Galvin Physics Forest Evaluation Plan

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Kidspace Physics Forest

The Kidspace children's museum was established in 1979 as a place for children and their parents to learn about science, art, and the humanities through unique educational programs and interactive experiences with exhibits. At its core is the philosophy of hands-on, interactive learning which allows children to explore individual interests and learn at their own pace. The museum offers an extensive range of indoor hands-on exhibits, outdoor spaces, specialized programs and activities that encourage growth and learning to approximately 225,000 museum visitors each year.

In the summer of 2012, Kidspace opened its newest exhibit, the Galvin Physics Forest (Physics Forest), which features thirteen new hands-on exhibits to engage visitors. Each exhibit is based on a different concept in physics (see **Logic Model page xx** for a brief description of each). The goal of the Physics Forest is to "inspire children to be the innovators and creators of tomorrow." The Physics Forest allows parents, teachers, children and others to interact with the exhibits in unique and different ways. Through its informal leaning milieu, visitors are offered a very dynamic program experience targeted to multiple learning styles. The thirteen exhibits within the Physics Forest could be combined and enjoyed in so many different ways that the guest experiences could be as diverse as the guests themselves, and what the visitor takes away such as learning or changes to thoughts and behaviors could vary similarly.

With the Physics Forest providing such an opportunity for exploration and diverse experience, Kidspace wanted to better understand and document what positive impacts the Physics Forest had on visitors. Toward that end, Kidspace contracted with the Evaluation & Training Institute (ETI) to develop an evaluation plan that would lay the groundwork for substantive study of the exhibit's effects on their target audience. This is the first step to provide information that can be used to highlight the program's impacts for current and potential funders, increase internal understanding of the program's potential, and market the program to teachers, administrators, and parents, among other uses.

Our Approach to Evaluation Planning

To evaluate a series of exhibits that act together as a complex system, ETI conducted detailed groundwork to understand the learning possibilities for the Physics Forest and develop a set of learning outcomes that can be measured. The groundwork consisted of a series of observations and interviews, detailed below in the **How We Developed the Plan** section. The **Impact Evaluation Plan** lays out our plan for evaluating students' and teachers' experiences in the Physics Forest. Our **Evaluation Toolkit (separate document)** provides sample measures for capturing relevant information.

An evaluation plan is essential for conducting a high quality, efficient and strategic evaluation that will provide clear feedback about how the Physics Forest affects educational experiences. Without a plan, given the wide array of guest experiences, age ranges, and educational programs connected to the exhibit, evaluation attempts would be haphazard and lack a cohesive focus. To give the evaluation focus, we have

developed a program level logic model to serve as a blueprint for this and future evaluation planning for the exhibit (see **Logic Model** narrative on **page 9**).
A program logic model is a systematic and visual way to present the fundamental aspects of a program. A logic model describes the logical connections among program resources or inputs, activities, outputs, and outcomes. Once a program has been described in terms of a logic model, program implementers can more accurately document and measure program implementation, as well as short- and long-range success.

The Physics Forest logic model crystallizes connections between guest experiences and intended outcomes and allows program developers, Kidspace staff, funders and partners to have a common framework for understanding the core exhibit elements. As a tool, logic models help funders and potential partners to quickly understand how programs work included the intended outcomes that can be expected as a result of interacting with the exhibits.

Using the logic model as a blueprint, we developed an evaluation plan that is designed to answer the following research questions:

- Did students' understanding of physical science concepts increase as a result of visiting the Galvin Physics Forest?
- Did students' interest in the physical sciences increase as a result of visiting the Galvin Physics Forest?
- Did students' attitudes toward science become more positive as a result of visiting the Galvin Physics Forest?
- Does the Galvin Physics Forest meet teachers' curricular needs? If not, how could the experience be improved?

How We Developed the Plan

To develop an effective logic model and evaluation plan, it was important for us to understand how the Physics Forest worked from the perspective of multiple stakeholders and to actually see the Physics Forest as it was being used as an interactive space for exploration of the physical sciences. This was all valuable for understanding the main activities and what it was possible to take away from the experience so that we could develop a realistic evaluation plan that would accurately measure the program's intended outcomes.

Understanding the Program Design

- ETI conducted interviews with program/curriculum designers
- ETI conducted a review of Physics Forest foundational and curricular materials

First, we wanted to understand the **program design** for the Physics Forest including its underlying concepts, goals and curriculum. For this we conducted interviews with program designers and also reviewed Physics Forest foundational documents.

We conducted three telephone interviews with individuals who had been involved in conceptualizing the Physics Forest. They were able to describe the original overarching

goals for the Physics Forest as well as more detailed physics concepts that would be imbedded in the exhibits. This feedback was vital in developing the first draft of the program logic model and gaining an initial understanding of the possibilities for the exhibit which helped us in formulating the program outcomes identified in the logic model.

The Physics Forest Foundational document informed our understanding of the program's inputs/resources, activities, teaching and learning strategies, and outcomes. The document formed the basis of our original draft of the logic model. We also reviewed supplemental materials detailing the concepts behind the exhibits, which were used to develop the signage in the Physics Forest. Finally, our review of Discovery program curricula designed to cater to grade bands K-1, 2-4, and 5-8 were helpful for understanding the concepts students could realistically be expected to take away from the experience appropriate to their age.

Understanding Physics Forest Teaching and Learning Strategies

- ETI conducted a focus group with Kidspace educators

A focus group we held with five Kidspace educators was vital for our understanding of the teaching and learning strategies that are unique to the hands-on environment of the Physics Forest. Educators described the range of structured activities including Discoveries and Explorations. They also described their role and how they facilitate learning with a diverse group of students with different age ranges, interests, learning styles, and abilities. The focus group was helpful for understanding the educator's role in the experience which they described as forming a liaison between the exhibit and the child and engaging the parent to facilitate the child's exploration. Educators also provided insight into the Exploration, Investigation, Expression approach built into the Discovery learning modules. They explained that exploration is the model of the museum, facilitated or independent exploring or observing. Investigation is going deeper, and this is where the education/content is most prominent. Expression is helping children to approach an activity themselves to solidify knowledge or experience. In addition to providing a helpful overall view of the teaching and learning approach at Kidspace, educators provided feedback that helped to inform our understanding of the program inputs/resources as well as anticipated outcomes. This feedback is included in the **Logic Model** section.

Understanding Exhibit Use and Audience

- ETI conducted interviews with self-guided family groups
- ETI conducted observations of the Physics Forest in use by self-guide family groups

We conducted 23 intercept interviews with family groups visiting the museum in order to inform the choice of sample we selected for inclusion in an evaluation and to deepen our understanding of possible learning outcomes. Our observations served a similar function and were conducted over a period of three half-days using an observation protocol. We wanted to learn first-hand how self-guided family groups interacted with the exhibits, the age range of children visiting the Physics Forest, the level and type of engagement with the exhibits, what it was possible to take away from the exhibits with a minimum of

structure. Our ultimate goal was to determine the extent to which the casual visitor could achieve the outcomes we included in the logic model including development of a positive attitude toward physical science, learning physical science concepts, and the development of understanding of how the physical world works, among others. We spoke to many visitors who had a very rich experience and also observed many visitors who engaged thoroughly with the exhibits. However, through the course of these interviews and observations we understood that the range of experience varied widely by age, level of engagement, use of exhibits, and depth of learning.

Having the opportunity to observe and interview guests was an important step in identifying the target audience to include in the evaluation. Our goal is to develop an evaluation that provides clear feedback about the program's impact, and thus necessitates that we include a sample of visitors who have a more consistent experience, such as those attend as part of a school group (see **Identifying the Evaluation Sample and Program Outcomes** section below).

Intercept Interview Findings

Since the Physics Forest is such a new exhibit, we understand that Kidspace is interested in any initial feedback or "findings" about the exhibit. While the data we collected was primarily intended to be used only as a basis for our planning, we have included the results of our data collection efforts here.

As described above, the interview sample represented a wide range of visitors by age, family group structure, and patterns of museum use. **Table 1** below details those characteristics.

Table 1
Intercept Interview Sample
N=23 family/visitor groups

Demographic Area	Sample Details
Number of visitors	23 family/visitor groups 37 children
Gender of children	13 gender unidentified 15 males 9 females
Age range or children	1 – 11 years of age 5.9 mean age
Family/group structure	Various ranging from multi-generational including grandparents and/or adult children, parents, and friends of parents chaperoning children
Museum use patterns	6 museum members with most reporting frequent visitors and/or visits in the past year 7 first-time visitors 7 visitors who had visited in the past 12 months with many reporting numerous visits in that time frame 3 visitor groups who had visited Kidspace previously but not in the past 12 months

In addition, visitors reported coming to the Physics Forest for various reasons. Ten of the groups knew about the existence of the Physics Forest while the others did not.

Table 2
Reasons for Visiting Kidspace

Reason for visit	Knew about Physics Forest Y/N	Number of Visitors
Because of Physics Forest • Saw an ad • Thought it would be cool, fun or educational • Were members or frequent visitors and came for the new exhibit	Y	N=9
For family or fun activity	N	N=8
Visit Kidspace in general	N	N=2
Educational properties of whole museum	Y	N=1
With child's pre-school	Unknown	N=1

The amount of time spent in the Physics Forest also varied widely. Visitor groups reported spending between 10 and 90 minutes in the Physics Forest with the average time just under half an hour (25.9 minutes). However, five groups were interviewed in the midst of their visit and planned to stay longer. They reported on the time they had spent so far. In addition, the observation days had extremely hot weather, which may have limited visitors' use of the outdoor spaces.

Visitors were asked to report which areas of the Physics Forest were most engaging for them. The highest number of visitors cited the roller coaster (n=9 responses), while the second most frequently cited exhibit was the tennis ball launch (n=6).

Table 3
Most engaging or interesting activity cited by self-guided visitors
N=23

Most engaging or interesting activity	Number*
Roller Coaster	9
Tennis Ball Launch	6
Ball Range	5
Bottle Rocket Launch	4
Pendulum	4
Air Cannon	3
Wheel Roll	2
Levers	1
Ball Bounce	1

*The number exceeds 23 because some visitors mentioned more than one exhibit.

When asked to follow up with why certain areas of the Physics Forest were engaging or interesting, parents described the children's experiences, noting first and foremost that they likes the hands-on or experimental nature of the exhibits (n=11 responses). This applied to more time-consuming exhibits like the roller coaster and also more immediately appealing exhibits like the bottle launcher. Younger students were more likely to enjoy or engage with the exhibits in a more purely physical way. In these cases,

parents reported that the children liked the fact that they got a chance to manipulate the exhibits or that the exhibits seemed appropriate to their strength (n=5 responses).

Guest Observation Findings

In keeping with the understanding that any feedback about Physics Forest would be helpful for Kidspace, we have also included the results of guest observations here. Similar to what we found when we conducted the intercept interviews, our guest observations of self-guided visitors reveals that guests had varied experiences in terms of the depth of their engagement with the exhibits and the exhibits' content. For example, we observed some parents who encouraged their children to experiment to get at the underlying concepts of the exhibits while other parents did not concerned about this aspect. The example below details extremes on this continuum.

Engaging parent and child example:

Dad (D): When they roll down, this energy transfers the wheel around. Try to lift it to the same level and the weight will distribute evenly. See how it goes?
Son (S): Oh yeah!
D: Let's try it again and this time we'll move the weights to the center to see what happens. Maybe it'll go faster or slower. What do you think?
S: I think it's going to go faster.
D: Oh you think so? Let's see. Now what about this. Each one is different.
S: That will be the next test.
S: Let's try all three in the center.
D: You know why? The weights transfer the energy one to another faster because they are closer.
S: I got another idea – let's do it like this and then like this. (Child moves one weight to the center and the other to the outside of the wheel.)
D: Then the energy is not going to transfer evenly. See what happened now?
S: Who's winning?
D: Maybe one of the weights is heavier than the other one.
S: That one!
D: We don't know, so we try. Right?

A different example:

As he manipulated the Cool Fan, an educator approached a middle-aged man

Educator: Do you guys know what's happening?
Man: Does it even matter?

Our evaluation plan does not include an approach for including self-guided visitors, however, if Kidspace is interested in adding an evaluation component that tracks visitor use such as the information above, we can discuss this option.

Identifying the Evaluation Sample and Program Outcomes

- ETI conducted an observation Physics Camp
- ETI observed school groups representing Grades K – 5
- ETI observed all three Discoveries being implemented with the target grade levels

We conducted observations of school or structured groups visiting the Physics Forest on three different days. Our first observation was a half-day observation of a week-long Physics Camp. On the day we observed there were 23 students ages 7 – 9. That number had remained fairly consistent throughout the week. The camp was new this year to showcase the recently opened Physics Forest. Activities included using the Physics Forest, using other parts of the museum such as the darkroom, physics-related classroom activities with supplemental materials, and physics-related outdoor activities with supplemental materials.

Following this initial observation we conducted two additional observations. We had the chance to observe students in Grades K-5 as well as all Discoveries being implemented. Our observations included the following:

- 30 Grade 2 students from a local elementary school; One lead T accompanied and 6 other parents/teacher chaperones (7 total adults). This was the first group to participate in a Physics Forest Discovery.
- 6 groups representing Grades K – 5 from the same school all attend at same time; 3 Discovery programs presented—one for each grade band

All three observations gave us very good insight into the outcomes it was possible to achieve through guided exploration of the Physics Forest and related activities. Prior to seeing the more structured activities included in the Discoveries and Explorations, we were unsure about the extent to which the activities and content around the Physics Forest were structured or consistent. **The observations also revealed very discernible learning goals and teaching strategies.** The program days were focused on very clear content which the educators delivered using an inquiry-based approach, asking students to make predictions and observations. Much time was given to hands-on learning and exploration.

Our observations of school group visits and Discovery participation also solidified our idea the target audience to be included in the evaluation. While the museum is geared to children, children's experiences can be deepened with structured learning opportunities mediated by adults. As described above in **Understanding Exhibit Use and Audience,** it is possible for self-guided visitor groups to have a rich Physics Forest experience however, for the purposes of evaluation we would like to establish a sample with a more consistent experience. **Our evaluation sample will include students who attend Kidspace and the Physics Forest as part of a school group in order to capture a more consistent "program model."** It seems more likely that there will be structured learning goals for these students (e.g., the Physics Forest may fit in with classroom content). In addition, students in school groups have the opportunity to participate in a Discovery, creating a standard experience with consistent content. Our evaluation sample will include the following:

- K – Grade 8 students
- Students visiting the Physics Forest as part of a school group (Discovery or non-Discovery participants).

Instrument Pilot Test

- ETI pilot-tested student surveys measuring attitudes toward science

- ETI pilot-tested teacher surveys measuring attitudes toward the Physics Forest experience

In October following interviews and observations, we had the opportunity to conduct a small-scale pilot test of some of our instruments. The goal of the pilot was to collect information from teachers about their expectations for the visit, test the relevance and grade level of appropriateness of questions for students, and target any issues with survey administration.

Teacher Survey Responses

The main purpose of administering teacher surveys was to find out some initial information about teachers' expectations for the visit. We anticipated that this type of information would be valuable as we developed a set of program outcomes. We also added some questions to help Kidspace understand how their exhibits were being used and the level of satisfaction teachers experienced as a result of their visit. Only three teachers (out of a possible six) completed the surveys since only three classroom teachers accompanied their classes for this field trip.

Even though only three teachers responded, their expectations for the experience were in alignment with our baseline logic model. When asked "What were you hoping your class would take away from the experience?" teachers provided the following responses:

- *"I'm hoping that they learned about balance, magnets, gravity, force."*
- *"More love for science!"*
- *"Able to "see" and "do" to gain knowledge of science."*

These aligned with the following outcomes:

- Learn physical science concepts
- Demonstrate positive attitude toward science
- Develop physical intuition of how the physical world works through application of concepts

Teachers were also asked to rank a series of items according to what they felt was most important for students to get out of the Physics Forest experience. All teachers rated learning science concepts as the most important. One teacher assigned a "1" to all items. Of the other two teachers, "Develop physical or motor skills was the least important" while "Practice social skills including teamwork and collaboration" was the second least important. Here's a rough ranking according to those two teachers:

Table 4
Teacher Ranking of Goals for Physics Forest

Rank	Expected Outcomes
1	Learn science concepts
2 / 3	Have the opportunity to problem solve and/or think critically
2 / 3	Develop a positive attitude toward science
4	Practice social skills including teamwork and collaboration
5	Develop physical or motor skills through interactions with the exhibit

All teachers were very satisfied with their experience. All three teachers assigned a "4," the highest rating possible when rating the extent to which the following aspects of the program were successful:

- Appropriateness of content for age group
- Length of Discovery
- Effectiveness of delivery by educator
- Overall hands-on approach to content
- Effectiveness of Discovery for increasing students' understanding of physics concepts

Teachers were also asked to rate the extent to which their experience aligned with what they were teaching on a scale of 1 – 4 with 4 being "Very Much So." Two kindergarten teachers and one Grade 5 teacher completed the surveys. The two kindergarten teachers felt that the experience at the Physics Forest was mostly aligned with what they were teaching (mean = 3.5). The Grade 5 teacher reported that it aligned "a little" (2). This teacher clarified by writing, "*Many science concepts talked about are not grade level specific but are concepts they should have knowledge of.*"

Teachers provided the following additional comments reflecting their positive experience:

- *"I would love to participate again in the future. Our students had a wonderful experience."*
- *"Great program. Great presenter (educator)."*
- *"Loved the kid friendly spaces."*

We think that the type of information included in the teachers' surveys is vital information that could continue to inform Kidspace in a formal evaluation. We have adapted this survey and included it in our **Evaluation Toolkit.**

Lessons Learned from Student Surveys

We developed a set of pilot instruments to gauge any changes to students' attitudes toward science. This was a pilot of student instruments designed to gauge the age appropriateness of the survey questions and to catch any difficulties in administering the surveys. Since we only had the opportunity to implement the survey at one point in time we decided on a retrospective design. A retrospective design measures change or increase by asking participants' to think about their knowledge or attitudes at two different points in time, *before* participating in a program or receiving treatment and *after.* Also, we focused on attitudes toward science as opposed to content because we had not yet seen all of the Discoveries being implemented or seen the range of experience for all grade level school groups. Student surveys were given to students in grades 2 – 5.

After piloting these instruments, we learned several valuable lessons. For one, we learned that the retrospective design was too complex for students younger than Grade 5. Our initial analyses showed that there was no change in students' responses when asked to think about their attitudes before or after the Physics Forest experience. This indicates that students had trouble understanding the format of the survey. Students in Grades 4 and 5 did show a difference, indicating not only that they understood the

questions, but that they benefited from their visit to the Physics Forest. To administer a more age-appropriate format for all students, we propose a pre-post student survey design (see **Outcomes Focused Evaluation** section below). We also recognized that some of the questions might have had confusing wording, e.g. "I cannot understand science even if I try really hard," and revised the items accordingly. Finally, survey formatting was also an issue. In the version that was given to students, two items were separated from their scales, and some students were confused and may have answered the question without knowing what they were responding to. This is something to keep in mind in the future.

SUMMARY

The groundwork that we conducted with multiple stakeholder groups gave us a clear understanding of the Physics Forest as its exhibits are currently being utilized. This provided us with the information we needed develop our logic model blueprint (see **Logic Model** section), our **Impact Evaluation Plan,** and our **Evaluation Toolkit.** This section is a summary of how the different components led to the development of these evaluation planning components.

First, we wanted to understand the **program design** for the Physics Forest including its underlying concepts, goals and curriculum. For this we conducted interviews with program designers and also reviewed Physics Forest foundational documents. **The Physics Forest Foundational document informed our understanding of the program's inputs/resources, activities, teaching and learning strategies, and outcomes. The document formed the basis of our original draft of the logic model.**

We conducted observations of school or structured groups visiting the Physics Forest. **The observations gave us very good insight into the outcomes it was possible to achieve through guided exploration of the Physics Forest and related activities. The observations also revealed very discernible teaching and learning strategies**. The program days were focused on very clear content which the educators delivered using an inquiry-based approach, asking students to make predictions and observations. Much time was given to hands-on learning and exploration. **Furthermore, through the focus group, educators gave us a solid understanding of the structured activities surrounding the Physics Forest and the teaching and learning strategies to engage children in exploration.**

Having the opportunity to observe and interview guests was an important step in identifying the target audience (sample) to include in the evaluation. Our goal is to develop an evaluation that provides clear feedback about the program's impact, and thus necessitates that we include a sample of visitors who have a relatively consistent experience. While the museum is geared to children, children's experiences can be deepened with structured learning opportunities mediated by adults. It is possible for self-guided visitor groups to have a rich Physics Forest experience however, for the purposes of evaluation we would like to establish a sample with a more consistent experience. **Our evaluation sample will include students who attend Kidspace and the Physics Forest as part of a school group in order to capture a more consistent "program model."**

Our **Logic Model** and **Impact Evaluation Plan** are included in the following sections.

The Physics Forest Logic Model

We drew from our **review of program materials**, specifically the Physics Forest foundational document to develop a "baseline" logic model including program inputs/resources; activities, and immediate outcomes. The foundational document was an excellent entry point into understanding the vision for the Physics Forest including how students could potentially engage with the exhibits and what they could take away from the experience. Understanding that this foundational document was theoretical, our job was to develop a "working logic model" that most practically aligns to what is happening at the ground level and can serve as a blueprint for practical and targeted evaluation across campuses. We took a grounded theory approach to developing a logic model that most accurately reflects our view of program implementation at the ground level.

Program Designer Interviews were helpful for clarifying the program vision and goals, and we took this feedback into account as well in developing our baseline logic model. When asked to describe the educational goals, interviewees provided the following feedback:

- Getting kids interested in science and physics
- Giving children confidence and showing them the fun side of science so that they might want to pursue it further or as a career that could benefit society
- Taking the scariness out of science
- Encourage exploration of the way the physical way the world works
- Instill desire to learn, discover, and increase understanding of how the world works
- Engage children in physics at an early age and provide activities that can translate into exploration at home

These were valuable insights that were supported by what we observed in the field, and we incorporated them into the logic model.

In addition, one curriculum developer reported that the following resources would move the program toward optimal operation:

- Educator at each station
- Curricular materials available for teachers
- Small scale side projects

We included educators in the Inputs section of the logic model, but we did not include curricular materials since these have not yet been developed. The small-scale side projects are included as "Explorations" in the Activity section of the logic model.

The **educator focus group** provided us with concrete information to shape our understanding of the different possible program components (e.g., self-guided interaction, Discovery, Exploration), and these were included in the **Program Activities** category of the logic model. In addition, educators provided insightful feedback that

helped to shape our logic model outcomes when asked what outcomes they would identify for the Physics Forest. These included:

- Cultivation of an appreciation of the physical sciences
- Confidence in learning—discovery
- The ability to see science in the everyday and apply physical science concepts
- Creation of lifelong learners
- Improved social skills
- Increase comfort level with science
- Increase enjoyment of science learning
- Increase willingness to explore or experiment

Program observations gave us an opportunity to further observe teaching and learning strategies in this hands-on interactive setting. This informed the **Teaching and Learning Strategies** section of our logic model as we were able to see Educators and other adults interact with students as well as see how students explored the space on their own. The observations also heavily informed the **Program Outcomes** we included in the logic model. During visits we took detailed field notes. We analyzed our observation data by assigning program outcomes we had developed in the baseline logic model to the different activities we had observed. In this way we were able to field test and vet the accuracy and relevance of the outcomes we had developed. Using this "ground up" approach ensures that we are measuring the program fairly and as it is actually occurring.

The Impact Evaluation Plan

After conducting extensive groundwork and gathering information from the key stakeholders described in the previous sections, we designed a detailed evaluation plan that aligns research questions with the objectives of Physics Forest. The following section presents our plan and includes a description of the evaluation design, procedures for data collection and analysis, descriptions of sample instruments and administration protocols, project timelines, and a detailed budget.

Evaluation Design Overview

- Pre-post student surveys
- Quasi-experimental research design (comparison student group)

To determine the impact of the Physics Forest exhibit and accompanying program elements on children's knowledge of physical science concepts and attitudes towards science, we propose using pre- and post-surveys to assess students before and after their Physics Forest experience. It is important to note that measuring students' outcomes before and after a program can tell a story about the program's effects, but this method does not rule out important, non-program effects.

We can rule out non-program effects, and achieve a higher level of research practice, by comparing Physics Forest visitors' outcomes to similar students who didn't visit Physics Forest**. Known as a "quasi-experimental research design," we would use a group of similar students who have not participated in the program as a control group and compare their results to students who have participated in Physics Forest, thereby providing a more robust study of the program's impact.** Although quasi-experimental designs may necessitate additional time and effort for Kidspace staff and increase evaluation costs, the use of comparison groups creates a more rigorous evaluation that enables us to draw stronger conclusions about program effects. Thus, we recommend using a **pre-post research design with a comparison group** of similar students to compare student thinking and attitudes before (pre) and (after) visiting the Physics Forest. We also recommend using a variety of instruments, including student attitudinal and content surveys, teacher surveys, and observation protocols to determine the impact of Physics Forest on students' attitude, knowledge, and behavior.

Measuring Program Impacts

Using data collected at two observation points (before and after visiting Physics Forest), our evaluation plan addresses the following research questions:

1. Are students who participate in Physics Forest more likely to have increased positive attitudes toward science and interest in science? Are these gains greater when Physics Forest participants are compared to similar students who do not visit Physics Forest?
2. Does the Physics Forest experience contribute to an increased understanding about physical science concepts and an enhanced physical intuition about how the world works? Are increases in physical science understanding for Physics

Forest students greater than any increases experienced by control students who do not participate in the program?

3. Does the Physics Forest program encourage students to engage in teamwork and collaboration? Do Physics Forest participants exceed their comparison counterparts in this dimension?

We would expect that students who participate in Physics Forest would have higher scores than similar students who have not visited Physics Forest on measures of physical science learning, positive attitudes towards science, and collaborative teamwork. Moreover, we anticipate that these results would be even more pronounced with students who participate in multiple components of the Physics Forest program (e.g., Discoveries, free exploration, Explorations, etc.).

Participants

- Students in Grades K – 8
- Students who are visiting the Physics Forest with a school group (includes Discovery participation and no Discovery participation)
- Teachers and teachers' aides with visiting classes

Based on our site observations, visitor intercept interviews, and discussions with Kidspace staff members, we identified three primary groups of child visitors to Kidspace: (1) children visiting with family; (2) children visiting as part of a self-guided school group (i.e., no Discovery); and (3) children visiting as part of a school group that incorporates a Discovery experience into their visit. Our observations and intercept interviews indicate that family visitors generally have younger children (0-5) and those children's experiences within that setting vary dramatically due to several factors, including the background knowledge of parents, whether or not the visit is child-directed or adult-directed, and the extent to which the motivation behind the visit was educational.

Because of the inconsistent experience of children visiting with family and their younger ages, we did not include them in the evaluation plan. Children visiting with school groups, however, are more likely to have a comparable and more unified experience. They are within a group of similarly aged peers, they are likely being directed by an adult with sufficient background knowledge, and, if they participate in a Discovery session, they have the additional benefit of learning from educators trained in inquiry-based pedagogical strategies that are directly tied to exhibit content. **Accordingly, our evaluation focuses on students visiting Physics Forest as part of a school group, and includes those school groups that incorporate a Kidspace educator-led Discovery session and those that do not.** We would expect that positive attitudes toward science and science understanding would increase in both groups. However, we also predict that due to the Discovery's focused curriculum that is closely aligned with the physics principles demonstrated in Physics Forest, students who participate in a Discovery session would experience greater gains in content knowledge than students who do not.

We also propose including teachers and teachers' aides that accompany students to Physics Forest in the evaluation as these adults can provide insight into student experiences and feedback on program delivery.

Measures

- Grade K – 1 student attitude and content surveys
- Grade 2 – 4 student surveys attitude and content surveys
- Grade 5 – 8 student surveys attitude and content surveys
- Teacher and teachers' aide surveys
- Behavior, skills, and attitudes observation protocol
- Science Thinking Task (optional)

All forms of instrumentation arose from the program logic model that is presented in the **Logic Model** section and will be finalized based on feedback from Kidspace leadership. To measure outcomes for students of varying developmental levels, we developed student instruments for three different grade bands that are representative of visitor demographics and correspond with the Physics Forest Discovery curriculum:

- Kindergarten and 1st Grade
- Grades 2 - 4
- Grades 5 - 8

In order to provide additional context for student-level data, we recommend administering surveys to teachers and teachers' aides. In addition, we recommend using an observational protocol for documenting student behaviors during program activities and free exploration of Physics Forest. We describe the measures in detail below and full sample instruments are included in the **Evaluation Toolkit**.

Student Pre-Post Science Attitudes Survey

- Outcome measured: Positive attitudes toward science

To uncover students' attitudes towards science, a primary outcome specified in the program logic model, we modified an existing instrument that was developed and validated with a sample of fifth grade students. Recognizing that attitudes towards science is a complex and multifaceted concept, the multidimensional Science Attitudes Survey measures student attitudes on four key constructs (sample items are provided in parentheses):

- Desire to do science ("I would like to do science activities at home.")
- Student's self-concept toward science ("Learning science is easy for me.")
- Anxiety towards science ("It makes me nervous to even think about doing science.")
- Value of science in society ("Science helps us solve problems in our lives.")

The published instrument has a grade four readability level; accordingly, it was left relatively intact for students in Grades 5 through 8. In order to ensure that the instrument was appropriate for younger students, we made several modifications based on our initial pilot testing. First, we reworded some survey items to simplify the language and eliminated items that were confusing or unclear. Second, we provided an alternate response scale to create an attention-getting, student-friendly response format for survey items for kindergarten-1st grade students. Response scales for older students consisted of a 6-point Likert scale of agreement that ranged from "1 = NO WAY!" (strongly disagree) to "6 = DEFINITELY YES!" (strongly agree) and K-1st graders selected their response from a picture of a smiling face (agree), a neutral face, and a

frowning face (disagree). The Science Attitudes Survey is presented by construct and grade band in the Evaluation Toolkit, along with full drafts of the instrument.

Student Pre-Post Science Content Survey

- Outcome measured: Comprehension of physical science concepts
- Outcome measured: Development of physical intuition of how the physical world works

In developing our instruments to gauge students' understanding of physics, we reviewed field notes from our site observations and studied the Discovery curriculum and other exhibit materials to ensure that the resulting measures were tied to exhibit content and representative of the principles covered in the Physics Forest. Additionally, we conducted a preliminary literature review of extant instruments and assessments of critical thinking and physical sciences.

Our developed measures of physical science content can be answered using various funds of knowledge acquired during the Physics Forest experience, such as through direct learning from a Discovery session, through experimentation and manipulation of the exhibits during free exploration, or through a more developed intuition of how the physical world works. Some content items incorporate key vocabulary, while others simulate a demonstration of a key concept or an application to real-word situations. To reduce the emphasis on reading ability for younger students and to keep the assessment connected to elements of the Physics Forest exhibit, we incorporated the use of child-friendly images and figures in our measure. The resulting instruments cover the following topics for the three grade bands:

Kindergarten-1st grade
- Key concepts: unbalanced force, balanced force, attract, repel, force
- Exhibits/activities: Giant lever, pendulum, magnets, clothespins, tug of war

2nd grade – 4th grade
- Key concepts: potential energy, kinetic energy, mechanical advantage, transfer of energy
- Exhibits: Ball bounce, pulley chairs, roller coaster

5th grade- 8th grade
- Key concepts: mechanical advantage, resonance frequency, air pressure
- Exhibits/activities: Giant lever, pulley chairs, singing glasses, pendulum, stomp rockets

Sample items for each grade band are included in the Evaluation Toolkit.

Science Thinking Task (*Optional*)

- Outcome measured: Scientific thinking skills

Currently, the format of the content measures is multiple choice and/or short answer to simplify administration, streamline recording of responses, and facilitate data analysis. However, we can incorporate an interview protocol such as the Science Thinking Task

(see Evaluation Toolkit) to administer individually to students that provides a window into students' scientific thinking and problem solving processes. The Science Thinking Task is an innovative open-ended assessment that uncovers whether or not students truly understand material and its applications by having them design authentic scientific investigations. We have added this as an optional item in the budget.

During the Science Thinking Task, students are asked to provide an answer or hypothesis in response to a real-world scientific question or problem. In an effort to measure students' ability to craft testable questions and design science investigations – key components of scientific inquiry and thinking – students are to describe a possible investigation or experiment to validate their answer. This component of the Science Thinking Task investigates students' ability to approach an authentic problem from a scientific perspective, using skills such as observation, prediction, and experimentation to creatively and logically reason through a scientific problem.

To go beyond traditional paper-pencil assessment administrations, the Science Thinking Task uses a "think aloud" procedure where students provide an oral explanation of the thinking behind their selected response. As part of the interview protocol, students are asked to make a diagram that accurately depicts their experiments. One advantage of this method is that it uncovers students' scientific reasoning as they justify their response and allows for prompts from the assessor to provide clarification. Additionally, the "think aloud" and drawing procedure provides students of varying reading and writing abilities the opportunity to effectively convey their understanding with rich detail.

Teacher Post-Only Survey

- Outcome measured: Positive attitudes toward science
- Outcome measured: Comprehension of physical science concepts
- Outcome measured: Student teamwork and collaboration

Surveying participating teachers and teachers' aides is an ideal opportunity to garner feedback relating to the larger effectiveness of Physics Forest, as well as the perceived and potential impact for students. Surveys for these adult stakeholder groups will be post-only and will provide a reflective opportunity that is particularly important when looking at the types of nuanced indicators in this evaluation. Specifically, teacher and volunteer post-surveys will include questions designed to capture adult stakeholders' perceptions of the following:

- The degree to which Physics Forest aligns with classroom teaching
- Satisfaction with the program and opportunities for improvement
- The extent to which student content knowledge and positive attitudes toward science have increased as a result of visiting Physics Forest.

Program Observations

- Outcome: Scientific thinking skills
- Outcome: Positive attitudes towards science
- Outcome measured: Student teamwork and collaboration

Observations of student behavior during various Physics Forest activities (e.g., Discoveries, Explorations, free exploration) can provide important contextual background

for interpreting student findings. We developed an observation protocol to capture student behavior indicative of scientific thinking, engagement, positive attitudes towards science, and collaborative peer relationships (see Evaluation Toolkit). The protocol can also be used to capture information that will feed into program revision and improvement efforts.

Observers record student behavior as part of the whole-group experience of a specific Physics Forest activity and document the degree to which specific behavioral indicators were present. In the protocol, we specify which observation indicators are relevant to each category, understanding that student opportunities for engaging in hands-on experimentation may be more applicable during free exploration than paying close attention to an educator-led Exploration session.

Procedure/Data Collection

- Teacher administration of student pre-test prior to Physics Forest visit
- Student completion of post-test onsite at Kidspace following visit
- Teacher completion of surveys onsite at Kidspace following visit
- Observations conducted during Physics Forest visit

Teachers will administer pre-tests to students in their classrooms before the visit to Kidspace. We have included directions for administering the instruments in our Evaluation Toolkit. These will be distributed to teachers along with survey packets prior to their visit to Kidspace.. Instructions will be read aloud to all students, and it is recommended that individual scale items be read to students in kindergarten through 4th grade. Students should complete the survey in the presence of an available adult so that clarification can be provided if necessary.

Post-surveys for students, teachers, and teachers' aides will be administered at the end of the program day and will be collected (along with student pre-surveys administer earlier in classrooms) at the conclusion of the Kidspace visit. The amount of time for student survey administration for the Science Content Survey and Science Attitudes Survey is estimated to be less than 15 minutes for an entire class. The observation protocol can be conducted by an outside evaluator or Kidspace staff can be responsible for administration after completing training.

Depending on the goals and needs of Kidspace, the Science Thinking Task interview protocol could be administered at the conclusion of the visit by trained Kidspace staff or evaluators (post-only) or before and after the visit (pre-post test). To reduce evaluation costs, we recommend that the Science Thinking Task interview be administered to a representative subsample of students.

Pilot Evaluation

We will work with Kidspace to finalize an evaluation plan and strategy for implementation based on the above components. At the beginning of evaluation implementation, we will reserve a small window of time to pilot test our instruments and administration procedures. This will give us an opportunity to collaborate with Kidspace and make any revisions necessary to the evaluation prior to collecting all data.

Data Management and Analysis

Survey data will be entered into a database and participant-generated identification numbers will be used to match individual students' pre- and post-surveys for quantitative data analysis. Student data will be linked with school-level information that documents key factors that may influence student outcomes, including whether or not the school participated in a Discovery or Exploration program, the duration of the school's visit, and the school's visiting history to Kidspace.

Quantitative data gathered from students will be analyzed using descriptive statistics (e.g., frequencies, means) to present an overall summary of student attitudes and knowledge. To measure the impact of participating in Physics Forest, we will utilize inferential statistics (e.g., paired t-tests, within subjects ANOVA) to determine if any differences in students' pre-program and post-program scores are statistically significant. Data collected from observation protocols will summarized with descriptive statistics and cross-referenced with survey data to validate survey responses and add more nuanced and contextual findings. Final results will indicate the extent to which students who participate in the Physics Forest program exhibit greater understanding of physical sciences and more positive attitudes towards science when compared to their pre-test scores and to a group of similar students who did not participate in Physics Forest. Additionally, formative data provided by teachers and observation protocols can be used to refine and improve the program.

The Impact Evaluation Plan

After conducting extensive groundwork and gathering information from the key stakeholders described in the previous sections, we designed a detailed evaluation plan that aligns research questions with the objectives of Physics Forest. The following section presents our plan and includes a description of the evaluation design, procedures for data collection and analysis, descriptions of sample instruments and administration protocols, project timelines, and a detailed budget.

Evaluation Design Overview

- Pre-post student surveys
- Quasi-experimental research design (comparison student group)

To determine the impact of the Physics Forest exhibit and accompanying program elements on children's knowledge of physical science concepts and attitudes towards science, we propose using pre- and post-surveys to assess students before and after their Physics Forest experience. It is important to note that measuring students' outcomes before and after a program can tell a story about the program's effects, but this method does not rule out important, non-program effects.

We can rule out non-program effects, and achieve a higher level of research practice, by comparing Physics Forest visitors' outcomes to similar students who didn't visit Physics Forest**. Known as a "quasi-experimental research design," we would use a group of similar students who have not participated in the program as a control group and compare their results to students who have participated in Physics Forest, thereby providing a more robust study of the program's impact.** Although quasi-experimental designs may necessitate additional time and effort for Kidspace staff and increase evaluation costs, the use of comparison groups creates a more rigorous evaluation that enables us to draw stronger conclusions about program effects. Thus, we recommend using a **pre-post research design with a comparison group** of similar students to compare student thinking and attitudes before (pre) and (after) visiting the Physics Forest. We also recommend using a variety of instruments, including student attitudinal and content surveys, teacher surveys, and observation protocols to determine the impact of Physics Forest on students' attitude, knowledge, and behavior.

Measuring Program Impacts

Using data collected at two observation points (before and after visiting Physics Forest), our evaluation plan addresses the following research questions:

1. Are students who participate in Physics Forest more likely to have increased positive attitudes toward science and interest in science? Are these gains greater when Physics Forest participants are compared to similar students who do not visit Physics Forest?
2. Does the Physics Forest experience contribute to an increased understanding about physical science concepts and an enhanced physical intuition about how the world works? Are increases in physical science understanding for Physics

Forest students greater than any increases experienced by control students who do not participate in the program?

3. Does the Physics Forest program encourage students to engage in teamwork and collaboration? Do Physics Forest participants exceed their comparison counterparts in this dimension?

We would expect that students who participate in Physics Forest would have higher scores than similar students who have not visited Physics Forest on measures of physical science learning, positive attitudes towards science, and collaborative teamwork. Moreover, we anticipate that these results would be even more pronounced with students who participate in multiple components of the Physics Forest program (e.g., Discoveries, free exploration, Explorations, etc.).

Participants

- Students in Grades K – 8
- Students who are visiting the Physics Forest with a school group (includes Discovery participation and no Discovery participation)
- Teachers and teachers' aides with visiting classes

Based on our site observations, visitor intercept interviews, and discussions with Kidspace staff members, we identified three primary groups of child visitors to Kidspace: (1) children visiting with family; (2) children visiting as part of a self-guided school group (i.e., no Discovery); and (3) children visiting as part of a school group that incorporates a Discovery experience into their visit. Our observations and intercept interviews indicate that family visitors generally have younger children (0-5) and those children's experiences within that setting vary dramatically due to several factors, including the background knowledge of parents, whether or not the visit is child-directed or adult-directed, and the extent to which the motivation behind the visit was educational.

Because of the inconsistent experience of children visiting with family and their younger ages, we did not include them in the evaluation plan. Children visiting with school groups, however, are more likely to have a comparable and more unified experience. They are within a group of similarly aged peers, they are likely being directed by an adult with sufficient background knowledge, and, if they participate in a Discovery session, they have the additional benefit of learning from educators trained in inquiry-based pedagogical strategies that are directly tied to exhibit content. **Accordingly, our evaluation focuses on students visiting Physics Forest as part of a school group, and includes those school groups that incorporate a Kidspace educator-led Discovery session and those that do not.** We would expect that positive attitudes toward science and science understanding would increase in both groups. However, we also predict that due to the Discovery's focused curriculum that is closely aligned with the physics principles demonstrated in Physics Forest, students who participate in a Discovery session would experience greater gains in content knowledge than students who do not.

We also propose including teachers and teachers' aides that accompany students to Physics Forest in the evaluation as these adults can provide insight into student experiences and feedback on program delivery.

Measures

- Grade K – 1 student attitude and content surveys
- Grade 2 – 4 student surveys attitude and content surveys
- Grade 5 – 8 student surveys attitude and content surveys
- Teacher and teachers' aide surveys
- Behavior, skills, and attitudes observation protocol
- Science Thinking Task (optional)

All forms of instrumentation arose from the program logic model that is presented in the **Logic Model** section and will be finalized based on feedback from Kidspace leadership. To measure outcomes for students of varying developmental levels, we developed student instruments for three different grade bands that are representative of visitor demographics and correspond with the Physics Forest Discovery curriculum:

- Kindergarten and 1st Grade
- Grades 2 - 4
- Grades 5 - 8

In order to provide additional context for student-level data, we recommend administering surveys to teachers and teachers' aides. In addition, we recommend using an observational protocol for documenting student behaviors during program activities and free exploration of Physics Forest. We describe the measures in detail below and full sample instruments are included in the **Evaluation Toolkit**.

Student Pre-Post Science Attitudes Survey

- Outcome measured: Positive attitudes toward science

To uncover students' attitudes towards science, a primary outcome specified in the program logic model, we modified an existing instrument that was developed and validated with a sample of fifth grade students. Recognizing that attitudes towards science is a complex and multifaceted concept, the multidimensional Science Attitudes Survey measures student attitudes on four key constructs (sample items are provided in parentheses):

- Desire to do science ("I would like to do science activities at home.")
- Student's self-concept toward science ("Learning science is easy for me.")
- Anxiety towards science ("It makes me nervous to even think about doing science.")
- Value of science in society ("Science helps us solve problems in our lives.")

The published instrument has a grade four readability level; accordingly, it was left relatively intact for students in Grades 5 through 8. In order to ensure that the instrument was appropriate for younger students, we made several modifications based on our initial pilot testing. First, we reworded some survey items to simplify the language and eliminated items that were confusing or unclear. Second, we provided an alternate response scale to create an attention-getting, student-friendly response format for survey items for kindergarten-1st grade students. Response scales for older students consisted of a 6-point Likert scale of agreement that ranged from "1 = NO WAY!" (strongly disagree) to "6 = DEFINITELY YES!" (strongly agree) and K-1st graders selected their response from a picture of a smiling face (agree), a neutral face, and a

frowning face (disagree). The Science Attitudes Survey is presented by construct and grade band in the Evaluation Toolkit, along with full drafts of the instrument.

Student Pre-Post Science Content Survey

- Outcome measured: Comprehension of physical science concepts
- Outcome measured: Development of physical intuition of how the physical world works

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