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Informing the Public about Microplastics through a University and Museum Partnership

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ABSTRACT: Microplastics have been found in the most remote locations on Earth as well as in where we live, work, and play. Despite increasing research focus on microplastics, efforts to inform the public about their omnipresence have lagged. To bridge this gap between research and public knowledge, we developed a museum exhibit with interactive and informative displays that explain what microplastics are, how they are formed, where they are found, and what individuals can do about it. In a partnership between researchers at the University of Michigan (Ann Arbor) and staff at the Dossin Great Lakes Museum (Detroit), the exhibit highlights the impacts of microplastic pollution in the region. Collected survey data revealed that museum visitors were aware of microplastic pollution and are worried about it, that they felt the museum exhibit was helpful and informative, and that they are likely to take simple actions to decrease microplastic pollution.

KEYWORDS: *General Public, Public Understanding/Outreach, Hands-On Learning, Environmental Chemistry, Microplastics*

INTRODUCTION

Microplastics are plastic fragments that range in size from 1−5000 μm,[1] which primarily arise from the physical breakdown of larger plastic items. Microplastics were first observed in the ocean,[2] motivating research on their ecological impacts. Since then, numerous studies have shown that microplastics pose a threat to aquatic life.[3,4] Exposure has also expanded across food chains through trophic transfer,[5] including human consumption of microplastic-containing fish. Microplastics have also been found on land[6] and in the air,[7] further exacerbating human exposure to microplastics through ingestion and inhalation.[8] While hundreds of studies have been published regarding microplastic pollution,[9] few studies have considered public perceptions of microplastics. Garcia-Vazquez and Garcia-Ael suggest that the little knowledge the public has about microplastics comes primarily from media sources.[10] Effective science education through informal sectors, like museums, has been well documented.[11,12] Indeed, this journal has previously highlighted chemistry-themed museum exhibits on topics including the structures of scents[13] and nanoscience,[14] among others.[15,16]

To bridge this gap between scientific research and public understanding of microplastics, and to motivate action, we created an interactive and informative museum exhibit titled *Microplastics: Here, There, and Everywhere* in a partnership between researchers from the University of Michigan (Ann Arbor) and staff at the Dossin Great Lakes Museum (Detroit).[17] Specific displays in the exhibit detail what microplastics are, where they are found, how they are formed, and what can be done to reduce their transfer to water systems and the broader environment. Special attention was given to microplastic prevalence in the Great Lakes region to connect this broader challenge to a local issue. Surveys were used to collect data from visitors about their previous knowledge of microplastics, whether they are worried about it, and how likely they are to take action to reduce their impacts on microplastic pollution. Lessons learned from planning and implementing this exhibit are provided herein along with suggestions for future projects that aim to engage and educate the public about microplastic pollution.

STRATEGIZING AND DESIGNING

The research team, consisting of graduate students and faculty from the University of Michigan, first underwent training on effective science communication practices in workshops led by museum staff from the University of Michigan's Museum of Natural History. The 6 h training was modeled after the

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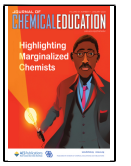

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National Science Foundation's Portal to the Public program.[18] The workshops began with a focus on how interactive activities can be created such that audiences will learn and retain information from museum exhibits. Next, the workshop facilitators explained how to communicate an exhibit's information effectively to broad audiences using learning theories. Avoiding jargon and paying close attention to the delivery of exhibit information such as consistent label formats, word lengths, and text level (e.g., eighth grade) was also covered. Finally, the research team brainstormed ideas for the exhibit and received feedback from the museum staff.

Following the workshop, the research team created microplastic-themed exhibit ideas; we considered the sources of microplastics (clothing, packaging, tires, etc.) as well as how they transfer to the environment (washing clothing, the weather's impact on discarded plastics, etc.). Collectively, we decided our primary focus was to communicate information about microplastics in the following sequence: how are they formed, where do they end up, and what can we do about it? Our team then searched for a museum that would host our exhibit and collaborate on its design. Because most research to date is focused on microplastics in water, we reached out to the Dossin Great Lakes Museum located in Detroit, MI. The Dossin Great Lakes Museum is part of the Detroit Historical Society, which aims to preserve history that is local to the Detroit area.[17] Located on Belle Isle, it first opened in 1949 and was originally titled Detroit's Maritime Museum. In 1960, it was reopened as the Dossin Great Lakes Museum. The museum's exhibits focus on the Great Lakes, including stories of Detroit's impact on regional and national maritime history. The museum attracts ∼120,000 visitors per year, including over 3,000 Detroit Public School students. There is a small fee ($5/person or $20/household) for entry.

Considering the museum's theme, the microplastics exhibit was centered on the Great Lakes with a focus on how microplastics translocate to and from water environments. Being mindful of the focus on plastic pollution and its impacts, we created as much of the exhibit as possible with repurposed plastic and other reusable materials; all remaining materials were made and printed in-house at the museum or locally to keep costs down (<$4000). The displays (described in detail below) were created in collaboration between the university researchers and the museum staff, leveraging the knowledge and expertise of each partner. The special exhibit opened in April 2023 and will be on display for one year, at which point a more permanent home will be identified.

THE EXHIBIT – *MICROPLASTICS: HERE, THERE, AND EVERYWHERE*

The goal was to inform museum visitors of microplastic pollution while providing them with both the motivation and the capacity to act by demonstrating how microplastics intersect with their everyday life and what individual actions can be taken to reduce its impacts. Many displays include data from research studies, which have been formatted and adapted to be understandable for all ages, and a QR code that links to the original research article.

Part 1: What Are Microplastics?

The first section of the exhibit helps visitors discover and familiarize themselves with microplastics (Figure 1 and Figures S4–S6). Foundational information about microplastics is provided along with images and descriptions. For example, a grain of rice, a pencil eraser, and a strand of hair were used as references for depicting the microplastic size. To illustrate how microplastics are generated through the breakdown of larger plastics, a plastic water bottle and plastic bag are depicted with a portion of it degrading into smaller fragments. Next, visitors can explore microplastics with a microscope (Figure 1a). Epoxy resin was used to encase samples of microplastics (synthetic rubber, polyethylene terephthalate, and polyester) and natural materials (sand, dirt, and bleached wood pulp) into small pucks, which can be visualized under the microscope. Adjacent flip boards depict high-resolution images of these materials, and here visitors are asked to guess if the image depicts a microplastic or a natural material. The rationale for the dual microscope/flip board display is to demonstrate how microplastics are difficult to distinguish from other materials of the same size and color and often require special equipment to identify and characterize them.

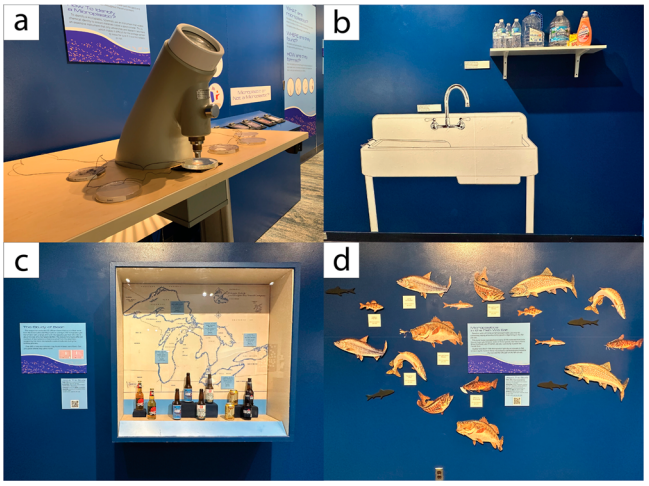

Figure 1. (a) Microscope display where guests visualize epoxy resin pucks that contain microplastics or natural materials and are asked to guess whether it is a microplastic. Adjacent flip boards with microscope photos on top provide the answers. (b) Drinking water display that compares the amount of microplastics contained in tap water versus bottled water. (c) Beer display with quantities of microplastics found in different types of beer brewed with water from the Great Lakes. (d) Fish display with amounts of microplastics contained in filets of Great Lakes fish.

Part 2: Where Are Microplastics Found?

Once museum visitors familiarize themselves with microplastics, the next several displays show that microplastics are found nearly everywhere, especially in substances that we consume. Although microplastics have been found in many food items,[19] we narrowed our focus to everyday items that align with our focus on the regional lakes, including drinking water,[20] beer,[21] and fish[22] (Figures 1b–1d).

The Great Lakes provide drinking water to 40 million people in the United States and Canada,[23] hence microplastics in this freshwater source should be of interest to its regional citizens, businesses, and governments. A placard describes a paper by Chen and co-workers,[24] which details the environmental, wildlife, and human impacts of microplastics in the Great Lakes region. Then, a thought-provoking display with an image of a kitchen sink and a collection of discarded plastic water bottles (Figure 1b and Figures S7 and S8) is used to reveal how drinking exclusively bottled water (as opposed to solely tap water) can lead to an annual difference of ∼2000% more

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microplastics consumed (90,000 versus 4,000 microplastics per year).[20] The main takeaway is that it is difficult to completely avoid microplastics in drinking water, but consuming tap water will lead to less ingestion of microplastics. Another display focuses on microplastics in various beer brands.[21] Continuing the Great Lakes theme, this exhibit displayed bottles and cans from five of those brands (one brand for each Great Lake) in a glass case (Figure 1c and Figures S9 and S10). These studies revealed predominantly microfibers in the beer, likely shed from clothing of the workers or filters rather than from lake water.

The last display in this section highlights work by Rochman and co-workers[25] showing microplastics in filets of wild-caught fish found in and near the Great Lakes (Figure 1d and Figures S11 and S12). This display explains that microplastics can translocate from the fish's gastrointestinal tracts to the liver and filets (the parts of the fish that are typically eaten). As a result, consuming these fish can lead to ingesting microplastics (from 52 to 680 microplastics per year, based on a diet of 0.5 lbs of fish per week).[25] To acknowledge the museum's location, the specific fish highlighted in color are also found in the Detroit River. Overall, this section of the exhibit shows that humans are consuming microplastics through drinking and eating, motivating the need to understand how microplastics enter the environment and what preventative actions can be taken to attenuate exposure.

Part 3: How Do Microplastics Enter the Environment?

The next section shifts visitors' attention toward sources of microplastic pollution, beginning with an art piece created from plastic litter collected from the Huron River watershed that was cut into smaller pieces and assembled into the shape of the Great Lakes (Figure 2a). The art piece illustrates how

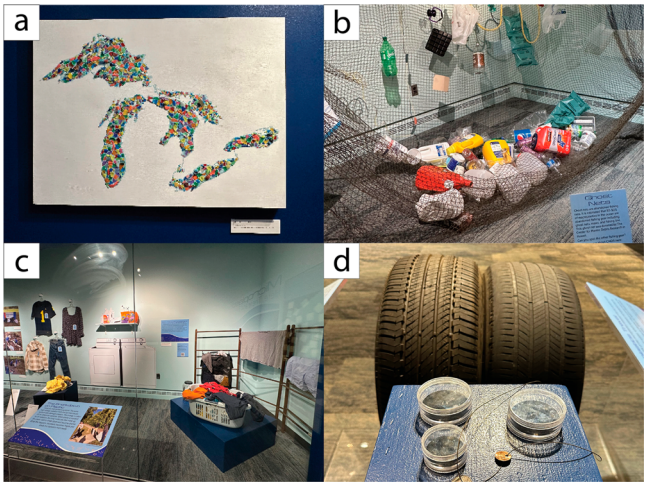

Figure 2. (a) Art piece created from plastic litter, titled *The Great Plastic Lakes*. (b) Net containing various pieces of plastic waste. (c) Display focused on laundry as a source of microplastic pollution. (d) Display focused on tire wear as a source of microplastic pollution.

microplastics are often formed from the breakdown of larger plastics. We also hope it provides ideas for repurposing plastic litter as a potential craft idea for families to try out after leaving the exhibit.

The next display shifts the focus to larger plastics and their consequences. A large fishing net is suspended along the wall in a display case (Figure 2b and Figures S15 and S16) and filled with various sizes and forms of plastics, from laundry detergent bottles to plastic shopping bags. A piece of a "ghost net" (abandoned or lost fishing net) that was captured and donated by the Center for Marine Debris Research in Hawaii is also displayed. It is estimated that 50−90% of macroplastics in the ocean are abandoned fishing gear, including ghost nets, ropes, and fishing line.[26] Stressing the importance of cleaning up larger plastics before they degrade into microplastics, we included images from local cleanup events[27] hosted by the research team from the University of Michigan.

The two leading sources of microplastic pollution, according to a report by the International Union for Conservation of Nature,[28] are synthetic textiles and tires. The following displays highlight how daily activities, such as washing laundry and driving, release microplastics into the environment. Synthetic textiles are estimated to be the largest contributor of microplastics in the oceans.[28] Correspondingly, an image of a washer and dryer, as well as pieces of clothing, are used to demonstrate how many microplastics are released from washed clothing (Figure 2c and Figures S17 and S18). Information for this display was adapted from the study by Avella and co-workers, which stated that anywhere from 640,000 to 1.5 million microfibers are released per kilogram of washed fabric.[29] To portray these amounts clearly, a pile of laundry weighing one kilogram was set at the front next to a full basket of laundry so visitors could estimate how many microplastics would be released per load of laundry. A placard describes how, after leaving the home, these laundry-based microplastics are concentrated in the biosolid waste from wastewater treatment plants, which are often used as a fertilizer on farms,[30] releasing microplastics into the local soil and groundwater (Figure S18).

The final display in this section involves the second leading source of microplastics in the ocean: tires.[28] Any rotating tire or wheel made from synthetic materials, especially synthetic rubber, experiences abrasion on roads. As tires wear down, tiny bits of rubber particles are flung into the air and settle in the environment. Rain and snow wash these particles into nearby stormwater drains, which often flow into rivers and oceans without any pretreatment. This display was designed to be hands-on, as it includes small, clear containers of micronized rubber that visitors may look at and interact with. Next to the stand holding the micronized rubber are two car tires, one with minimal wear and one with substantial wear (Figure 2d and Figures S19 and S20). Visitors are encouraged to place an attached penny between the treads of the two tires and compare how much of Lincoln's head is visible. This trick is commonly used by the public to determine whether a tire needs to be replaced. This interactive display enables guests to see how much tire tread can erode and be released as microplastics into the environment. Overall, these displays highlight how microplastics are entering the environment from homes and communities through everyday activities such as driving and washing clothing, which inspires some of the recommended actions (e.g., washing clothes less often or driving less) described in the next section.

Part 4: What Can We Do about Microplastics?

To wrap up the exhibit, we offer suggestions for ways the public can help decrease the level of microplastic transfer to the environment. Specifically, we provide an interactive wall where visitors are asked to share (with sticky notes) what they will do to make a difference, along with a bulleted list of

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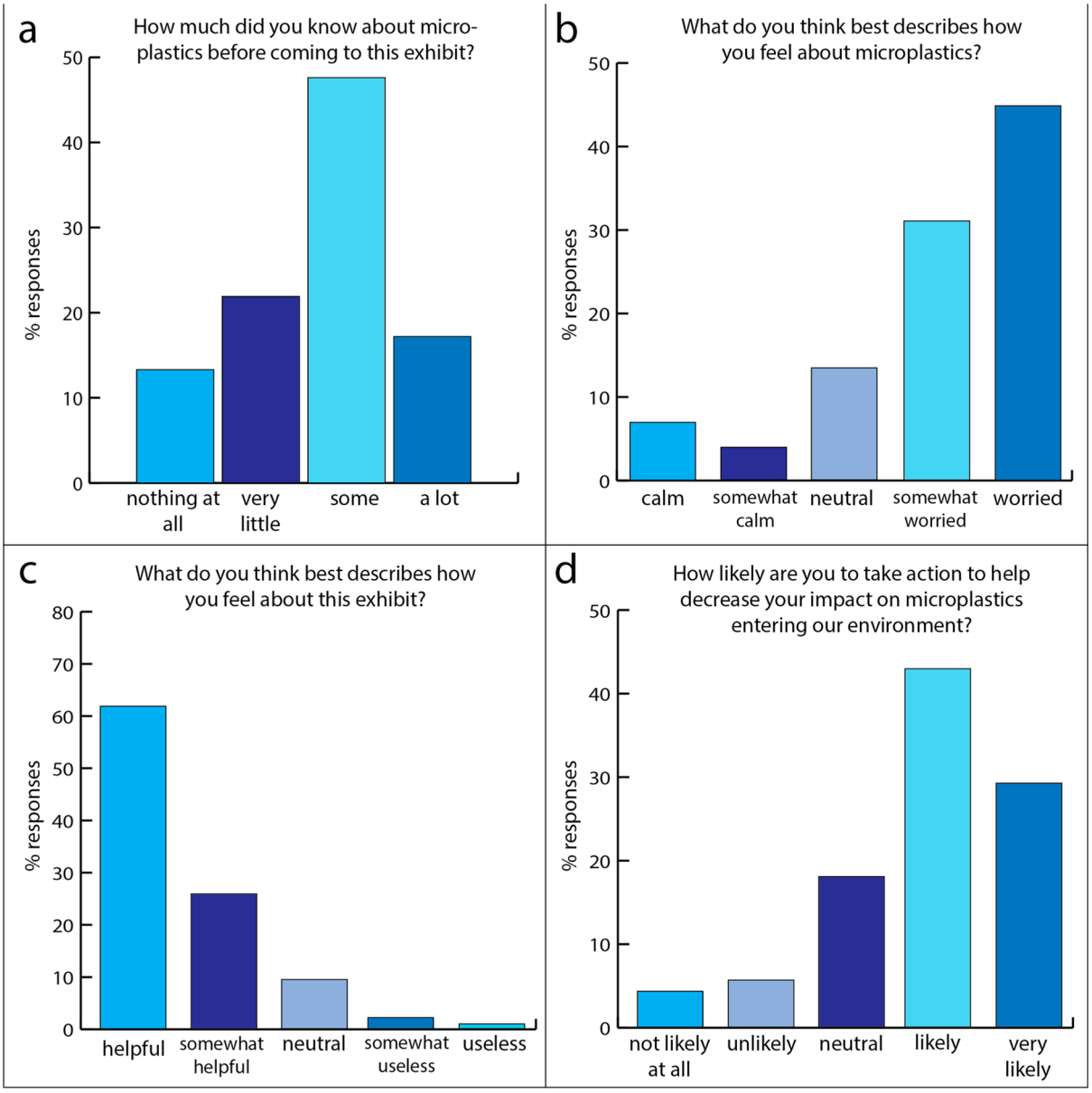

Figure 3. Results for survey questions: (a) How much did you know about microplastics before coming to this exhibit? (b) What do you think best describes how you feel about microplastics? (c) What do you think best describes how you feel about this exhibit? (d) How likely are you to take action to help decrease the impact of microplastics entering our environment? (N = 231).

suggestions (Figure S22). Adjacent to this post-it space, a large image of the exhibit's logo is displayed for selfies. Here, visitors are encouraged to take a picture and share it on social media to bring further awareness to microplastic pollution and the exhibit. We also provide a pamphlet to take home that includes information about the leading sources of microplastic pollution in oceans (Figures S24 and S25).[28] The pamphlet also includes a list of "action items" aimed at reducing microplastic pollution from the two leading sources (tires and clothing), including purchasing nonsynthetic clothing and driving less. At the end of the pamphlet, we also urge visitors to contact local and national politicians to share their concerns about microplastic pollution. We hope that this prompt will spread awareness of microplastics to larger entities, perhaps leading to wider-scale change. For example, California recently became the first state to require testing of drinking water for microplastics.[31] The back of the pamphlet includes information about the collaboration between the University of Michigan and the Dossin Great Lakes Museum and funding acknowledgments. Finally, a survey is provided to ask visitors about their prior knowledge of microplastics and their experience with the exhibit (Figure S26).

SURVEY RESULTS

Our goal for this exhibit, increasing the public's awareness of microplastic pollution and its impacts on the environment, was assessed by an optional survey provided to visitors. The survey consisted of seven short questions that collected information about how visitors felt about microplastics and the exhibit. The survey was adapted from Holme and co-workers, who designed a survey to assess children's attitudes and motivation at museum events.[32] Briefly, this multiple-choice survey asks visitors for their age and educational level, previous knowledge of microplastics, feelings toward microplastics, feelings toward

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the exhibit, and likelihood to take action to decrease their impacts on environmental microplastic pollution. The results of the four nondemographic survey questions are displayed in Figure 3. Finally, an open-ended question is provided for visitors to share any final thoughts or feedback.

The survey was provided on paper, adjacent to a bin of pens and a cardboard collection box (Figure S21). There was a QR code on the selfie wall to take the survey online, but none of the visitors chose this method. The University of Michigan Institutional Review Board considered the survey to be exempt from review. Data analysis was conducted on 231 surveys that were filled out in full, with a handful of surveys being discarded if incomplete. The survey was not required and therefore does not reflect the opinions of all visitors. All survey data can be found in Figures S27 and S28.

Museum visitors who completed the survey consisted of individuals of various ages, though most were younger than 30 years (74%). The surveys revealed a variety of educational backgrounds. Almost 65% of visitors knew "some" or "a lot" about microplastics prior to the museum visit (Figure 3a). Nearly 76% of visitors said they were "somewhat worried" or "worried" about microplastics (Figure 3b). Because the survey was taken at the end of the exhibit, their visit may have influenced these responses and increased visitors' knowledge and level of worry. Gratifyingly, 62% of visitors felt the exhibit was helpful and another 26% said "somewhat helpful" (Figure 3c). Several of the responses to the final open-ended survey question support this finding. Many visitors expressed gratitude toward us for creating the exhibit, while others shared their appreciation for the interactive and informative displays. One visitor wrote: "*Thank you for putting together this exhibit. It was interesting to see the microplastics and I learned lots about sources of microplastics I hadn't even considered before (tires, laundry, etc.)*". There were other instances where visitors asked us to provide more ways in which they can help to alleviate the microplastic problem. Although most visitors said they were "likely" or "very likely" to act (72%), a surprising 18% of people that claimed a "neutral" stance and another 10% said there were either "unlikely" or "not likely at all" (Figure 3d).

To support the survey data, museum visitors were asked to write down what actions they might take after leaving the exhibit on a sticky note and post them on the exit wall. The sticky notes with relevant comments (N = 130) were thematically analyzed and categorized based on the types of messages that visitors wrote down (Figure S29). Figure 4 displays the major themes that the authors wrote about. The bulk of the messages (75%) were related to environmentally conscious actions or phrases such as reduce, reuse, and recycle, not littering or cleaning up litter, and other generic environmental messages such as "*keep the ocean blue*" or "*be respectful to the earth*". A smaller portion of the messages was specific to the exhibit displays (25%), in which visitors stated they would drive less, drink tap water instead of bottled water, purchase less plastic, change laundry habits, or hold corporations responsible for their contributions to microplastic pollution. Nearly all of the sticky notes contained responses associated with simple preventative actions (i.e., recycling, not littering) rather than significant actions that would mitigate the leading sources of microplastics (i.e., driving less, changing laundry habits).

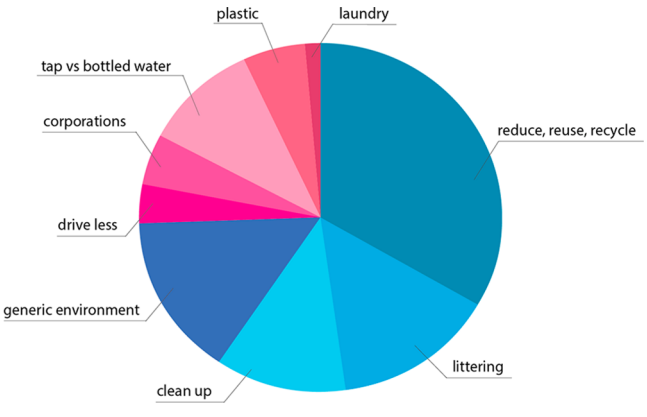

Figure 4. Themes from analysis of the sticky notes left by attendees (N = 130).

Overall, the survey results demonstrated that most visitors are at least somewhat worried about microplastics (76%) and saw the museum exhibit as helpful (88%). The data also showed that most visitors (72%) will attempt to mitigate their individual impact on microplastic pollution, although they are most likely to take simple preventative actions. As such, our goal of informing the public about microplastic pollution and motivating them to take action seemed to be successful according to these responses.

LESSONS LEARNED

We offer the following recommendations for those interested in creating similar museum exhibits to communicate scientific information to the public.

Choose a Focus Early

Narrow the focus of the exhibit in the early stages of planning as having too many varied ideas at the start hindered our progress. Display ideas began to converge only after we determined our exhibit's theme following the partnership with the Dossin Great Lakes Museum. The entire process, from initial training and brainstorming to identifying a museum and creating the exhibit, spanned two years, with the most intense, focused effort taking place over the final five-month period.

Set Clear Goals for the Partnership

Communication is essential, and it is important to ensure that the goals of each partner are aligned at the outset.[33] Discuss funding sources early and assign roles and responsibilities to each team member. Set realistic timelines and be ready to be flexible with those deadlines.

Involve Museum Staff Early in the Design Process

The design team should include at least one individual with exhibit design expertise, who can help the team determine how much information should be included as well as how it should be communicated considering the exhibit's audience. This editorial expertise is important, as it was often tempting for the researcher to add too much information, which would make the exhibit less digestible to the audience.

Highlight Positive Action Items

Consider the overall impact that the exhibit has on participants. Our exhibit, for example, included information on microplastic pollution that may have left viewers anxious or discouraged. As a result, our pamphlet has suggestions for what they can do to help minimize their own microplastic footprint and how they may spread awareness about the topic. Nevertheless, we received feedback from visitors that suggested that either they did not see the pamphlet or they felt that the

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action items should have been featured more prevalently within the exhibit. One visitor stated: "*If you make people aware of a problem, a large part of your exhibit should give them ways to combat the problem.*" Similarly, only 25% of the sticky notes referenced an action item from the exhibit. To overcome this limitation, we suggest making a large display that includes positive action items at the end of the exhibit, so visitors may leave with a more positive outlook and actionable ideas.

CONCLUSION

The microplastic pollution crisis continues to grow unabated, despite increased attention and concern from scientists. For widespread change to occur, attention must also be brought to the key stakeholders, including the public, who can advocate for change, and politicians, who can enact change. To meet this challenge, we designed a museum exhibit to inform the public about microplastic pollution and empower them with actionable items to help mitigate it. Partnering with a local museum focused on the Great Lakes provided a theme for the exhibit. The exhibit addressed what microplastics are, where they are found, and how they got there. A take-home pamphlet provided ideas for attenuating their own footprint and advice on how to contact their local politicians. Analyses of sticky notes and survey results suggested that the exhibit was successful in informing visitors and motivating them to act; however, most visitors focused on simple actions rather than the more challenging ones that will make a bigger difference.

ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available at https://pubs.acs.org/doi/10.1021/acs.jchemed.3c01017.

Additional exhibit photos, the survey, and analyzed survey data (PDF)

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Notes

The authors declare no competing financial interest.

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