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Plastics Crash Course: A Website for Teaching Plastics Recycling and Microplastics Prevention through Infographics

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Abstract: Microplastic particles have been found virtually everywhere, including within our food and drinking water. While the implications of microplastics on human health are not fully known, early effects have been seen on marine life and the environment. Studies have shown that microplastics can cause changes in the reproductive habits of marine life by blocking digestive tracts, causing abrasions to the mouth and esophagi of small animals upon ingestion, and altering feeding behavior. While much of the blame for our plastics pollution problem should be shifted to irresponsible manufacturing, we as consumers must make choices to benefit the environment by reducing our use and learning how to effectively recycle plastic waste. The Plastics Crash Course combines visual learning with plastics recycling knowledge to educate the public about why we need plastics and why we should recycle them. Microplastics formation and general guides for plastic recycling were also included in the Plastics Crash Course. Out of 120 participants, 95% responded that they had learned new information. From the pre-survey, participants responded, saying they thought all plastic was the same and that it just varied in density to provide different properties, so they would recycle everything. After reading the infographics on the Plastics Crash Course website, most participants said they learned what plastics can be recycled and what their resin identifying codes mean, how microplastics form, and that there is more than one type of plastic.

Keywords: plastic recycling; infographics; engineering education; remote learning; science; technology; engineering; the arts; mathematics (STEAM) education

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Citation: Reed, M.R.; Chen, W.-T. Plastics Crash Course: A Website for Teaching Plastics Recycling and Microplastics Prevention through Infographics. *Recycling* **2022**, *7*, 65. https://doi.org/10.3390/recycling7050065

Academic Editor: Silvia Serranti

Received: 30 July 2022
Accepted: 2 September 2022
Published: 7 September 2022

1. Introduction

Plastics are pervasive environmental contaminants polluting the planet as far as the Arctic and in the deep sea. More than eight billion tons of plastic waste have been released worldwide in the past 50 years [1]. About 32 million metric tons of mismanaged plastic waste leak into the environment every year [2]. If the current trends continue, our oceans will have more plastic than fish by 2050 [1]. Most synthetic polymers take hundreds of years to degrade. As these polymers slowly degrade over time, they release toxic compounds [3,4]. This plastic pollution poses serious threats to our planet's ecosystems, drinking water, and food supply [5–8].

Due to their small size, microplastics (MPs) in particular can be ecotoxic by physically damaging tissues, blocking digestion, limiting nutrient absorption, inducing immune responses, and reducing organismal survival and reproduction through their interactions with food intake [9–12]. MPs are plastic particles and fibers (<5 mm in length and/or width) that are either mass-produced or broken down from larger pieces of plastic waste [7]. As plastics break down into microparticles, the large surface area of MPs enables them to interact with aquatic organisms such as phytoplankton. MPs can cause adverse toxicological impacts, including compromised digestive and reproductive systems in shellfish [13–17], as well as induced hepatic stress in fish [18–23]. MPs can also leach toxic chemicals that can cause inflammation in organisms (including humans) [24–26]. In short, MP pollution is a growing area of research as it attracts increasingly negative publicity [7,8].

While efforts to understand MPs are increasing, outreach activities to effectively educate the public about MPs in a remote setting are lacking. These outreach activities are needed not only due to the impact of the COVID-19 pandemic on education, but also due to the increased environmental concerns caused by MPs and plastic pollution. Educating the public on plastics recycling will enable consumers to make informed decisions and implement proper recycling practices in their daily lives to help mitigate the plastics waste crisis.

Plastics recycling can be sorted into two categories. The most common method is mechanical recycling. In this type of recycling, plastic is sorted by type or color, washed, then ground up and melted to produce new pellets [27]. Most plastic that is recycled undergoes mechanical recycling. However, not all products can be mechanically recycled. For example, plastic bags and films cannot be mechanically recycled at the average materials recovery facility. These products become tangled in the processing equipment and can force the facility to shut down if the equipment becomes jammed [28]. The second type of plastics recycling, called chemical recycling, can fill in this gap. While still in the early stages of development, chemical recycling promises recycling of any plastic product an infinite number of times [29]. Chemical recycling processes vary depending on the end-product desired. The typical process involves exposing plastic waste to any combination of solvents and high temperatures and pressures to generate smaller molecules that can be reprocessed into plastics or other components that typically come from crude oil [30].

In theory, all plastics can be recycled. In practice, however, the U.S. only recycled approximately five to six percent of all plastic waste in 2020 [31]. This is due to many reasons. One being that mechanical recycling is inefficient and costly. Plastic products have to be sorted and cleaned to prevent contamination before being ground and melted. This process is energy- and water-intensive, which partly limits the government from investing more into improving the facilities. Recycled resin is also not the same quality as virgin resin and can sometimes be more expensive. It is estimated that plastics can only be mechanically recycled three to seven times before they have a substantial drop in properties [32,33]. This can cause the final product to have less desirable properties, which makes it difficult for manufacturers to control the quality of products. The resin is also not the same quality. Plastic products have many different additives and colorants added that cannot be removed. This also interferes with the quality of the recycled resin [34]. Government funding and community outreach can improve recycling, as seen in other countries.

In the past, there have been government subsidized programs that have been proven effective in increasing the recycling rate and reducing waste production. In 1997, the Taiwanese government started the Four-in-One Program which combined four players, being the community residents, municipal garbage collection teams, recycling enterprises, and the recycling fund management board. This system has been extremely successful, as the island boasts a recycling rate of 55% and generates half as much waste per person as the U.S. [35]. This is largely achieved by the community, as each person is responsible for their own waste and can receive a financial incentive which applies to using the mass transit system, and those caught improperly disposing of waste face fines and public shaming [36]. Taiwan is a great example that shows that, through large-scale community engagement and financial incentives, high recycling rates can be achieved, and waste can be reduced. Similarly, in 2020, the United States Environmental Protection Agency (U.S. EPA) announced the national recycling goal to increase the U.S. recycling rate to 50% by 2030 through five strategic objectives: (1) Improving Markets for Recycling Commodities, (2) Increasing Collection and Improving Materials Management Infrastructure, (3) Reducing Contamination in the Recycled Materials Stream, (4) Enhancing Policies to Support Recycling, and (5) Standardizing Measurement and Increasing Data Collection [37].

This study aims to educate the community through arts (using the University of Massachusetts Lowell as an example), which can be a valuable tool to train students for scientific communication and to broaden participation in engineering. Literature has shown that arts can be a powerful tool to train students for scientific communication and that the general public responds more to visual aids such as infographics than to texts [38,39]. Infographics combine visual elements, such as graphics and color, with informational content. Because of this, they can be used as stand-alone education and do not require additional explanation [40]. Infographics are shown to be an effective learning tool as they make it easier for viewers to understand and retain the information in the short term [41]. In short, multiple studies proved that visual tools such as infographics can largely improve participants' engagement and enhance students' understanding of information.

The authors hypothesize that outreach activities using infographics or e-comics will effectively train students in creative thinking and can attract more people to learn about sustainability in the plastics industry. To examine this hypothesis, the Plastics Crash Course site [42], an interactive website for people with any background to learn about plastics recycling by reading infographics, was designed. A series of surveys was administered starting 2021, spring semester (note: because the labs were at limited occupancy due to the COVID-19 pandemic, this project had to be completed remotely). First, on the Plastics Crash site, there was a pre-survey to gauge the base knowledge level of the participants. Next, the participants were invited to read the infographics and blog posts tailored to recycling before completing a post-survey to determine if anything was learned. To expand community engagement, by the end of this study, the authors also invited students from a local high school (Lowell High School) to design their own infographics after reading literature about plastic materials, MPs, and plastic recycling.

2. Results

2.1. Pre-Survey

Questions for the pre-survey can be found on the Plastics Crash Course website [42]. The pre-survey received 407 responses in total. Analyzing the pre-survey, it is found that 86% of the participants recycle and the majority (71.7%) are between the ages of 16 and 25. Among the 407 participants, 71.6% consider themselves to be experienced in recycling, 16% consider themselves intermediate recyclers, 11% consider themselves experts who know a lot about recycling, and 1.5% do not recycle or think about it. The majority of participants answered 7 out of the 9 questions correctly. For experience level, the trend continues as expected; experienced participants scored primarily between 6 and 7 correct answers, experts scored between 8 and 9 correct, and intermediates scored between 6 and 7 correct, with 6 as the majority. Notably, there were a few outliers. For example, participants who classified themselves as experts had a higher percentage of people who scored between 2 and 5 than the experienced participants. Based on the pre-survey results, it seems that no clear trend can be found on whether there were generational or geographical gaps to explain this, as these participants were from various cities and towns across Massachusetts and in every age range.

For the questions, the most impactful results will be highlighted. For the most part, people scored well but there were a few questions that many people got wrong. On question 1, "can all materials with the plastics recycling sign be recycled," only 48.5% of people answered that question correctly. For question 2, "can black plastic food containers go in your home bin," only 35.2% of people got it correct by saying that black plastic cannot be recycled. For the remaining questions, a large majority answered them correctly, so the authors decided to make sure these two points were emphasized in the infographics and post-survey.

2.2. Post-Survey

The post-survey had 120 responses in total (note: this number is different from the pre-survey (407 responses) because not everyone who participated in the pre-survey was able to complete the post-survey). The majority age range was 16–25 again, making up 88.3% of participants. Among 120 participants, 83.3% recycle regularly. Out of all 120 participants, 76.7% consider themselves to be experienced in recycling, 11.7% consider themselves intermediate recyclers, 10.8% consider themselves experts who know a lot about recycling, and 0.8% do not recycle or think about it. Similar to the pre-survey, most people scored well, with only one question not being answered correctly by a significant majority. Question 1 "Can all materials with the plastics recycling symbol, or resin identification code (also known as RIC), be recycled" improved from 48.5% to 52.5% correct but this was still not a significant majority even though 62.3% of people got the next question (asking "what numbers are most commonly accepted") correct. The explanation for this may be due to how the question was worded, as pointed out in the feedback section. The results for the question as to whether black plastic can be recycled improved greatly (from 34.7% to 75% correct) in the post-survey.

Overall, most people said they learned from participating in the surveys, with only seven people saying that they did not learn anything new or that it reinforced what they had already learned. The most common responses as to what people learned were what plastics can be recycled and what the numbers mean, how microplastics form and how much we consume, and that there is more than one type of plastic. The last one was an unintended result, but participants responded saying that they used to recycle everything because they thought all plastics were the same and just varied in density. This may be part of the reason why many people do not understand why the recycling rates are so low and could be good for a future topic. The top three favorite topics of participants were microplastics origin, the recycling guide, and quantifying the recycling rates. This reinforced the reasoning for the design of the infographics-people would enjoy comic style graphics that can relate to their daily lives and provide quantifiable value for a complex topic.

2.3. Feedback

While there were only four responses on the feedback survey, the participants provided great perspective. First, people liked that the infographics were condensed and easy to follow, and that examples were quantifiable and related back to their own lives. Many people responded in the post-survey that they will use this information to be more conscious about their plastics use and improve their recycling habits. For any changes made, one response mentioned that the recycling symbols question was confusing. The image in both surveys was initially just the recycling symbol with a 1 in it, which could have caused some people to misinterpret the question as being about just #1 plastics rather than about all numbers 1–7. This confusion probably skewed the results to be closer to 50/50 rather than one answer having a clear majority. After reading this suggestion, the image was changed to show numbers 1–7, but at that point about 75 people had already responded.

Participants also wished more information was included on single-stream versus dual-stream and how to find recycling information based on specific municipalities. Another suggestion was to place infographics before the blog posts to place an emphasis on the poster and to group similar topics together (e.g., the two microplastics images). Finally, one last suggestion was to create a dedicated social media page to post and advertise the infographics. The responder made a good case in saying that they wished they had seen these each as they were posted so they could have engaged with the posts and sent in comments and questions, as the website did not allow for participants to set up notifications. Overall, the results and feedback were overwhelmingly positive, with many great suggestions that should be implemented if the project is to continue.

3. Discussion

3.1. Art Education

Art education is an essential part of future work. Notably, 65% of the population is composed of visual learners and they learn better when given graphics and text rather than just text. Students are likely to retain information better with graphics and examples that relate back to the real world and their experiences. Studies have shown that graphic novels increase retention rates and allow readers to learn more in-depth compared to traditional textbooks [43–45]. While not all courses have graphic novels pertaining to the content, even adding visuals to PowerPoint slides or having students draw graphs or figures in their notes while learning will promote engagement and knowledge retention.

3.2. Community Engagement at UMass Lowell

For future work at UMass Lowell, the next steps would be spreading plastics education and proper recycling education. As mentioned in the results, several participants stated that they learned that there was more than one type of plastic. One participant responded, saying that they thought all plastics were one material, just with varying densities which gave them their properties. This could be a large factor in why people do not understand why certain items cannot be recycled, or why they think that all plastics can be recycled. The next module should be designed to talk about basic plastics knowledge, such as different types, the differences between thermoset and thermoplastic polymers, basics on how plastic products are made, differences in structure leading to different properties (without going into too much chemistry), and which factors are stopping us from recycling everything and what we can do to help improve recycling rates. Similar to the first module, these infographics should be designed in such a way that people with non-scientific backgrounds can understand the content easily.

A more interactive medium can be used in future modules to promote engagement. Some options include creating animated videos rather than infographics, creating an app with mini games to highlight the important points, or redesigning the website to become more interactive for participants. It is accepted that active-learning methods improve retention for initial knowledge uptake as compared to passive ones [46]. Another step in future work would be to collaborate with the Office of Sustainability on campus and teach students about proper recycling practices to improve recycling and reduce single-use plastics on campus. Some examples are to add recycling bins to every floor of the residence halls and at the apartments, have posters above recycling bins on what is accepted and what is not, go through the recycling bins and manually take non-recyclables out, and show students examples, which are practices that Lowell Sustainability Council have been implementing.

On a larger scale, adding classes on plastics sustainability that are accessible for all is also suggested. For example, an intro course that could count as a science elective for both STEM and non-STEM majors that talks about plastic basics, sustainability, and recycling could be introduced. The survey was primarily responded to by UMass Lowell students, and some did not know that there was more than one type of plastic. An accessible course like this would teach students how important plastics sustainability is without having to be in STEM fields. In fact, the plastics engineering department at UMass Lowell has been offering an elective class focusing on plastics recycling and the fate of plastic waste in the environment (PLAS. 5970-Plastics and Environment) constantly since 2018. In addition, since the 2022 spring semester, the same department has launched a freshman level course focusing on polymer sustainability (PLAS.1080-Introduction to Polymer Sustainability), which can also be considered as a general education (gen-Ed) credit for non-engineering students at UMass Lowell. Another example is that University of Buffalo recently established a stand-alone department of Sustainability within the College of Arts and Sciences. More complex topics of sustainability such as the life cycle of environmental waste, how to design parts for recyclability, synthesis of biodegradable materials, and so on could be taught by a department like this, which can offer additional classes for engineers, scientists, and non-STEM majors. Having a course focusing on sustainability or a department of sustainability will encourage both STEM and non-STEM majors to think about plastics sustainability in a productive way that could actually lead to solutions.

3.3. Broader Impacts

The authors acknowledge that plastics recycling education is only the first step to creating significant changes in dealing with the plastics waste crisis. While in theory all plastics are recyclable using various processes, the U.S. does not have the infrastructure to support this. In 2021, the U.S. had a meager recycling rate of between five and six percent. The EPA reports that the average person in the U.S. generates 218 pounds of plastic waste in a year, with approximately 13 pounds being recycled [31]. It will take widespread awareness to teach proper recycling habits. Plastics education will teach consumers how to improve our recycling system and will empower them to pressure the government into action. Companies and consumers must start reducing the amount of plastic waste generated. Government restrictions and subsidies can enforce this and will encourage more environmentally friendly alternatives.

3.4. Impacts from the COVID-19 Pandemic on Teaching

This study was completed during the academic year 2020–2021. Apparently, this educational study was impacted by the COVID-19 pandemic and had to be completed entirely remotely. A large goal of this study was to try and connect with participants (mostly college students), which proved difficult in a remote setting. To gather interest, the website and surveys were sent via email and were shared on social media. This study demonstrated the importance of community engagement in engineering education, as over 400 participants engaged with the materials.

4. Materials and Methods

The materials used to create the Plastics Crash Course were Autodesk Sketchbook [47], a drawing tablet, and Wix website editor [48]. This project was accomplished in five steps, these being website design, pre-survey, infographic design, post-survey, and feedback.

4.1. Website Design

Wix website editor was used as a free and user-friendly method. It includes a large database of images and templates used from other websites. As this project had to be completed before the end of the 2021 spring semester, the features to be included had to be prioritized. In the final version of the site, an initial survey, a blog section for text posts and infographics, a section for questions and discussion, and a post-survey to be completed after all infographics were posted. A feedback forum and a contact form were also available.

4.2. Initial Survey

The initial survey was designed to be short, and was meant to encourage people to think about what can and cannot be recycled. Listed at the top were instructions for people to take this survey before reading the infographics. The first question asked for the participant's location because recycling policies can differ between municipalities, so, if many participants were from New Hampshire, for example, information would have been included about Massachusetts and New Hampshire recycling procedures. Participants were then asked to select their age range. Since most of the advertising was directed at students at the University of Massachusetts Lowell (UMass Lowell), it was expected that most of the participants would be around college age. This is important for the results and future work, to potentially gear the next sections towards a specific age range as well as teaching the UMass Lowell community. Next, participants were asked if they would be interested in participating in a post-survey after all infographics were posted, to determine if people would be interested in continuing to engage with the project over time. Then, participants were asked how they rate their knowledge of recycling into four categories: (1) expert, someone who knows a lot about plastics recycling and what can or cannot be recycled in their area, (2) experienced, someone who recycles plastics that they think will be accepted but do not know for certain whether it all is, (3) intermediate, someone who recycles and they do not think about if the plastics can be recycled or not, or (4) non-recycler, someone who does not recycle or think about it. Participants were asked what type of recycling their city or town offers, either dual-stream (i.e., recycle plastics and non-plastics separately), single-stream (i.e., recycle plastics and non-plastics together), other, or unknown. This was asked because many towns have switched from dual-stream to single-stream in Massachusetts. Dual-stream recycling involves separating recycling into paper, glass, metal, and plastics, whereas single-stream throws it all into one bin and allows the user to be less engaged in consciously separating out their waste. This question was asked to see if this lack of engagement showed any correlation with experience level and correct answers (however, in the results, there was no clear trend). For the knowledge-based section, nine multiple choice questions were asked. The first asked if all materials with the plastics recycling sign can be recycled, as this is a common misconception. The next eight questions asked if a specific product could be recycled. These items were: black plastic food containers, plastic water bottles, plastic straws, plastic soap dispenser bottles with the push top, cling wrap, plastic broomstick or mop handles, thin non-reusable plastic bags, and Styrofoam (Figure 1).

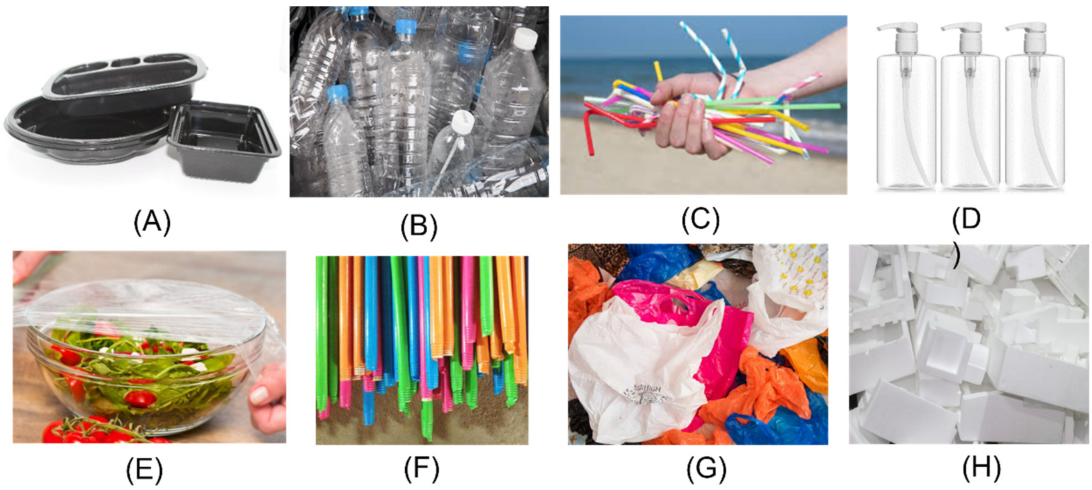

Figure 1. Plastic products used in pre-survey. (**A**) Black plastic food containers [49], (**B**) Water bottles [50], (**C**) Plastic straws [51], (**D**) Plastic soap dispenser bottle [52], (**E**) Cling wrap/Saran wrap [53], (**F**) Plastic broomstick/mop handle [54], (**G**) Plastic shopping bags [55], (**H**) Styrofoam packaging [56].

Several of these items were identified by the recycling subcommittee of the Lowell Sustainability committee. Prior to COVID-19, the city of Lowell pulled non-recyclable items from bins and explained to residents what items in their recycling bins were accepted and what were not in an effort to improve recycling in the city.

4.3. Blog and Infographics

The infographics covered six topics:

1. What are plastics and why do we need them?
2. Plastics recycling rates.
3. Why should we recycle?
4. Microplastics consumption.
5. Microplastics: origin and consequence.
6. Recycling by the numbers: A general guide to what plastics can and cannot be recycled.

Other topics considered but ultimately not chosen were misconceptions about plastics and recycling, the difference between micro, macro, and nano plastics, sustainability practices to add at home, and how to find specific recycling guidelines for a certain county.

Sometimes when explaining STEM topics, it can be difficult to relate back to real-world examples. The infographics were designed to include quantifiable aspects and use language that people without a STEM background could understand. Each infographic was designed to have enough information that it could be posted alone without an accompanying blog post, so if someone was to see these without the post, they would still be able to understand the concepts. Because of this, a poster design rather than comics was used for all infographics except for the origin and consequence of microplastics. While the poster style makes it easier to include more information and takes less time to design, the comic style infographic was included to see what style participants liked more, as comics can be more interactive but take a longer time to design. The infographics and blog posts are included in the Supplementary Materials (Figures S1–S6).

4.4. Post-Survey

The post survey was designed to be similar in length and based on the results of the pre-survey. At the beginning of the survey, the six infographics were posted to encourage people to actually view them rather than redirecting everyone to the website and expecting people to view them. The first two questions asked if participants read the infographics and took the pre-survey. If any participant answered "No", their results would be discarded. The same first questions asked on the pre-survey were asked again: what your age group is, do you recycle, what is your knowledge level of plastics recycling, what kind of recycling does your town offer, and if all materials with the recycling symbol are accepted. Next, participants were asked if they knew what microplastics were before viewing the media posts. Participants were asked which numbers of plastics were most accepted for recycling to see if people had retained information from the recycling guide. Answers were accepted as being correct if they did not contain numbers 3, 6 or 7, which are rarely recycled. Based on the results of the pre-survey, more questions were included on the post-survey about whether all materials with the recycling symbol or resin identification code can be recycled and if a certain product can go into their home bins. The products included this time were PVC piping, black plastic food containers, and yogurt cups. Participants were also asked what their favorite infographic was and if they learned anything from the series.

4.5. Feedback

The feedback section was for any participants who had additional comments or suggestions. Next, participants were asked again whether they had taken the surveys and viewed the infographics. Participants were then asked a series of questions: (1) if they would change anything about how the content was delivered, (2) if there were any topics they wish were included, (3) any improvements that could be made, (4) what was done well, and (5) if they would be interested in learning more if the project were to continue.

5. Conclusions

Overall, the results of this project are very positive and show potential methods for future education about sustainability and STEM topics. The number of participants demonstrated the public need for a convenient and comprehensive source for plastics education. Participants learned basic plastics recycling knowledge through visual learning and short blog posts which were seen to be effective methods for conveying these topics, as more than 95% of participants in the post-survey said they had learned something. This work has built a foundation for building plastics sustainability knowledge, but future work must continue to build on this momentum to promote STEM education at a young age and contribute to solving the world's plastic waste crisis.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/recycling7050065/s1, Figure S1: What are Plastics and Why Do We Need Them Infographic; Figure S2: Plastics Recycling Rates; Figure S3: Why Should We Recycle; Figure S4: Microplastics Consumption; Figure S5: Microplastics: Origin and Consequence; Figure S6: General Recycling Guide.

Author Contributions: Conceptualization, M.R.R. and W.-T.C.; methodology, M.R.R. and W.-T.C.; software, M.R.R.; validation, M.R.R.; formal analysis, M.R.R.; investigation, M.R.R. and W.-T.C.; resources, W.-T.C.; data curation, M.R.R.; writing—original draft preparation, M.R.R.; writing—review and editing, M.R.R. and W.-T.C.; visualization, M.R.R.; supervision, W.-T.C.; project administration, W.-T.C.; funding acquisition, W.-T.C. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by the University of Massachusetts Lowell (through start-up funds and the Office of Research and Innovation Internal Seed Grant).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available upon request from the corresponding author.

Acknowledgments: The authors would like to thank Yanfen Li for valuable discussion and for comments to improve the quality of the paper. The authors are also grateful to Nicholas Farfaras and Olivia Hosterman for their valuable feedback and for proofreading the paper.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Jambeck, J.R.; Geyer, R.; Wilcox, C.; Siegler, T.R.; Perryman, M.; Andrady, A.; Narayan, R.; Law, K.L. Plastic waste inputs from land into the ocean. *Science* **2015**, *347*, 768–771. [CrossRef]
2. Ritchie, H.; Roser, M. Plastic Pollution. Available online: https://ourworldindata.org/plastic-pollution (accessed on 15 January 2021).
3. Rochman, C.M.; Browne, M.A.; Halpern, B.S.; Hentschel, B.T.; Hoh, E.; Karapanagioti, H.K.; Rios-Mendoza, L.M.; Takada, H.; The, S.; Thompson, R.C. Policy: Classify plastic waste as hazardous. *Nature* **2013**, *494*, 169–171. [CrossRef] [PubMed]
4. David, O.; Oluyege, A. Effect of Open Refuse Dumpsite on the Quality of Underground Water Used for Domestic Purposes in Ado-Ekiti, Nigeria-A Public Health Awareness Study. *J. Environ. Ecol.* **2014**, *5*, 2. [CrossRef]
5. Koelmans, A.A.; Nor, N.H.M.; Hermsen, E.; Kooi, M.; Mintenig, S.M.; de France, J. Microplastics in freshwaters and drinking water: Critical review and assessment of data quality. *Water Res.* **2019**, *155*, 410–422. [CrossRef]
6. Royte, E. We Know Plastic Is Harming Marine Life. What about Us? Available online: https://www.nationalgeographic.com/magazine/article/plastic-planet-health-pollution-waste-microplastics (accessed on 15 April 2021).
7. Microplastics in Our Nation's Waterways. Available online: https://labs.waterdata.usgs.gov/visualizations/microplastics/index.html (accessed on 15 April 2021).
8. Lim, X.Z. Microplastics are everywhere-but are they harmful? *Nature* **2021**, *593*, 22–25. [CrossRef]
9. Rochman, C.M. Microplastics research-from sink to source. *Science* **2018**, *360*, 28–29. [CrossRef] [PubMed]
10. Law, K.L. Plastics in the Marine Environment. *Annu. Rev. Mar. Sci.* **2017**, *9*, 205–229. [CrossRef] [PubMed]
11. Ma, P.; Lui, H. Research on ecotoxicology of microplastics on freshwater aquatic organisms. *Environ. Pollut. Bioavailab.* **2019**, *31*, 131–137. [CrossRef]
12. Erickson, B.E. Getting A Grip on Microplastics' Risks. Available online: https://cendigitalmagazine.acs.org/2022/05/27/getting-a-grip-on-microplastics-risks-2/content.html (accessed on 15 April 2021).
13. Aljaibachi, R.; Callaghan, A. Impact of polystyrene microplastics on Daphnia magna mortality and reproduction in relation to food availability. *Peer J.* **2018**, *6*, e4601. [CrossRef]
14. Horton, A.A.; Walton, A.; Spurgeon, D.J.; Lahive, E.; Svendsen, C. Microplastics in freshwater and terrestrial environments: Evaluating the current understanding to identify the knowledge gaps and future research priorities. *Sci. Total Environ.* **2017**, *586* (Suppl. C), 127–141. [CrossRef] [PubMed]
15. von Moos, N.; Burkhardt-Holm, P.; Köhler, A. Uptake and Effects of Microplastics on Cells and Tissue of the Blue Mussel Mytilus edulis L. after an Experimental Exposure. *Environ. Sci. Technol.* **2012**, *46*, 11327–11335. [CrossRef] [PubMed]
16. Bråte, I.L.N.; Blázquez, M.; Brooks, S.J.; Thomas, K.V. Weathering impacts the uptake of polyethylene microparticles from toothpaste in Mediterranean mussels (*M. galloprovincialis*). *Sci. Total Environ.* **2018**, *626*, 1310–1318. [CrossRef]
17. Sussarellu, R.; Suquet, M.; Thomas, Y.; Lambert, C.; Fabioux, C.; Pernet, M.E.J.; Le Goïc, N.; Quillien, V.; Mingant, C.; Epelboin, Y.; et al. Oyster reproduction is affected by exposure to polystyrene microplastics. *Proc. Natl. Acad. Sci. USA* **2016**, *113*, 2430–2435. [CrossRef] [PubMed]
18. Galloway, T.S.; Cole, M.; Lewis, C. Interactions of microplastic debris throughout the marine ecosystem. *Nat. Ecol. Evol.* **2017**, *1*, 0116. [CrossRef] [PubMed]
19. Pedà, C.; Caccamo, L.; Fossi, M.C.; Gai, F.; Andaloro, F.; Genovese, L.; Perdichizzi, A.; Romeo, T.; Maricchiolo, G. Intestinal alterations in European sea bass Dicentrarchus labrax (Linnaeus, 1758) exposed to microplastics: Preliminary results. *Environ. Pollut.* **2016**, *212*, 251–256. [CrossRef] [PubMed]

20. Li, W.C.; Tse, H.F.; Fok, L. Plastic waste in the marine environment: A review of sources, occurrence and effects. *Sci. Total Environ.* **2016**, *566* (Suppl. C), 333–349. [CrossRef]
21. Syberg, K.; Khan, F.R.; Selck, H.; Palmqvist, A.; Banta, G.T.; Daley, J.; Sano, L.; Duhaime, M.B. Microplastics: Addressing ecological risk through lessons learned. *Environ. Toxicol. Chem.* **2015**, *34*, 945–953. [CrossRef] [PubMed]
22. Athey, S.N.; Albotra, S.D.; Gordon, C.A.; Monteleone, B.; Seaton, P.; Andrady, A.L.; Taylor, A.R.; Brander, S.M. Trophic transfer of microplastics in an estuarine food chain and the effects of a sorbed legacy pollutant. *Limnol. Oceanogr. Lett.* **2020**, *5*, 154–162. [CrossRef]
23. Rummel, C.D.; Jahnke, A.; Gorokhova, E.; Kühnel, D.; Schmitt-Jansen, M. Impacts of Biofilm Formation on the Fate and Potential Effects of Microplastic in the Aquatic Environment. *Environ. Sci. Technol. Lett.* **2017**, *4*, 258–267. [CrossRef]
24. Schirinzi, G.F.; Pérez-Pomeda, I.; Sanchís, J.; Rossini, C.; Farré, M.; Barceló, D. Cytotoxic effects of commonly used nanomaterials and microplastics on cerebral and epithelial human cells. *Environ. Res.* **2017**, *159*, 579–587. [CrossRef]
25. Hwang, J.; Choi, D.; Han, S.; Choi, J.; Hong, J. An assessment of the toxicity of polypropylene microplastics in human derived cells. *Sci. Total Environ.* **2019**, *684*, 657–669. [CrossRef] [PubMed]
26. Campanale, C.; Massarelli, C.; Savino, I.; Locaputo, V.; Uricchio, V.F. A Detailed Review Study on Potential Effects of Microplastics and Additives of Concern on Human Health. *Int. J. Environ. Res. Public Health* **2020**, *17*, 1212. [CrossRef]
27. Ragaert, K.; Delva, L.; Van Geem, K. Mechanical and Chemical Recycling of Solid Plastic Waste. *Waste Manag.* **2017**, *69*, 24–58. [CrossRef]
28. What Can Be Recycled. Available online: https://www.beverlyma.gov/227/What-Can-Be-Recycled#!rc-cpage=296042 (accessed on 15 June 2022).
29. Tullo, A.H. Plastic Has A Problem; Is Chemical Recycling the Solution? *Chem. Eng. News* **2019**, *97*. Available online: https://cen.acs.org/environment/recycling/Plastic-problem-chemical-recycling-solution/97/i39 (accessed on 15 June 2021).
30. British Plastics Federation. Chemical Recycling 101. Available online: https://www.bpf.co.uk/plastipedia/chemical-recycling-101.aspx#_Toc31632535 (accessed on 15 June 2021).
31. Milbrandt, A.; Coney, K.; Badgett, A.; Beckham, G.T. Quantification and evaluation of plastic waste in the United States. *Resour. Conserv. Recycl.* **2022**, *183*, 106363. [CrossRef]
32. Yin, S.; Tuladhar, R.; Shi, F.; Shanks, R.A.; Combe, M.; Collister, T. Mechanical Reprocessing of Polyolefin Waste: A Review. *Polym. Eng. Sci.* **2015**, *55*, 2899–2909. [CrossRef]
33. Gandhi, N.; Farfaras, N.; Linda Wang, N.-H.; Chen, W.-T. Life Cycle Assessment of Recycling High-Density Polyethylene Plastic Waste. *J. Renew. Mater.* **2021**, *9*, 1463–1483. [CrossRef]
34. Anderson, L.; Yu, E.; Chen, W.-T. Chemical Recycling of Mixed Plastics in Electronic Waste Using Solvent-Based Processing. *Processes* **2021**, *10*, 66. [CrossRef]
35. Taiwan's Transition-From Garbage Island to Recycling Leader. Available online: https://www.rapidtransition.org/stories/taiwans-transition-from-garbage-island-to-recycling-leader/ (accessed on 17 May 2021).
36. Magazine, S. How Taiwan Has Achieved One of the Highest Recycling Rates in the World. Available online: https://www.smithsonianmag.com/innovation/how-taiwan-has-achieved-one-highest-recycling-rates-world-180971150/ (accessed on 17 May 2021).
37. Strategies on Building a Circular Economy for All. Available online: https://www.epa.gov/recyclingstrategy/strategies-building-circular-economy-all#strategy (accessed on 13 June 2021).
38. Bisbee O'Connell, K.; Keys, B.; Storksdieck, M.; Rosin, M. Context Matters: Using art-based science experiences to broaden participation beyond the choir. *Int. J. Sci. Educ. Part B* **2020**, *10*, 166–185. [CrossRef]
39. Wang, Z.; Wang, S.; Farinella, M.; Murray-Rust, D.; Henry Riche, N.; Bach, B. Comparing effectiveness and engagement of data comics and infographics. In Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems, Glasgow, Scotland, UK, 4–9 May 2019; pp. 1–12. [CrossRef]
40. Jaleniauskiene, E.; Kasperiuniene, J. Infographics in Higher Education: A Scoping Review. *E-Learn. Digit. Media* **2022**. [CrossRef]
41. Otten, J.J.; Cheng, K.; Drewnowski, A. Infographics and Public Policy: Using Data Visualization to Convey Complex Information. *Health Aff.* **2015**, *34*, 1901–1907. [CrossRef] [PubMed]
42. Plastics Crash Course. Available online: https://plasticscrashcourse.wixsite.com/my-site (accessed on 20 January 2021).
43. Zaelzer, C. The Value in Science-Art Partnerships for Science Education and Science Communication. *ENEURO* **2020**, *7*. [CrossRef] [PubMed]
44. Hill, S.; Grinnell, C. Using digital storytelling with infographics in STEM professional writing pedagogy. In Proceedings of the 2014 IEEE International Professional Communication Conference (IPCC), Pittsburgh, PA, USA, 13–15 October 2014; pp. 1–7. [CrossRef]
45. Jawed, S.; Amin, H.; Malik, A.; Faye, I. Classification of Visual and Non-visual Learners Using Electroencephalographic Alpha and Gamma Activities. *Front. Behav. Neurosci.* **2019**, *13*, 86. [CrossRef] [PubMed]
46. Freeman, S.; Eddy, S.L.; McDonough, M.; Smith, M.K.; Okoroafor, N.; Jordt, H.; Wenderoth, M.P. Active Learning Increases Student Performance in Science, Engineering, and Mathematics. *Proc. Natl. Acad. Sci. USA* **2014**, *111*, 8410–8415. [CrossRef] [PubMed]
47. Autodesk Sketchbook. Available online: https://www.sketchbook.com/ (accessed on 14 December 2020).
48. Wix Website Editor. Available online: https://www.wix.com/ (accessed on 15 December 2020).

49. Black Plastic Food Containers Image. Available online: https://recyclingworksma.com/how-to/materials-guidance/recycled-plastics/ (accessed on 15 March 2021).
50. Water Bottles Image. Available online: https://www.azocleantech.com/article.aspx?ArticleID=790 (accessed on 15 June 2022).
51. Plastic Straws Image. Available online: https://paragram.id/berita/jenis-jenis-sampah-paling-banyak-di-bumi-pasti-pernah-kalian-buang-gitu-aja-6594?page=2 (accessed on 15 June 2022).
52. Plastic Soap Dispenser Bottle Image. Available online: https://zabiva.com/empty-shampoo-pump-bottles-32oz%281liter%29-bpa-free-plastic-%28pete1%29-cylinder-pack-of-3-ABSB07795FX8F-1279017 (accessed on 15 June 2022).
53. Cling Wrap/Saran Wrap Image. Available online: https://shopee.ph/Food-grade-100m-plastic-cling-wrap-food-wrap-kitchen-tools-heavy-duty-food-packaging-i.500080645.9689480589 (accessed on 15 June 2022).
54. Plastic Broomstick/Mop Handle. Available online: https://www.alibaba.com/product-detail/PVC-coted-plastic-broom-handle-Colorful_60750159779.html?spm=a2700.pc_countrysearch.main07.17.210330a5jjRa6J (accessed on 15 June 2022).
55. Plastic Shopping Bags Image. Available online: https://www.theguardian.com/environment/2020/jul/30/use-of-plastic-bags-in-england-drops-by-59-in-a-year (accessed on 15 June 2022).
56. Styrofoam Packaging Image. Available online: https://www.chainalytics.com/3-trategies-to-reduce-eps-foam-in-your-packaging-system/ (accessed on 15 June 2022).