Microplastics: Making the Invisible Visible

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ABSTRACT

Mounting scientific evidence suggests that the impacts of plastic, polluting the environment, are manyfold and serious. Consequently, worldwide, there are numerous excellent programs that engage children to participate actively in combatting this persistent environmental problem. Here, we present the program *Living a Life Less Plastic*, which we developed for Australian primary school students in Years five and six (US grades fifth and sixth). The program combines creative arts activities with a real-life scientific investigation on microplastics in beach sand, with the aim to encourage children to apply their creativity and critical thinking in the fight against a world choking by plastic.

INTRODUCTION

Plastic pollution is one of the great environmental challenges of our time. The figures are staggering: more than five trillion plastic pieces are estimated to currently float in the world's ocean with six to eight million tonnes of plastic entering the ocean every year (Eriksen et al. 2014; Jenna et al. 2015). An estimated 80% of all seabirds have plastic in their stomach at present, which is due to increase to 99% by 2050 (Wilcox et al. 2015), and most recently researchers found microplastics in sea salt (Karami et al. 2017) and tap water collected from around the world. Most children these days sadly have heard of the great garbage patches in the ocean and have an understanding about the enormous size of these patches (Lebreton et al. 2018). Many children also understand that plastic is not biodegradable, meaning it is not digested by living organisms into soil and other natural elements. However, fewer children are familiar with the concept and the impacts of microplastic pollution. Invisible to the naked eye, microplastics pose a hidden threat. Our microplastic experiment for Year five and six students in Australia (US grades fifth and sixth) aims to demonstrate the abundance of these tiny plastic particles in the environment. Investigating and detecting microplastics firsthand allows the children (10-12 years old) to draw their own conclusions about the scale of the problem and makes its hidden nature more tangible for children. We first included the microplastic experiment in a four-week sustainability program for Year five and six students called, *Living a Life Less Plastic*. We also incorporated it into a teaching resource on beach ecology called, *Beach Detectives*.

The *Living a Life Less Plastic* school program started when Jane Théau, an artist with a background in scientific research, gave a lesson to her son's Year six class on plastic pollution. It comprised an introduction explaining the history and science of plastic and its impacts on the environment, a screening of a satirical video on the life of a plastic bag, and an art class based on what had been learned. The lesson generated a lot of interest and other teachers requested the materials for their classes. An excursion to the local beach was also arranged to collect data on plastic debris as part of the Teachwild education program, giving Australian school children the opportunity to be citizen scientists, and contribute real data to the CSIRO's National Marine Debris Survey. (See Resources for more information on the Teachwild program.)

Concurrently, Inke Falkner, marine scientist and outreach coordinator from the Sydney Institute of Marine Science, was designing experiments to educate children on the impacts of plastic pollution in the marine environment. Théau and Falkner joined forces to create an enhanced program incorporating five separate sessions addressing several areas of the New South Wales Education Department Year five and six curriculum (Table 1). When discussing the implementation of the program with schools, teachers were also encouraged to become partners by using the theme of plastic to augment other curriculum areas, including English, mathematics, and public speaking.

The program currently runs over a four- to five-week period, covering one program lesson per week. This arrangement seems to work best with the teachers' schedules. However, the program could also be conducted as an intensive one-week program, where the field trip and microplastic experiment are combined in one longer session, for example. Alternatively, the field trip could be conducted before the introduction in the classroom, so the children actively investigate the plastic pollution on the beach first before they learn about plastic and its history in the classroom.

CREATIVE COMPONENT

The aim of the creative component of the program is to heighten the students' awareness of the scale and impact of plastic consumption. There are two main activities employed.

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TABLE 1. Overview of the program content, the curriculum areas covered in each lessons, and the time allocated for each lesson.

Lesson	Content	Curriculum Areas	Time Allocated
Introduction	History of plastic production: discovery, manufacture, uses, economic benefit, societal benefit, environmental impacts, and limits to recycling. Case studies on container deposit and plastic bag legislation.	**History and Society:** global interconnectedness, human environmental interaction, government policy, decision-making processes **Science:** basic chemistry of plastic, biodegradation	1.5 hours
Creative Component	Using plastic waste, the children create art works that emphasize the impact of plastic debris.	**Visual Art:** making art works informed by student's investigation of the world as subject matter; consideration of audience; literacy of signs and symbols	2 hours
Field Trip	Excursion to beach: learn how to mark out transects, collect and tally plastic debris, and collect sand samples for microplastic analysis.	**Science:** interaction between living things and ecosystems; human impact on the environment; scientific method **Mathematics:** measurement; data collection, organization and interpretation; use of tables/graphs	1.5 hours onsite + travel time to site
Science Experiment and 'Call to Action'	Microplastic extraction from beach sand. Filter-feeding demonstration. Brainstorming ideas on how to tackle plastic pollution and 'call to action'.	**Science:** scientific method; use of technology (microscopes) **Mathematics:** measurement; data collection, organization and interpretation; use of tables/graphs	2 hours
Conclusion	Recap of what has been learned. Children present a speech, poem, piece of prose, letter of activism, or video that they have made in the preceding weeks, on an aspect of the impact of plastic pollution.	**English:** persuasive writing; creative writing; public speaking skills	1.5 hours

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In the first activity, the children are asked to bring in plastic shopping bags (not lightweight ones) they have at home. The bags are cut into similar sized squares, which are sewn together to create a quilt, either by hand or, ideally, using sewing machines volunteered by parents. A class of 30 children quickly creates a very large quilt—our first quilt covered 28 m^2. This quilt was hung from a second-floor balcony facing the school quadrangle and was a highly visible and colorful demonstration of the mass of plastic in our environment.

In the second activity, the children are again asked to bring in plastic bag along with the square plastic ties that are used to close plastic bags with food. The bags are then cut into large circles. The students pinch the center of the circle and push it through the bread tie, creating a flower form with a bamboo skewer that is used to pierce through the base of the flower. Each flower represents a sea turtle, dolphin, fish, or bird that has died from ingestion of or entanglement in plastic bags. When the children go to the beach the following week for their field work, the flowers are placed in the sand while they are there, thus, creating a memorial garden. The flowers are subsequently planted again in the school garden, precipitating discussion in the rest of the school.

Once these artworks are installed within the school, one of the students can be chosen to speak in front of the school assembly, explaining the meaning of the installations and what they have learned in the program.

These creative activities elicited an enthusiastic response from the children. However, it is important that the resulting impression is not that plastic can be made beautiful, but that plastic is made into objects that demonstrate the overwhelming proliferation of plastic (activity 1) and the negative impact of plastic on the environment (activity 2).

FIELD TRIP

Since we are located on the coast in Sydney, Australia, we have been using beach sand to conduct the microplastic experiment. However, the experiment could be carried out using other materials collected in the environment such as river sand and soil (as long as the organic matter content is not too high). (Note that organic matter, when floating in the saline solution, may interfere with the microplastic particles and a pre-filtration of the solution might be needed before separating the microplastics.)

Children constructing a quilt made of plastic bags. Courtesy of Jane Théau

Children conduct their own fieldwork, including a plastic survey and collection of sand samples for the microplastic extraction later in the classroom. Courtesy of Inke Falkner

If possible, students collect their own sand samples. This allows the children to explore the environment, potential sources of plastic pollution, and mode of distribution. At the beach, the students examine and discuss where rubbish found on the beach may come from. Has it drifted with currents and tides onto the beach, is it litter dropped by beachgoers, or was it washed onto the beach in a fresh-water creek entering the beach? Is it a busy beach and are there rubbish bins provided? Are there recycling bins? At this point, the students can also conduct a survey and collect the rubbish found on the beach. This opens up more discussion as to what types of rubbish were found and its previous uses.

The sand samples are collected in a scientific fashion along a transect line, which follows the tidal high watermark on the beach, also called the wrack line. Before the students set out to collect the samples, the importance of replication and standardization in science are discussed. Why do we use a transect line and a quadrate to collect the samples? The students are then divided into small groups and are instructed to collect sand for further analysis. The students collect two replicates at set points along the transect line; for example, every 5 or 10m, using a pre-made quadrate, spoon, and re-usable plastic bags. Back in the classroom, the students are always surprised and amazed to see how the samples differ in size despite the standardized sampling.

MICROPLASTIC EXPERIMENT

The separation of microplastic particles from sand is based on the physical principle that plastic is light and floats, while sand is dense and sinks in water. We designed this experiment in consultation with researchers working on microplastic pollution and devised simple and cheap tools to conduct the experiment using recyclable beverage containers, paper coffee filters, and a saline solution made of table salt dissolved in tap water.

The experiment is conducted in steps with clear instructions given before each step so all students can follow along. First, students mix the saline solution and sand to separate the microplastic particles. They do this by stirring the mixture vigorously before setting it aside for a few minutes to allow the microplastic to float to the surface of the solution. This is a good time to introduce the various sources of microplastics, and what these tiny plastic particles can look like.

The next step involves pouring the saline solution through a filter. We found that paper coffee filters work very well in retaining microplastics. Once the water is filtered, the inside of the paper filters can be opened and inspected under a microscope by gently pulling the seam of the filter apart. The students have enjoyed getting to know a light microscope and inspecting the filter paper during this part of the lesson.

There is always great excitement when students start to find microplastic particles. In our experience, fibers are by far the most abundant microplastic items in sand samples along Sydney's beaches. The students find them in almost all samples, which illustrates the scale of the problem.

FILTER-FEEDING DEMONSTRATION

Following the experiment, students question why the issue of microplastic pollution matters to them or the environment. Who cares if there are microplastics on the sea floor or on the beach? A demonstration of filter feeding in oysters; for example, greatly helps in answering these question. In this demonstration, students can witness live how tiny particles, in this case carmine dye, is filtered and accumulated by the filter-feeding oyster. This experiment could also be used with other filter-feeding and sediment-eating organisms found at the base of the food web.

CALL TO ACTION

After watching the filter-feeding demonstration and discussing the impacts of microplastics on marine organisms, the students are shown an image of plant pots made from recycled plastic containers. In this context the 'Three R's' are discussed: what are the opportunities and challenges of 'Reducing, Reusing, Recycling' plastic? Each student pledges to make a change or adopt a habit to reduce plastic waste. Many children also rally their parents to stop using single-use plastic bags and unnecessary packaging, or ask to have their lunches packed in lunch boxes or paper bags instead of plastic wrapping.

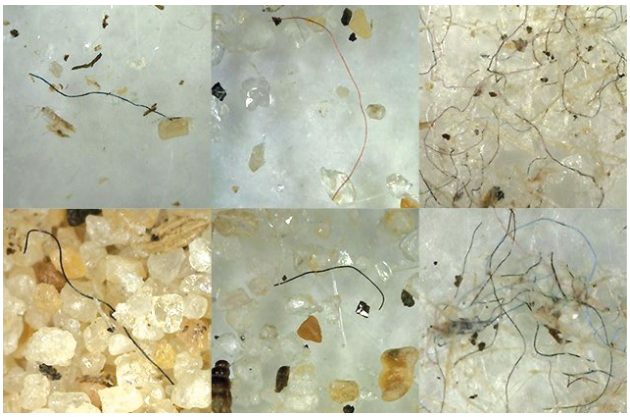
Some schools have also implemented plastic-free lunches or changed their recycling systems to encourage students to bring re-usable water bottles. One class hosted a fashion parade at their school, where the children showcased handbags that they had made from plastic waste, to raise awareness. Another class of students handed out self-made leaflets to local café customers and urged them to use re-usable take-away cups.

It is encouraging to see how the students take ownership and develop an activity that has a direct impact on their local environment. The students feel empowered when they take action and find their own solutions.

The *Living a Life Less Plastic* program worked most effectively when the teachers became partners in the project and incorporated the theme into other aspects of the term's lesson plan.

Concentrated and vigorous stirring of the sand-saline solution mix allows the microplastic particles to be 'released' into the saline solution. Courtesy of Inke Falkner

One of the highlights of the experiment is the use of a mini microscope. The students practice first how to use the microscope before they search for microplastic particles on the filter paper. Courtesy of Inke Falkner



Examples of microplastic fibers found in the beach sand. Fibers have been the most abundant microplastic component found in the sand samples. Courtesy of Inke Falkner

STEM education has become a focus worldwide. The *Living a Life Less Plastic* program and the *Beach Detectives* teaching resource are not just STEM programs—they can be set up as citizen science programs with a STEM focus that actively engage the whole community. The data collected by school children could form a benchmark for microplastic presence in our environment.

Learning by doing, active participation, and understanding the scientific process are the keys to developing critical and creative thinkers. By working together, students from all over Australia and globally could take part in a very exciting project that has positive outcomes for all.

If you would like to receive the step-by-step instructions for the microplastic experiment, please contact Alana Rooney at the Sydney Institute of Marine Science.

RESOURCES

The following videos and films about plastic pollution can be shown in the classroom:

- http://www.youtube.com/watch?v=GLgh9h2ePYw
- http://storyofstuff.org/movies/story-of-bottled-water/
- http://www.plasticoceans.net/
- http://www.midwayfilm.com

General information about plastic pollution:

- http://marinedebris.noaa.gov
- www.jenniferlavers.org
- http://plasticbank.org
- http://5gyres.org

Teachwild program information:

- https://research.csiro.au/marinedebris/projects/teach-wild/
- https://www.youtube.com/watch?v=rp4GIn4F7Lw

ACKNOWLEDGMENTS

We would like to thank the many scientists affiliated with the Sydney Institute of Marine Science who contributed to the content of the programs with their expertise. A particular 'thank you' to Dr Vivian Sim, who generously provided material and guidance on the microplastic experiment. We would also like to thank the Rotary Club of Freshwater Bay, Western Australia for providing the mini microscopes for the activity, and the SIMS Foundation for raising funds to purchase the mini microscopes and run the program. Last but certainly not least, we would like to thank the teachers and schools who have worked with us. The passion with which the teachers have co-taught this topic has been fantastic.

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