# Exhibit Features and Visitor Groups' Engineering Design Practices

A research brief from *Designing our Tomorrow — Mobilizing the next generation of engineers*

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# Preface

This document provides a brief story about how the *Designing our Tomorrow* team explored some of their questions about exhibit features by using the C-PIECE Framework: Framework of Collaborative Practices at Interactive Engineering Challenge Exhibits.

This exploratory line of inquiry looked at relationships between exhibit features and visitor groups' Informed engineering design practices. This brief includes an Introduction, Methods and Findings, Summary, and Implications.

This exploratory line of inquiry was conducted to inform the development of the *Designing our Tomorrow* exhibit and future implications for OMSI.

Before beginning our story, we provide a User Orientation for the C-PIECE Framework on slides 5-13, signified by this icon:

*Dear Colleagues,*

*We are excited to share the C-PIECE Framework.*

*Sticky notes, like this one, annotate the User Orientation with our thinking about the value of the framework for practitioners.*

*As you read this brief, we welcome your feedback on the C-PIECE Framework and your thoughts on how it contributes to the field of informal engineering education.*

*Please leave comments at: [www.engineerourtomorrow.com](www.engineerourtomorrow.com).*

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# Introduction to The C-PIECE Framework

Informal STEM educators in museums and science centers create engineering design activities for families and groups. While this work is nascent, evaluations of projects such as *Designing Our World* show that museums can effectively engage groups in engineering design process steps and other aspects of engineering. Our growing interest in informal engineering education, along with conversations with researchers in the field, inspired us to look closely at the work of Crismond and Adams (2012)[1] from formal engineering education and their *Informed Design Teaching and Learning Matrix* (Matrix).

The Matrix was our foundation for seeking more nuance and detail in informal engineering practices. To do this, our team embarked on a research process to adapt the Matrix into a draft framework for exhibits, then we studied three exhibits through this framework lens. This process culminated in the creation of the C-PIECE Framework, a tool that provides a nuanced lens of engineering design proficiencies, practices, and practice sets to inform exhibit development on a new exhibit, *Designing our Tomorrow*.

*The C-PIECE Framework helps practitioners like us identify new possibilities for activities to foster richer and deeper engagement with engineering design practices at exhibits.*

*The C-PIECE Framework was developed with input from families, researchers, and practitioners.*

1. Crismond, D., & Adams, R. (2012). The informed design teaching and learning matrix. *Journal of Engineering Education, 101(4)*, 738–797.

# Definitions of the C-PIECE Framework

***The C-PIECE Framework***: The Framework of Collaborative Practices at Interactive Engineering Challenge Exhibits is a product of our research and development efforts to adapt theory-based constructs of engineering proficiencies for plausible use in an informal learning context. The Framework is organized into two proficiencies—*Defining a problem* and *Improving a design*—and by practices that exhibit visitor groups exercise as part of those proficiencies. The practices are in categories of theoretically-inferred levels of proficiency—Beginning, Intermediate, and Informed.

***Defining a Problem Proficiency***: The *Defining a problem* proficiency includes the process of establishing a goal or parameters for success, and identifying constraints to designs based on materials, context, or cost. Associated practices include: Exploring resources, Brainstorming ideas, and Considering benefits and trade-offs of materials.

***Improving a Design Proficiency***: This proficiency is the process of modifying a design in ways that increase its effectiveness in achieving an intended outcome. Associated practices include: Describing what happened, Explaining results, Diagnosing issues, and Testing specific variables.

***Practices***: Practices are approaches, or series of actions, that are part of engaging in an engineering proficiency. The practices are categorized in columns by theoretically-inferred levels of proficiency in the C-PIECE Framework.

***Sets of Practices***: a group of practices that share a similar purpose or are associated with a particular step in an engineering process as grouped by rows in the C-PIECE Framework.

*The C-PIECE Framework can be used as a lens for the constructs of proficiencies, practices, and practice sets. It can also be used as a lens for proficiency levels.*

*In all cases, our intention is for the C-PIECE Framework to be used to assess the affordances of activity designs, not to assess or evaluate individuals or groups.*

# Example of an Engineering Design Process Model


Image from Head Start on Engineering :
https://www.terc.edu/hse/resources-for-families/everyday-engineering/

*The C-PIECE Framework builds upon, extends, and is compatible with engineering design process models.*

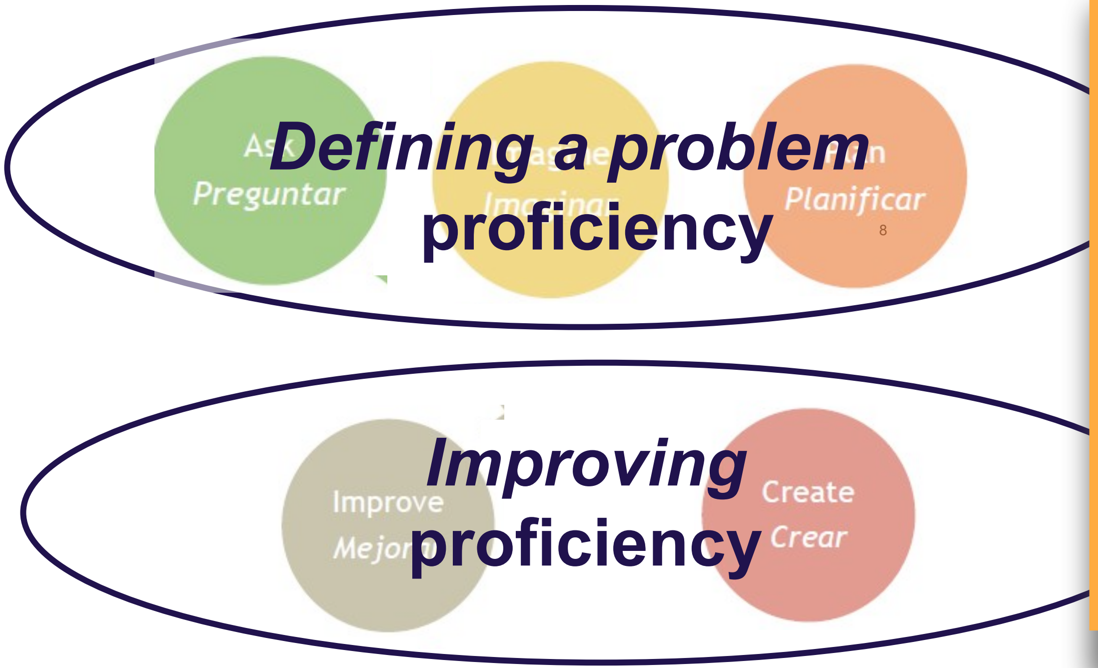
*One of our initial steps for developing the C-PIECE Framework was to look at existing engineering design process models from both formal and informal education projects.*

*We found that engineering design models were good for visualizing the steps (usually a cycle) that engineers might use to plan, create, and test solutions to solve a problem.*

*Our team referred to nine engineering process models as part of developing the C-PIECE Framework, including this one from the Head Start on Engineering project.*

*If you prefer a particular engineering design process model, you will likely find that it can easily be used in combination with the C-PIECE Framework.*

# Engineering Design Process and the C-PIECE Framework




*The C-PIECE Framework builds upon research to describe two proficiencies.*

*This figure illustrates how the C-PIECE Framework proficiencies might relate to steps in an engineering design process model.*

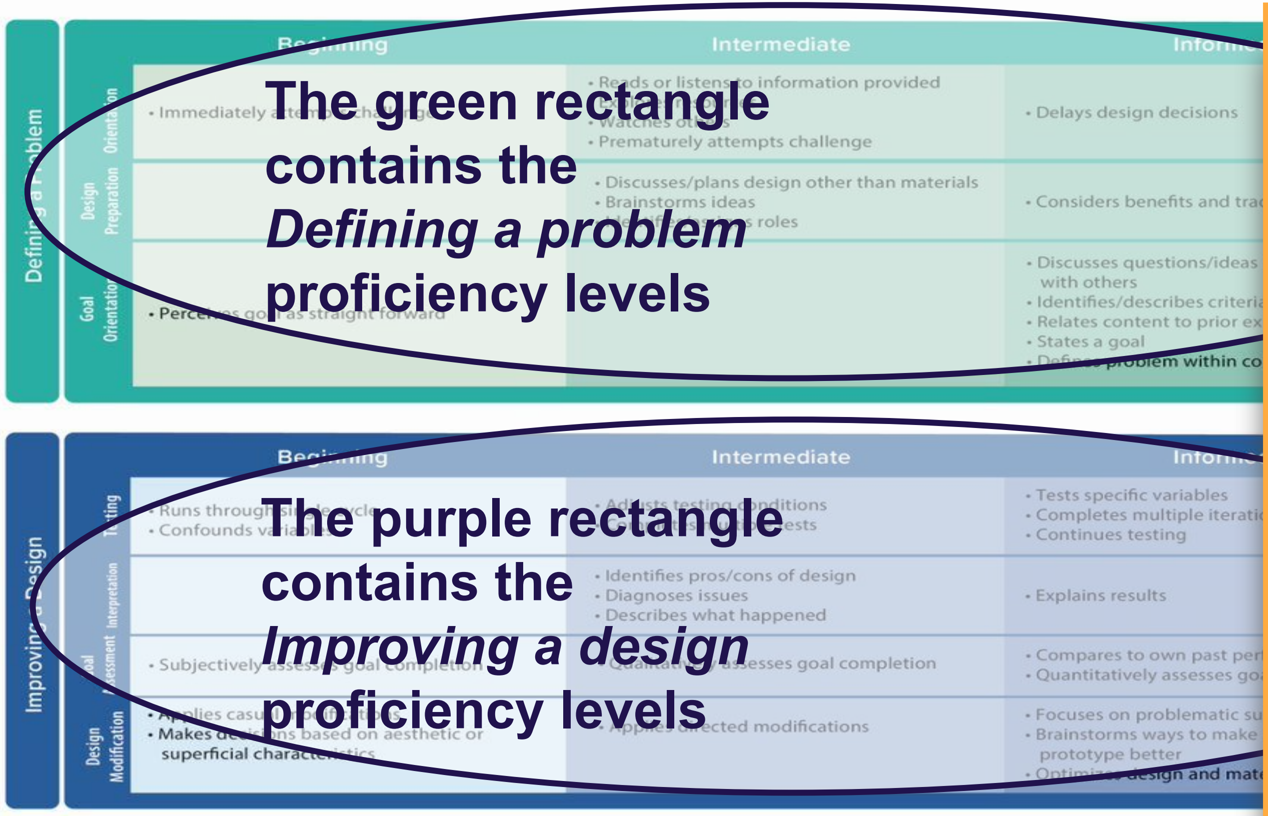
*The C-PIECE Framework was developed to show more detail on evidence-based practices at exhibits than we found in the nine process models we reviewed.*

*This is the C-PIECE Framework.*

| Defining a Problem | | Beginning | Intermediate | Informed |
|---|---|---|---|---|
| | Orientation | • Immediately attempts challenge | • Reads or listens to information provided<br>• Explores resources<br>• Watches others<br>• Prematurely attempts challenge | • Delays design decisions |
| | Design Preparation | | • Discusses/plans design other than materials<br>• Brainstorms ideas<br>• Identifies/assigns roles | • Considers benefits and trade-offs of materials |
| | Goal Orientation | • Perceives goal as straight forward | | • Discusses questions/ideas about the process with others<br>• Identifies/describes criteria or constraints<br>• Relates content to prior experience<br>• States a goal<br>• Defines problem within context |

| Improving a Design | | Beginning | Intermediate | Informed |
|---|---|---|---|---|
| | Testing | • Runs through single cycle<br>• Confounds variables | • Adjusts testing conditions<br>• Completes multiple tests | • Tests specific variables<br>• Completes multiple iterations<br>• Continues testing |
| | Interpretation | | • Identifies pros/cons of design<br>• Diagnoses issues<br>• Describes what happened | • Explains results |
| | Goal Assessment | • Subjectively assesses goal completion | • Qualitatively assesses goal completion | • Compares to own past performance or record<br>• Quantitatively assesses goal completion |
| | Design Modification | • Applies casual modifications<br>• Makes decisions based on aesthetic or superficial characteristics | • Applies directed modifications | • Focuses on problematic subsystems<br>• Brainstorms ways to make successful prototype better<br>• Optimizes design and materials |

# The C-PIECE Framework




*The C-PIECE Framework shows three levels of proficiencies—Beginning, Intermediate, and Informed. These are inferred from the theoretical framework we used in combination with the judgment of stakeholders.*

*Given the nature of exhibit experiences and learning in informal environments, our perspective is that exhibits can foster practices from visitor groups at all levels in almost any order.*

# The C-PIECE Framework

Each row is a set of practices

Each bulleted line of text is a practice

| | | Beginning | Intermediate | |
|---|---|---|---|---|
| Defining a Problem | Orientation | • Immediately attempts challenge | • Reads or listens to information provided<br>• Watches others<br>• Prematurely attempts challenge | • Delays desig |
| | Design Preparation | | • Discusses/plans design other than materials<br>• Brainstorms ideas<br>• Identifies/assigns roles | • Considers be |
| | Goal Orientation | • Per | | • Discusses qu with others<br>• Identifies/de<br>• Relates cont<br>• States a goa<br>• Defines prob |

| | | Beginning | Intermediate | |
|---|---|---|---|---|
| Improving a Design | Testing | • Runs through single cycle<br>• Confounds variables | • Adjusts testing conditions<br>• Completes multiple tests | • Tests specifi<br>• Completes n<br>• Continues te |
| | Interpretation | | • Identifies pros/cons of design<br>• Diagnoses issues<br>• Describes what happened | • Explains resu |
| | Goal Assessment | • Subjectively assesses goal completion | • Qualitatively assesses goal completion | • Compares to<br>• Quantitative |
| | Design Modification | • Applies casual modifications<br>• Makes decisions based on aesthetic or superficial characteristics | • Applies directed modifications | • Focuses on p<br>• Brainstorms prototype b<br>• Optimizes d |

*The C-PIECE Framework presents detailed practices that can be exercised at exhibits and that our team observed and documented among visitor groups using exhibits.*

*This means that exhibit practitioners can plan and evaluate their activity designs to exercise particular practices at all proficiency levels.*

*With this nuanced lens, we expect to create new activities that help visitor groups stretch their practices more than they did with our old activities.*

| Defining a Problem | | Beginning | Intermediate |
|---|---|---|---|
| | Orientation | • Immediately attempts challenge | • Reads or listens to information provided<br>• Explores resources<br>• Watches others<br>• Prematurely attempts challenge |
| | Design Preparation | | • Discusses/plans design other than materials<br>• Brainstorms ideas<br>• Identifies/assigns roles |
| | Goal Orientation | • Perceives goal as straight forward | |

| Improving a Design | | Beginning | Intermediate |
|---|---|---|---|
| | Testing | • Runs through single cycle<br>• Confounds variables | • Adjusts testing conditions<br>• Completes multiple tests |
| | Interpretation | | • Identifies pros/cons of design<br>• Diagnoses issues<br>• Describes what happened |
| | Goal Assessment | • Subjectively assesses goal completion | • Qualitatively assesses goal completion |
| | Design Modification | • Applies casual modifications<br>• Makes decisions based on aesthetic or superficial characteristics | • Applies directed modifications |

*The C-PIECE Framework is a useful, evidence-based tool; each of the practices has an operationalized definition.*

*You can find the operational definitions of the practices in the C-PIECE Framework Graphic Summary on the Designing Our Tomorrow website: https://engineerourtomorrow.com/research-overview/study-1/*

*As we used the framework in this line of inquiry, we learned how combinations of exhibit features influenced the presence of practices in visitor experiences.*

| Defining a Problem | | Beginning | Intermediate |
|---|---|---|---|
| | Orientation | • Immediately attempts challenge | • Reads or listens to information provided<br>• Explores resources<br>• Watches others<br>• Prematurely attempts challenge |
| | Design Preparation | | • Discusses/plans design other than mate<br>• Brainstorms ideas<br>• Identifies/assigns roles |
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| Improving a Design | | Beginning | Intermediate |
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*We envision that the C-PIECE Framework can be used in multiple ways.*

***Researchers and Evaluators***
*The C-PIECE Framework can serve as a starting point for discussions and theoretical exploration around exercising group engineering practices at exhibits.*

***Activity Designers and Developers***
*The C-PIECE Framework can inform collaborators' ambitions to create experiences that exercise groups' practices related to* Defining a problem *or* Improving a design.

***Facilitators***
*The C-PIECE Framework can support conversations between exhibit facilitators and participants when visitor groups engage with engineering design challenges.*

# Research Story Introduction

This particular research story begins with our curiosity about the engineering proficiencies, *Defining a problem* and *Improving a design*, because they are so relevant to our work in the research, design, and development of engineering design challenge exhibits.

Our interest was piqued by pilot observations of engineering design challenges that revealed visitors often define their own problem and create their own challenges, regardless of the challenges exhibit developers had intended or proposed. This opened many questions for our research and development team to explore.

This research brief describes three existing, strategically-selected, engineering design challenge exhibits and the engineering practices visitor groups exercised at those exhibits, including what we refer to as *Informed* engineering practices. Our data suggest an inseparable relationship between exhibit activity, exhibit interface, and educational content when visitors determine what they will do at an exhibit.

We documented the practices elicited by each exhibit and speculated on the exhibit features that fostered those practices. Our observations and speculations can meaningfully inform the features of new design challenge experiences to promote Informed engineering design practices among exhibit visitors.

Our team is creating a traveling exhibit that is intended to promote groups' engagement with exhibit-based engineering design challenges that focus on sustainable design exemplified by biomimicry. This line of inquiry directly informs the design of this new exhibit.

# Research Objective

The purpose of this line of inquiry was to explore exhibit features in engineering design challenges that support visitors groups' exercise of the engineering proficiencies, *Defining a Problem* and *Improving a Design* and the practices associated with those proficiencies.

Through the lens of the C-PIECE Framework, we investigated the questions:

- What engineering practices did we observe visitor groups exercising across the three exhibits?
- What features of the exhibits appeared to support groups' practices associated with the engineering proficiencies, *Defining a problem* and *Improving a Design*?

This exploratory line of inquiry is just one portion of a larger C-PIECE study from *Designing Our Tomorrow—Mobilizing the Next Generation of Engineers* (DOT), a five-year project (2018 - 2023) led by the Oregon Museum of Science and Industry (OMSI) with the support of NSF (DRL-1811617) and project partners.

# Research Methods and Findings

We used qualitative, culturally responsive research methods to collect data on three exhibits and to speculate on the features of the exhibits that seemed to foster practices associated with the proficiencies *Defining a problem* and *Improving a design*. For this, we used evidence gathered through naturalistic observation, video recorded exhibit interactions, and participant interviews.

Data from these three methods allowed us to identify Informed practices elicited by each of the exhibits and associate those practices with exhibit features that seemed to foster those practices.

# The three exhibits we studied

Informed by prior studies of interactive exhibits and engineering, our team created criteria to select three exhibits used in the C-PIECE study:

- Articulate an explicit goal or challenge
- Allow for multiple outcomes
- Permit multiple acceptable answers
- Provide clear feedback for success
- Offer opportunities for improvement to designs or approaches
- Allow multiple people to engage in the activity

Because the new *Designing our Tomorrow* exhibit will include biomimicry, exhibit content that had a connection to sustainability was preferred. Pilot testing of the activities that best matched these considerations led the research team to choose three exhibits for this study: *LEGO® Drop*, *Catch the Wind*, and *Build a Boat*. All of the exhibits had copy panels in Spanish and English.

# *LEGO® Drop* exhibit description

Visitors build a breakable crate from LEGO® bricks. Then they use the materials to create a protective container for the crate. Visitors test their designs by dropping them from towers of different heights.

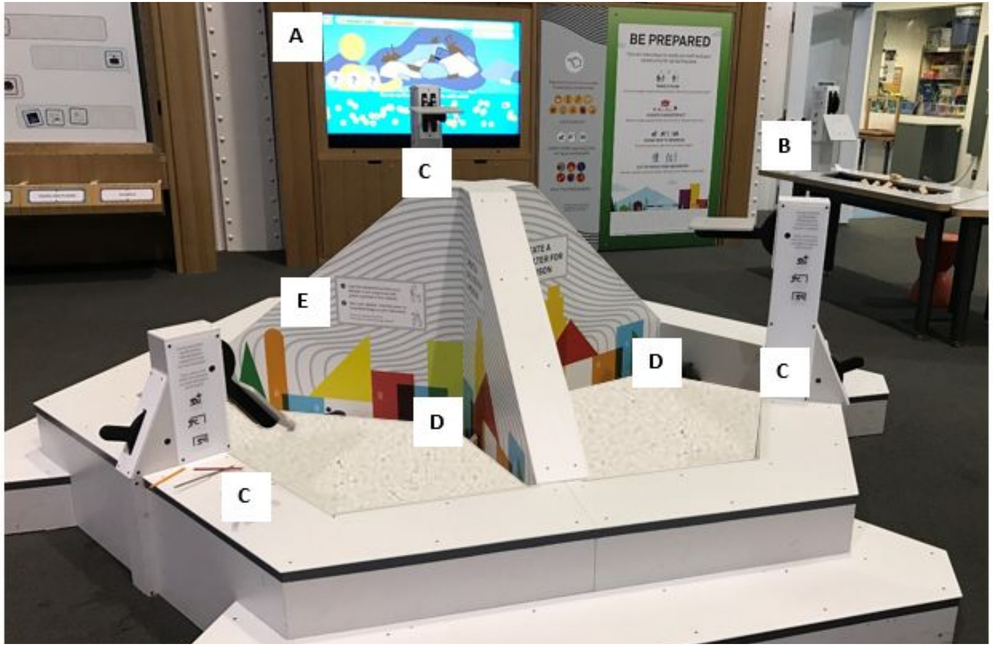
A. Inspiration screen with slide show of how nature slows or cushions a fall

B. Materials table with LEGO® bricks to build breakable crate and items to make protection

C. Towers of different heights from which crates are dropped

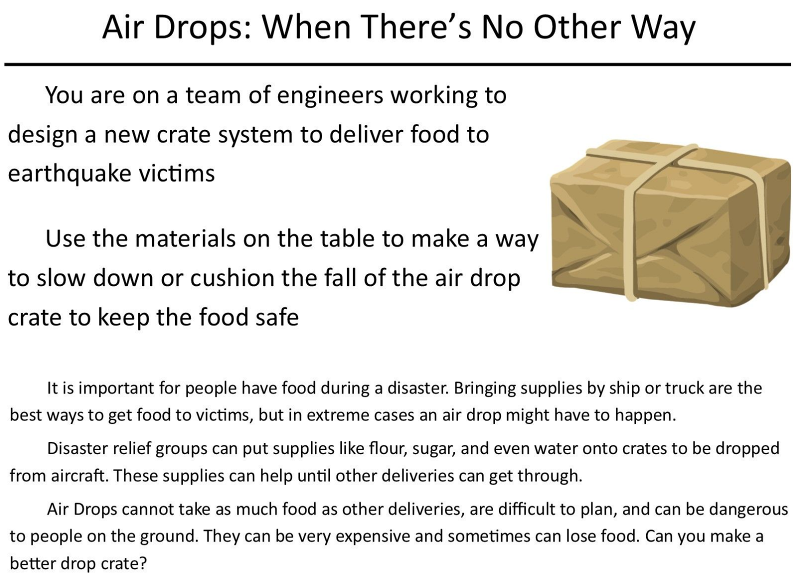
D. Crate landing area

E. Instructions



# *LEGO® Drop* copy description

At *LEGO® Drop*, copy was located in two areas: the testing area and the materials table.

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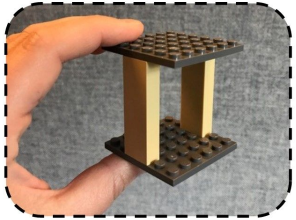
RESEARCH BRIEF

# *LEGO®* *Drop* copy description

At *LEGO® Drop*, copy was located in two areas: the testing area and the materials table.

1 Build the supply crate

Make a crate that looks like this:



2 Design a way to protect the crate from the fall

Use the materials at the table

See the screen for inspiration!

3 Test your design in the Drop Zone

What happens to the crate?

**Iterate:** Make a new design and Try Again!

| 1 | 2 | 3 |
|---|---|---|
| Place your design on one of the shelves | Pull lever to make the crate drop off the shelf | Note what happens to the crate |

It broke!

How can you improve your design?

Test again!

It survived!

Try testing it from a higher level!!

# *LEGO® Drop* and Informed practices

We observed this exhibit afforded the Informed practices:

- **Delays design decisions**
- **Relates content to prior experience**
- **Continues testing**

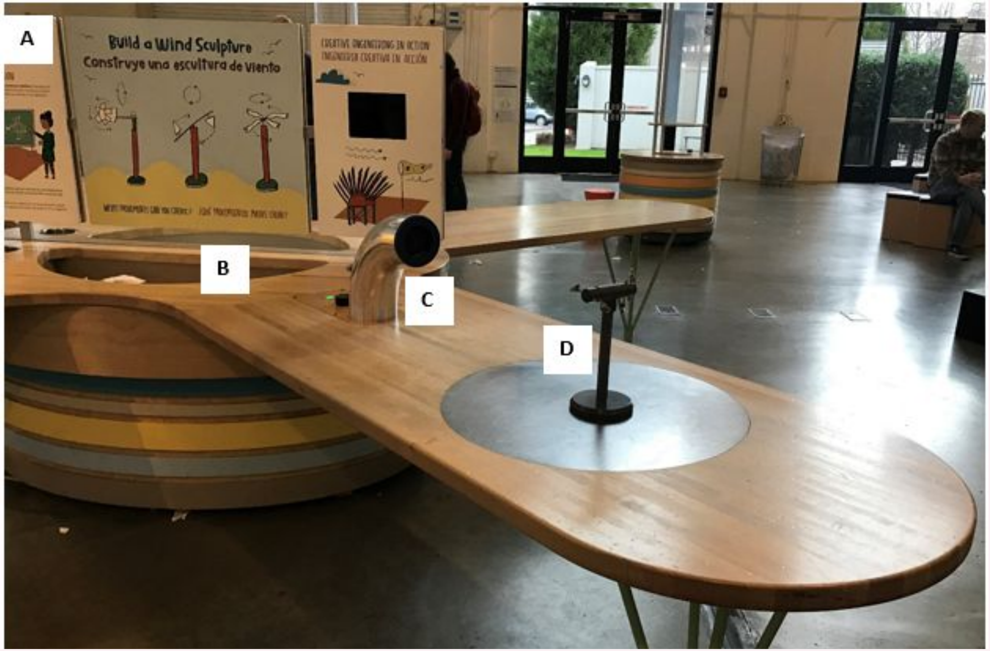
The layout of the copy and the materials at this exhibit appeared to influence the *Delays design decisions* practice. The building and testing areas were separate and both areas had copy that was relevant to that part of the process. Visitor groups frequently read label copy on the table in the building area before starting their designs and group members referred to it while working on their designs. Most groups spent time discussing the wide variety of materials before and while building their designs.

The materials and the different tower levels for testing allowed groups to *Continue testing* their designs by launching them from different positions or introducing brief modifications. Some groups demonstrated *Relates content to prior experience* by stating that the challenge reminded them of another activity such as an "egg drop" that they had done or seen previously.

# *Catch the Wind* exhibit description

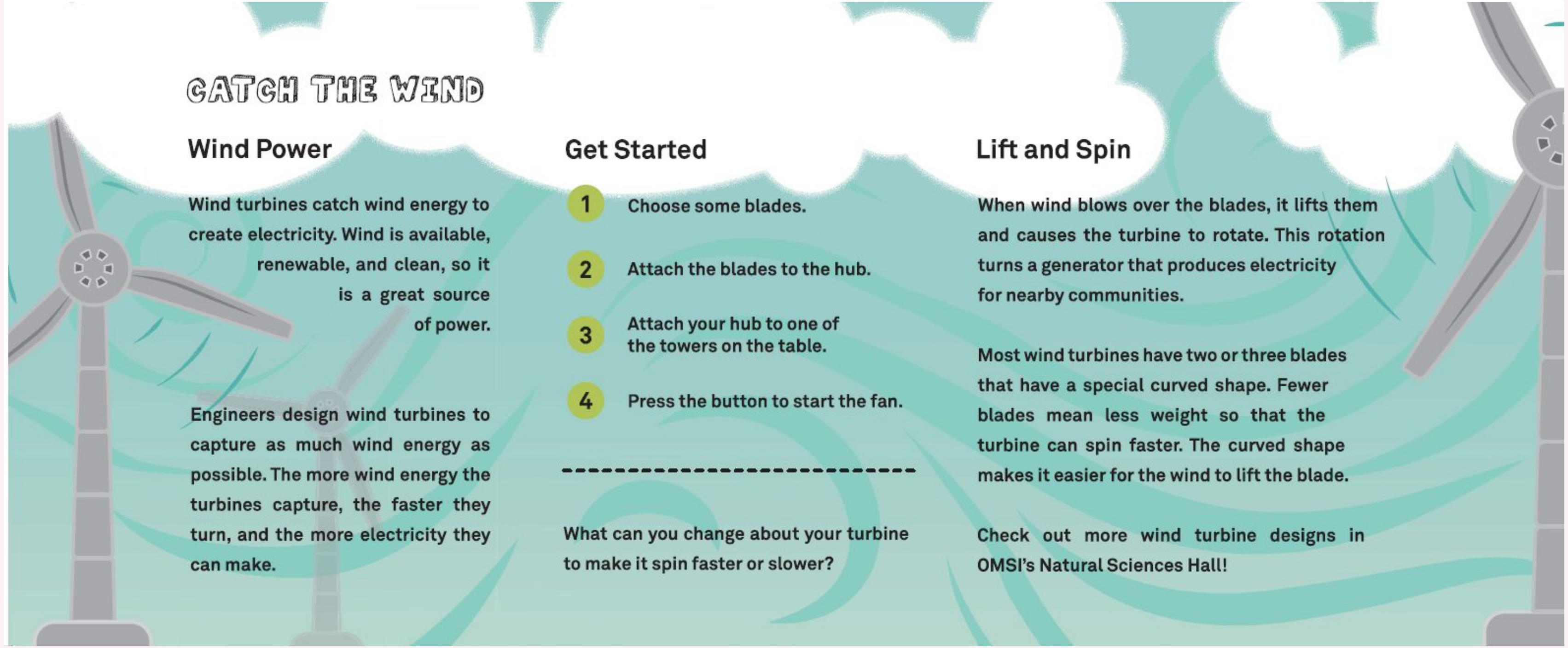
Visitors try to create a wind turbine by connecting K'Nex pieces and plastic blades to a stand. Visitors test their turbine creations by placing them in front of the blower and turning it on.

A. Exhibit Copy
B. Bin to hold materials
    a. K'Nex pieces to connect with the hub of stand
    b. Plastic blades for the turbines; in three different colored shapes
C. Blower with adjustable speed to provide "wind" to turn the turbine
D. Stand to hold blades to create a turbine. There were several available.



# *Catch the Wind* copy description

At *Catch the Wind*, the copy panel was in front of the building and testing table with the materials.



# *Catch the Wind* and Informed practices

We observed this exhibit afforded the Informed practices:

- **Considers benefits and trade-offs of materials**
- **Completes multiple iterations**
- **Continues testing**

Overall, groups started with the goal of getting their design to spin; once that was achieved, the goal shifted to getting their design to spin fast.

The fact that the building area and the testing were close and shared a table allowed groups to build, adjust testing conditions, and make design changes quickly and easily. This led to *Continues testing* and *Completes multiple iterations*, which often involved changing the number of blades and the angle of the turbine blades with respect to the wind source.

Having blades of three distinct shapes that were color-coded facilitated discussion of materials providing groups with a way to reference the blades. Some group members were observed talking about how the shape of the blade would affect performance (*Considers benefits and trade-offs of materials*).

# *Build a Boat* exhibit description

The *Build a Boat* exhibit included materials at a building station, a testing water tank, and two copy panels.


**Materials**
Materials were usually located at the building station, an area that offered  hull pieces in different shapes and sizes, three sizes of sails, and cargo.

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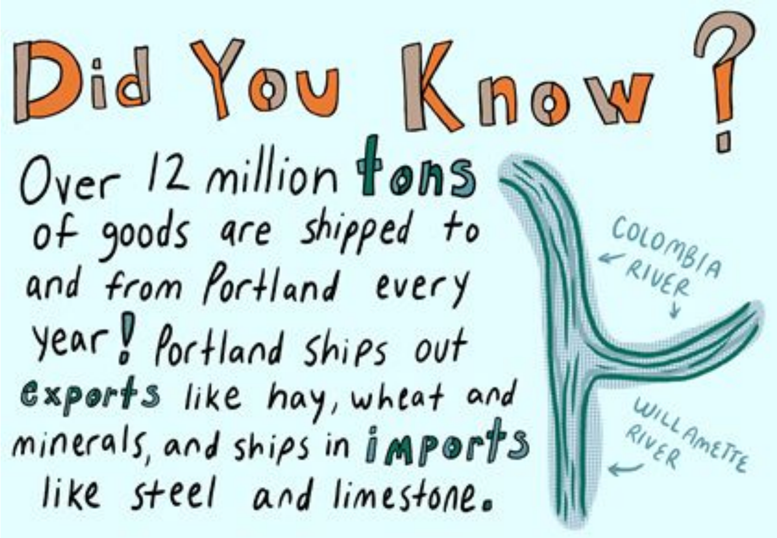
**Building and testing areas**
This exhibit contained two spaces: a building station and a testing tank. The building station consisted of a table where materials were organized. The testing tank contained water, an air blower, one obstacle, and a finish line to provide participants with an opportunity for approach opportunities and test different solutions for several engineering problems.

# ***Build a Boat*** **copy description**

The copy for the *Build a Boat* exhibit was located at one end of the testing tank, stating the challenge, "*Build a boat that can make it from the dock to the finish line! How much cargo can your boat carry?*"

# *Build a Boat* and Informed practices

We observed this exhibit afforded the Informed practices:

- **Completes multiple iterations**
- **Continues testing**
- **Compares to own past performance or record**

Although the building and testing areas were separate and distinct, both areas appeared to contribute to groups demonstrating building and modifying design behaviors.

While most groups did not read the copy panel (located near the testing area) when creating their designs, many groups engaged in discussions about the type and number of materials they were using, how big their boat would be, which sail they would use, etc. The large testing area and the opportunity for multiple members of the group to create their own design allowed for group members to watch others build, test, and modify their designs. These indicators contributed to *Compare to own past performance or record*.

Once groups completed a design, testing and iteration often occurred rapidly in the testing area. The variety of materials and the ease with which they could be changed and provide additional options for a design, led to group members performing multiple modifications to their designs and hence *Continue testing* and *Complete multiple iterations*.

# Summary of Observations

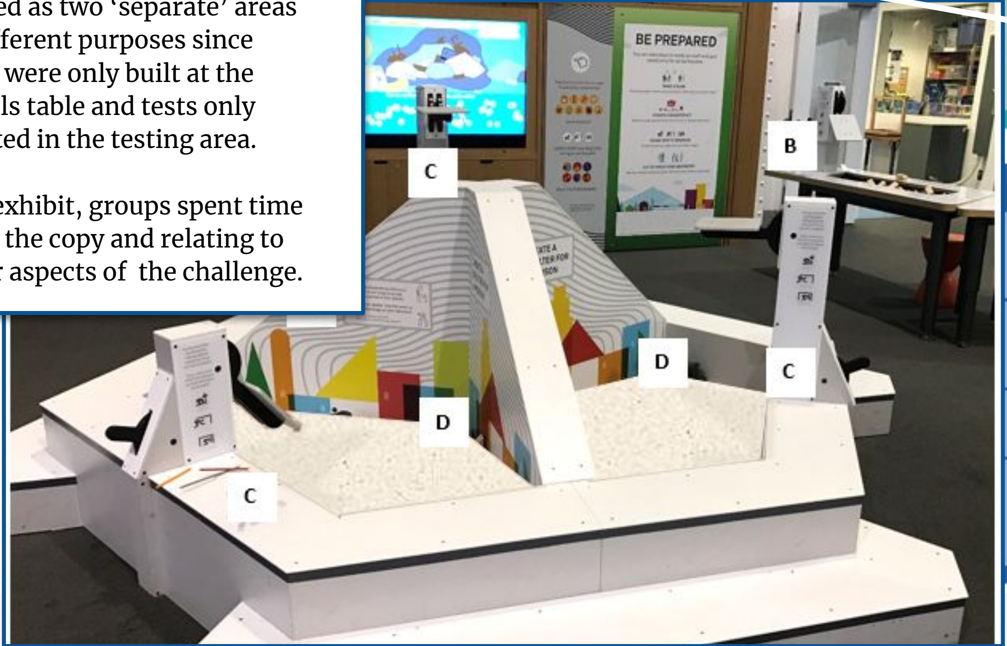
The design of the **exhibit copy** and **the building and testing location** appear to influence the Informed practices of *Delays design decisions* and *Relates content to previous experience* as seen in the *LEGO® Drop* exhibit.

The building and testing areas were perceived as two ‘separate’ areas with different purposes since designs were only built at the materials table and tests only conducted in the testing area.

At this exhibit, groups spent time reading the copy and relating to familiar aspects of  the challenge.

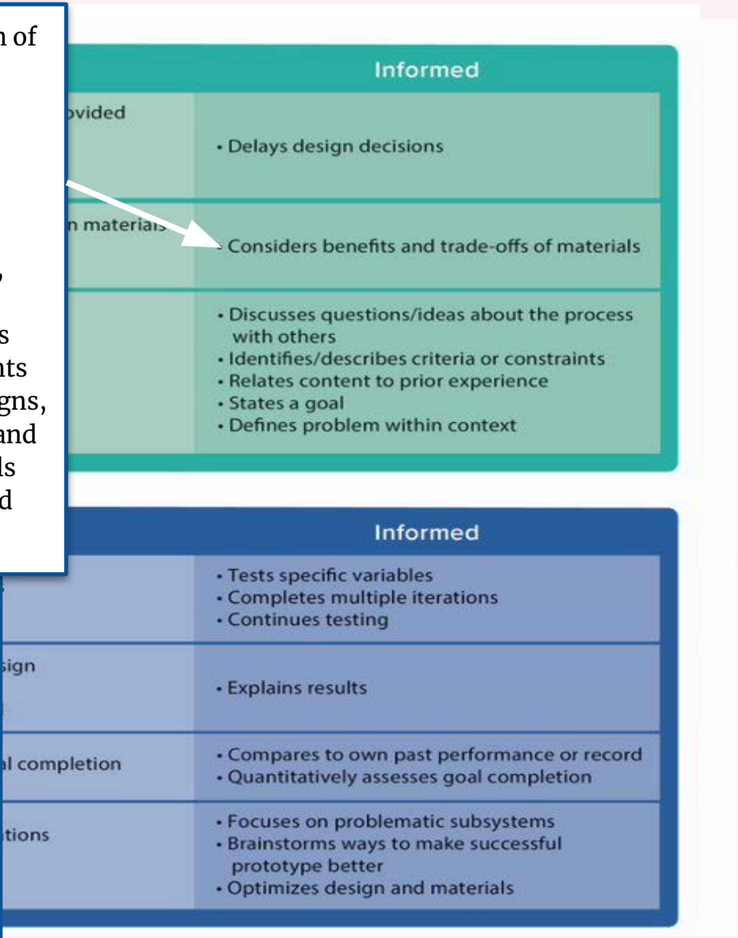
| ...ning | Intermediate | Informed |
|---|---|---|
| ...s challenge | • Reads or listens to information provided<br>• Explores resources<br>• Watches others<br>• Prematurely attempts challenge | • Delays design decisions |
| | • Discusses/plans design other than materials<br>• Brainstorms ideas<br>• Identifies/assigns roles | • Considers benefits and trade-offs of materials |
| | | • Discusses questions/ideas about the process with others<br>• Identifies/describes criteria or constraints<br>• Relates content to prior experience<br>• States a goal<br>• Defines problem within context |

| Informed |
|---|
| • Tests specific variables<br>• Completes multiple iterations<br>• Continues testing |
| • Explains results |
| • Compares to own past performance or record<br>• Quantitatively assesses goal completion |
| • Focuses on problematic subsystems<br>• Brainstorms ways to make successful prototype better<br>• Optimizes design and materials |



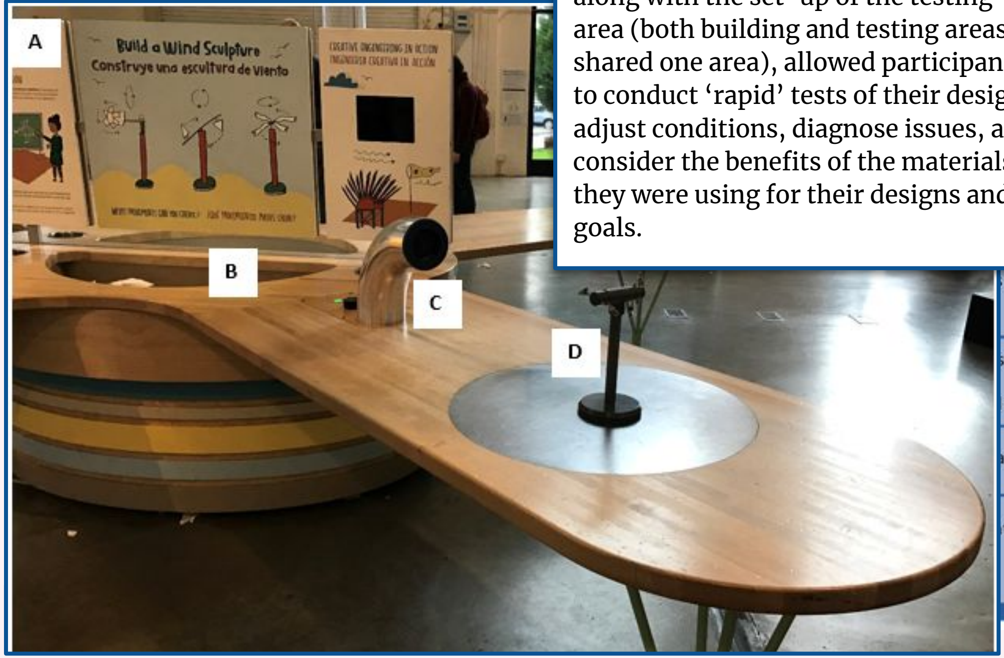
# Summary of Observations



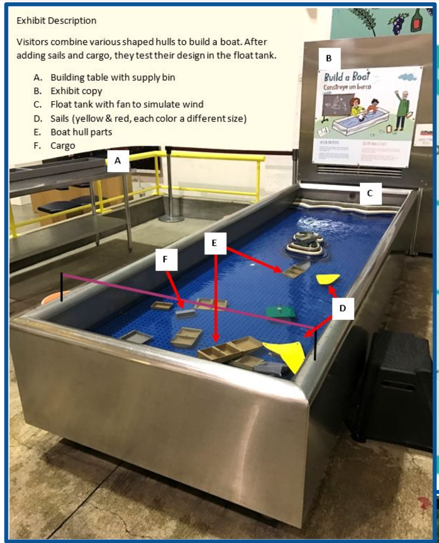


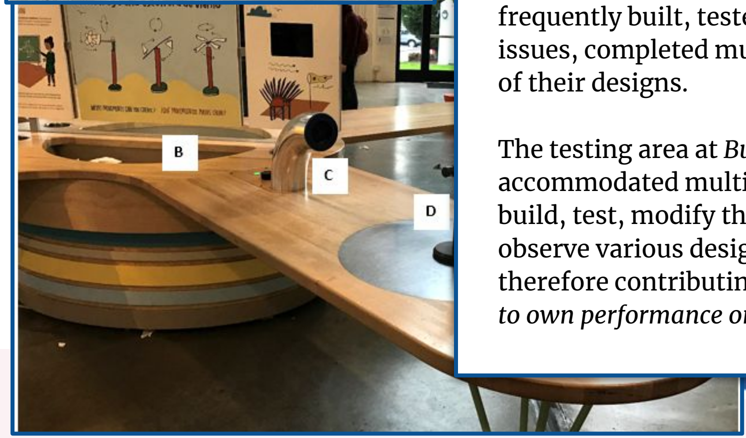

The type of **materials** and the design of the **building and testing location** appear to influence the Informed practices of *Considers benefits and trade-offs of materials* as seen in the *Catch the Wind* exhibit.

The type of materials at this exhibit, along with the set-up of the testing area (both building and testing areas shared one area), allowed participants to conduct 'rapid' tests of their designs, adjust conditions, diagnose issues, and consider the benefits of the materials they were using for their designs and goals.



# Summary of Observations

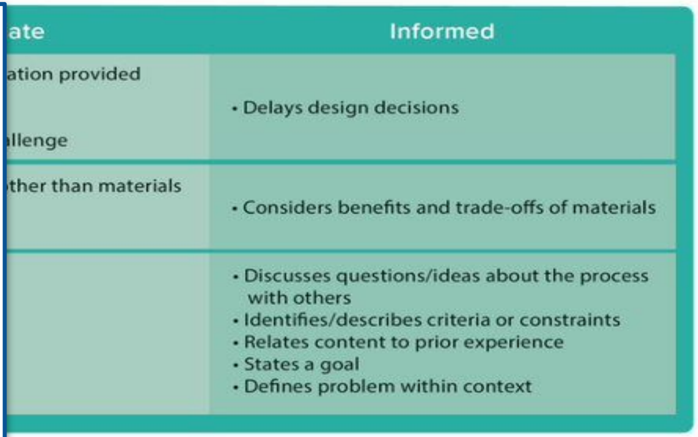


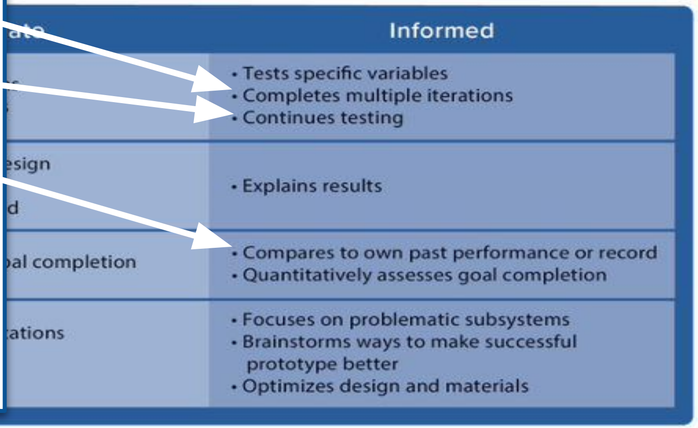




The design of the **building and testing areas** appears to influence the Informed practices of *Complete multiple iterations* and *Continues testing* as seen in *Build a Boat* and *Catch the Wind* exhibits. In both of these exhibits, participants built, modified, and created several design iterations often in the testing area.

This was more evident at *Catch the Wind* since the building and testing area was shared on the same table. Participants at this exhibit frequently built, tested, diagnosed issues, completed multiple iterations of their designs.

The testing area at *Build a Boat* accommodated multiple members to build, test, modify their designs and observe various designs at one time, therefore contributing to *Compares to own performance or record.*



# Summary of Observations

| Defining a Problem | | Beginning | Intermediate | Informed |
| --- | --- | --- | --- | --- |
| | Orientation | • Immediately attempts challenge | • Reads or listens to information provided<br>• Explores resources<br>• Watches others<br>• Prematurely attempts challenge | • Delays design decisions |
| | Design Preparation | | • Discusses/plans design other than materials<br>• Brainstorms ideas<br>• Identifies/assigns roles | • Considers benefits and trade-offs of materials |
| | Goal Orientation | • Perceives goa | | • Discusses questions/ideas about the process with others<br>• Identifies/describes criteria or constraints<br>• Relates content to prior experience<br>• States a goal<br>• Defines problem within context |

| Improving a Design | | | | Informed |
| --- | --- | --- | --- | --- |
| | Testing | • Runs through<br>• Confounds va | | • Tests specific variables<br>• Completes multiple iterations<br>• Continues testing |
| | Interpretation | | | • Explains results |
| | Goal Assessment | • Subjectively a | | • Compares to own past performance or record<br>• Quantitatively assesses goal completion |
| | Design Modification | • Applies casual<br>• Makes decisio<br>superficial cha | | • Focuses on problematic subsystems<br>• Brainstorms ways to make successful prototype better<br>• Optimizes design and materials |

The evidence presented above illustrates that certain exhibit features seem to support groups' exercise of particular Informed engineering practices related to *Defining a problem* and *Improving a design*.

The practices that groups exercised less often at these exhibits include:

- *Discusses questions/ideas about the process with others*
- *Identifies/describes criteria or constraints*
- *States a goal*
- *Defines problem within context*
- *Tests specific variables*
- *Explains results*
- *Quantitatively assesses goal completion*
- *Focuses on problematic subsystems*
- *Brainstorms ways to make successful prototype better*
- *Optimizes design and materials*

# Implications for *Designing our Tomorrow*

Although not exhaustive, this exploratory line of inquiry provided evidence that certain combinations of exhibit features can elicit Informed engineering design practices—a strong affirmation for including these features in exhibits intended to exercise these particular practices.

These exploratory findings, in combination with other research and evidence, are being integrated in the development of the design challenges and activities in the the *Designing our Tomorrow* exhibit. The exhibit will undergo evaluation that can further inform our understanding of the relationships between exhibit features and engineering design practices.

These findings, in combination with other research and evidence, will also inform the professional development products created by the *Designing our Tomorrow* team. These professional development products will be available by 2023.

*Dear Colleagues,*

*Now that we've shown you an example of how we used the C-PIECE Framework, we invite you to use it for your own objectives and questions.*

*We encourage practitioners to try to elicit and document practices presented in the C-PIECE Framework. We want to hear about the design features you use to elicit Informed practices that we rarely observed at these three exhibits, such as,* Identifies criteria and constraints.

*We want to be part of conversations including: In what ways does the C-PIECE Framework help us stretch professional practices and perspectives? In what ways does it need to evolve? How is it helping visitors? What input do partners, visitors and learners have for the C-PIECE Framework?*

*Please leave comments at:*
[*www.engineerourtomorrow.com*](http://www.engineerourtomorrow.com).

*Thank you for your interest!*

# Supporting Materials

Below are links to the materials that supported the development of this brief.

Methods
We used qualitative, culturally responsive research methods to collect data on three exhibits.

Analysis
Data from the observations and interviews provided insights into the groups' practices across exhibits.

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Results
The results of the analysis are reported by the frequency of nine sets of practices for each exhibit.

References
This is a list of references that guided the development of the C-PIECE research study.