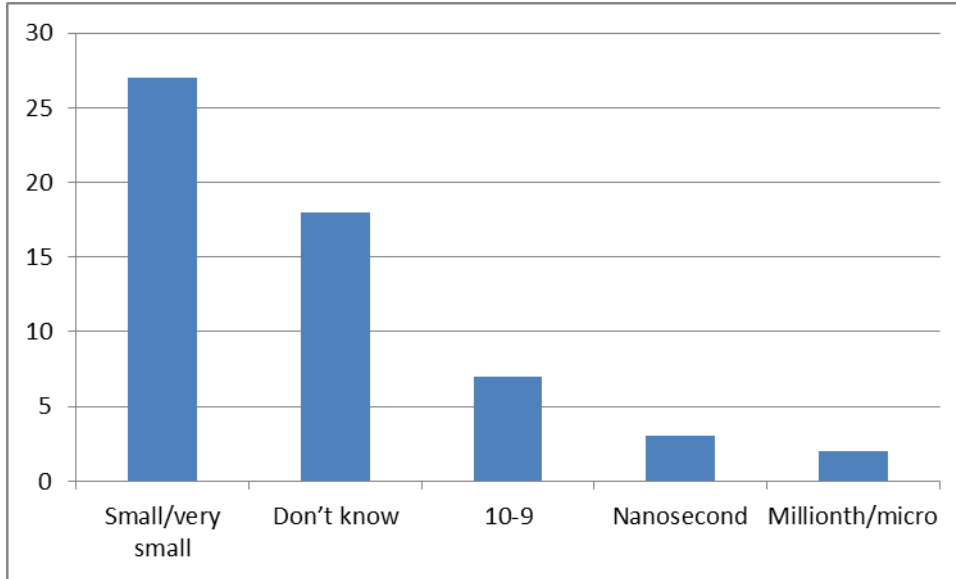
Seeing micro/nanoscale	Atoms/molecules	No response	Science
38	13	12	7



3. What do you think nano means?

The majority of respondents thought nano meant “very small”, while others simply did not know what nano means. Several visitors responded with 10^{-9} , showing that they had a functional knowledge of “nano”. A small number of visitors mentioned nanosecond, or millionth/micro.

Small/very small	Don't know	10^{-9}	Nanosecond	Millionth/micro
27	18	7	3	2



4. What are molecules? What do they do?

The majority of visitors mentioned building blocks and atoms in their responses to this question. The next most common response was “don’t know”, but then others responded with an answer related to size, an answer referring to something in the body including cells, and examples of molecules.

Building blocks/atoms	Don't know	Size-related response	In body/cells	Example of a molecule
23	12	5	4	3

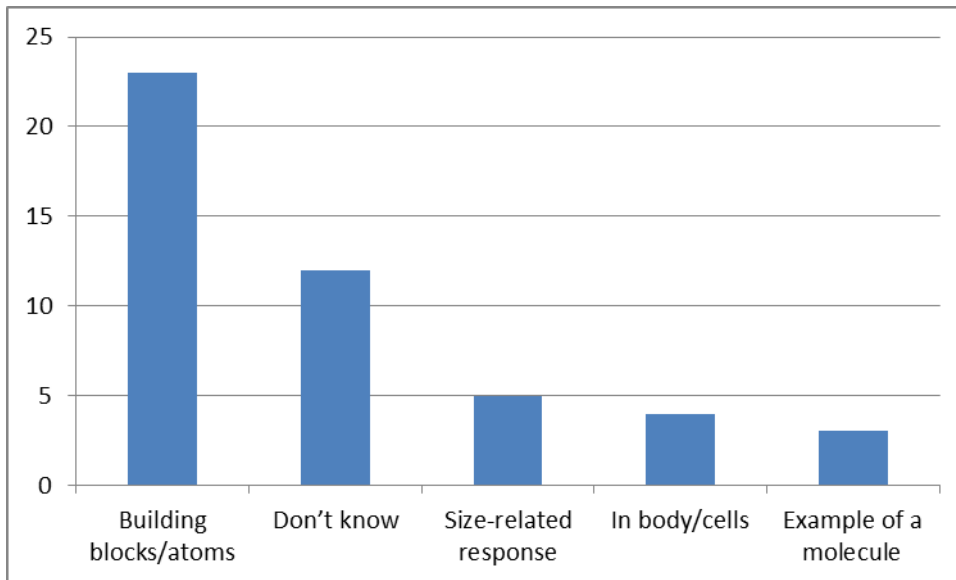


EXHIBIT-SPECIFIC QUESTIONS

Not all respondents agreed to answer questions regarding specific exhibits. Specifically, 11 responded to questions about “RopeScope”, 35 to questions about “Zoom”, and 15 to questions about “Touch a Molecule.” This data appears in the section below, sorted by exhibit.

ROPESCOPE

Each visitor who responded to questions about RopeScope answered three questions in series. This data is presented per individual below. All visitors responded with answers that included size, scale, or seeing things inside the body. No visitors thought that you could see nanometer sized objects with the RopeScope.

Visitor	What are these tools used for?	Why do scientists use tools like this?	Can you see nanometer sized objects with this tool?
1	microscope	seeing cells	No
2	magnification	to see things	No
3	science	to look more into what they think they see	No, if it was more powerful you could.
4	looking at things	to see small things	No
5	seeing the penny up close	to see tiny things	No
6	seeing stuff close up	to zoom in on things	No
7	seeing small things	for magnifying glass	No
8	things you can't see	so they're able to see smaller cells	No, too small.
9	I don't know	looking into stuff you can't see like the body	No
10	microscopes	examine molecules	No
11	microscopes	to look at cells, things inside the body	No

ZOOM

The 37 responses to this set of two questions were highly variable. Most respondents indicated that they were seeing something up close and could identify the object(s). When asked how big the objects were, most visitors responded with “very small” or “nano”. The next most common response was “I don’t know”.

Visitor	What are you seeing in this zoom?	How big are the objects?
1	Shells	
2		atomic scale
3	how detailed it is	very small
4	dragonfly wing	big at first
5		very small
6	silicone; micro chips	nano
7	looking at a butterfly up close	pretty big
8	atoms	small as transistors in computer chips. I used to work at an electronics factory.
9	it zooms	pretty small
10	butterfly parts close up	big at first and then small
11	a butterfly and its beautiful wings	up close, they're really small
12	really close up stuff	big and then you go closer
13	atoms at the end of it	atom size
14	objects close up	
15	butterfly and dragonfly	I don't know.
16	an insect wing	big at first, then small
17	insect	I don't know.
18	stuff close up	I don't know.
19	butterfly	some are nano

20		nano
21	butterfly	I don't know.
22	dragonfly wing	all the way down, to atoms
23	butterfly	millions of times smaller
24		as big as the butterfly; but not that big
25	a shell	big and small
26	electron microscope pictures	small
27	butterfly	really really small, maybe nano
28	forces between atoms	they aren't objects
29	dragonfly parts down to really small	really small
30	dragonfly	really small
31	zoom down to atoms	
32	zooming in and out of different things	a lot more than you can see with your eyes
33	things close up and small	big and then small
34	living things	really small
35	close up	small
36	butterfly	nano?
37	butterfly wings	yea, nano.

TOUCH A MOLECULE

Fifteen visitors responded to questions about Touch a Molecule. The most common response to “what are you doing with this molecule” involved motion. When asked what the molecule was made of, the most common response referred to atomic structure (e.g., H₂O, oxygen, atoms). Responses to how molecules move were highly variable, but several answers described how different molecules move differently. Other responses related to the user-interface (e.g., when you press on the screen you move them).

Visitor	What are you doing with this molecule?	What is the molecule made of?	How do molecules move?
1	learning things	atoms	
2	discovering what materials things are made of	H ₂ O, oxygen	frozen moves slower; warmer moves faster
3	popping it	more hydrogen and oxygen; would help to put that on the screen	going down
4	moving it	H ₂ O, oxygen	I don't know. Here, you touch them.
5	looking at a molecule	H ₂ O	stick together
6	spinning	hydrogen and oxygen	move slowly
7	moving it to see different parts	H ₂ O	when you press on the screen you move them
8	I like the H ₂ O; here is the hydrogen and oxygen (pointed).	Hydrogen and Oxygen	different; each one is different
9	moving it		all molecules move differently
10	smallness of molecules and how many it takes to make up a item		each is different
11	It's a lot of info (ESL)		
12	silicone, hemoglobin--moving them	atoms	
13	moving it	water	slowly
14	silicone; I don't know.	sand?	I don't know.
15	reading the signs--I didn't do it.	water; silicone	I don't know.

CONCLUSION

The Nanooze exhibit met its goals, reaching millions of visitors at *Epcot*[®]. Dissemination materials have made an impact with at least 100,000 people in addition to 100,000 web site hits. Visitor responses to questions asked on site when the exhibit opened indicated an acquisition of content related to the exhibit. The PI of the project also has secured funding for additional installation at the *Disneyland*[®] Park in California. The impact of this project will continue as additional visitors at *Epcot*[®] interact with the exhibits.