Incorporating Visitor Experience into Exhibition Design
Deconstructing a Student Project

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Abstract

The Raja at length, being desirous of seeing with his own eyes how his Education Department busied itself with the little bird, made his appearance one day at the great Hall of Learning. From the gate rose the sounds of conch-shells and gongs, horns, bugles and trumpets, cymbals.... The pundits began chanting mantras with their topmost voices, while the goldsmiths, scribes, supervisors...loudly raised a round of cheers.... The Raja said: "it does seem so fearfully like a sound principle of Education!" The Raja was about to remount his elephant, when the fault-finder, from behind some bush, cried out "Maharaja, have you seen the bird?" "Indeed I have not!" exclaimed the Raja, "I completely forgot about the bird."

The Parrot's Training *by Rabindranath Tagore*[1]

Rabindranath Tagore's parable about the education of the parrot can be seen as a reminder to museum professionals everywhere. How many times do we forget the visitor? How often do we build elaborate museums and expensive displays without ever talking to visitors in order to understand what will serve them best? This article examines a project created by the authors and conducted with their students during the nine-day "Science Learning in Non Formal Settings" course for the MS in Science Communication in Kolkata in November 2009. The purpose of the project was to provide the students with a brief but intense experience in how to incorporate visitor voices and understandings into the conceptualization and design (or re-design) of exhibitions. In addition to describing the project itself, the authors will also discuss its theoretical underpinnings. The experience itself took place in the last four days of the course. The previous five days of class involved reading and discussion of research in science education, learning theory, developmental and cognitive psychology, design of informal spaces, visitor research, visitor evaluation processes, and other studies of museum practice. The article concludes with the authors' assessment of the students' experience and of the successes and challenges of the project.

Incorporating the visitor voice. It is a subject that is explored with increasing frequency in books[2], conferences[3], journals[4], and websites[5]. Why should museums include this perspective in their planning and development of exhibitions and programs? In what forms? By what means?

In November 2009 the authors were members of a group of Smithsonian-sponsored faculty teaching in the MS in Science Communication program at the main campus of the National Council of Science Museums (NCSM) in Kolkata, India. Our ten students consisted of six museum professionals with years of experience as curators, designers, or educators, and four Fellows at the beginning of their museum careers. We decided to expand our course—normally focused only on non-formal learning---to include the study of family learning in museums and methods of incorporating visitor feedback into the interpretive planning process. A key goal in our joint effort was to address this issue of the visitor voice and its role in exhibition development, which research links to improved visitor engagement and understanding[6]. How could we emphasize the importance of this concept in the students' formation as science museum communicators?

We proposed combining traditional classroom teaching and discussion with a workshop in which students would have to redesign an exhibit based on visitor feedback. In keeping with the theories we were teaching about active and experiential learning, we concluded that the best way to teach about incorporating the visitor voice would be to model some best practices that have been developed over years of study and research in museums. We would create a brief but intense experience in soliciting, listening to, and integrating visitor voices and understandings into the conceptualization and design (or re-design) of an exhibition. We hoped to provide students with new skills and the confidence to utilize them back at their museums.

Description of the Student Project

Background

On one of our first days in Kolkata, before the course had begun, the authors visited Science City, a large, popular science museum and science park. We were looking for an exhibition component that did not seem to engage visitors as the curators had no doubt intended. We spent several hours observing, talking with visitors, and photographing exhibits both with and without visitors. After discussing our afternoon's work and reviewing our notes and photographs, we decided that a component called "Principles of Flight", featuring sections on both "lift" and "drag", might be a candidate for our student project.

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Fig. 1. "Principles of Flight" exhibit at Science City, Kolkata, India.

The component, shaped like a large squared-off "U", contained artifacts and a discussion of the physics of flight in the middle section. Each of the two "arms" of the U had a button-activated interactive element and explanatory text, one side on "lift" and the other on "drag", two aerodynamic forces that must be understood in order to learn how airplanes fly. Visitor groups stopped briefly at each section; some operated the interactive; few read the text. Family groups in particular did not spend much time reading or operating the interactive parts. A few visitors, with whom we could speak in English, told us that they understood the text because they already knew what "lift" and "drag" meant, but they did not think the ordinary visitor would grasp the technical explanations.

Using Borun's Family Learning Study as Our Model

Following our visit to Science City, we began our class with reading, analysis, and discussion of current findings and best practice in learning theory and visitor studies. We will discuss this theoretical material later in the article, applying it to the prototype the students created. As our work shifted in preparation for making revisions to the "Lift" & "Drag" exhibits, we focused on an important piece of research on family learning in museums. The study, led by researcher Minda Borun, involved four science learning spaces in the city of Philadelphia, Pennsylvania, USA. Each facility (the Academy of Natural Sciences, The Franklin Institute, the Philadelphia Zoo, and the New Jersey State Aquarium) had selected a component that it hoped to improve for use by families or other multigenerational groups.

After observing and talking with visitors using each component, the Borun research team developed an observation form that focused on behaviors that appeared to be linked to engagement and retention of information about the components – reading, pointing, talking with each other, engaging with the activities, etc. They also developed interview questions designed to assess a family's level of engagement with an understanding of the key ideas of the exhibit. The research teams then used observation, interviews, and videotaping of family groups at each of the components to discover what elements might encourage more engagement and learning. They modified each element incrementally, observing and interviewing each time, until the exhibit held families' attention, engaged them in the activity and in conversation with each other, resulting in increased understanding of the exhibit's goals. Based on this study, which was conducted during three phases with over 500 families at the four locations, Borun and colleagues developed seven principles of family-friendly exhibits:

1. Multi-sided: the family can cluster around the exhibit.
2. Multi-user: interaction allows for several sets of hands and bodies.
3. Accessible: the exhibit can be comfortably used by children and adults.
4. Multi-outcome: observation and interaction are sufficiently complex to foster group discussion.
5. Multi-modal: the activity appeals to different learning styles and levels of knowledge.
6. Readable: the text is arranged in easily-understood segments.
7. Relevant: the exhibit provides cognitive links to visitors' existing knowledge and experience[7].

Our student project aimed at reproducing this study in miniature, requiring students to combine learning theory with the practice of visitor-centered design. Most of our students were familiar with the "Lift" & "Drag" exhibits as they had been presented in science centers for many years, so these components were an interesting choice for re-design.

Phase 1: Designing the Observation and Interview Sheets

Before we could embark on an interpretive redesign of the exhibit components, we needed to understand how visitors were using the current ones. During class discussions, the students became acquainted with a large body of scholarship on how to collect, interpret and utilize visitor behavior data[8]

as part of the exhibition planning process. When it was time to put that information to work, the instructors were pleased that many students were eager to apply the academic precepts to actual visitors.

Yet some students seemed less convinced, asking exactly how a small, informal sample of visitor data could lead to substantive insights or an "improved" exhibit. As with many museum professionals, there is a tendency to think that visitor assessments must always be based upon hundreds of observations, expensive prototypes, complex statistical analysis, and lengthy reports. While large-scale studies are sometimes necessary, in this instance we opted to use a method that would fit the time constraints and resources of our class project. We decided to develop an observation sheet much like the one used in the Borun study. The student observers, using one form per family, would watch to see if families engaged with the exhibit, read the text, asked or answered questions among themselves.

The students did not anticipate the challenge of writing effective interview questions. Before they had actually experienced visitor observation and testing, the students had conflicting ideas about the vocabulary to use in the survey, the learning outcomes to look for, and even the number of questions to ask. Later they would realize that watching and talking with visitors brought clarity to the process of developing good questionnaires. More immediately obvious was the need for translation. The students wrote the questionnaires in English, and then created written translations in Hindi and Bengali. Of course all of the students spoke both English and Hindi, and about half also spoke Bengali.

Two questionnaires were created, one for the "Lift" exhibit and one for the "Drag" exhibit. Research in the United States indicates[9] that using phrases like "in your own words" alleviates some of the self-consciousness people may feel if they sense they are being judged for their answer, so the exact phrasing of each question became a careful construction. Each survey began with "in your own words, explain what "lift" ("drag") is". Each contained four questions (see Appendix A) that investigated how the exhibits were used and understood. We had to assume that this wording would work well with Indian audiences. It might be an interesting future project to study what kinds of interview wording work best in different languages and cultures. We created two teams of five students each, a "lift" team and a "drag" team. Each team consisted of three museum professionals and two Fellows.

Phase 2: Observation and Discussion with Visitors

On Saturday morning, a day when many families visit Science City, we met our students at the museum. We planned that members of each team would take on

Fig. 2. NCSM student (center) interviewing a visitor group at Science City.

explained the project and asked if visitors would be willing to be interviewed after they had looked at the exhibit; if families were not approaching on their own, a recruiter would seek out people, explain the project, and bring willing groups over to the exhibit; **observers** stood unobtrusively near the "lift" and "drag" sections of the exhibit, and completed an observation form for each family; and **interviewers** (at least one of whom spoke Bengali) talked with families after they had tried either the "lift" or "drag" section of the exhibit.

Fig. 3. NCSM student observing a family at the "Lift" exhibit.

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Observers and interviewers also had to work together to link the observations and interview notes for the same family. We had hoped that all students could rotate through the three roles throughout the morning, but we were able to organize only two rotations. The first half hour or so was a bit disorganized, with the students learning their roles "on the job", and we two instructors trying to be everywhere at once, answering student questions, coaching students' interactions with visitors, and documenting the project with our cameras. But the study soon settled into a smooth pace, with recruiters, observers, and interviewers working together with the family groups.

Phase 3: Decoding Visitor Understanding of "Lift" & "Drag"

At the end of the morning we retired to a nearby classroom, and debriefed with a welcome offering of tea and cookies from the museum. The students first discussed their findings within their own groups, and we then talked as a whole class. The immediate conclusion of both groups was that the visitors had understood almost nothing about "lift" and "drag". Upon further examination of the visitors' own words, however, we came to see that they did have their own understandings of these concepts, based on their personal prior knowledge and what they experienced in doing the interactive. But what visitors understood about how to operate the exhibits and the concepts they presented was always not what the museum intended. The students discovered that visitors were confused by how to operate and understand the exhibits. As they had learned in class, this was not a problem unique to Science City[10].

Technical understanding: Visitors did not understand that they had to hold the button to keep air flowing from a blower that would activate the exhibit. They pressed the button and walked away.

Vocabulary issues: Overall most family groups did not understand the exhibit and rarely read the labels, which had terms (*aerofoil, aerodynamic, fuselage*), that were difficult to understand. A number of visitors asked why the text was not in Bengali as well as Hindi and English.

Prior knowledge shaped/interfered with understanding: Most visitors had never flown so were unable to relate the concept of "lift" or "drag" from personal experience of a plane. People seemed to think the exhibit was about plane wings tilting rather than actually flying. People who had flown thought it might have something to do with turbulence.

Cultural issues: Women in mixed-gender groups rarely activated the exhibit. Mainly they watched while the men engaged with the activity though they would engage in discussion about exhibit topics despite their lack of participation. Women alone with children did engage with the exhibit.

Phase 4: Redesigning "Lift" and "Drag" to Optimize Visitor Experience

Our challenge to the students (and to ourselves): Could we redesign the "lift" and "drag" exhibits, including the text and graphics, taking into consideration visitors' perceptions and misperceptions in a way that would improve their understanding of these two principles of flight?

We spent the next two days of class reflecting on what the students had observed at the "Principles of Flight" exhibit. We approached the prototyping process with a blend of the theoretical and the practical: reviewed what the visitors had said about their understanding of the exhibit and text; associated our observations with research about why the human brain resists releasing inaccurate concepts about scientific phenomena for accurate ones[11]; and brainstormed the kinds of experiences that might engage visitors and connect to their everyday understandings of "lift" and "drag". Finally, we developed prototypes out of Styrofoam, lightweight wood, and construction paper, using materials such as tape, glue, scissors, and markers, provided by the NCSM program; tested the prototypes with each other; wrote text; and created graphics.

Fig. 4. "Lift" prototype with blower being discussed in the classroom.

"Lift" Prototype

The main problem with the original "Lift" component was that even if a visitor held the button to keep the blower on, it was hard to see much difference in how each shape was affected by the air current. We decided to use a small model, already built, that some of the students located in the central design offices. The model displayed two clearly different shapes attached to wires. The two shapes, one a wedge and one a curved wing, illustrated both "lift" and "drag" immediately, as the wedge remained stationery while the wing shape rose when a blower was trained on them. Using this model also gave us more time to focus on re-writing the labels and developing new graphics.

"Drag" Prototype

In the original "Drag" component the phenomenon was again subtle and difficult to notice. The students decided to carve several large Styrofoam shapes that a visitor could hold in front of a blower. They began with three shapes and then narrowed them down to two. Visitors (it was hoped) could experience "drag" (and even "lift") with their bodies as the forms reacted to the wind from the blower.

The Theory Behind the Practice

Below we discuss the theories and research underlying the changes the students made to the original exhibit as they developed their prototypes. As we watched them grapple with this iterative process, we could see them incorporating and applying new understandings into their own considerable life and work experience.

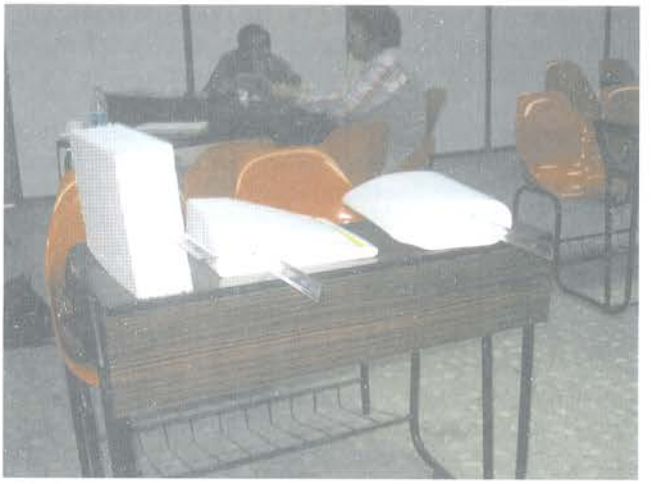

Fig. 6. "Drag" prototype forms (the middle one was eliminated from final prototype)

1. **The students had come to see that learning is change – the acquisition of new understandings, knowledge and skills – that can be measured**[12]. Earlier we had had a number of interesting class discussions on a question raised by one of the students – is learning tangible or intangible? As part of the answer to this question, we read about and viewed video of a number of ingenious testing situations wherein developmental psychologists were able to observe and measure even young children's' acquisition of new understandings and knowledge – for example replications of Piaget's studies of children's' understanding of conservation of matter. We came to the conclusion that while the concept of learning may be abstract and intangible, the **effects** of learning, are tangible and measurable, even with children who may not be able to talk at

Fig. 5. Close-up of original "Drag" exhibit

Fig. 7. Testing one of the "drag" prototypes in the classroom

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length (or at all) about what they understand. It was with this understanding that we approached our visitor studies project.

The students grasped the importance of design (as well as content) for science communication in informal settings. They had read and discussed several chapters from a recent report by the National Research Council of the National Academies of Science in Washington, DC. Entitled *Learning Science in Informal Environments: People, Places, and Pursuits,* the report summarizes and analyzes the past 50 years of visitor studies, cognitive studies, developmental psychology, and a host of other disciplines as they relate to science learning in informal settings. An important theme of the report is that **museums are intentionally designed spaces; science exhibit design can be both a form of interpretation and a catalyst for science learning.** According to the report, exhibits that encourage science learning should:

be shaped by intentional design & personal interpretation (prior knowledge);
stimulate excitement, interest, & comfort;
feature direct experience and direct access to phenomena;
model scientific processes through interactivity; doing and seeing; meaning making and explanation (stimulate prior knowledge); questioning and predicting; self-reflection on learning;
be designed to encourage adult-child interaction[14].

The photographs of the prototyping process both in the classroom and in the museum gallery show that the students applied at least some of these principles, in particular, the idea that **design which takes into consideration visitors' levels of understanding and skills is a powerful interpretive tool.** The students were transformed by this insight and spent much of the class time designing a prototype to include visitors' prior knowledge of "lift" and "drag", to create interactivity, and to provide direct access to the phenomena they were trying to illustrate.

The students came to understand that learning is meaning making, an active process: "...the contemporary view of learning is that people construct new knowledge and understandings based on what they already know and believe[15]."

During observations and interviews, students became aware that many visitors had not flown before. So instead of relying on airplane-related

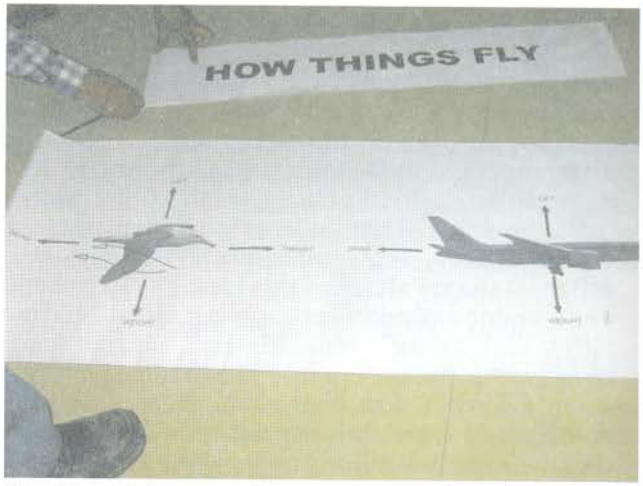

Fig. 8. Linking everyday experience to the science of flight

examples, they discussed everyday experiences people might have had – experiences that would form their "prior knowledge" of the phenomena of "lift" and "drag": watching birds fly; flying a kite; feeling an umbrella "lift" in the wind or resist the wind; holding one's arm out against the wind from the window of a moving car; riding a bicycle or motorbike with clothes flapping, or wearing more body-hugging clothing; swimming with baggy or sleek swimwear.

The idea of creating large forms that visitors could hold – one a block that would pull back when held in front of a blower, and one shaped like a wing, that would remain more or less stationary as the blower air flowed over it – developed from these discussions of visitor prior knowledge, the efficacy of direct experience, and from the desire of the students to have visitors "feel" both "lift" and "drag", thereby connecting their past experience

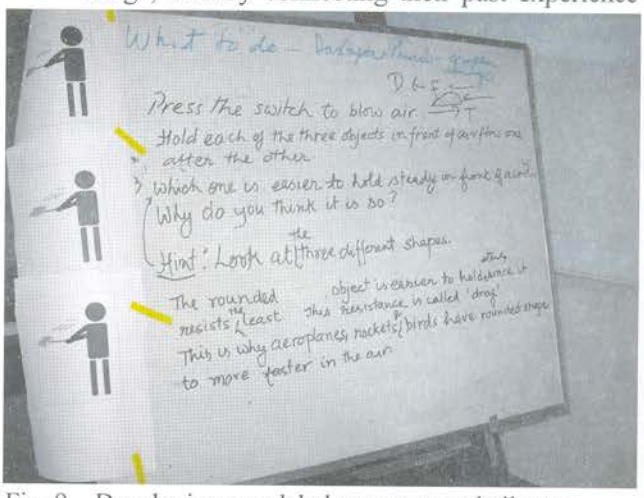

Fig. 9. Developing new label copy was a challenge

with the scientific phenomena being explained. Related to this was another modification - to develop graphics demonstrating a range of everyday "lift" & "drag" experiences alongside the scientific concepts. As we discussed in class, "experience design" can help visitors connect what they already to know to ideas they are encountering for the first time[16].

4. **The students decided that the exhibit should have one Big Idea** that integrated the phenomena of "lift" and "drag". Guided by Beverly Serrell and her seminal work *Exhibit Labels, an Interpretive Approach*[17] the students decided that the big idea which brought the phenomena of "lift" & "drag" together was "how things fly". Interpreting one big idea often creates the cognitive space for people to connect in different ways to that idea which is a goal of learning in non-formal environments. One big idea also can support "sidebar" ideas, such as the variations of how things fly that the students wanted visitors to experience and feel with their own bodies.

5. **The students realized they would have to create various types of label copy:** Instructions on how to use each side of the exhibit From observing visitors, they noted that the original exhibits were not intuitive to use and even may have lead people to do or think the wrong thing. Striving for a more intuitive exhibit oftentimes includes clarifying the experience, using pictures to communicate and allowing for multiple outcomes[18]. Not all labels are instructions so it is important to visually distinguish instructive from contextual labels to help visitors engage and extend their experience New instructive labels like the one that said "push and hold" were placed directly at exhibit buttons, while a different color and location were selected for the placement of contextual labels and graphics.

A glossary The original exhibits introduced unfamiliar words and concepts so a glossary of terms was created to help decode these for visitors. "Lift", "drag", "velocity" and concepts like "angle of attack" were explained in glossary labels at each redesigned exhibit. Visitors could read them for general interest or refer to them when trying to figure out new concepts. Since one of the main goals of presenting science in informal learning environments like science.museums is to evoke pro-social behavior--specifically to engage people in broader discussion about science and technology in their daily lives--it is essential to give them the tools and sense of empowerment to do so[19].

Explanations that linked to visitor experience Current brain research suggests people who become successful scientific thinkers do so, in part, because they've learned how to make effective assumptions. The idea is that over time, individuals capable of making good scientifically guesses eventually learn how to normalize the process, which in turn leads them to conclude they are "thinking scientifically". As with so many other things in life, you are what you believe. The students tried to write labels that linked everyday phenomena to abstract concepts like "drag" with the hope that if people could relate to the umbrella experience, they could assume the more abstract ideas. However, writing labels that were easy to read and understand yet also explained scientific phenomena accurately and clearly, proved a

Fig. 10. Putting the prototype exhibit together at Science City.

difficult task. Moreover, some students still struggled to transform their own views about how much content a visitor needed or wanted in an exhibit label. Much debate, negotiation and eventually, collaboration occurred before acceptable labels emerged[20].

Other characteristics that were considered when developing the labels included: type size and color, visual contrast, illustrations and diagrams. These technical factors have a very human impact when it comes to how visitors react to and perceive the exhibit[21] as do other aspects of visual, physical and intellectual accessibility. In class, students reviewed accessibility guidelines that are used in the United States, but these guidelines are not mandatory for Indian museums.

Testing the Re-Designed Exhibits

For those who may wonder whether exhibit prototypes can be assembled quickly and tested effectively with minimal time, take note of what our students accomplished! The night before final testing was to occur, we left them with a

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Fig. 11. Final touches to prototype.

number of assignments: complete the exhibit layout, print up large computer generated graphics and labels, find two blowers (one of the authors promised to bring her hair dryer just in case), find a wall with a plug where we could tack up our signs and plug in the blowers, etc. We weren't sure what we would find at Science City on testing day, when visitors would be coming to try to new versions of "lift" and "drag".

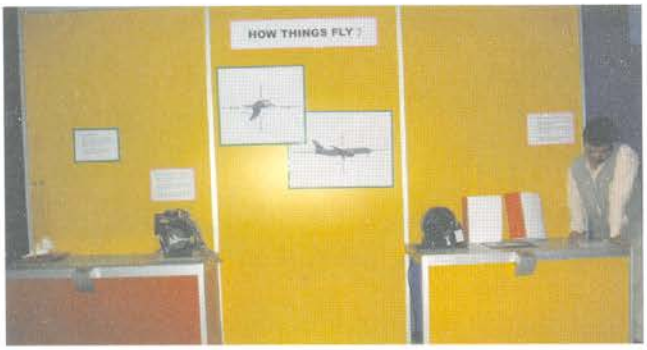

Fig. 12. The prototype exhibit ready for visitor testing.

When the authors arrived at Science City the next morning, we were impressed with the work that the students had done late into the night and early in the morning. The Fellows had created large graphic panels, including technical vocabulary, instructions for each interactive, and a large label for the entire exhibition. Several students who worked at Science City had located Mila walls and platforms, placed them near an outlet, found a second blower, and connected each blower to a red button for visitors to activate. The prototype exhibition was much more professional looking than anything we had anticipated. The students' teamwork and expertise had paid off.

Students from several Kolkata secondary schools had been organized by Educator Raju Manigandan of Science City and were waiting to try out the new exhibits. Photographs show the students and their teachers trying the exhibit while being observed and later interviewed by NCSM students. We had anticipated that the student visitors would be more knowledgeable about the principles of flight, and we were right. It would, of course, have been more scientifically useful if we had been able to test the new exhibits with the same number of family groups that had used it before. But we had to work with the usual visitation of most science museums – general visitors on weekends and school groups on weekdays. We were able to profit from the student visitors because we could observe whether or not they easily understood how to use the exhibits (most needed a bit of coaching). They seemed to enjoy the interactions. There were a few families visiting, and so were able to collect a small amount of data on family usage of the exhibit.

Debriefing the Prototyping Session

We were running out of time – we had only an hour or so at the end of the testing session to discuss our findings; our students had to get back to campus for further classes. But we did process the following from our morning's testing:

* Observations showed that students and families did try the activities, and seemed to enjoy them, but still needed coaching.
* Interviews revealed that visitor understanding of the new labels and activities was somewhat improved over the original exhibits, but not as much as we had hoped. Visitors (both the students and the families) still didn't know exactly what to do, and still didn't read the copy.

Fig. 13. A student trying the "Drag" exhibit, with observers behind.

* Interviews also revealed that the student visitors had been studying principles of flight in school; their familiarity with the phenomena and with the explanations from physics made them somewhat

impatient with our simpler explanations. This raised another question- might we need two levels of explanation?

* It may be that "lift" and "drag" are better understood in relationship to each other rather than as separate components. This would require thinking about how to perhaps integrate the two components into one.
* To really make the component engage visitors and involve them in doing the activities and reading the text, we would have had to do at least one more iteration, testing new label placement and explanations for how to use the interactive. Unfortunately, this was our last day of class, so it would not be possible.

Lessons Learned

What We Learned

We were inspired by our experiences on campus and in the museums and cities we explored during our time in India. We learned that we share a passion for exhibitions and a commitment to enhancing their education potential with our Indian colleagues, and that families everywhere face the same challenges when they embark on a museum visit. As with many museums in the United States, interest in incorporating the visitor voice is high but not yet fully incorporated into institutional culture. We learned that Science City and other NCSM museums attract vibrant audiences that bring many different kinds of science curiosities with them.

What We Think the Students Learned

By pairing *Learning in Non Formal Environments* with *Visitors Studies* in both theoretical and practical applications, we believe we succeeded in amplifying the experience for the MS students. Each component of the course energized the other – one goal was to demonstrate that individual staff members can enhance each other's role & results by a team approach. Another goal was to demonstrate that putting more focus on the learner will not diminish the curatorial role or the design role; it accentuates the skill each staff member brings because everyone works towards the goal of crafting a meaningful experience for visitors. We wanted to give the MS students hands-on experience with prototyping, label writing, visitor observation, visitor tracking, data synthesis, interpreting results, and learning to see an exhibition from the visitor's perspective. Their work during the project and their examination writings make us hopeful that they will retain and apply the following ideas in their museum practice:

* **Including the visitor voice need not be expensive:** It does not require hiring a professional evaluator or the use of expensive design techniques and materials. A great deal can be learned from simple, inexpensive prototypes that are observed, tested, and iteratively modified by museum curatorial, exhibits, and education staff.
* **Museum staff can work together to organize and create multiple ways to incorporate the visitor voice:** The students had four days of experience in a variety of visitor study techniques: observation; tracking; interviewing; developing simple modifications to existing exhibits. They also became familiar with existing visitor studies, such as the Borun family learning study, that can serve as models for future work.

Fig. 14. A mother and child at the "Lift" prototype

* **Family and multigenerational groups can and should be studied;** Too often visitor research is aimed at individuals; but research has shown that people all over the world tend to visit museums as multigenerational groups, and thus their museum experience is a social one[22].

* **Exhibits can and should be created to engage groups rather than individuals;** The prototypes developed by the students attempted to incorporate the seven elements of family-friendly exhibits. Museum professionals sometimes dismiss the knowledge and skill needed to effectively connect families and exhibits[23]. Our students understand the payoffs that will come from their persistence.

* **Including the visitor voice takes time, planning and trust**: Museum staff can do this but they must be allowed the time and space to set up, conduct, and process prototyping, observing, and conversing with visitors. Colleagues may also need time to learn to trust that visitor input is valid.

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Fig. 15. NCSM students (standing) interviewing students who had tried the prototype

NCSM and Incorporation of the Visitor Experience

NCSM's encouragement of our visitor studies project and its integration into the MS program indicates to us a commitment to increased inclusion of the visitor voice in museum practice. This is an important step toward implementing further studies and resources required to ensure that conversations with visitors and

Fig. 16. NCSM student talking with local student testers of the prototype

utilization of their perspectives in museum, exhibition, and program design are part of the long range planning of the organization.

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Acknowledgements

We wish to thank Science City's Director Arijit Dutta Choudhury for giving us permission to use the museum as our teaching/learning laboratory and Raju Manigandan, formerly with Science City and now Project Coordinator at the North Bengal Science Centre, for scheduling students to test our prototypes.

Fig. 17. The authors and their students:
Front row, left to right: B. B. Srivastava; K.S. Murali; N. Dasgupta; K. Lee; G. Jennings; S. Majumder; P. Grover; S. Chaudhuri. Back row, left to right: R. Das; K. K. Singh; S. Chakraborty; V. Subhaprada.

APPENDIX-A

"LIFT" QUESTIONNAIRE

1. In your own words, explain what "lift" is?
2. When you used the exhibit, did you push both buttons? What happened? Prompt: Did you see a difference?
3. Do you think the shape of the two objects (in the case) affects how they move? Explain.
4. Do you see a connection between this exhibit and how an airplane flies? Explain.

"DRAG" QUESTIONNAIRE

1. In your own words, what is "drag"? Prompt: Did you use the exhibit, see something occur?
2. Did you push both buttons? What happened? Prompt: Did you see a difference?
3. Did the shape or orientation of the two objects you watched (prompt: a yellow one, a clear, flat one) affect how they moved when the air hit them? Explain.
4. Do you see a connection between this exhibit and how an airplane flies? Explain.

END NOTES

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