Building Awareness about Sea Urchins at the Noyo Center for Marine Science

Seeing Scientifically 2.0 (Phase 3) Formative Evaluation

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THIS IS **NOT** A DEFINITIVE FINAL REPORT

FORMATIVE evaluation studies like this one often:

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

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

SUMMARY

In this report, I discuss findings from a formative evaluation of an interactive microscopy exhibit, *The Rise of the Urchins*, located at the Noyo Center for Marine Science in Fort Bragg, California. The exhibit features larval urchins under a microscope slide and an object-detection artificial intelligence (AI) that identifies different stages of larval urchin development and parts of their anatomy. Here, I provide findings about visitors' awareness and feelings about sea urchins before and after they used the exhibit, and discuss visitors' responses to a structured interview about their background knowledge, what they found interesting at the exhibit, and questions they had about urchins after using the exhibit. Lastly, I provide considerations for next steps for potential future iterations of the exhibit.

Key findings

Prior to exhibit use

- Most visitors demonstrated some prior familiarity with sea urchins
- Visitors expressed both positive and negative feelings about sea urchin, but mostly positive
- Visitors had a high degree of relevant background that may have helped them better understand what they saw at the exhibit

After using the exhibit

- Visitors' awareness about urchins' development increased
- Visitors' positive feelings towards urchins increased
- A small subset of visitors reported increased negative feelings, specifically about the harm urchin can have on their environment
- Visitors rated the exhibit highly, and expressed that the unexpected aspects of urchins' development were especially interesting
- Visitors generated numerous questions about sea urchin, especially regarding urchins'
    - developmental traits and processes
    - life cycle beyond the larval stages
    - ecological roles, both beneficial and detrimental

BACKGROUND

Seeing Scientifically 2.0 is an NSF-funded, *Innovations in Development* project to better understand how to engage and scaffold informal learners in scientific observation of live, microscopic specimens. In collaboration with our technical partner, the Fletcher Laboratory at UC Berkeley, and two other Informal Science Environments (ISEs): BioBus in Harlem, New York, and the Noyo Center for Marine Science in Fort Bragg, California, the Exploratorium created and studied a new microscope exhibit platform that uses imaging technologies to spark and support visitors' investigations of the dynamic, living

microcosm. The platform was developed to work across different contexts, content, and audiences in an effort to 'democratize' advanced imaging technologies in microscopy.

In this third and final phase, the *Seeing Scientifically* team developed prototypes that feature different organisms across the three ISEs: The Exploratorium, BioBus, and the Noyo Center for Marine Science. This evaluation focuses on the Noyo Center's prototype. The exhibit, *The Rise of Urchins*, is located at the Noyo Center for Marine Science's Discovery Center (Figure 1) in Fort Bragg, California. The Noyo Center is a small nature center with three locations spread throughout Fort Bragg. Its Discovery Center is located in the center of town and contains a small storefront and a paid exhibit space. The exhibit space features marine specimens for visitors to view and interact with, including mammal skeletons and pelts, as well as a few microscope exhibits. *The Rise of Urchins* adds an interactive microscope exhibit to the Center's exhibit collection.

PURPOSE

This evaluation was conducted to answer the following questions:

- Before using the exhibit, what do visitors know about sea urchins?
- How does engaging with an AI-supported microscopy exhibit change visitor awareness of
    - Purple sea urchins' development, metamorphosis, larval anatomy, and reproduction
    - Urchin's importance within the marine ecosystem
    - Urchins' role in large-scale environmental change
- How does engaging with the exhibit affect visitor's affective relationship with sea urchins?

EXHIBIT DESCRIPTION

The Rise of Urchins seeks to increase visitor awareness of sea urchins through microscopic observation, supported by AI object detection. The exhibit features a large touchscreen and a microscope to the right (Figure 2). The image from the microscope slide is shown on the screen, where the visitor can engage with interactive prompts that scaffold information about planktonic forms of sea urchin, focusing on their development from one form to another and anatomical parts visible in each form.

Figure 3 shows the interaction flow of the exhibit. At the start, the AI identifies urchin planktonic forms by their age (a). On the next screen, the AI introduces these planktonic forms by name—blastula, gastrula, and plutei—as well as some of their body parts (b). From there, the visitor can choose which larval form to explore further—blastula (c), gastrula (d), or plutei (e)—or watch a time-lapse video of urchins transforming from a fertilized egg to adult (f). Each of the three larval screens include prompts with information about each larval stage and questions to help guide visitors' attention and foster their curiosity about young urchins. Visitors can navigate deeper into each larval stage. From the blastula and gastrula screens, they can access images of blastula and gastrula anatomy (g and h, respectively). From

the plutei screen (e) visitors can watch a video of how plutei excrete waste (i), see an image of their arm development (j), watch a video of how they eat (k), or learn about urchins' metamorphosis after the plutei stage (l). From the metamorphosis screen (l), visitors can also access the time-lapse video of sea urchin growth (f). Additionally, visitors can switch between lighting conditions—brightfield and darkfield—and they can interact with the microscope by turning a knob that moves the slide from side to side, providing interactive elements beyond the on-screen interactivity.



Figure 1. *The Rise of Urchins* (left) at the Noyo Center for Marine Science's Discovery Center.

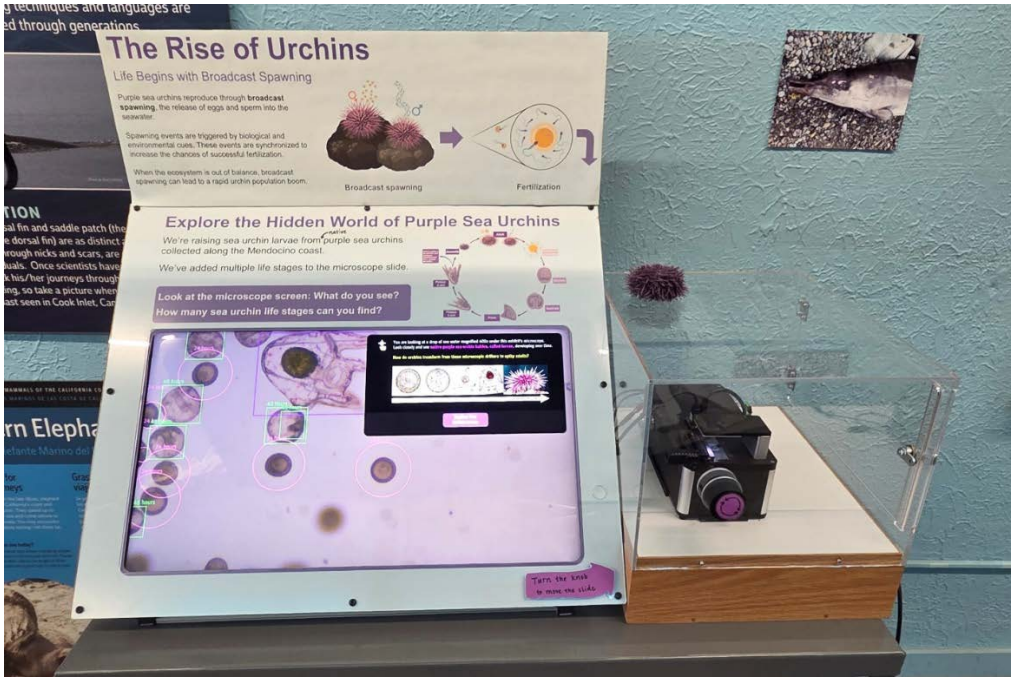


Figure 2. Close-up of *The Rise of Urchins.*

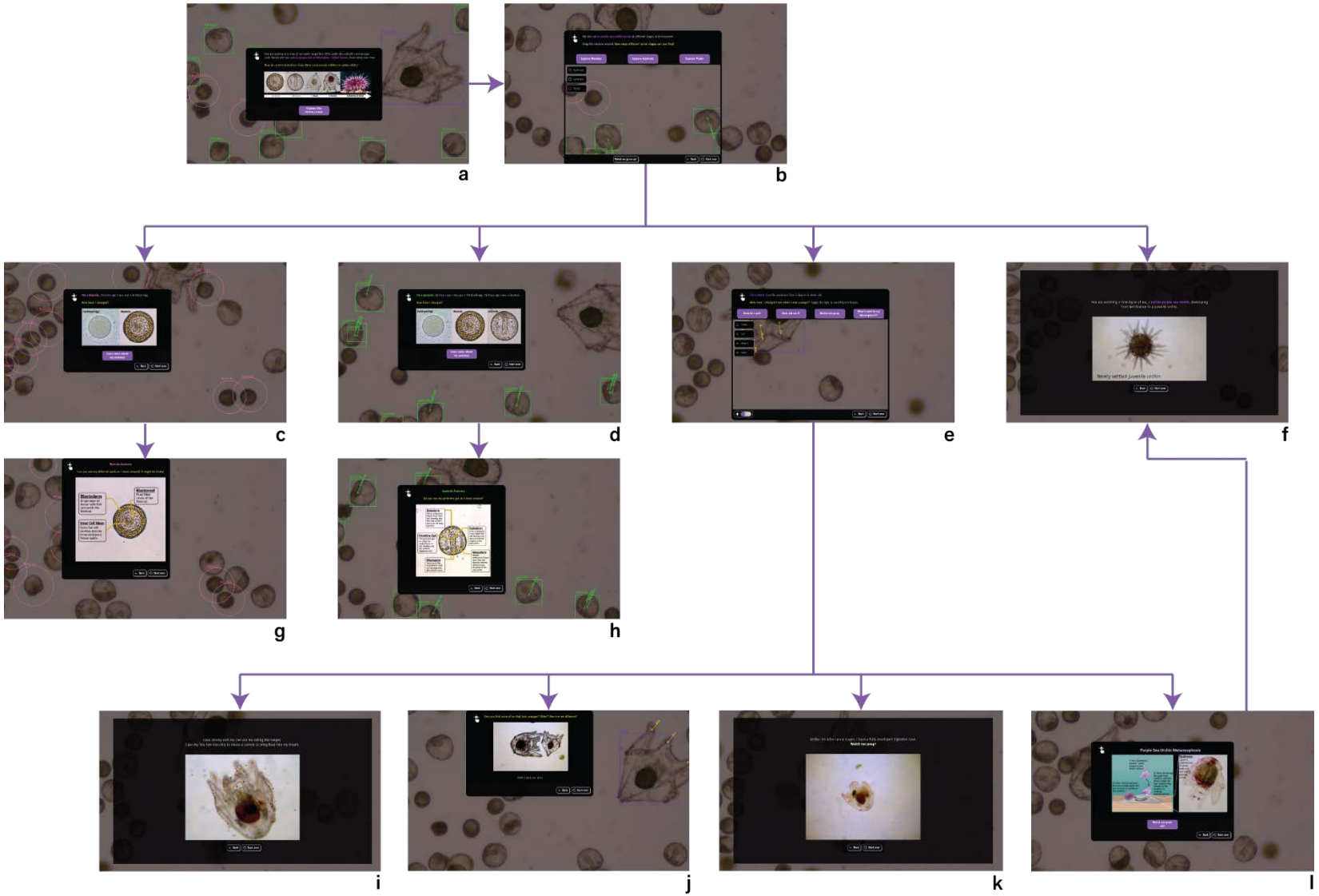


Figure 3. Exhibit interaction flow: (a) larval stages identified by age, (b) larval stages identified by name, (c) blastula screen, (d) gastrula screen, (e) plutei screen, (f) time-lapse video, (g) blastula anatomy, (h) gastrula anatomy, (i) video of plutei excreting waste, (j) plutei arm development, (k) video of plutei eating, (l) metamorphosis from plutei to adult.

METHODS

Data collection took place Thursdays–Saturdays between October 3–November 28, 2025. An evaluator approached every third adult visitor who crossed from the store into the paid museum space (Figure 4) and asked them if they would be willing to try a new exhibit and give feedback. Participants could be individuals or dyads, and to qualify they had to be at least eight years old or older and fluent in English. Minors also had to have an adult's verbal consent.

Before visitors began to use the exhibit, the evaluator asked the participants to sit next to the exhibit (Figure 5), rather than in front of it, to create a concept map of everything they knew about sea urchins and, separately, to list what they liked and disliked about sea urchin, in an affect list. See Figure 6 and Figure 7 for examples of a concept map and an affect list, respectively. Visitors then had a chance to use the exhibit for as long as they liked. When done, the evaluator followed up with a semi-structured interview about the visitors' experience using the exhibit, starting with asking the visitors to make any changes they wanted to their concept map and their affect list. See Appendix A for more information about the recruitment and interview process. I qualitatively coded visitors' pre- and post-exhibit concept maps, pre- and post-use affect lists, and interview responses. In addition, I performed statistical analyses on visitors' concept maps and affect lists to assess shifts from pre- to post-exhibit use.



Figure 4. View of the threshold (green line) from the store into the museum space. Participants had to cross into the museum space in order to be recruited.



Figure 5. Example of a mock visitor interview taking place next to the exhibit. Here, the mock visitor is creating a concept map with the help of the mock evaluator.

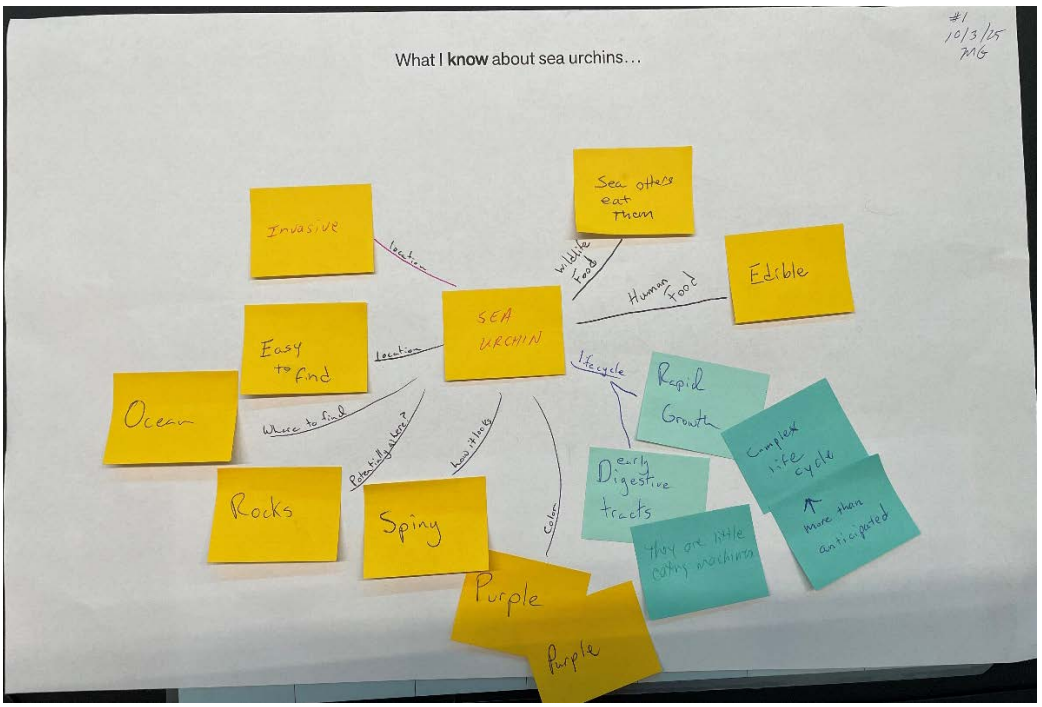


Figure 6. Example of a concept map.

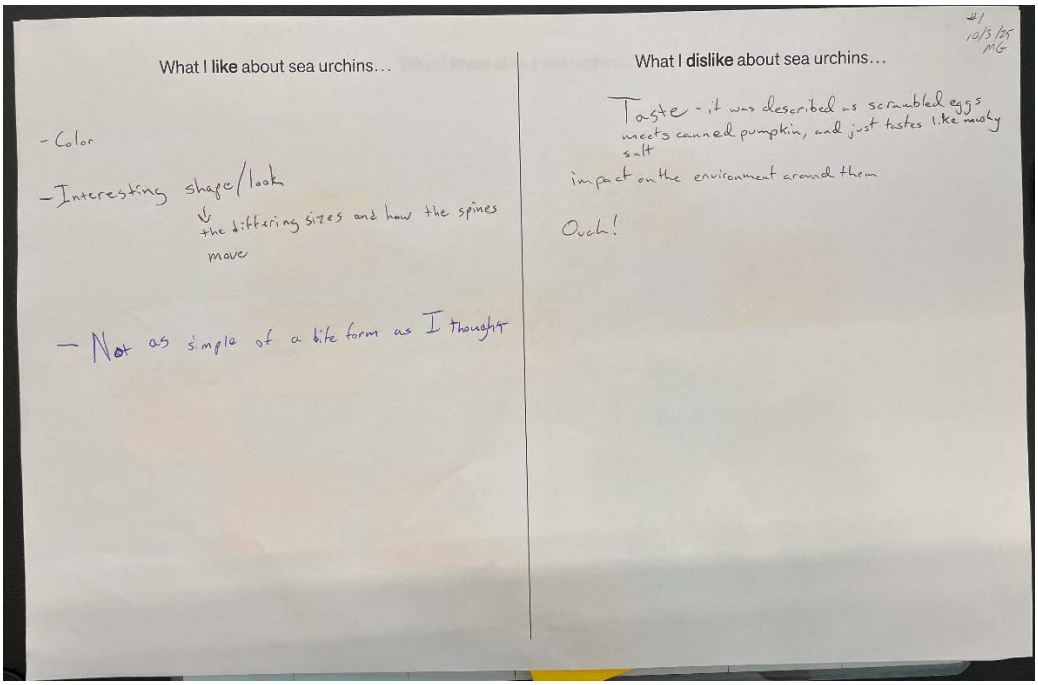


Figure 7. Example of an affect list.

DATA COLLECTED

Evaluators conducted 37 interviews, of which $n = 36$ are included in the analysis. One visitor group experienced technical glitches with the exhibit screen, enough to compromise their exhibit experience; so, their data is not included in this analysis. Of the 36 groups, 12 were individual visitors and 24 were dyads. The majority of visitor groups consisted only of adults. See Table 1 for the breakdown of group composition.

Table 1. Visitor group composition.

Group Type	Count	Percentage
Adult(s) only	28	78%
Minor(s) only	3	8%
Multigenerational	5	14%

To gauge visitors' prior experience, evaluators asked them when they had last used a microscope, if ever, and if they had any relevant interests or experience that might have helped them understand what they saw at the exhibit. Because the unit of analysis is the group rather than the individual, when members of a dyad provided different responses, I used the highest-order response within the pair. In other words, I classified the group based on the most recent microscope use and the most salient form of relevant experience reported by either member. The results are shown in Table 2 and Table 3, respectively, in order of highest to lowest order.

Most visitor groups (33 out of 36) had used a microscope at least once before. Likewise, most visitor groups (29 out of 37) said they had some relevant experience that helped them make sense of what they saw at the exhibit. Interestingly, 22% of visitor groups (8 out of 36) expressed living close to the ocean, including habitually exploring tidepools or going SCUBA diving; two of those visitors specifically mentioned being ReefCheck divers, volunteers who monitor reefs around the world. This suggests these eight visitors may have a close relationship with the ocean ecosystem.

Table 2. Visitors' most recent microscope use.

Last microscope use	Count	Percentage (out of 36)
Within the past year	12	33%
1-5 years ago	12	33%
More than 5 years ago	9	25%
Never	3	8%

Table 3. Visitors' relevant past experience.

Relevant interest or background	Count	Percentage (out of 36)
Job	4	11%
Education	6	17%
Hobbies or interests	11	31%
Other	1	3%
None	7	19%

FINDINGS

Their exhibit experience

Holding Time

Visitors' average holding time at the exhibit was 5 minutes and 33 seconds. However, because participant recruitment was cued, visitors likely used the exhibit longer than they might have on their own. See Figure 8 for visitors' holding time.

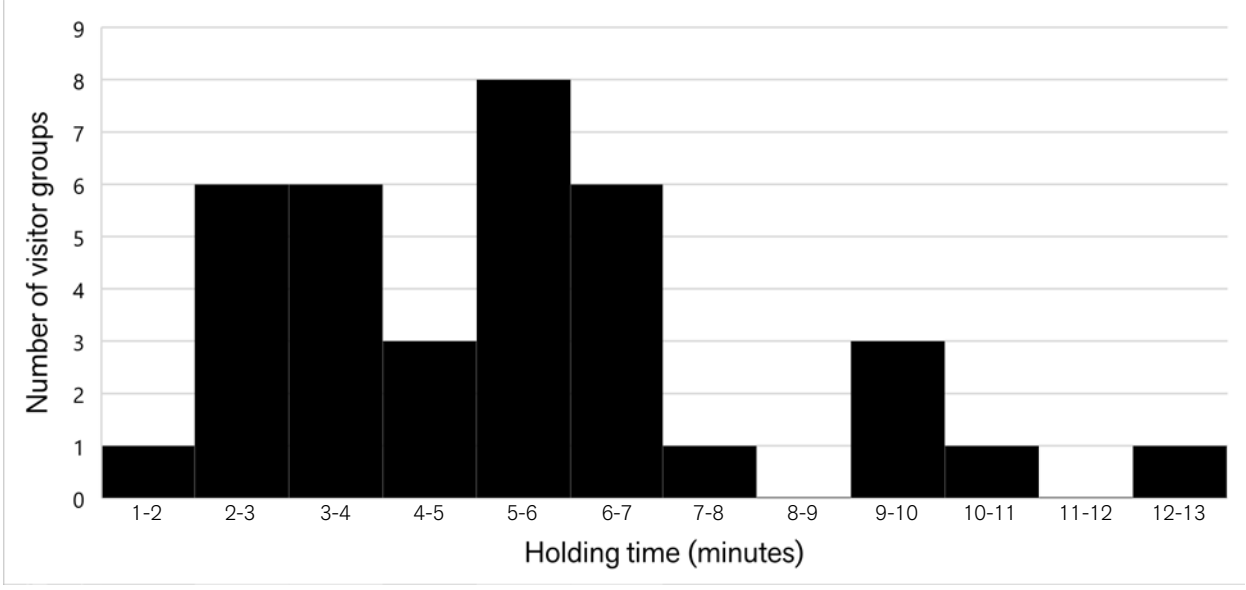


Figure 8. Visitors' holding times at *The Rise of Urchins*.

Before their exhibit experience

Baseline Sea Urchin Knowledge

To get a sense of visitors' baseline knowledge of sea urchins, evaluators asked each group to create a concept map of everything they knew about sea urchins before using the exhibit. Visitors' concepts fell into one or more of these categories: urchins' developmental traits, larval urchin anatomy, other facts and opinions and urchin not related to development or larval anatomy, and misconceptions about urchin.

Most of what visitors included on their pre-use concept maps was a fact or opinion about urchin, not about their development or larval anatomy. In fact, 94% of visitor groups (or 34 out of 36) included at least one fact or opinion about sea urchins, primarily that they have spines (72% of visitors, or 26 out of 36), are edible to humans (61%, or 22 out of 36), are important to the marine food chain (36%, or 13 out of 36), are purple (33%, or 12 out of 36), can be harmful to the marine ecosystem (28%, or 10 out of 36), and can hurt humans if handled incorrectly (25%, or 9 out of 36). This suggests that **most visitors have prior awareness about sea urchins**.

Some visitors also added concepts about urchin development (17%, or 6 out of 36) and their larval anatomy (6%, or 2 out of 36), two topics which are the focus of the exhibit. This suggests that **few visitors had prior knowledge about urchin development and larval anatomy**.

Additionally, 39% of visitor groups (14 out of 36) included misconceptions about purple sea urchins on their concept maps, mainly incorrect assumptions that they are venomous or invasive to northern California. While visitors already have some prior factual knowledge about sea urchins, there are still plenty of visitors who **mistakenly believe incorrect information about them**.

Baseline Affect

To understand how visitors feel about urchin, evaluators also asked each group to create affect lists (i.e. their likes and dislikes) about sea urchins. Before using the exhibit, 97% of visitor groups (35 out of 36) listed at least one thing they liked about sea urchins and 86% of visitor groups (31 out of 36) listed aspects about sea urchins that they did not like. This suggests that **most visitors arrived at the exhibit already holding some positive and negative feelings about sea urchin, but mostly positive**.

After their exhibit experience

Sea urchin knowledge – what changed

After visitors had a chance to use the exhibit, evaluators asked them to revisit their concept maps and make any edits they wished. Evaluators let visitors know they were allowed to make changes or additions. However, visitors only added to their concept maps. None of the visitor groups removed anything from their pre-exhibit concept maps, nor did they change how their concept maps were organized.

The most notable changes to visitors' concept maps pre- and post-exhibit use reflect their awareness about sea urchin's development and their larval anatomy. See Table 4 for a detailed breakdown of how specific sub-concepts contributed to these changes between pre- and post-use concept maps and examples of such sub-concepts.

Because of the formative nature of this evaluation and its small sample size, the statistical tests reported below are intended to provide a quantitative description of observed changes rather than definitive causal inference. Results should be interpreted in light of the study's design limitations, including the absence of a control condition and the small number of visitor groups. Additionally, because the concept categories were not mutually exclusive (i.e. visitor groups could show increases in more than one category simultaneously), the tests are not independent. To account for multiple correlated tests, I adjusted p-values using the Holm correction, which controls the family-wise error rate and is valid under dependent testing conditions.

A two-sided exact binomial test indicated a significant change in visitors' use of concepts about sea urchin development after interacting with the exhibit. Overall, 83% of visitor groups (30 out of 36) added or expanded on urchin development concepts in their post-exhibit concept maps, exceeding the 50% expected under no directional change, $p < .001$ (Holm-adjusted), 95% CI [0.67, 0.94]. Among these, 24 visitor groups had not included any related concepts about urchin development prior to using the exhibit, suggesting that most increases reflected the introduction of new ideas (i.e. visitors who did not add a particular concept in their pre-use concept maps, but did on their post-use maps) rather than elaboration on existing knowledge (i.e. visitors who added a particular concept on their pre-use maps and added more related concepts in their post-use maps). Together, these findings suggest that **using the exhibit was associated with increased awareness of urchin development**, although results should be interpreted in light of the study's limited sample size.

Conversely, a two-sided exact binomial test indicated insufficient evidence of a change in visitors' use of urchin anatomy concepts after using the exhibit. Only 39% of visitor groups (14 out of 36) included concepts about urchin anatomy on their post-exhibit concept maps, which did not differ from the null expectation of 50%, $p = .24$ (Holm-adjusted), 95% CI [0.23, 0.57]. Notably, 13 of these 14 visitor groups had not included any urchin anatomy concepts on their pre-use concept maps, indicating that most increases reflected the introduction of new concepts rather than elaboration on prior knowledge. These findings suggest that while baseline awareness of urchin anatomy was low, **there was insufficient evidence to conclude that the exhibit use was associated with a change in visitors' awareness of larval urchin anatomy**.

In addition, a two-sided exact binomial test indicated insufficient evidence of a statistically significant change in visitors' use of such facts and opinions unrelated to urchin development or larval anatomy after using the exhibit. Only 31% of visitor groups (11 out of 36) included such facts or opinions on their post-use concept maps, which did not differ from the null expectation of 50%, $p = .06$ (Holm-adjusted), 95% CI [0.16, 0.48]. Even so, 10 of these 11 visitor groups had not included any such facts and opinions on their pre-use concept maps, indicating that most post-use increases reflected the introduction of new concepts rather than elaboration on prior knowledge. These findings suggest that **there was insufficient evidence to conclude that the exhibit was associated with a change in visitors' inclusion of facts and opinions unrelated to urchins' development and larval anatomy**; however, the pattern may warrant further investigation with a larger sample.

No visitor groups added misconceptions to their post-use concept maps, so I did not perform statistical analyses. This suggests that **using the exhibit did not increase visitors' incorrect beliefs about sea urchins**.

Table 4. Number of visitors who mentioned concepts and sub-concepts about urchins in their pre- and post-use concept maps, including percent increases from pre- to post-use maps, and examples of sub-concepts. Differences from pre to post only reflect new additions of sub-concepts and do not capture visitors' further elaborations on concepts included in the pre-use maps. Bolded quotes are especially illustrative or representative examples of visitors' responses.

Developmental traits	**Pre**	**Post**	**% ↑**	**Visitor**	**Quote**
	6	**30**	**67%**		
Urchins undergo metamorphosis	3	19	44%	G03: G11: G18: G26:	have **multiple life stages** different developmental forms three stages of life **they go through metamorphosis**
Urchins reproduce via broadcast spawning	2	12	28%	G03: G26: G27: G31:	mass spawning **broadcast spawning** rapid breeders via the water **eggs and sperm are released into water separately**
Urchins have a larval stage	0	7	19%	G07: G20:	larval stage they are one of the only **larvae that poop**
Young urchins grow rapidly	1	7	17%	G04: G33:	they **grow at a fast rate** in the later stages they grow rapidly
Sequence of developmental stages	0	5	14%	G11: G19: G29:	**blastocyst, gastrocyst, plutei** 24 hrs → 48 hrs → 6 months the **development from egg to 8 legs prism**
Mention of development without additional context	0	4	11%	G01:	**complex life cycle**
Larval urchins are microscopic	0	2	6%	G20: G36:	they are **really small** microscopic
Larval urchins are abundant	3	4	3%	G24: G29:	in a drop there's **a lot of baby sea urchins** abundant
Urchins have a planktonic stage	0	1	3%	G04:	**starts life floating in water**
Larval anatomy	**Pre**	**Post**	**% ↑**	**Visitor**	**Quote**
	2	**14**	**33%**		
Mention of at least one plutei anatomical part or function	2	11	25%	G03: G04: G20: G29:	pluteus with 8 [arms] start developing pigment; **rudiment before metamorphosis** **have mouth, gut, and anuses**; cilia to bring in food; progressively grow legs/arms they are one of the only larvae that poop attachment to sea floor
Mention of gastrula's primitive gut	0	5	14%	G01: G03:	**early digestive tracts** gastrula = making of the gut
Mention of plutei arms as an age marker	0	3	8%	G33: G35:	**can tell how old by arms** plutei age can be determined by number of arms

Other facts and opinions	Pre	Post	% ↑	Visitor	Quote
	34	35	3%		
Urchins can harm the ecosystem	10	13	8%	G02: G08: G13: G27:	**misbalanced**; eating too much kelp **purple over populated**; damaging environment eat kelp fast; destructive; **now understand how they destroy kelp forest** not enough predators North of SF Bay; voracious eater of kelp
Urchins live on the sea floor	2	4	6%	G12: G28:	**stay on sea floor** live on bottom
Urchins have spines	26	27	3%	G01: G13: G19: G34:	**spiny** long spikes **spines; prickly** black spiky balls
Urchins are purple	12	13	3%	G10: G19:	**purple** purple; colorful
Urchins are edible / taste good	22	22	0%	G02: G10: G25: G35:	**tasted good** uni; iron-y **edible** human food source
Urchin are important to the food chain	13	13	0%	G04: G27: G34:	**eat kelp**; eat micro algae **food for some starfish** **otters eat them**
Urchins are painful to humans	9	9	0%	G07: G27:	**ouch** urchins hurt when I step on them
Urchins are beautiful	2	2	0%	G25:	**beauty of the ocean**
Urchins are a native species	2	2	0%	G03:	**different species in CA: red, purple, crowned, starry**
Urchins are invertebrates	2	2	0%	G16:	**invertebrate**
Urchins are useful to humans	1	1	0%	G03:	**used for making marble**; their spines can be used to make dye
Urchins are ugly	1	1	0%	G12:	**not pretty**
Misconceptions about purple urchin	**Pre**	**Post**	**% ↑**	**Visitor**	**Quote**
	14	**14**	**0%**		
Urchins are venomous	12	12	0%	G10: G20: G30:	deadly; **step on spike=dead** **poisonous** stinging
Urchin are an invasive species	6	6	0%	G:21	**invasive**

Visitors' feelings about sea urchin – what changed

Visitors' likes

After visitors edited their post-use concepts maps, evaluators asked them to revisit their affect lists. Evaluators let visitors know they were allowed to make changes or additions, but visitors only added to their lists. No visitor groups removed anything from their pre-exhibit affect lists.

After using the exhibit, 78% of visitor groups (28 out of 36) listed additional aspects they liked about sea urchins, including one group who did not list any likes before using the exhibit. A Wilcoxon signed-rank test indicated that visitors expressed statistically significantly more positive statements after interacting with the exhibit, $V = 0, Z = 5.07, p < .001$, with a large effect size (rank-biserial correlation = .85). This suggests that **visitors' positive affect toward sea urchins increased after using the exhibit**. See Table 5 for aspects about sea urchins that visitors said they liked, percent increases from pre- to post-exhibit use, and examples of what visitors said.

Table 5. Aspects of sea urchin that visitors stated they like and example visitor quotes. Percentage increases reflect the proportion of positive statements visitors included in their post-exhibit affect lists. Bolded quotes are especially illustrative or representative.

What visitors like about sea urchins	Pre 35	Post 36	% ↑ 3%	Visitor	Quote
Developmental process	2	20	50%	G07:	the journey they take to get to a noticeable size
				G21:	I like that they have a **complex life cycle**
				G27:	very **cool that they metamorph**
				G29:	how their development resembles other living organisms
				G33:	**I like their arms** during the growth process
They are generally interesting	20	33	36%	G01:	**not as simple of a life form as I thought**
				G11:	unique
				G18:	they are **mysterious**
				G22:	fun to watch swim around
Beauty or appearance, other than color	24	29	14%	G03:	fun looking; almost **alien-like**
				G11:	interesting shapes
				G16:	unique look
				G22:	**cute as little blobs**
				G27:	they are **beautiful**
Resilience	4	7	8%	G04:	admire their **adaptability**
				G19:	hope they thrive/**resilient**
				G24:	**a lot of offspring** is impressive to me
Role in the environment	17	19	6%	G03:	**helpful in coral reef ecosystems**
				G07:	**essential** to kelp ecosystem
				G09:	**helps clean the ocean**; home to other species
				G19:	chain of life (part of it)
Color	16	18	6%	G11:	**bright colors**
				G14:	they are colorful
				G20:	they are **purple**

What visitors like about sea urchins	Pre	Post	% ↑	Visitor	Quote
Flavor	6	7	3%	G05:	tasty (sometimes)
				G32:	flavor - yum!; **delicious**
Purpose	6	6	0%	G07:	**many use for urchin (marble, food, jewelry, doorstop, fertilizer)**
				G16:	dried urchins as decor
Spines	5	5	0%	G01:	**how the spines move**
				G13:	how they are able to protect themselves
				G26:	**weren't as sharp as I expected** (when held)

Visitors' dislikes

After using the exhibit, 17% of visitor groups (6 out of 36) added aspects that they disliked about sea urchin, including one group who had not listed any dislikes before using the exhibit. All six of these visitors listed dislikes about the impact that urchin can have on marine environments; one of them also listed disliking urchins' spines. A Wilcoxon signed-rank test indicated a **significant change in the number of negative statements that visitors expressed after interacting with the exhibit**, $V = 0$, $Z = 2.45$, $p = .03$, with a moderate effect size (rank-biserial correlation = .41). However, this change was **driven by a small subset of visitors and was limited to concerns about the ecological impact of sea urchins**. See Table 6 for aspects about sea urchins that visitors said they disliked, percent increases from pre- to post-exhibit use, and examples of what visitors said.

Table 6. Examples of sea urchin aspects that visitors stated they dislike. Percentage increases reflect the proportion of negative statements visitors included in their post-exhibit affect lists. Bolded quotes are especially illustrative or representative.

What visitors dislike about sea urchins	Pre 31	Post 32	% ↑ 3%	Visitor	Quote
Environmental impact	30	36	17%	G04:	**they are not beneficial** to anything except urchinite
				G07:	**too resilient** in current context; out of control
				G09:	invasive in some areas
				G19:	**taking food from other creatures**
				G27:	devastate areas when no predators present; **breed like aliens**
				G29:	don't like their appetite for kelp; maybe like a pest
Spines	23	24	3%	G03:	being poked by sea urchin spines; **wetsuit destruction**
				G13:	**sharp** when you step on them
				G20:	**pain**; you can't hold them
Flavor or smell	8	8	0%	G15:	meat inside **too slimy**
				G22:	the thought of eating them
				G32:	**smell**
Toxicity	3	3	0%	G18:	they **can be dangerous**
				G26:	**poisonous**
Appearance	1	1	0%	G18:	they **have no face**

Feedback on the exhibit experience

To gauge visitor interest in the exhibit, evaluators asked groups to rate how interesting they found it. Since the unit of analysis is the group rather than the individual, I averaged dyad's interest ratings to produce a single score. **Most visitor groups rated the exhibit positively, with an average interest rating of 5.9 on a 7-point scale**: 1 being "not at all interesting" and 7 being "completely interesting." See Figure 9 for visitors' interest ratings.

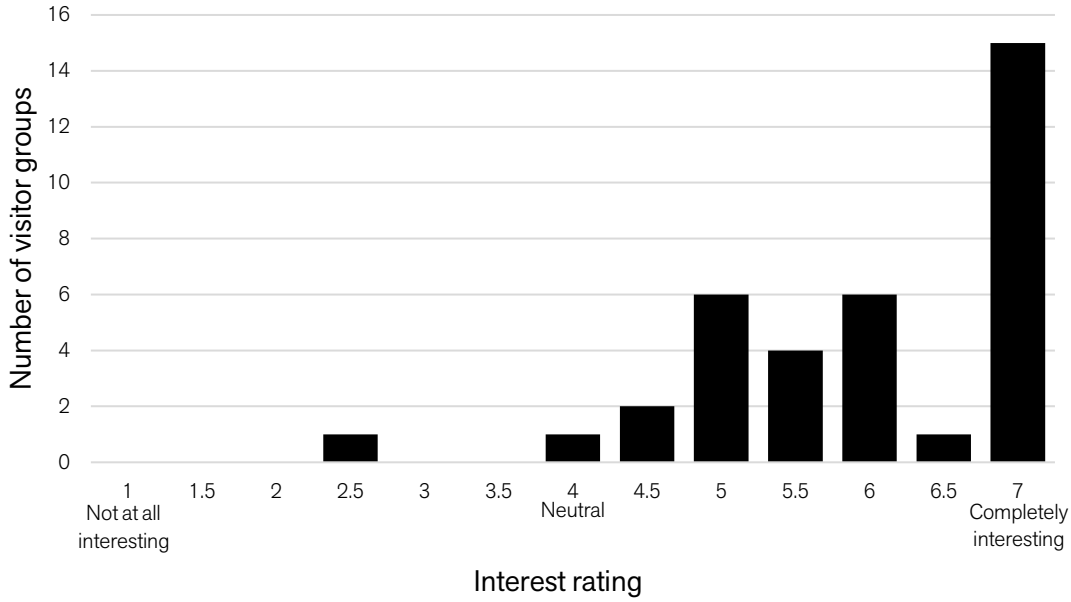


Figure 9. Visitor groups' interest rating. Dyad's ratings were averaged together to produce a single rating per dyad.

What visitors found interesting

To understand what aspects of the exhibit visitors found interesting, evaluators asked them to elaborate on why they gave a particular interest rating. Most visitor groups (30 out of 36) said **they appreciated exploring urchins' life cycle**. Of those, 18 mentioned at least one other aspect of sea urchins that they found interesting. See Table 7 for a breakdown of what visitors found interesting about sea urchins and example visitor quotes.

Table 7. Example quotes from visitors on aspects about urchins that they found interesting. Bolded quotes are especially illustrative or representative examples of visitors' responses.

Visitor	Quote
Urchins' life cycle (83%, or 30 out of 36 visitors)	
G01:	I like that we could see them from beginning to end.
G02:	Seeing the life-cycle and seeing how you guys do it, I think is really cool.
G05:	**I've heard this life cycle before, but this made me understand the life cycle better.**
G06:	I couldn't find the 6-7 week one, but seeing all the others was very [. . .] fascinating.
G12:	**I didn't realize the life cycle had so many stages... seems like there were 8-10.**
G15:	**The rapid growth, the activity 24-28 hours.** [. . .] **Some are still floppy at 6 months.**
G19:	Amazing for it to take 6 months for it to become an adult it seemed like it was a long time for a sea urchin.
G22:	**Being able to see the different stages is not something you can see in the ocean**
G25:	Learning more about sea urchins from those stages... fertilization almost to adult... 6-7 life stages.
G29:	Went through all the stages, and gave me an understanding of what it takes to develop.
G36:	The different stages is wild - the 24 hours, 48 hours etc.
Urchins' body parts or bodily functions (17%, or 6 out of 36 visitors)	
Visitor	Quote
G19:	Seeing the tube feet
G21:	**You don't see them eating, pooping [in nature] and here you see all of that.**
G26:	**The way they eat algae is also interesting.**
G31:	Liked how it identified arms, mouth
Larval urchins' small size (11%, or 4 out of 36 visitors)	
Visitor	Quote
G20:	**Didn't know they were microscopic, larval.**
G26:	Concerned that if I swallow sea water, there's stuff in it
G36:	**I had no idea they were so small.**
How pleasing it is to look at larval urchins (8%, or 3 out of 36 visitors)	
Visitor	Quote
G01:	I liked the movement of it.
G29:	**I liked it, and it was beautiful and fun.**
That urchins undergo metamorphosis (8%, or 3 out of 36 visitors)	
Visitor	Quote
G03:	**I did not know there was a rudiment or metamorphosis for sea urchins.**
G34:	It was kind of interesting to [. . .] watch the cells change.
Urchins' broadcast spawning (8%, or 3 out of 36 visitors)	
Visitor	Quote
G19:	Liked learning about broadcast spawning.
G26:	**The broadcast spawning was the most fascinating part.**

Some visitor groups (23 out of 36) also mentioned aspects of the exhibit design they found interesting. Of those, 13 liked the interactivity of the exhibit, including the knob used to move the microscope slide from side to side. Some visitor groups (9 out of 36) said they liked seeing the AI identify the urchins' larval stages and anatomy. Some (8 out of 36) said they appreciated seeing live specimens. See Table 8 for aspects of the exhibit that visitors found interesting and example visitor quotes.

Table 8. Example quotes from visitors on what they found interesting about the exhibit. Bolded quotes are especially illustrative or representative examples of visitors' responses.

Visitor	Quote
The interactivity of the exhibit experience, including the knob (36%, or 13 out of 36 visitors)	
G02:	**I liked how you could move the slide around**
G17:	The interactions with the slide. What's on the slide on the plate and stuff.
G19:	The exhibit was colorful and interactive
G26:	**I like that it was hands on.**
G32:	**I like that it's more interactive - you can move things around on the screen.**
Exhibit was informative or educational (31%, or 11 out of 36 visitors)	
Visitor	Quote
G07:	I liked being able to let my eyes wander and pick up new information.
G30:	Very informative and entertaining.
G32:	**I learned things I didn't know.**
G33:	Liked how clear [. . .] straightforward labeling. Liked how you could expand to learn more.
G35:	**The depth of information makes it easy to understand.**
The way AI identified urchin life stages & anatomy (25%, or 9 out of 36 visitors)	
Visitor	Quote
G05:	Having AI identify body parts was very, very cool.
G07:	I liked seeing the effort put into seeing the labeling boxes that show the part. **The effect with the machine learning classification. It made me feel that I was in the world of a scientist.**
G24:	AI tagging them was very cool. That was more impressive. That feature was like a 6 rating.
G26:	I like the life stage detector... feature. That was pretty cool... instead of just looking at a picture.
Getting to see live specimens in real-time (22%, or 8 out of 36 visitors)	
Visitor	Quote
G03:	I appreciated seeing live urchin specimens vs pictures.
G05:	The aspect of looking at a live feed containing all the examples was very, very cool.
G24:	**I like that those are actual samples from a drop of water. As soon as I found out that it was the real thing, the real living little babies that just made it so cool.**
G35:	Well, the fact that there was a live, living display was remarkable.
Exhibit was a positive, novel experience for them (6%, or 2 out of 36 visitors)	
Visitor	Quote
G02:	**I practically grew up in aquariums like Monterey, and this is completely new for me.**
G22:	Just something we don't get to see where we're from.

What confused visitors

Four visitor groups mentioned being confused about what to do at the exhibit or how to get started with it. See Table 9 for visitors' quotes about their confusion.

Table 9. Example quotes from visitors on what confused them about the exhibit. Bolded quotes are especially illustrative or representative examples of visitors' responses.

Confusion about how to interact with the exhibit (4 out of 36 visitors)	
Visitor	Quote
G10:	**I didn't know what was going on.** [. . .] There's not much going on. **You could move it around, but only see 1 row.**
G23:	**It was kind of hard to figure out which stage they were in with them bouncing around**, and that's why the 6.
G24:	**There were so many words, it's like... just a lot to read.** I'm a kinetic learner and I was too busy trying to figure out how to operate the thing.
G28:	It took me a while to figure out what was going on.

Visitors' questions

Evaluators asked visitors what questions, if any, came up for them after using the exhibit, both to gauge visitors' awareness of the exhibit content and to understand what sort of information may be useful to include in future iterations of the exhibit. Most visitor groups (33 out of 36) asked at least one question. See Table 10 for a breakdown of the sort of questions visitors asked and examples of them.

Table 10. Example questions that visitors had about sea urchins. Bolded quotes are especially illustrative or representative examples of visitors' responses.

Development (42%, or 15 out of 36 visitors)	
Visitor	Quote
G03:	What is the purpose of the pluteus life stage? Is it for eating a lot to develop? Why not remain a ball shape?
G04:	Wanted to learn more about [. . .] metamorphosis
G05:	If the mouth and anus develop differently.
G07:	I got really curious about the stage before fertilization.
G11:	More of the life stages when they become adults. I wanted to know more about their adult form.
G13:	**What happens when they mature?**
G15:	**What's the total time for it to be fully grown?**
G24:	We see the babies, but do these urchins interact?
G26:	Can they live or breathe out of water?
G28:	**How soon do they start eating? When do they start doing damage to the kelp?**
G30:	Do they rely on the sun?
G31:	How big do they get?
G32:	**How does it get from plutei to full adult?** Why are they developed the way they are?
G33:	**Wanted to know more about the final stages of life [. . .] and what is the rest of their life cycle like?**
G34:	Do they start single cellular or do they become multicellular? Are the spines part of the urchin or are they like antlers on a deer?

Predators (28%, or 10 out of 36 visitors)

Visitor	Quote
G03:	**Who eats the larvae?**
G14:	Their natural enemies, what destroys their habitat?
G19:	Wondered what eats them? Seals, otters?
G21:	**Why would they need spikes?**
G26:	**Who is their predator?**
G28:	Do other fish or animals eat them?

Reproduction (22%, or 8 out of 36 visitors)

Visitor	Quote
G03:	**What induces their spawning? Environmental cues? Stress?**
G26:	Do they have the same partner for life? Is it only purple to purple, or can they cross breed? **How many times can they reproduce?**
G27:	**Why is it when the ecosystem is doing poorly that they want to reproduce more?**
G29:	Do their abundances wax and wane? **Have we ever seen a cycle of high abundance and then low abundance?** Why are there so many?
G31:	Want to know more about how broadcast spawning can lead to population booms? Are sea urchins solitary?
G34:	**How do they reproduce?**

Locomotion (22%, or 8 out of 36 visitors)

Visitor	Quote
G04:	How did it float in the water column? [Confused about] if they move or how do they? Wanted to learn more about attachment.
G05:	**How far out does the planktonic plutei drift?**
G13:	**Where they're going, how they attach themselves, where do they move to, and what do they move for?**
G15:	**How fast can they move through the water?**
G18:	**How they move as adults**
G22:	Can they jump or do they crawl?
G26:	Do they swim or float? Do they travel to different rocks for food?

Diet (22%, or 8 out of 36 visitors)

Visitor	Quote
G01:	**What is it exactly that they were eating?**
G04:	**Confused how they eat kelp.** Wanted to learn more about [. . .] what they eat
G19:	**What do they eat**
G24:	What are they eating, larvae?
G28:	Do all urchins eat kelp?

Role within the ecosystem (19%, or 7 out of 36 visitors)	
Visitor	Quote
G18:	**[How they are] interacting with life at the seabed?**
G25:	How are they part of the ocean life ecosystem?
G29:	**What is their benefit?**
G30:	**How do they fit into the food chain?**
G31:	What's their role?
G32:	**Why are they important?**

Environmental Impact (19%, or 7 out of 36 visitors)	
Visitor	Quote
G04:	How are they negatively impacting the kelp?
G09:	**Wanted to know more about awareness and what they are doing to the environment.**
G27:	**How and why did they become an issue?**
G28:	Do they do any damage to other living things, like red urchin? **Do they do anything good for the environment?** Is the reason they are so bad for the kelp is because there are so many of them?
G35:	**Are they threatened, sensitive populations?**

Relationship with humans, including why we should care about them (19%, or 7 out of 36 visitors)	
Visitor	Quote
G12:	**Why are we focusing on them? Why do we care?**
G18:	How they relate to the human world. How they see them as edible, where they catch and eat them.
G25:	**I want to know if the Noyo Center is concerned about sea urchins in our oceans.**
G30:	What do they feel like when they are larvae? **Are they actually edible?**
G31:	Why try and spawn them? Why showcase purple sea urchins? Why is the exhibit focused on them?
G35:	**How are they responding to human consequences?**

Habitat (17%, or 6 out of 36 visitors)	
Visitor	Quote
G11:	I wanted to know more about [. . .] the environment.
G14:	**What kind of habitat?**
G30:	**Where do they live in the ocean?**

Toxicity (17%, or 6 out of 36 visitors)	
Visitor	Quote
G09:	Are they toxic?
G24:	**Are they poisonous?**
G30:	**Do they sting?**

Color (17%, or 6 out of 36 visitors)	
Visitor	Quote
G03:	How do they continue to develop their pigment through their life? **What is the purpose of the pigment?**
G09:	Are there different colors of urchin?
G15:	**What gives them their color?**
G19:	**Are they different colors than purple?**
G20:	Wanted to know if they turn purple after they die?
G32:	Why purple versus brown?

Range, including whether they're invasive (11%, or 4 out of 36 visitors)	
Visitor	Quote
G22:	**How far do they spread?**
G29:	Where did they come from and how did they come to be?
G31:	**Thought they were invasive and brought here? What about them makes them native? How long is a species around before it is not considered invasive?**
G32:	Are they only here?

Population control, including How humans can help (11%, or 4 out of 36 visitors)	
Visitor	Quote
G03:	**Does knowledge of the urchin lifecycle give us clues on how to control the urchin population?**
G29:	**How do we control their population?**

Lifespan (11%, or 4 out of 36 visitors)	
Visitor	Quote
G04:	**How long do they live?**
G16:	**What their lifespan is.**

Defense mechanisms (8%, or 3 out of 36 visitors)	
Visitor	Quote
G01:	**They seem defenseless at the larval stage.**
G09:	**Wanted to know more about defense mechanisms.**

Sexual differentiation (6%, or 2 out of 36 visitors)	
Visitor	Quote
G02:	**How would I be able to differentiate male and female other than size difference?**
G22:	Is there a male, female urchin?

Taxonomy (6%, or 2 out of 36 visitors)	
Visitor	Quote
G35:	**How if at all are they related to sea stars, and are they subject to the same diseases?**
G36:	**Are they their own species, category?**

NEXT STEPS

Visitors' average interest rating of 5.9 out of 7 suggests that the Noyo Center's exhibit, *The Rise of the Urchins*, was well-received. Furthermore, this formative evaluation indicates that the exhibit helped increase visitor awareness about sea urchins, particularly about their development and larval anatomy, which are the topics the exhibit most focuses on. If there are to be further iterations of this exhibit, it is important to consider that it is already performing well in supporting visitor's awareness about the aforementioned topics.

Visitors seem to arrive at the Noyo Center with at least some awareness about sea urchins, including what they look like and the role they play in the marine ecosystem, both beneficial and detrimental. Because the Noyo Center for Marine Science is located in the coastal town of Fort Bragg, California and is only a short walk from the ocean, it is possible that visitors to the Center, particularly locals, are more aware of sea urchins than visitors to other science centers. This is supported by the high number of visitor groups who had relevant prior experience, especially the eight visitors who mentioned they live near the ocean and visit it frequently. While visitors' familiarity with sea urchin is advantageous to their engagement with the exhibit, it also presents a limitation of this study, as the Noyo Center's visitors may be more familiar with sea urchins than visitors to other nature centers and science museums.

Findings show that visitors already had already formed some opinions about sea urchins even before they engaged with the exhibit, perhaps even before they entered the Noyo Center. That said, the exhibit seems to have had a positive impact on visitor's appreciation of urchin, especially regarding their development, which visitors found particularly compelling. Conversely, the exhibit seems to have had little impact on visitors' negative opinions about sea urchin, and even then, the only increase was their dislike about the detrimental effect that urchins can have on the marine ecosystem. This small increase in visitors' negative affect towards urchins is perhaps unsurprising, as the exhibit focuses on larval urchin development and barely touches on their impact on the environment.

Visitors mentioned appreciating the interactive aspects of the exhibit, including the touchscreen and the knob that allows them to move the microscope slide. This does not necessarily mean that visitors would dislike an exhibit that features a pre-recorded video instead of a live slide. In other words, it is possible that visitors would not miss what they don't know they're missing; in fact, a previous study suggests that they would not. Future versions of the exhibit should consider keeping the live slide, as long as it is feasible. However, if a future iteration will use pre-recorded video instead, it may be beneficial to remove the microscope knob so as to not misguide the visitor about the level of control they are afforded regarding slide movement.

Few visitors encountered usability issues at the exhibit. However, those who did were primarily confused about how to interact with the exhibit. To address these concerns, future iterations of the exhibit could consider including a bit more framing of what visitors should expect when they first approach the exhibit. For example, it may help visitors to know that the exhibit is specifically about larval

urchin development. It may also be beneficial for visitors to know that the exhibit uses AI in real-time to identify different larval stages; this may help visitors understand why the AI labels, including the boxes and circles, move around so much.

Lastly, visitors had many questions about sea urchins after using the exhibit. This suggests that visitors were interested in and engaged by the exhibit content. Some visitors expressed wanting more information, particularly about urchin development, but also about their lives after the larval stage. Future iterations of the exhibit and other complementary exhibits may benefit from taking visitors' questions into account when considering potential changes. That said, while it is common for visitors to ask for information to be added to an exhibit, it is important to keep in mind that too much information can be detrimental to the visitor experience. Care should be taken to avoid overwhelming visitors with too much information, especially too much text.

Overall, *The Rise of the Urchins* seems to do a good job of increasing visitors' positive feelings about sea urchins as well as their awareness of urchin development; this aligns with the exhibit's intended goals. The exhibit leverages its interactive design, live microscopic specimens, and real-time AI identification to drive visitor awareness and interest about purple sea urchins.

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Appendix A

Interview instrument

Cued Recruitment

- Every 3rd adult visitor (OR after 15+ minutes have passed) who crosses from the store into the exhibit space of DC
- Participant(s) can be individuals or dyads (but no more than 2 participants)
- Every participant must be 8 years old or older
- Every participant must be fluent in English
- Minors must have guardian's verbal consent

Recruitment Script

Excuse me, my name is XXX. and I work here. May I ask you some questions?

1. Is this your first time visiting the Discovery Center?
2. Are you visiting alone or with a group?
3. How many people are in you group?
4. *[If NO to 1st visit]* Have you used that *[point to]* exhibit before today?

[If NOT fluent in English]
Thank you. Those are all my questions. Have a good day.

[If FLUENT in English]
We're trying to improve one of our exhibits, and we'd like your help. Would [you / two people from your group] be willing to take a look at the exhibit and give us some feedback? The exhibit works best for people at least 8 years old. It will take about 10 – 15 minutes.

Are there one or two people
[for multigenerational groups] 8 years or older
from your group who might be willing to help us?

[If NO] I understand. Have a great visit!
[If YES] Great!

Part 1: Pre-Use Questions

This is the exhibit here. Before we begin…we are trying to learn what our visitors think about sea urchins. So we have two activities before interacting the exhibit that will help us understand your current thoughts about sea urchins. Is that ok? [Lead the participant(s) to the table]

Activity 1

First, we are asking people to jot down everything they know about sea urchins. There is nothing too big or too small, no right or wrong. Just anything that comes to mind when you hear me say "sea urchins." We're going to use one sticky note per idea.

So let me put the main topic SEA URCHIN in the center [Write SEA URCHIN on a yellow/pink sticky note and place it on the center of the paper].

Now what is one thing that comes to mind when you think of sea urchins? [Write their idea on a sticky note and draw a line connecting it to sea urchin]

What else? Feel free to write or draw things on your own or I can do it for you.

[When they finish] Now, I want you to organize the sticky notes. Try to group things that are related.

Now let's draw lines and label them so we know how these things (the sticky notes) are related to sea urchins. [If needed: So what is this group? How is it related to sea urchins?]

Thank you, this is very helpful!

Activity 2

Now for the next activity, we want to know how you feel about sea urchins. Is there anything you like about them? [Write some things down] Anything you don't like about them? [Write some things down]

[If nothing: look for any feelings-related sticky notes from the first activity and mention those]

Exhibit Use

Now let's look at the exhibit. Before I tell you about the exhibit, I just have to set some things up. [Turn on the screen]

I'd like you to use this exhibit however you like. Please don't feel that you need to look through everything unless you want to. I'm going to step away while you use it. Whenever you feel you're done just let me know. And at that point, I'll ask you a few questions.

Interview Questions

1. On a scale from 1 to 7, how interesting did you find this exhibit? With 1 being 'not at all interesting' and 7 being 'completely interesting' ?

    a. What made it a _____ for you? [*Probe:* Anything else that made it a _____ for you?]

2. This is everything that came to your mind before using the exhibit. Is there anything you'd like to change about this or add to after using the exhibit? Anything?

    [If no changes] Was there anything that you found surprising? Was there anything new you feel you learned?

3. How about what you like or dislike about sea urchins? Is there anything you'd like to change or add to it?

    [If no changes] Did any of these feelings [pt to feelings] change, become stronger, or reduce?

4. Did looking at this exhibit bring up any questions for you about sea urchins?

5. We're almost done. Do you have any special interest or background that might have helped you understand what you saw at this exhibit? [If they need clarification: Perhaps you've seen something like this before?]

    a. Have you ever looked at microscopic living things before today? [If confused, rephrase: tiny creatures you cannot see just with your eyes]

    b. Before today, when was the last time you used a microscope?

[At the end] Those are all my questions. Thank you very much for your help! May I also give you a sticker to wear? It will let other people know that you've already helped us out today and we won't stop you again to ask you questions. Thanks again. Have a great visit.