

# DEEP Content Guide

MDP 2023 Cohort Team - December 2023

# The Principles Behind This Guide:

The recommendations in this document are guided by academic papers about effective learning and testing techniques, 21 UX Laws as listed in Jon Yablonski's *Laws of UX*, the book *e-Learning and the Science of Instruction* by Ruth Colvin Clark and Richard E. Mayer, as well as the testing data collected by the UX team over the summer.

## Relevant UX Laws:

The UX laws mentioned below are used primarily in content presentation.

### 1. Hick's Law:

- **DEFINITION:** Decision time increases as the number of choices goes up.
- **HOW THIS APPLIES:** Narrow down how many answer choices to present (combined with field observation while testing the app).

### 2. Peak End Rule:

- **DEFINITION:** People judge an experience largely based on how they felt at its peak and at its end, rather than their average experience overall.
- **HOW THIS APPLIES:** Badges and cheering screens are presented at the end of the experience to reward students for finishing the DEEP question set. One question from the DEEP exhibit that encapsulates a key science concept or peak experience is printed and given to students at the end of their field trip to remind them of what they learned during their visit.

### 3. Jakob's Law:

- **DEFINITION:** Users expect a website/app to work the same way that they have experienced other websites/apps.
- **HOW THIS APPLIES:** Common question formats such as multiple choice questions are used throughout DEEP to reduce the learning curve for using the app and allow students to focus on educational content instead. All DEEP exhibits are made to have consistent formats and interaction types so that students can become comfortable using DEEP after a single experience with an exhibit.

### 4. Postel's Law:

- **DEFINITION:** Be liberal in the types of input you accept and conservative in the types of output given.

- **HOW THIS APPLIES:** Single-answer drag-and-drop questions can be answered by either tapping the option or dragging it. Users can easily toggle between options or deselect them in multiple-choice questions or select all that apply questions.

**CITATION:**

Yablonski, Jon. Laws of Ux. O'Reilly Media, 2020.

## **Relevant Academic Paper Findings:**

### **Three Options Are Optimal for Multiple-Choice Items: A Meta-Analysis of 80 Years of Research:**

- Three options (1 correct answer + 2 plausible distractors) are optimal for multiple-choice questions in most settings.
  - **RESEARCH METHOD:** analyzing the item difficulty, score reliability & validity by comparing differentiations when changing options from 5-4, 5/4-3, and 5/4-2.
- In some contexts, distractors can provide diagnostic information where distractors are coded to map to common misconceptions. In such cases, more distractors may be needed.
  - **HOW THIS APPLIES:** Common misconceptions can be used as incorrect answer choices in multiple-choice questions to enhance student understanding through subsequent explanations.

**CITATION:**

Rodriguez, M. C. (2005). Three Options Are Optimal for Multiple-Choice Items: A Meta-Analysis of 80 Years of Research. *Educational Measurement: Issues and Practice*, 24(2), 3–13. <https://doi.org/10.1111/j.1745-3992.2005.00006.x>

## **Relevant *e-Learning and the Science of Instruction* Book Findings:**

### **1. Chapter 4: Applying the Multimedia Principle**

- It is recommended to use words (written & spoken) and graphics (static & dynamic) together.
  - **RATIONALE:** people are more likely to understand material when they can engage in active learning, which is encouraged by multimedia presentations.
- Ways to use graphics that serve instructional roles (that are applicable to DEEP):
  - Graphics can be used to show relationships.

- Graphics can demonstrate procedural processes.
- Using words and graphics is particularly important for learners who have low knowledge of the domain rather than learners who have high knowledge of the domain.
- Dynamic graphics are not always better than static graphics. Some ways to effectively use dynamic graphics include:
  - Using animation to illustrate procedures (e.g. IR Camera).
  - Using animation as interpretive graphics (showcasing how a seed grows over time).
  - Adding visual cues to animations (to create a focal point) using arrows, circles, changes of colors, etc.
- **HOW THIS APPLIES:** DEEP exhibits should include graphics to explain concepts better. Graphics can replace wordy text or enhance the textual content on the screen.

## 2. Chapter 10: Applying the Segmenting and Pre-training Principles

- Breaking excessive amounts of information into small segments but not leaving out which will decrease the accuracy (all information is essential).
  - It allows the learner to engage in essential processing without overloading the learner's cognitive system, that is, it allows the learner to manage essential cognitive processing.
  - **HOW THIS APPLIES:** Hints in questions are used as a method of pre-training before providing explanations. Content is broken up into different screens or separated using transitions to reduce information overload. Only key concepts are highlighted.
- Ensure that learners know the names and characteristics of key concepts.

## 3. Chapter 11: Engagement in Learning

- Psychological engagement, not behavioral engagement, promotes learning.
- **HOW THIS APPLIES:** Rather than complex question types that increase cognitive load, simple explanations and multiple-choice questions are largely used. Engagement with the physical exhibit (rather than intricate engagement with the application) is encouraged to promote psychological engagement.

## 4. Chapter 12: Leveraging Examples in e-Learning

- Worked examples, practice problems, and self-explanations can aid learning.

- **HOW THIS APPLIES:** Provide feedback on questions along with an example of why it is correct/incorrect and questions that evoke thinking and self-explanations (talk to peers, apply a scientific principle to a specific context) are used in DEEP. Provide “worked examples” by showing how to productively interact with an exhibit to observe a science concept in action.

## 5. Chapter 13: Does Practice Make Perfect?

- Principles (applicable to DEEP) that maximize the benefits of practice interactions that promote learning:
  - Incorporate effective feedback to learner responses to properly explain concepts.
  - Position the feedback on the screen so that the learners can see the question, their response to the question, and the feedback in close physical approximation to minimize split attention.

## 6. Chapter 14: Learning Together Virtually

- The ideal group size for collaborative learning is 2-4 people. Collaborative learning *can* be more effective than individual or competitive learning when used properly.
- **HOW THIS APPLIES:** DEEP is generally designed such that it can be completed individually or in groups of 2-4 people. To incentivize students to use DEEP, it has been gamified such that class goals are set and students can earn points to meet these goals — a feature that automatically encourages cooperative collaboration. DEEP also features some questions that explicitly encourage collaborative discussion (although their use is limited to ensure that the experience appeals to students who individually want to answer questions)

### CITATION:

Clark, Ruth C., and Richard E. Mayer. E-Learning and the Science of Instruction. Edited by Ruth Colvin Clark and Richard E. Mayer, 4th ed., John Wiley & Sons, 2016.

## Testing Data Findings:

Much of the recommendations below are directly based on insights derived from user testing with students at the museum. Some key points from this testing data are summarized below.

- 1. Students tend to abandon the app after 5-7 questions.**
  - **HOW THIS APPLIES:** Limit the number of questions, and time taken to complete each question, and use graphics and animations to keep the app exciting and engaging.
- 2. Students often go through the questions very quickly without properly understanding the content.**
  - **HOW THIS APPLIES:** Make sure to provide popup explanations to ensure that the student has the opportunity to understand what the correct answer should be, or what scientific principle applies.
- 3. Students do not properly read lengthy question choices or explanations.**
  - Students often do not follow instructions such as “Select All That Apply”, especially if answer choices are long to read.
  - **HOW THIS APPLIES:** Text length in questions and answer choices should be reduced wherever possible. The number of answer choices should be limited to 3 or less when possible. Select all that apply questions should be used sparingly, only when they enhance understanding of a concept.
- 4. Students sometimes need explicit instruction on how the question relates to the physical exhibit.**
  - Students may not make the connection that the question is asking them to interact with the physical exhibit.
  - **HOW THIS APPLIES:** A simple instruction at the beginning asking the student to interact with the exhibit can reduce confusion.
- 5. Students often do not follow explicit instructions to discuss with peers.**
  - **HOW THIS APPLIES:** Limit questions that require explicit discussion so that most questions can be answered individually.
- 6. Younger students get confused about drag-and-drop questions.**
  - **HOW THIS APPLIES:** Allow students to tap on an option even in drag-and-drop questions, and use multiple choice for the majority of questions to reduce the learning curve.
- 7. Students do not approach tablets because they are not sure what their purpose is.**
  - **HOW THIS APPLIES:** Make the landing page consistent with exhibit signage and branding and position it so that it is easily accessible from the exhibit.

# Overview of Redesign and Testing Procedure

*\*This overview does not take into account software testing and only focuses on the user experience components of redesigning.*

*\*The below steps are listed in the order that they should be completed in.*

## **1. Re-evaluate existing DEEP experience, assessing how well its content meets the guidelines listed in this guide.**

- Important considerations from the guide include experience and content length, use of visual aids, and effectiveness of questions in encouraging engagement.
- Consider removing or rewriting questions that are inconsistent with the guide's principles or do not add significant educational value to the experience.
- It may help to sketch out the user flow of questions and address potential areas for change.
  - *Changes may include adding explanation screens since those were omitted in the original DEEP design.*

## **2. Redesign the content to follow the new UI guidelines.**

- Revise all the text and the content architecture using the content guide.
  - Novel question types may need to be modified for consistency with DEEP stylistic principles.
- Follow the style guide to transform the content into Figma prototypes.
  - If design details are modified to improve the experience, it is critical that they be modified across exhibits and documented in the style guide for standardization.

## **3. Test the new experience at the museum.**

- Place the tablet in a position accessible from the exhibit. Try to test with students in the target age group.
- Place a sign to make it obvious that this is a testing spot and that interacting with the tablet is encouraged. You may have to approach students, guardians, or teachers to get participants.
- Although active efforts to recruit students for testing may be needed, try not to provide too much explicit instruction or interfere with the interaction process. Do not ask participants to keep continuing with the experience if they wish to abandon it.

- Take note of usability issues (ex. visible confusion, using the exhibit incorrectly), participant eagerness for participation, and the average number of questions till abandonment. If possible, ask the participant how the experience was.
- Try to test with groups of 3-4 children along with individual children. Note differences between groups, individual children, and children with a guardian present.
- While taking notes, also note the grade level of the participant.

#### **4. Assess what changes are necessary and implement them in the next round of prototyping.**

- Analyze notes from the testing session to identify common usability issues and areas for improvement. These improvements may look different for every exhibit. If the improvements seem consistent with the broad principles from this guide as well as other learning design principles, implement them in the next Figma prototype.
- Keep in mind that interaction behavior can vary a lot between each participant, and no design can be “perfect” for every participant. Choose to fix issues that are either commonly seen, important to the experience, or easy to fix.

#### **5. Repeat the above two steps till usability issues are resolved.**

- Typically after a few rounds of iterative design and testing, the qualitative observations will saturate and no new addressable issues can be gleaned through testing. This is a good time to hand off designs for final implementation.
- It may be unrealistic to iteratively test till ALL issues are resolved, but at the minimum, 2 rounds of testing are suggested.

# Text Usage Guide:

## Question Length:

- The amount of text in both questions/instructions should be no more than 2 lines at the current font size/spacing. The amount of text in answer choices should be as limited as possible (3 lines in multiple-choice questions sketch with text, 5 lines in multiple-choice questions no sketch), and should be a comfortably readable font size\*.
  - In general, less text should be used for content made for children in younger grades (in comparison to content made for older students).
  - Further testing may be needed regarding optimal text length.
  - *\*Font sizes are specified in the style guide. For content length reference, using DEEP Figma templates and guidelines may help.*
- Have no more than 4 answer choices (\*unless the choices are only a single word long), but try to limit the number of answer choices to 3.

## Question Type:

- Instruction



- Do not put two separate instructions on one screen unless necessary.
- If doing the above is necessary for the comprehension of the instruction, use animation to reveal one instruction first and then reveal the second one at the next interaction point (next button).

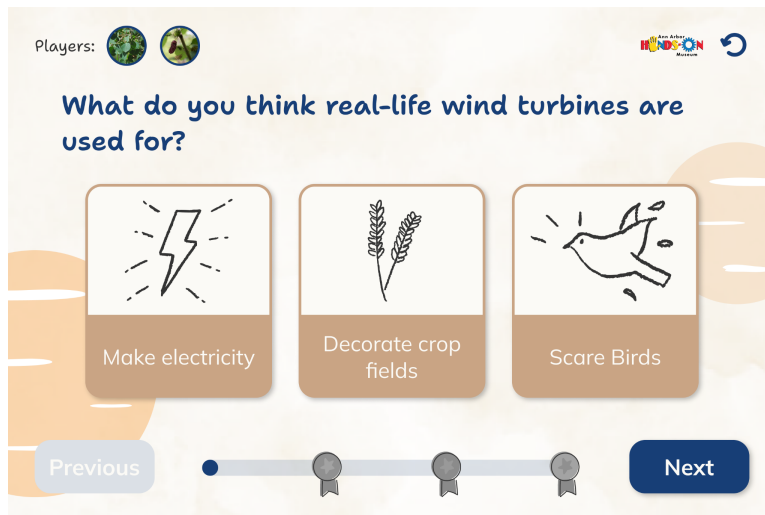
- This helps make sure that students aren't getting too much information at the same time.

- **Multiple Choice Questions - No Sketch, Text Only**



- At most 4 answer choices should be used - try to limit to 3 answer choices whenever possible.

- **Multiple Choice Questions - Sketch with Text**



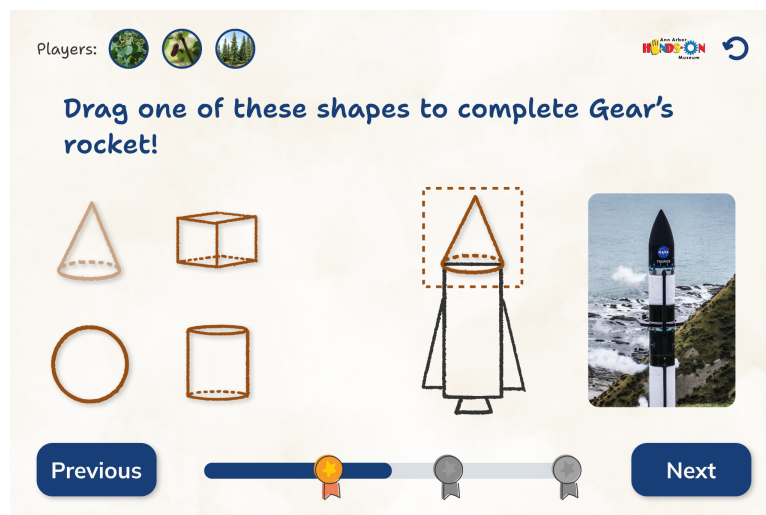
- Use when sketches can simplify or enhance the meaning of the text.
- At most 3 answer choices should be used (4 choices will cause excessive screen clutter).

- **Select All That Apply**



- Use sparingly since this question type can be lengthy and confusing.
  - This question type can be used for students recording observations about the exhibit.
  - Subsequent explanations (if any) should mention all possible answers.
- Each answer choice length should be no more than 1-2 words.
  - There should be no more than 6 answer choices given.

- **Drag and Drop (multiple types)**



- If there is only 1 answer blank\* to fill out, then have the option to tap as well.
- Otherwise, the number of blanks\* to fill should be 3 at most.
- *\*Blank refers to the box where students will drag an answer choice in.*

- Limit using this question type — only use it when it enhances the understanding of a concept (ex. matching ideas, understanding positional concept).
- **Discuss With a Friend**



- Use secondary characters here.
- Try to limit to only 1 of such questions for each exhibit. These questions are often skipped by students and do not appeal to students who are individually interacting with DEEP.
- The question should still encourage simple interaction with the exhibit or open-ended discussion of science concepts.

## Number of Questions:

- Have around 7 questions in a DEEP experience.
  - Tested on 5-9 questions/instructions (excluding explanations):
    - 9 questions are very long - students would get tired and abandon the experience.
    - 5 questions are short but acceptable.
- The optimal number of questions can change based on the particular exhibit.
  - Factors include exhibit popularity and the level and type of interaction necessary with the exhibit.
    - If an exhibit is extremely popular, be cautious that adding lengthy DEEP experiences can cause backups and increase lines.

- If an exhibit is very exciting\*, have fewer questions because most children usually want to interact with exciting exhibits directly rather than an app.
- *\*An exhibit is exciting if it encourages visitors to move around quickly or brings out heightened emotional responses like surprise or laughter.*
- DEEP works best for exhibits where instruction is needed for interaction or enhances the quality of interactions. An example of such an exhibit is the Wind exhibit — DEEP guides students to conduct experiments to understand how airflow can affect the wind turbine's speed.

## Order of Questions:

- Start with an instruction that lets students understand how to interact with the exhibit properly.
- Next, have questions that encourage direct interaction.
- Do not have complex questions in the beginning to reduce the rate of abandonment. Try to have multiple choice questions at the beginning of the experience to ease students into using DEEP.
- Keep questions about conceptual understanding/real-world applications for the end. Ending on a broad note allows for reflection and encourages application in the future
- Keep discussing with a friend questions in the middle. If the question is introduced too early, then students lose interest. If it is placed at the end — students are unlikely to answer.

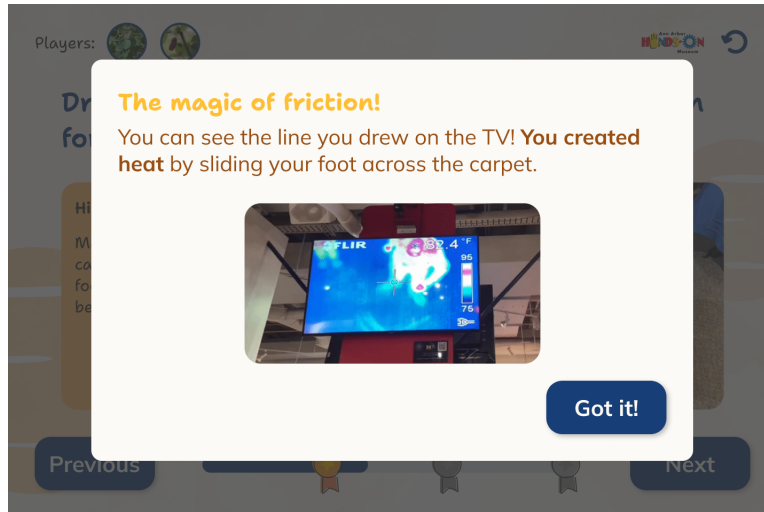
## Hints:

### Hint:

White, red and orange are the hottest areas. Blue, green, and yellow are the coolest.

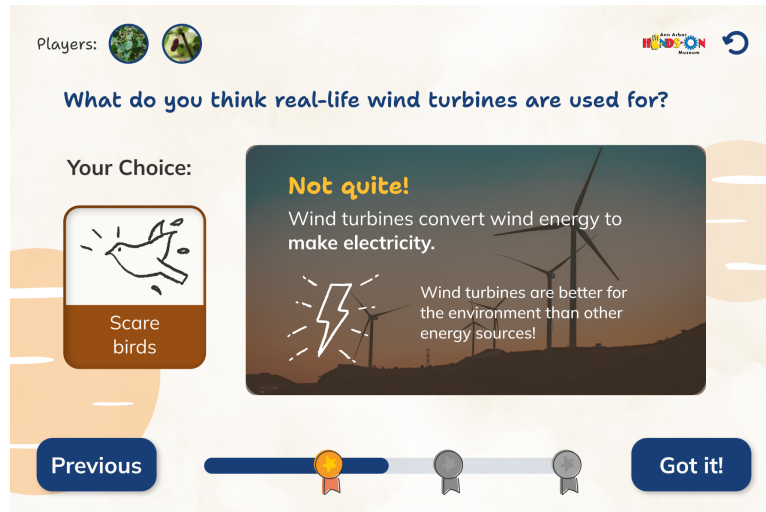
- Screens that require hints:
  - Where supplementary instruction is needed for properly following a task given.
  - Where questions are particularly challenging and require some type of prior knowledge or understanding of the exhibit.

## Overlays:

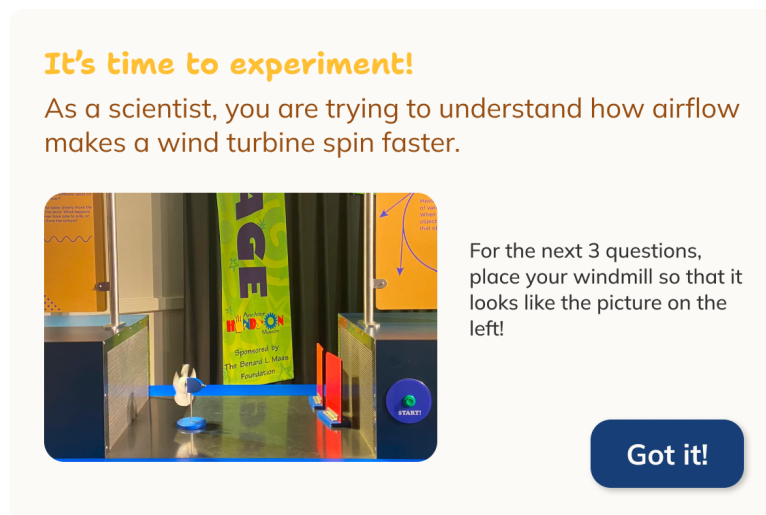


- *\*Do not have consecutive overlays since they can cause confusion.*
- Using overlays for answers or explanations:
  - Keep explanations short, but include more science concepts for older grade content.
  - Include a picture wherever possible:
    - Picture of the exhibit with the right answer (ex: pointing out heat)
    - Character: Gear thinking, cheering, etc.
    - Prioritize text if there is not enough space
  - For questions that have correct answers:
    - If a student gets the question wrong, don't use harsh/absolute language — use constructive language that encourages more interaction with the exhibit.
      - Constructive phrases can include: “Play around one more time”.
      - Try to avoid phrases that indicate the “correctness” of a response — instead focus on explaining the answer.
  - For open-ended questions:

- Encourage further interaction, or leave them with something to think about.
- *\*Test further: presenting the explanation/feedback on the same screen as the question itself to contextualize the answer*



- Other applications:
  - Sets of Questions:



- Some questions are inherently linked (a series) but cannot be combined on one page due to length. A set-up tutorial or explanation may be necessary for such sets of questions.
- EXAMPLE: The *Wind* exhibit has a set of 3 questions framed as an experiment.
- *\*Need to test this redesign.*

# Media Usage Guide:

*\*More specifications regarding media usage are mentioned in the style guide.*

*\*With minor exceptions, characters, sketches, and images should not appear together on the same screen.*

## Graphic Characters:

- *\*Refer to the style guide for character design.*
- Character usage:
  - *There are no strict rules for using the characters. The following are just recommendations. More research and testing need to be done on potential applications of the characters for branding as well as creating a story in DEEP experiences.*
  - Primary character (Gear):
    - Use on any screens that do not have additional graphics.
    - When a milestone is achieved.
    - When giving feedback to the students — ex. a thinking Gear.
  - Secondary characters (Triangle, Square, Circle):
    - When a group activity (e.g. discuss with your friends) is prompted.
      - Gear could be incorporated into the group but only with a clear storyline in which Gear is the protagonist (due to style differences).
- Expression usage:

| Character                           | Action                   | Usage                                                                                                                                  |
|-------------------------------------|--------------------------|----------------------------------------------------------------------------------------------------------------------------------------|
| <b>Gear<br/>(Primary Character)</b> | Regular standing gesture | As Needed                                                                                                                              |
|                                     | Jumping                  | When students achieve a goal/reach a milestone (complete an exhibit, earn a badge, etc.)                                               |
|                                     |                          | When students answer a question right                                                                                                  |
|                                     | Thumb Up                 | When students achieve a goal/reach a milestone (complete an exhibit, earn a badge, etc.)                                               |
|                                     |                          | When students answer a question right                                                                                                  |
|                                     | Reading                  |                                                                                                                                        |
|                                     | Investigating            | When a task is in progress                                                                                                             |
|                                     | Thinking                 | When a question is raised                                                                                                              |
|                                     |                          | With the "try again"/"not quite" prompt                                                                                                |
|                                     | For ALL                  | For storytelling or other purposes as needed                                                                                           |
| <b>Secondary Characters</b>         |                          |                                                                                                                                        |
| <b>Triangle</b>                     | Regular standing gesture | As Needed                                                                                                                              |
| <b>Rectangle</b>                    | Regular standing gesture |                                                                                                                                        |
| <b>Circle</b>                       | Regular standing gesture |                                                                                                                                        |
| Secondary Characters Assembly       | Group Discussion         | As Needed. Recommended for question types prompt for group discussion/interaction. Could incorporate primary character within the set. |

- Future applications:
  - Potential future applications include gifs and short animations for instructions/ storytelling. More gestures and facial expressions for each character can also be created.

## Sketches/Icons:

- How to make sketches:
  - Keep them as simple icons (look at Noun Project for inspiration on simple sketches and icons).
  - Sketch on Notes/any drawing application with the Pencil stroke. The current sketches used are made with the pencil stroke on the native Apple Notes app.
  - Convert into SVG format as it allows for editing shape and changing colors.
- What type of question requires sketches:
  - Multiple choice questions with short answers that can be represented with an icon. Some drag-and-drop questions may also include sketches.
  - Use especially for younger grade/ESL learners content (to accompany short text) since these students might not be able to read options very well.
  - DO NOT use sketches when unnecessary since they take up additional space.
- *\*Further A/B testing should be done regarding when/whether sketches should be used and the amount and type of impact they make on understanding and enjoyment.*

## Images/GIFS/Videos:

- Which screens should have images:
  - Instruction screens that are enhanced by an image (an image increases clarity regarding what the text is conveying).
  - Question screens which are enhanced by an image AND have fewer option choices (to reduce screen clutter).
- What type of images should be used:
  - Pictures of an exhibit:
    - For instructions that require interaction with an exhibit.
    - Could be used as answer choices - different states of the exhibit.
      - Example: The Rocket Fuel exhibit has a drag-and-drop question matching PSI to rocket height.

- Pictures of a person interacting with the exhibit:
  - For instructions that require interaction with an exhibit.
  - As part of an explanation screen that shows how to interact with the exhibit to reach the correct answer.
  - May include a stopwatch or timer for timed interaction.
- Pictures to connect with a real-life concept:
  - Primarily to be used for explanation screens.

# Gamification Overview:

## User Flow:

### 1. Booking a DEEP Field Trip:

- A school books a field trip at AAHOM for a classroom (Grade 3-5). They indicate that they want a DEEP-enhanced experience and the grade level of the students.

### 2. Introducing DEEP on Arrival:

- Upon arrival they get a bundle of beacons with (anonymized) name tags, a class quest, and an individual quest printed on it. The students are given a quick introduction to DEEP and told that as they play with the exhibits, they can answer questions on the tablets at various stations throughout the museum to earn points to fulfill the quest. If they complete the quest, they will receive a reward.

### 3. Interacting with Tablets:

- As students walk near an exhibit's DEEP tablet, their "name" (from name-tag/beacon) will show up. They can answer questions (MCQ, Select All That Apply, Drag and Drop, or instructions on how to interact with the exhibit) and their progress will get recorded automatically.

### 4. Earning Points and Badges:

- The questions are not graded, but points are awarded based on how many questions the students answer. Students can earn a gold, silver, or bronze badge based on their completion of the questions at the exhibit's tablet. Students will get feedback after answering questions indicating whether their answer was right and an explanation.

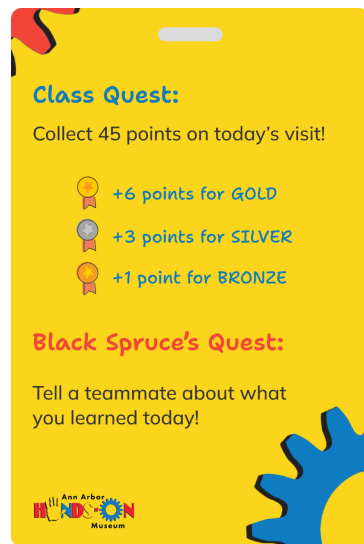
### 5. Summarizing What Was Learned:

- At the end of their visit, students are given a paper summarizing the concepts they learned/answers they gave to show to parents. Teachers are given a digital report of students' interactions and performance with DEEP.

### 6. Offering Rewards:

- If the class completes the quest successfully, they are given a reward such as museum pencils/collectibles or an extra experience (the museum has fun workshops offered as well). A class with the most points may also get a reward given by the school (ex: pizza party) etc.

## Example Student Name Tags:



## Example Modified Reward Screen:

*\*Modified to show total points awarded.*



## Future Ideas for Gamification and Beyond:

*\*These ideas are in no particular order.*

1. At the end of the visit, students can get a title such as “Astronaut”, “Sound Engineer” etc. based on the exhibits that they spent the most time at.
2. The name tags can be uniquely printed for every visit and also be used as a collectible that is given to students to keep.
  - Students could receive a stamp/sticker on the name tag OR on their visit summary to indicate that they completed a quest.
3. Scoreboards can be integrated into tablets or any other screens across the museum to show which class has the highest score. A physical scoreboard at the museum lobby can also be used to show the historically highest-scoring classes to further incentivize DEEP use.
4. DEEP progress can be tracked across visits, incentivizing students to come back to the museum with parents to earn more points and potential rewards.
  - There can be additional optional quests given to students that they can come back and complete for rewards etc.
5. The tablet stations themselves can be designed in a manner consistent with gamification — they can include the characters (Gear, Triangle, Square, Circle) or other physical iconography such as badges to encourage students to approach the tablets.
6. DEEP interface can be customized by the exhibit — background images, animations, etc. can be made to be unique to the exhibit’s content.
  - Confetti animations (maybe sound effects) can be added to the ending sequence of screens.
7. Students can create their personal profile avatars.
8. Exhibits can communicate with DEEP tablets to directly record interaction data.