

# C-PIECE Framework

## Collaborative Practices at Interactive Engineering Challenge Exhibits

### A Graphic Research Summary



#### Preferred Citation

Randol, S., Benne, M., Herran, C., Ramos-Montañez, S., & Shagott, T. (2021). *The C-PIECE Framework: Collaborative Practices at Interactive Engineering Challenge Exhibits—A Graphic Research Summary*. Oregon Museum of Science and Industry.

#### Research from the project

*Designing Our Tomorrow-Mobilizing the Next Generation of Engineers*

© 2021 Oregon Museum of Science and Industry



*This material is based upon work supported by the National Science Foundation under Grant No. DRL-1811617. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.*

# C-PIECE Framework

## Collaborative Practices at Interactive Engineering Challenge Exhibits

### How can the C-PIECE Framework support my work?

Are you interested in co-creating fun activities that exercise groups' engineering practices? Are you curious about the types of practices that groups can exercise through exhibits?

The Framework of Collaborative Practices at Interactive Engineering Challenge Exhibits (C-PIECE Framework) provides informal education professionals with a guide when co-developing, designing, facilitating, evaluating and researching engineering design challenge experiences.

This framework was developed with input from inter-generational families, including girls 9 to 14 years old. It was adapted from theory-based constructs of engineering proficiencies and refined using evidence and iterative reviews for use in an informal learning context. This framework can help all of us stretch our work in new directions.

The C-PIECE Framework (on page 3) is organized to show categories for describing engineering design practices through:

- Two engineering proficiencies—
  - *Defining a problem* and *Improving a design*
- Three levels of proficiencies—
  - Beginning, Intermediate, and Informed
- Seven practice sets—
  - Three for the *Defining a problem* proficiency and four for the *Improving a design* proficiency
- Thirty-seven practices—
  - Organized by their associated proficiency, proficiency level, and practice set

The process for researching and developing the C-PIECE Framework included a thorough literature review of existing research, models, and measures related to engineering proficiencies as well as vetting and refining data collection instruments, findings and the actual framework based on input from collaborators—families, community educators, informal STEM educators, and researchers.

The C-PIECE Framework focuses on two proficiencies that can be measured in an informal setting: *Defining a problem* and *Improving a design*. *Defining a problem* is the process of establishing a goal or parameters for success, and identifying constraints to designs based on materials, context, cost or client. *Improving a design* (testing and iteration) is the process of modifying a design in a way that increases its effectiveness in achieving the desired outcome.

This document contains: a C-PIECE Framework graphic, operational definitions of the practices identified within the C-PIECE Framework, and an illustration of the C-PIECE Framework research process. For more details on the C-PIECE Framework research and the *Designing our Tomorrow* project, or to share your feedback, please visit [www.engineerourtomorrow.com](http://www.engineerourtomorrow.com).

#### Examples for professionals

Professionals can use the C-PIECE Framework to study design challenge experiences and co-develop fun, relevant activities that exercise participants' engineering design practices. The examples below illustrate some ways the framework could be used in collaboration with partners and participants.

#### **Researchers and Evaluators**

The C-PIECE Framework can serve as a closer and more nuanced look, informed by families, for discussions and exploration around the topic of engineering practices at exhibits.

#### **Designers and Developers**

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

#### **Facilitators**

The C-PIECE Framework can support conversations between exhibit facilitators and participants as participants talk about their goals and experiences while engaging with engineering design challenges.

# C-PIECE Framework

## Collaborative Practices at Interactive Engineering Challenge Exhibits

Defining a Problem		Beginning	Intermediate	Informed
Orientation	• Immediately attempts challenge	<ul style="list-style-type: none"> <li>• Reads or listens to information provided</li> <li>• Explores resources</li> <li>• Watches others</li> <li>• Prematurely attempts challenge</li> </ul>	<ul style="list-style-type: none"> <li>• Discusses/plans design other than materials</li> <li>• Brainstorms ideas</li> <li>• Identifies/assigns roles</li> </ul>	<ul style="list-style-type: none"> <li>• Delays design decisions</li> </ul>
Design				<ul style="list-style-type: none"> <li>• Considers benefits and trade-offs of materials</li> </ul>
Goal	• Perceives goal as straight forward			<ul style="list-style-type: none"> <li>• Discusses questions/ideas about the process with others</li> <li>• Identifies/describes criteria or constraints</li> <li>• Relates content to prior experience</li> <li>• States a goal</li> <li>• Defines problem within context</li> </ul>

Improving a Design		Beginning	Intermediate	Informed
Testing	<ul style="list-style-type: none"> <li>• Runs through single cycle</li> <li>• Confounds variables</li> </ul>	<ul style="list-style-type: none"> <li>• Adjusts testing conditions</li> <li>• Completes multiple tests</li> </ul>	<ul style="list-style-type: none"> <li>• Tests specific variables</li> <li>• Completes multiple iterations</li> <li>• Continues testing</li> </ul>	
Interpretation		<ul style="list-style-type: none"> <li>• Identifies pros/cons of design</li> <li>• Diagnoses issues</li> <li>• Describes what happened</li> </ul>	<ul style="list-style-type: none"> <li>• Explains results</li> </ul>	
Assessment	• Subjectively assesses goal completion	<ul style="list-style-type: none"> <li>• Qualitatively assesses goal completion</li> </ul>	<ul style="list-style-type: none"> <li>• Compares to own past performance or record</li> <li>• Quantitatively assesses goal completion</li> </ul>	
Design Modification	<ul style="list-style-type: none"> <li>• Applies casual modifications</li> <li>• Makes decisions based on aesthetic or superficial characteristics</li> </ul>	<ul style="list-style-type: none"> <li>• Applies directed modifications</li> </ul>	<ul style="list-style-type: none"> <li>• Focuses on problematic subsystems</li> <li>• Brainstorms ways to make successful prototype better</li> <li>• Optimizes design and materials</li> </ul>	

# C-PIECE Framework

## Collaborative Practices at Interactive Engineering Challenge Exhibits

### General definitions

**Proficiency:** Overarching collection of practices.

**Practice:** A strategy, approach, or series of actions that are part of engaging in an engineering proficiency.

**Practice set:** a group of practices that share the same purpose within the engineering processes.

### Operational definitions of practices related to *Defining a Problem* proficiency

#### Beginning

**Immediately attempts challenge:** Group creates and/or tests a design prior to watching others, exploring resources, reading panels.

**Perceives goal as straight forward:** Group reports the problem or challenge solely as a goal to be met.

#### Intermediate

**Brainstorms ideas:** Group makes suggestions for a design.

**Discusses/plans design other than materials:** Group talks about or report considering intended form, function and behavior of their design prior to or during construction.

**Explores resources:** Group learns about what resources are available and how they work. This may include looking at, touching, discussing and/or comparing materials without assembling or placing them, figuring out how the exhibit works or responds to input (pushing buttons, turning knobs, carefully observing), examining models, prototypes, existing designs left by other visitors, sketches or other artifacts that suggest ideas for a design.

**Identifies/assigns roles:** Group identifies and/or takes responsibility for specific tasks related to the challenge/problems.

**Prematurely attempts the challenge:** Group creates and/or tests a design after briefly watching others, exploring resources or reading panels.

**Reads/listens to information provided:** Group appears to focus on text panels, points to or references the text, reads text aloud.

**Watches others:** Group observes other groups or individuals participating in the activity or working with materials. Watching others can occur while participating in other behaviors.

#### Informed

**Considers benefits and trade-offs of materials:** Group reports or discusses alternative materials and associated potential differences.

**Defines problem within context:** Group describes the challenge as a goal with associated constraints, conditions, context, etc.

**Delays design decisions:** Group watches others, explores resources and reads panels for an extended length of time, or discusses processes, ideas or goal prior to creating a design.

**Discusses questions/ideas about the process with others:** Group members talk about how they should approach the ideation, construction or testing of their design.

**Identifies/describes criteria or constraints:** Group members talk about what needs to be done to accomplish a goal, measures of success of a test or restrictions for the design.

**Relates content to prior experience:** Group associates the current task or design to something they have experienced in the past.

**States a goal:** Group uses their own words to articulate, define, restate, reiterate or clarify challenge or goal.

# C-PIECE Framework

## Collaborative Practices at Interactive Engineering Challenge Exhibits

### Operational definitions of practices related to *Improving a Design* proficiency

#### Beginning

**Applies casual modifications:** Group makes changes, often several at once, to their design with little or no evidence of consideration of how the changes will affect performance or are based on earlier tests.

**Confounds variables:** Group changes more than one aspect of their design between tests.

**Runs through single cycle:** Group builds and tests one design with few or no modifications.

**Subjectively assesses goal completion:** Group defines success in terms of a personally relevant measure.

**Makes decisions based on aesthetic or superficial characteristics:** The group creates or makes changes to a design based solely on how it looks.

#### Intermediate

**Adjusts testing conditions:** Individual(s) in the focal group appear to systematically change the conditions under which they are conducting tests.

**Applies directed modifications:** Group makes changes that improve the performance of a design to address issues to help it achieve the goal.

**Completes multiple tests:** Group repeats testing of a single design.

**Describes what happened:** Group summarizes or describes the result of attempting the challenge.

**Diagnoses issues:** Group reports or talks about figuring out why the design did not perform well.

**Identifies pros/cons of design:** Group talks about what seems to be working well and what seems to be a problem with their design; includes comparisons and trade-offs of design elements and materials.

**Qualitatively assesses goal completion:** Group defines success in terms relative to a general standard or previous performance.

#### Informed

**Brainstorms ways to make successful prototype better:** Group propose ideas to improve the performance of a design that has achieved the challenge.

**Compares to own past performance or record:** Group reports or talks about results of a test in terms of previous trials.

**Completes multiple iterations:** Group tests a design after each of several modifications: cycles of modify, test, observe.

**Continues testing:** Group continues to improve and test a design after the goal was successfully achieved. **Explains results:** Group proposes and/or discusses ideas about underlying mechanisms for performance of a design.

**Focuses on problematic subsystems:** Group identifies aspects of their design that are not functioning well and modify those while leaving other parts alone.

**Tests specific variables:** Group makes one specific change to their design and retests.

**Optimizes design and materials:** Group makes changes based on feedback to continue to improve a design after the goal is met.

**Quantitatively assesses goal completion:** Group defines success in terms of a numerical standard.

#### Others (behaviors that were part of the observation instrument as indicators of more complex practices)

**Attempts the challenge:** Group puts their design 'to the test' by trying it out to see if it meets the challenge or goal.

**Completes the challenge:** Group tests whether the current design iteration successfully meets the criteria of the goal or challenge presented.

**Modifies/manipulates design:** Group makes a change about the design they are working with. This includes minor modifications or refinements, repositioning parts, etc. as well as major modifications.