# Lift

Joyce Ma

June 2005

THIS IS **NOT** A DEFINITIVE FINAL REPORT

FORMATIVE evaluation studies like this one often:

- **are conducted quickly**, which may mean
  - small sample sizes
  - expedited analyses
  - brief reports

- **look at an earlier version** of the exhibit/program, which may mean
  - a focus on problems and solutions, rather than successes
  - a change in form or title of the final exhibit/program

# Outdoor Exploratorium: Formative Evaluation
# **Lift**

Joyce Ma
June 2005

## PURPOSE

To determine

- What did visitors do at the exhibit
- What visitors found interesting/ not interesting
- What did visitors think it's about
- What questions did visitors have about what they experienced

## METHOD

- The prototype was mounted along the railing next to the bay, as shown in Figure 1 and Figure 2.
- An evaluator sat and observed visitors who stopped in front of the exhibit for more than 3 seconds and approached them for interviews as they were leaving the exhibit. The observation and interview instruments can be found in Appendix A. The same evaluator also noted what the airfoils were doing while the visitors were at the prototype (i.e., if any of the airfoils lifted, if the airfoils spun at the exhibit base, or if the airfoil were completely stationary at the exhibit base).
- We observed and interviewed people between 12 pm – 4:30 pm on Thursday, June 2, and between 12 pm – 4:30 pm on Thursday, June 9.

**Figure 1. Prototype Location**

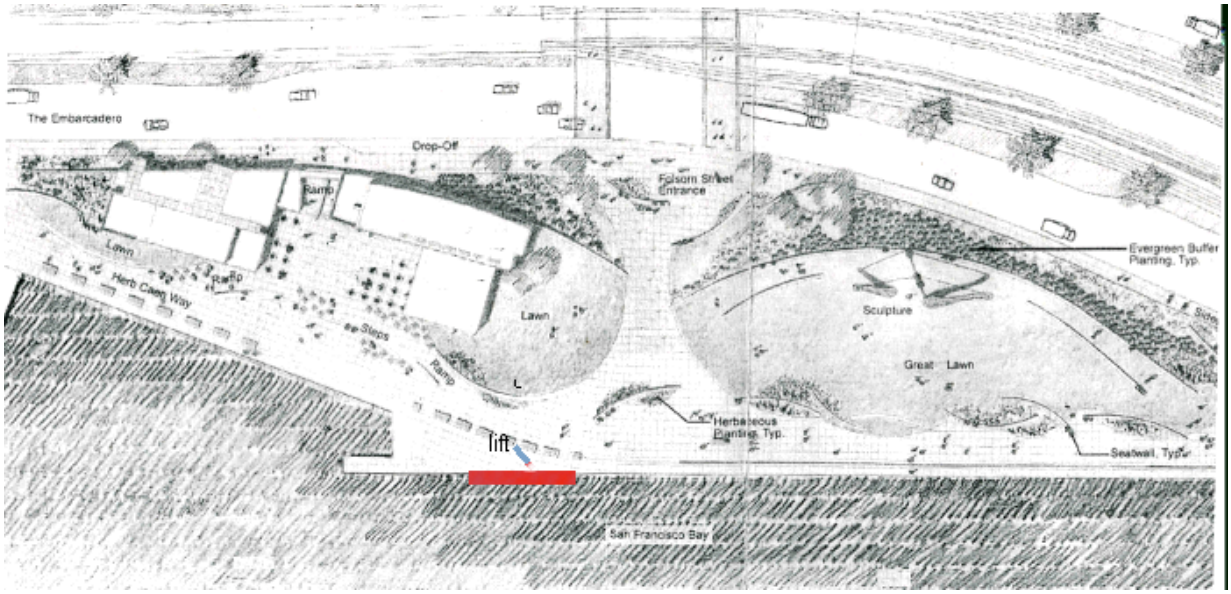



**Figure 2. Prototype Setup**





## DATA CORPUS

- N=24

| Group Type | Count (out of 24) |
|---|---|
| Individual adults | 6 |
| Adult peer group | 18 |

## RESULTS

In the following we use different color text to distinguish between visitor groups who reported seeing an airfoil lift (green), spin at the bottom (violet) of the exhibit, or do nothing (red).

What did visitors do at the exhibit?

- The following lists what visitors reported they tried to do at the exhibit prototype beyond watching the airfoils.
  - Read the label (8 groups; 3 / 3 / 3)
  - Block the wind (7 groups)

    Visitor10: I tried to block the wind. Since the wind was rotating I couldn't do it, I looked at what it was doing and tried to do what the panel [sign] suggests.

    Visitor22: Tried to block the wind, but a wind vane would be good to tell what direction it's blowing to try to block it.

    Visitor24: (1) I blocked the wind.

    Visitor4: I stood in front of where I thought the wind was coming from and tried to figure out if the wind was coming from 1 spot and I waited for a gust.

    Visitor12: We thought we were blocking the wind so we got out of the way.

    Visitor6: We tried to block the wind to change the direction.

    Visitor7: I tried to block the airflow down at the end there
  - Blow on an airfoil (2 groups)

    Visitor14: Tried blowing, tried to see what the direction the wind was blowing.

    Visitor7: I tried to block the airflow down at the end there; I tried to blow on it; then I got embarrassed.
  - Move an airfoil up and down (2 groups)

    Visitor9: I tried positioning it at different levels to make adjustments. Now it's doing something (the wind blew the foils up).

    Visitor12: Then I moved it myself to make sure it could move.
  - Otherwise, assessing the foils (2 groups)

    Visitor8: A.) I was looking to see if they were heavy, light or at a certain angle.

    Visitor13: I wanted to look at how it was made. I weighed one with my finger.

- Only one group was confused about what to do, and this was a group that came upon the exhibit when airfoils were *not* moving.

  Visitor2: A.) The text said something about wind
  B.) I was just looking at it, I touched it. I couldn't figure it out

- (9/24) visitors reached out to touch an airfoil. We did not find a statistically significant difference in the percentage of visitors who touched the airfoils between visitors who saw the airfoils lift and those who did not; Fisher's Exact Test, $p > .05$.

| What the airfoils did | Count |
|---|---|
| Lift | 7 (out of 12) |
| Spin at the bottom | 1 (out of 6) |
| Nothing | 1 (out of 6) |
| Total | 9 (out of 24) |

How interesting did people find the experience?

- On average, visitors found the exhibit *somewhat interesting*, regardless of whether or not visitors saw the airfoils lift.

| Interest Rating | Count (out of 12 who saw it lift) | Count (out of 6 who saw it spin) | Count (out of 6 who saw no movement) | Count (out of 24 total) |
|---|---|---|---|---|
| Interesting | 5 | 2 | 3 | 10 |
| Somewhat Interesting | 5 | 2 | 1 | 8 |
| Neutral | 2 | 0 | 2 | 4 |
| Somewhat Not Interesting | 0 | 1 | 0 | 1 |
| Not Interesting | 0 | 1 | 0 | 1 |

- What was interesting about the experience
  - It helps you notice the wind (6 groups)

Visitor16: It's very visually noticeable. (Little?) things that make you think about nature, science.

Visitor17: The simple instrument to measure direction of wind--simple version of science. Instru(ctive?).

Visitor18: We do things in the desert with wind, so we appreciate things that let us see the wind in a different way.

Visitor19: I like the simplicity--and that you can see something larger--wind movement--in a smaller scale.

Visitor4: I had to call my husband, he's interested in planes; the personal connection helped me understand it. It's a great visual representation having so many of them helps to see it.

Visitor15: To see how wind works--but I haven't seen it lift yet.

- People were in general curious about the exhibit and what it does (5 groups)

  Visitor8: B.) I wanted to figure out how it works.

  Visitor21: My curious mind I suppose--I'm a mechanical engineer.

  Visitor24: (1) Whenever I see something weird I look at it. I thought it was so stupid that was the reason; kids would love it. (2) Cool but wow, kids could learn from it.

  Visitor6: I couldn't figure out what they were so I had to come check it out.

  Visitor11: To figure out what it was how it works. Seeing how it works supp what we guessed. Thought of how to make it different.

- It's aesthetically appealing (3 groups)

  Visitor8: A.) The color and moving it's pretty neat

  Visitor13: That it was beautiful.

  Visitor7: The color; it's so out of place for this area and this walk

- It moves (3 groups)

  Visitor8: A.) The color and moving is pretty neat

  Visitor9: (Before the foils went up) Nothing going on. (Then the foils lifted and he changed his answer) The wind developed movement.

  Visitor5: The potential and concepts. It deals with a moving contraption.

- It's something novel along the Embarcadero (1 groups)

  Visitor14: It's different than stuff we see everyday, something actually happens- educational- we refreshed some of our scientific concepts.

- What was ***not*** interesting about the experience
  - It doesn't do very much (5 groups)

    Visitor9: (Before the foils went up) Nothing going on.

    Visitor2: A.) It doesn't make sense unless it's windy, that's a design flaw. If it worked it would be a lot better.

    Visitor20: Isn't very much wind today, so they're not doing much.

    Visitor1: A.)I'm not interested in wind. B.) It doesn't do anything

    Visitor12: When it's doing something it's really interesting. But there was some wind and it was not doing anything so we thought it was broken

  - It looks too simple (2 groups)

    Visitor2: A.) I was wondering is that someone's art project? It looks like a school project. B.) Seeing the purple things and people doing surveys, there was nothing flashy though.

Visitor3: It's too simple.

- There's not enough information, or depth of information (2 groups)

  Visitor22: It needs a bit more explanation.

  Visitor23: [rated as neutral] Just very commonsense--you know that when the wind blows, they'd raise, follow the direction.

- One group would have liked additional ways to explore the phenomenon (1 group)

  Visitor10: I could look at it and not interact with it; maybe split it in half one with the wind blocked

What did visitors notice about the wind at the exhibit?

- Its direction (10 groups)

  Visitor8: A.) It blows from higher than lower, different angles

  Visitor10: was coming from different directions.

  Visitor13: Yes [meant wind blowing harder]; if wind oriented perfectly when a puff came they flew. Otherwise they'd turn, but often not in time to fly on that puff of wind.

  Visitor14: The wind was changing directions. You can tell if you know and it's pretty intuitive as you watch. It's wind.

  Visitor16: I get some kind of idea--I don't think the wind... It was to be stronger to push them up higher. And (exhibit) can tell direction.

  Visitor17: Easily can see direction

  Visitor21: Yes, you can tell what direction it's coming from

  Visitor19: Wind was blowing west to east--was blowing one direction, in waves.

  Visitor3: Which direction the wind blows.

  Visitor4: I could tell the wind was erratic in direction and speed and generally not strong enough to lift them.

- *Varying* strength (8 groups)

  Visitor9: Yes; when the wind wasn't blowing they were still; the wind had a peak

  Visitor10: It was being erratic, it picked up and died down

  Visitor13: Yes- meant wind blowing harder; if wind oriented perfectly when a puff came they flew. Otherwise they'd turn, but often not in time to fly on that puff of wind.

  Visitor17: speed of wind

  Visitor21: how strong, constant breeze or blusters.

  Visitor22: Could tell that the wind was NOT at a constant rate

Visitor23: Then you know the wind is stronger when they go up.

Visitor24: [Note: (2) left] (1) It would go up and down because of the wind.

- The presence or absence of (strong) wind (6 groups)

  Visitor2: A.) It's not doing very much

  Visitor6: Not much; it's pretty still

  Visitor20: A little bit now [it's moving now], but not at the time--I'd think that they'd all line up the same way, but they don't. It might have been more interesting with a child--to try to... Saw from a distance--attracted by the color.

  Visitor12: I could tell the wind was blowing. Otherwise no, their moving meant the wind was blowing.

  Visitor5: Yeah; the wind is behaving mildly

  Visitor4: generally not strong enough to lift them.

- Different airfoils react differently (3 groups)

  Visitor16: I still don't get it entirely--why is the wind only on the (3rd and 2nd foils)?

  Visitor22: one side less active than the other.

  Visitor7: It seemed like the wind was erratic; one piece was going this way and the others were going that way. I wonder what it's like on a windy day.

- Nothing - You *cannot* tell anything about the wind (2 groups)

  Visitor1: A & B.) No

  Visitor15: No, not enough.

<u>What did visitors think was the point of the exhibit?</u>

- It's about the wind (12 groups, 6 / 3 / 3)

  Visitor8: B.) Wind + speed = direction A.) Same

  Visitor16: Wind works differently than you think; it draws your attention to it a little more.

  Visitor17: Trying to show direction and speed: slow, fast.

  Visitor22: Is the fact that it's next to the ocean and between two buildings across the street--does its being in this particular location make a difference? Land breezes versus ocean breezes?

  Visitor23: Just relating to the wind--that you can see them go when you feel the wind.

Visitor24: (1) It shows the force of wind; the power of the wind to hold the weight of whatever you call those plastic things.

Visitor2: A.) Wind power. I think he's on salary. B.) Maybe that it's windy here

Visitor6: Wind direction and speed; by seeing how many there are it shows how differential the wind is in each time and space.

Visitor7: Looking at flows of wind whether it's up down or around; I think I read it over there.

Visitor1: A.) Wind.

Visitor3: Wind velocity; to show that there is wind when there doesn't appear to be any. I would put different colored windsocks spaced further apart.

Visitor12: I think it's about wind direction and lift; displaying the property of wind in a 3-D way.

- It's about airfoils and lift (7 groups, 3/ 1/ 3)

  Visitor13: How Air foils work

  Visitor14: Yes, how he airplane works. It might be showing lift, but maybe also bird behavior.

  Visitor18: Makes you figure out principles of lift on your own--principles of how wind behaves--how easy it is to amuse people with simple ideas.

  Visitor20: Supposed to be hands-on demonstration of an airplane wing--what happens when wind comes under it or goes up.

  Visitor4: Because of the subject I was on board. (Trying to show) what lift is and how lift works; more specifically how air foils give lift.

  Visitor5: The interaction of the wind with wind foils. Probably having to do with lift generated. It's clear from the nature of the poles they're designed to go up when there's enough wind.

  Visitor15: Show how wind lifts the thing.

- It's about getting energy from wind (2 groups)

  Visitor9: About wind power; energy can be generated by wind.

  Visitor21: Maybe to do with renewable energy. how to extract energy from the wind--or just to look good.

- It's an art piece (2 groups)

  Visitor21: Maybe to do with renewable energy. how to extract energy from the wind--or just to look good.

  Visitor11: No- it's an artistic impression

- Other

  Visitor10: Maybe the environment of San Francisco how the elements ties into it.

Visitor19: Seems pretty simple: putting on a physical representation out here--being able to see something you can normally see.

What did visitors become curious about?

- Some aspect of the wind (9 groups)

  Visitor10: The rate of how wind blows; I go sail and I wondered what the purple panel was doing. The San Francisco bay's different specifically how it changes typically.

  Visitor6: We see that it's [the wind] very effective by it's movement; I always wonder how everyone sails out here.

  Visitor7: Yes about the wind in San Francisco; how we can use it to help us. I wanted to find out more about and it just extends that interest.

  Visitor4: I was thinking it's an interesting spot to pick; the wind tends to go in circles in the city between the buildings. If it was at pier 39 it might be coming from a steady one direction. It would be a great modified scarecrow

  Visitor15: Yes, of course--how wind works--how the thing works.

  Visitor12: Architecture and incorporating wind into the design.

  - More specifically, a few visitors wondered: Why do the different airfoils behave differently?

    Visitor8: A.) Wind direction, weather prediction.
    B.) In different places it worked; is it really the wind blowing differently at different angles?

    Visitor16: Curious about how spotty the gusts of wind were. Didn't realize the streams of wind were so narrow... I assume that's what it's showing.

    Visitor5: About the air foils shape and their interaction with the wind. I was curious about why they're all facing different directions. One would think the wind would hit them all from the same direction.

- The airfoils (3 groups)

  Visitor17: Like to show kids. [wondered about shape of the pink plastic, and how that would change what it does.]

  Visitor18: The wind comes and in pieces of velocity. And Bartolini's [Bernoulli??] principle--the concept of the wing.

  Visitor5: About the air foils shape and their interaction with the wind. I was curious about why they're all facing different directions. One would think the wind would hit them all from the same direction.

- The exhibit, in general (3 groups)

  Visitor22: Curious about what it was--how bad my science/physics is.

Visitor2: A.) I was curious what it's about

Visitor3: No. The "under construction" sign made me curious.

- Replicating the exhibit (3 groups)

  Visitor17: [They wanted to know what the white plastic thing was made from to make one]

  Visitor18: … Want to take a really large version to Burning Man: maybe 5 poles, with seats to float people under the wing.

  Visitor19: First thought: I thought I should build this in my backyard--but there's maybe not enough wind.

- Nothing in particular (9 groups, 6 / 2 / 1)

## SUMMARY

- On average, visitors found the prototype *somewhat interesting*, regardless of whether of not they saw the airfoils lift off the base of the exhibit. Visitors thought the exhibit was interesting because it helped them notice the wind[1], it provoked their curiosity, it's aesthetically appealing, it moves, or simply because it was something new they encountered along the Embarcadero.
- However, some other visitors felt that the exhibit did not do very much or was too simple. We note that all such comments came from visitors who did *not* see the airfoils lift because the wind was not strong enough at that time. Furthermore, a few of the visitors seemed confused because the prototype did not appear to be doing anything: one groups was not sure what they were supposed to do, and another group even thought the exhibit was broken. This highlights a key challenge in developing outdoor exhibits, particularly those designed to respond to the ever changing, unpredictable outdoor environment: *under certain conditions, an exhibit may not appear to be working (e.g., there's no wind to lift the airfoils), and consequently some people may think that the exhibit is broken*.
- Not surprisingly, we found that *the noticing experience was richer when the airfoils were lifting and moving as opposed to sitting at the base of the exhibit*. Visitors who saw the airfoils lift were more likely to notice the wind's direction and its ever-changing speed, or strength.[2] On the other hand, most of the visitors who did *not* see the airfoils lift only noted the absence of any wind; furthermore, some didn't think that the exhibit showed them anything about how the wind was behaving.

[1] Visitors who did not see the airfoils lift talked more about the potential of the exhibit and what they envisioned it would do.

[2] 11/12 visitors who saw the airfoils lift mentioned the wind's direction or its changing speed. This is compared to only 3/12 visitors who did not see the airfoils lift off the exhibit base. We found a significant difference between these two groups in their noticing wind direction or speed. Fisher's Exact Test, $p = .003 < .05$.

- Some suggestions for addressing the preceding two points are:
  - *building more responsive airfoils, which lift with less wind*
  - *on a windless day, focus visitors on other things to notice. As one example, graphics may encourage visitors to note how the airfoils' orientation records the direction of the last puff of wind.*
- Nonetheless, close to half of the visitors thought the exhibit was about the wind and about 30% (7/24) of the groups believed that it showed them something about how airfoils work.
- Eleven out of the 24 (45%) groups tried to interact with the exhibit beyond simply observing what the airfoils did. For example, visitors tried to block the wind, a few blew on an airfoil to make it lift, while others touched and moved the airfoils to figure out how and if it worked. In addition, a few of the visitors asked for additional information as well as other ways of interacting with the exhibit. For example,

  Visitor10: maybe split it in half one with the wind blocked

  These data indicate that people are interested in interacting with the exhibit and point to promising ways of fostering hands-on inquiry about the mechanics of lift and wind at this exhibit --- if this were an indoor exhibit. Unfortunately, because Lift will sit in an unsupervised, outdoor environment, we will need to worry about how different hands-on activities impact the exhibit's durability and, hence, maintenance needs. One of the key challenges in developing the next iteration of this prototype is to *determine what avenues of inquiry can allow visitors to interact with the exhibit while minimizing wear and tear* (e.g. allowing visitors to block the wind but preventing them from touching the airfoils).
- To help identify possible questions that visitors are interested in exploring at this prototype, we asked visitors what they became more curious about at the exhibit. This report lists visitors' responses that include questions about different aspects of the wind and the shapes of the airfoils. We also note that 3 of the visitor *groups were puzzled as to why the airfoils move differently. It seems counter-intuitive and begs for some interpretation.*

**ACKNOWLEDGEMENTS**

The author would like to thank Fay Dearborn, Mary Kidwell, and Heather Posner for collecting the data for this study. This material is based upon work supported by the National Science Foundation under Grant number 0104478. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

## APPENDIX A

### *Observations*

Note anything of interest. In particular, make note of the following:

1. Did they try to reach and touch the exhibit?
2. What were the airfoils doing while the visitor(s) were looking at it?
3. Did they try to interact with it (e.g. blowing on it, fanning it, blocking wind with their bodies)?
4. Other observations…

### *Questions*

1. How interesting did you find that experience? Would you say that was …

| Uninteresting | Somewhat Uninteresting | Neutral | Somewhat Interesting | Interesting |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

2. What made it _____ for you?
3. Can you tell me what you tried doing at the exhibit?
4. Can you tell me what happened at the exhibit? Did the exhibit do anything?
5. Did the exhibit make you curious about anything? Anything in particular about the wind? Anything you would like to know more about?
6. Can you tell what the wind was doing or how the wind was behaving by looking at this exhibit? [Probe: say more? So, when these things were moving up and down, what did that mean about the wind?]
7. Does this exhibit remind you of anything else you've seen or experienced before?
8. I know that there's very little information about the exhibit, but can you make a guess as to what this exhibit is about? What do you think the exhibit designer is trying to show or tell you with this exhibit?