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Measuring Students' Pro-Environmental Attitudes and Behaviors Before and After Demonstration-Based Instruction

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Abstract

A growing amount of research exists on environmental education programs which incorporates the viewpoints of students into its assessment of the program's efficacy. This research seeks to add to that body and evaluate an environmental education program about the sustainability of plastics, using both quantitative and qualitative data collected from participating students. The data was collected after a 90-minute instructional block of demonstration-based environmental education meant to inform students on the variability of plastics' properties and the sorting and remolding processes of recycling. It also aimed to help build pro-environmental attitudes and behaviors in the students, and a sense of civic responsibility for safe and effective management of plastic waste. The final data analysis utilized both the qualitative and quantitative data to build a picture of students' learning and thinking in the activity. While few significant results were found due to a variety of factors, several suggestions were included to improve both the educational program and its evaluation.

Introduction

As the amount of plastic waste continues to increase, plastic waste management becomes an ever-growing problem. An overabundance of waste can cause harm from the level of an individual person, plant, or animal up to an entire habitat or ecosystem. Plastic waste in particular poses a problem that is difficult to solve. Plastic has come to be a highly useful and versatile material in both durable and non-durable products (Environmental Protection Agency, 2020), yet it is these same properties that make managing plastic waste challenging. The most recent US EPA data from 2018 reports that plastic waste represented 18.5% of all municipal

solid waste that was landfilled. This percentage represents about 27 million tons of plastic (Environmental Protection Agency, 2020). Crucial to effective management of this issue is effective environmental policy, which can only follow from effective environmental education. Effective environmental education programs should impart knowledge of the problems and available solutions. They should also invite students to participate in investigating problems and designing and testing solutions in local contexts (Dalu et al. 2020, National Research Council 2005, Pursitasari & Suhardi 2018, & Zhan, He, & So, 2018). This paper evaluated an investigation of an existing environmental education program delivered on the topic of plastic waste and recycling to determine its effectiveness and to provide suggestions to design more effective environmental education programs concerning plastic in the future.

Background

Several research studies have explored the effectiveness of education programs about plastic. Some publications focused on teacher or other professional interviews in schools to gauge effectiveness (Dalu et al., 2020); others focused on community factors which affect acceptance of these and other plastic management programs (Huijts, Molin, & Steg, 2011 & Dütschke, 2011). In recent research, there has been a growing interest in evaluating these programs utilizing student perceptions (Soryte & Pakalniškienė, 2019).

Zhan, He, & So (2018) discussed elementary student performance and perceptions about water conservation. Their study sought to measure students' action competence for environmental causes. They used Stevenson's definition of action competence: a student's capacity for "acting on their own choice and influencing environmental decision making" (Stevenson, 2007, as cited in Zhan, He, & So, 2018, p. 2). The study also identified four components of action competence: knowledge, self-efficacy, willingness to act, and experience

(Zhan, He, & So, 2018). The educational program evaluated by this paper aimed to help build these factors by giving students knowledge of plastic recycling capabilities and processes through demonstration activities. Several activities were designed to model what is possible with plastic recycling as well as portions of the plastic recycling process.

It was also important that the content of the program being evaluated was framed in a way that its application and relevance to the students is clear. This emphasis is supported by existing science education frameworks, such as the Next Generation Science Standards. These standards focus not only on science content, but on helping to engage students with thinking and writing practices utilized by scientists by outlining their Science & Engineering Practices (NGSS, 2013). These practices can be incorporated into active, inquiry-based learning which allows students to build deeper and longer-lasting connections with both the material and the practices themselves. This helps students become better-prepared to make informed decisions about science, science-related policy, and general problem-solving in their lives after high school education (National Research Council, 2005).

Several other publications also suggest that contextualizing the content of environmental education in its everyday application and experiences for students helps them build stronger connections to that content (Pursitasari & Suhardi, 2018, Nicol, 2014). Pursitasari & Suhardi's (2018) environmental pollution teaching book was designed to consider context-based learning in its delivery. The book was designed to be an aid to both students of environmental education programs and to help instructors situate the content of the programs within local contexts. The context-based teaching book was found to significantly build students' critical thinking skills about pollution and problems related to pollution, which relates it primarily to the knowledge dimension of action competence. Nicol's 2014 e-mail survey was conducted in a master's level

university course, but the experiential learning "pyramid" model he puts forth is applicable across grade levels. This model places learning through experience as the foundation which supports all other types of learning. This idea is also supported by the educational theory of constructivism, which posits that students construct meaningful learning through direct educational experiences. The 2005 findings of the National Research Council report, *How Students Learn: Science in the Classroom*, further supports this model. Its findings suggest situating educational content within experiences that build a broader contextual framework for application of knowledge (National Research Council, 2005). Nicol's 2014 survey found that experiential learning in their master's level course influenced at least surface-level behavior and attitude changes in five out of ten students enrolled in the course, and significantly large changes in behaviors and attitudes were reported in three out of the ten students.

Another component of effective environmental education identified by existing research is relating programs to local non-governmental organizations (Dalu et al., 2020). The group activities and demonstrations in this program gave students opportunities to engage with experiential learning and were part of a community partnership between the school and a local recycling initiative, Zips Precious Plastics (ZPP). This partnership aimed to build connections to the application of the program's content by allowing students to interact with people who use the content on a regular basis. These kinds of community relationships demonstrate to students that the information is not only useful to know but can also be used to affect local change. This was meant to help students build self-efficacy regarding their ability to have an impact on scientific policy issues in the future.

Several publications also explored the community acceptance of environmental education technologies and programs. This research was considered in the design of the curriculum. Huijts,

Molin, & Steg (2011) identified three possible factors which can affect the acceptance of environmental technologies: cost-benefit evaluations, moral evaluations, and positive/negative feelings about the technology. The curriculum described in this paper aimed to build positive feelings about the capability of plastic recycling process, as well as knowledge of its limitations, to allow students to make informed decisions about plastic use and plastic policy in the future. Including knowledge of the limitations of current recycling technology and of different methods of recycling allowed students to perform more accurate cost-benefit evaluations in their futures as well.

Curriculum and Delivery

The curriculum delivered during the observed class segment was adapted for a 5th grade classroom from the 4H Polymers *Sustainable Polymers* curriculum for grades 3-5 (Stevenson, McCambridge, & Mondl, 2020) and Dr. James Eagan's existing university-level course, Sustainable Plastics. Highly academic vocabulary, such as technical names for types of plastic, were reduced to the minimum that is necessary for understanding of the content. The observed segment was a 90 minute instructional block with a group of 12 students. The objectives of the curriculum were to show, through demonstration, that there are many different types of plastics with different properties (including ease of recycling), to provide students with an understanding of what happens in the recycling process, and to foster a sense of capability and responsibility to take positive environmental action. This was done through several demonstrations (Rubber Duck demonstration, Plastic Show & Tell) and group activities (Melt Mystery, sorting plastic). The curriculum involved many opportunities for students to interact with physical props such as plastic molds. It also included an opportunity for students to direct some of their own learning during the Plastic Show & Tell activity, during which students shared a piece of plastic they used

during the day or at home and other students helped to describe some of its characteristics. The three major sections of the observed segment are detailed below.

Many Kinds of Plastic

This section opened with a short introductory discussion about what plastic is, what recycling is, and other necessary background knowledge such as the vocabulary that was used in the activity to describe characteristics of plastic and recycled plastic. This transitioned into the Plastic Show & Tell activity, which was student-led and allowed students an opportunity to use the new vocabulary to describe the plastic they brought with them for the activity. After Plastic Show & Tell, the professor led the Rubber Duck Demonstration. This activity was meant to give students opportunities to make predictions about how a piece of plastic (the rubber duck) will react under differing heating and cooling conditions. To again demonstrate the differences between different types of plastics, the Rubber Duck Demonstration transitioned into Melt Mystery, which asked students to try to identify what products a cooled down piece of melted plastic used to be and identify ways these different plastic products melted differently. Melt Mystery concluded with a live demonstration where the professor melts two pieces of plastic made out of different types of plastic and allowed students to elaborate on and revise their initial predictions about how plastic might react under different conditions. Students used a worksheet in this portion which asks them to create a before and after drawing for the melted plastic, and in the discussion, they compared how they are different and why they might be different.

Sorting Plastic

This segment followed Melt Mystery, which helped students solidify their understanding that there are different types of plastics with different properties. They participated in a sorting

activity where they separated two types of plastic, one which floats and one which sinks, using a beaker of water and small nets. The floating pieces of plastic were removed and put in a small bowl. Students made observations about how the plastic separated and which ones seemed to separate out, and these observations were recorded by the professor who gave students opportunities to elaborate on their thoughts.

Melting Plastic

This segment began with Mixed/Separated Mystery, an activity where students formed predictions using several examples of plastic films and molds to determine whether the plastic props they had were made of sorted plastic (separated) or unsorted plastic (mixed). This was followed by another live demonstration done by the professor which guided the students to understand how sorted plastic films have stronger physical properties than unsorted films. The learning segment ended with a brief show and tell of plastic molds made out of recycled plastic using a melt press, and the students designed their own mold shape.

Methods

This study sought to investigate students' pro-environmental attitudes and/or behaviors concerning plastic waste and recycling when the information is delivered through a demonstration-based educational program. Data collection sources included a survey instrument on attitudes towards recycling and observation data. The observational data were used to understand the context for the study and suggest areas of improvement for this program and future programs to both strengthen student understanding of the content and encourage pro-environmental behavior, perceptions, and attitudes.

Data Collection and Analysis

Research publications on environmental education evaluation helped to inform the creation of the survey used for this evaluation. The questions in the student survey were cooperatively designed by the author and the professor who delivered the observed segment. The questions asked were based on the questions found in a similar assessment of student knowledge conducted by Hammami et al. (2017), although the questions in this study did not have a predetermined correct answer. The evaluation guidelines created by Thomson and Hoffman (2010) informed the choice to collect both quantitative and qualitative data from student surveys. Qualitative data was collected in this study through three open-ended survey questions and the observation protocol (Science Learning Activation Lab, n.d.). Quantitative data was collected through 13 Likert-type survey items. There are six questions about attitudes on a five-point scale (SD/D/N/A/SA) and seven questions about behaviors on a five-point scale (Never/Almost Never/Sometimes/Often/Always). The survey was administered both before and after instruction in order to collect pre-/post-data. The survey was designed to focus only on one aspect of behavior and one aspect of attitudes out of the several dimensions of both identified by Vezeau et al. (2017) in their development of scales to measure knowledge elaboration and pro-environmental behaviors in students. This is because their scale development found the separate aspects to have a highly complex relationship which would be difficult to isolate, and as such it would be more productive to focus on individual aspects. The survey was used to evaluate the program's impact on personal attitudes and at-home/at-school behaviors.

Mean, median, mode, and frequency of each response were calculated based on data collected before and after instruction. The qualitative data was analyzed using thematic analysis. Student responses were grouped into codes, which were then grouped into themes. Frequencies

of themes for each question are reported. The thematic analysis was supplemented by data from classroom observation during the program. Observational data allowed for analysis of student engagement with the content and materials used in the program, as well as engagement in scientific thinking and practices. Data from the classroom observation was also utilized to provide suggestions for the improvement of this and future educational programs about plastic and plastic recycling in the Discussion section.

Limitations

The data collected from the surveys was limited primarily by sample size. Only nine pairs of pre-/post-data were able to be collected. The frequency of response table shows responses from all subjects who responded to each question, but the whole class is still only a sample size of 12. This limited the usefulness of analyzing change in students' behaviors, but the qualitative data allows for an analysis of patterns of thinking and learning in the class during the demonstration-based program. Although a t-test was performed on pre- and post-survey data, meaningful conclusions about behavioral change cannot be drawn because there was no time between the delivery of the program and the post-survey. Instead, the behavioral data was used to help identify and contextualize patterns in students' attitudes about and perceptions of plastic waste and recycling.

Two other major limiting factors were prior knowledge of the subject material and the survey tool used. The students in this sample class seemed to have some past experience learning about plastic and recycling, which could skew the quantitative data towards the extremes of the given options. This compounded with an assumption made by Likert-type questions that the differences between response "levels" are equal across the levels. Because these questions were designed to collect data about opinions and frequency of behaviors, this assumption was not

necessarily true. For this reason, the mean and t-test p-value may not have been reliable statistics on their own and were supplemented with other modes of analysis.

Results

In the Likert-type survey, students were asked to respond to a variety of questions concerning their attitudes about plastic waste and recycling, as well as the frequencies of behaviors related to recycling. Students answered on a 5-point scale in each section. In the Attitudes section, a 1 corresponds to “Strongly Disagree” and a 5 to “Strongly Agree”. In the Behaviors section, a 1 corresponds to “Never” and a 5 to “Always”. Table 1 shows the means, medians, modes, and p-values for the student responses to each question on the survey.

Little change was observed in both the median and mode values. Most median values stayed the same or increased by a point or less. Attitudes Question 6, asking whether plastic products should be replaced by products made of other materials, was the only one which exhibited a decrease by a full point in the median value. Most of the mode values in the behavior section remained the same, except for on Q1 and Q2 (if the student or their family recycles at home) which exhibited a one point increase. Similar to the median, Q6 in the Attitudes section was the only question which showed a decrease, and it again decreased by a full point. Small changes in the mode were expected, as the post-survey was administered immediately after the educational program so there was not significant time between the pre- and post-surveys for large behavioral changes to take place. Significant changes were observed in the mean values of Attitudes Question 1, which asked if students believed plastic products are more useful than non-plastic alternatives, and in Behaviors Question 5, which asked if friends or family members of students recycle plastic in school or other public places.

Table 1

Pre/Post Mean, Median, and Mode for Quantitative Survey Responses

Survey Item	Median		Mode		Mean		p-value*
	PRE	POST	PRE	POST	PRE	POST	
	Attitudes						
Q1: Plastic products are more useful compared to other options	3	4	3	4	2.73	3.9	0.007**
Q2: Plastic use is more acceptable if the waste is recycled.	4	5	5	5	4	4.11	0.815
Q3: All plastic waste that can be recycled should be.	5	5	5	5	4.82	4.67	0.351
Q4: Multiple-use plastic products are better than single-use products.	4	4	4	3	4.18	3.8	0.782
Q5: Options other than single-use plastic products should be made.	4	4.5	4	5	4.09	4.3	0.782
Q6: Plastic products should be replaced by other products.	3	2	3	2	2.45	2.3	0.645
	Behaviors						
Q1: I recycle plastic waste at home	4	4.5	4	5	3.55	4.3	0.111
Q2: I have friends/family who recycle plastic waste at home.	4	4.5	4	5	3.82	4	1
Q3: I, or people I know, check the type of plastic before recycling it	3	3.5	3	3	2.73	3.5	0.095
Q4: I recycle plastic waste at school and/or in public places.	4	4	4	4	3.8	3.89	0.736
Q5: I have friends/family who recycle plastic waste at school and/or in public places.	4	3.5	4	4	3.55	3.3	0.050**
Q6: I encourage people to recycle plastic waste.	4	5	5	5	3.73	4.4	0.512
Q7: I know people who encourage others to recycle plastic waste.	3	4	3	3	3.18	3.9	0.133

Note. *The t-test to obtain this p-value was carried out with a sample size of 9, since that is all the paired data points. The means shown in this table are calculated from all available data points, including ones which do not have a pair in the surveys. ** indicates a difference was found to be statistically significant in the t-test.

In the Attitudes section of the survey, little change was observed in the frequency of responses. Two exceptions are Question 1 and Question 6. Question 1, which asks students if they believe plastic products are more useful than alternatives, saw a large number of students change their attitudes from “Disagree” or “Neutral” to “Agree” or “Strongly Agree”. While 10 out of 11 students who submitted pre-survey responses were neutral or expressed some degree of disagreement, 7 of 10 students who submitted post-survey responses indicated they either agreed or strongly agreed that plastic products are more useful than non-plastic alternatives. Question 6, which asks students if they believe plastic products should be replaced by non-plastic alternatives, saw many students switch from neutral or agreeing responses to “Disagree”, with only one student out of ten submitting a post-survey response that strongly agreed with the statement. Five students disagreed, two strongly disagreed, and two were neutral. Table 2 compares the frequency of each response to an Attitudes item in the pre- and post-surveys.

Table 2

Frequency of Each Response to Attitude Survey Items

Survey Item	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Q1: Plastic products are more useful compared to other options	1	0	3	1	6	2	0	4	1	3
Q2: Plastic use is more acceptable if the waste is recycled.	1	0	1	1	0	2	4	1	5	5
Q3:All plastic waste that can be recycled should be.	0	0	0	0	0	1	2	1	9	7
Q4:Multiple-use plastic products are better than single-use products.	0	0	0	1	2	3	5	3	4	3
Q5:Options other than single-use plastic products should be made.	0	0	0	0	3	2	4	3	4	5
Q6: Plastic products should be replaced by other products.	3	2	2	5	4	2	2	0	0	1

In the Behaviors section of the survey, little change was observed in median and mode values for questions 1 and 2 across the whole class, which asked students how frequently they and their friends or family recycle plastic waste at home (*Table 1*). However, looking at frequencies of responses (*Table 3)* showed that many more students answered that they or their family/friends recycle more frequently in the post-survey than they did in the pre-survey. In the post-survey, no student answered that they recycled plastic less frequently than "Sometimes" and only one answered that their family/friends recycle less frequently than "Sometimes". The number of students who answered "Often" also decreased significantly between pre- and post-surveys. "Always" was the most frequent response to both of these questions in the post-survey, but not in the pre-survey.

The most noteworthy change in this section was that more students indicated in the post-survey that they check the type of plastic before recycling it more frequently (Question 3), with only a small number of "Never" or "Almost Never" responses. Little change was observed in student responses about the frequency they or their family/friends recycle plastic waste in school or in other public places (Question 4 and 5). Notably, all students indicated that they encourage others to recycle at least as often as "Sometimes" (Question 6). Similarly, students indicated that people they know also encourage others to recycle at least as often as "Sometimes", with no responses which indicated a frequency of "Never" or "Almost Never" in the post-survey.

Table 3

Frequency of Each Response to Behavior Items

Survey Item	Never		Almost Never		Sometimes		Often		Always	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Q1: I recycle plastic waste at home.	0	0	2	0	2	2	6	3	1	5
Q2: I have friends/family who recycle plastic waste at home.	1	0	0	1	1	3	7	1	2	5
Q3: I, or people I know, check the type of plastic before recycling it.	2	1	3	1	3	3	2	2	1	3
Q4: I recycle plastic waste at school and/or in public places.	1	0	0	1	1	1	6	5	2	2
Q5: I have friends/family who recycle plastic waste at school and/or in public places.	2	1	0	1	1	2	6	4	2	1
Q6: I encourage people to recycle plastic waste.	1	0	1	0	2	2	3	2	4	6
Q7: I know people who encourage others to recycle plastic waste.	2	0	1	0	3	4	3	3	2	3

In the first written-response question, students were asked their opinions about usage of disposable plastic products. Common themes which appeared across their answers were: the usefulness of plastic products, concerns about plastic waste, awareness of alternatives to disposable plastics (recyclable plastics or non-plastic alternatives), knowledge of recycling, environmental benefits of plastic, and awareness of alternatives to recycling (burning, landfill, etc). In the pre-survey, nine students out of eleven indicated that they believed single-use plastics were useful. Three indicated a concern for plastic waste. Out of those three, two also indicated that they believed single-use plastics were useful but that too many of them are produced or thrown away. The most notable change in the themes identified in these responses is a large reduction in the number of students who expressed the belief that disposable plastic products are useful. Only five out of ten students indicated this belief in the post-survey, compared to nine out of eleven in the pre-survey. Responses also indicated little increases in the themes that would

suggest a change in thinking about this topic, with the exception of the environmental benefits of plastics which was identified in three of the post-survey responses. These three students expressed the belief that recyclable plastics provide a benefit to the environment since they do not enter it as waste, but do not say anything about disposable single-use plastics. Table 4 shows the frequency that each theme appears in student responses for the first written response question on the student pre-/post-survey. Some responses were assigned multiple main ideas, so the sum of the pre- or post-survey frequencies may not reflect the size of the class.

Table 4

Frequency of Themes in Qualitative Survey Item 1

Theme	PRE-Q1: What do you think about our use of disposable (made to be thrown away) plastic products?	POST-Q1: What do you think about our use of disposable (made to be thrown away) plastic products?
Usefulness of Plastic	9	5
Concern about Waste	3	2
Awareness of Alternatives to Disposable Plastic	1	0
Knowledge of Recycling	2	3
Environmental Benefits	0	3
Awareness of Alternatives to Recycling	1	0

In the second written-response question, students were asked about whether they believe the amount of plastic waste that people produce is a problem. Common themes which appeared in their answers were: a concern about plastic waste, no concern about plastic waste, awareness of human impact on the environment, awareness of the health impact waste has on humans, awareness of the environmental impact of waste, awareness of alternative processes to recycling, and awareness of possible future waste management problems. The most noteworthy change in

these responses was the decrease in awareness expressed for the health and environmental impacts of plastic waste. No students expressed an awareness or concern for the health impact of waste in the post-survey, and six out of ten (compared to eight out of eleven) expressed an awareness or concern about the environmental impact of waste. The student who expressed concern about a possible future waste management problem also expressed that they have no concern about the current amount of plastic waste. Students who expressed a concern about waste in the pre-survey also expressed awareness of at least one of the three "impact" themes (Human Impact, Health Impact, and/or Environmental Impact). In the post-survey, this does not hold for one of the eight students who expressed a concern about plastic waste. Table 5 shows the frequency of each theme identified in the responses. Some responses were assigned multiple themes, so the sum of pre- or post-survey frequencies may not reflect the actual size of the class.

Table 5

Frequency of Themes in Qualitative Survey Item 2

Theme	PRE-Q2: Is the amount of plastic waste we create a problem? Explain your answer	POST-Q2: Is the amount of plastic waste we create a problem? Explain your answer
Concern about Waste	9	8
No Concern about Waste	1	1
Awareness of Human Impact on the Environment	1	1
Awareness of Health Impact of Waste on Humans	2	0
Awareness of Environmental Impact of Waste	8	6
Awareness of Alternatives to Recycling	0	1
Awareness of Possible Future Problems	0	1

In the third written-response question, students were asked what they think should be done with plastic waste. Common themes identified in their answers were: knowledge of recycling, awareness of alternative processes to recycling, and knowledge of plastic waste types. Fewer students (two out of ten compared to four out of eleven) referenced alternative processes to recycling in their post-survey responses, although there was also one less response referencing recycling at all in the post-survey. A notable change is the appearance of student knowledge of plastic waste types in the post-survey. No students referenced this knowledge in the pre-survey, and only one student referenced it in the post-survey. Students often made broad references to recycling or other processes such as landfill or combustion, which made the appearance of this specific mention notable. Table 6 shows the frequency of each theme identified in the written responses to the third question on the pre-/post-survey. Some responses were assigned multiple themes, so the sum of the pre-/post-survey frequencies may not reflect the actual size of the class.

Table 6

Frequency of Themes in Qualitative Survey Item 3

Theme	PRE-Q3: What do you think should be done with plastic waste that we create?	POST-Q3: What do you think should be done with plastic waste that we create?
Knowledge of Recycling	7	6
Awareness of Alternatives to Recycling	4	2
Knowledge of Plastic Waste Types	0	1

Discussion

Student Attitudes

As shown by the paired t-test (*Table 1*) using nine of the paired student responses, only two items on the Likert-type survey had a statistically significant change in their means. The first attitude question showed a statistically significant change, and so did question five in the behaviors section. The change in the attitude question indicates that after receiving instruction, on average students agreed more strongly with the idea that plastic products are more useful than their non-plastic alternatives. The p-value for this question is well below the selected alpha value of 0.05, so it is likely that the instruction played at least some part in this change. This is also supported by an increase of a full-point in both the median and mode of the data set for attitude question 1. *Table 2* further supports this and shows that a substantial number of students switched their answer from either strongly disagree or disagree to either agree or strongly agree. Very few students responded with any level of disagreement to the first question in the post-survey. The change in the fifth behavior question's mean would indicate that students knew more people who would recycle in school or in other public places, or that these people encouraged recycling more frequently than at the time of the pre-survey. The p-value that returned from the t-test for this question is much closer to the selected alpha value of 0.05. The mode remains the same, indicating that the most common response in the sample classroom did not change. As such, this change was likely not the result of instruction but of the limitations placed on the data by the evaluation tool and sample size.

As shown in *Table 4*, the two largest changes observed in the response frequencies to the first written response were in the themes "Usefulness of Plastic" and "Environmental Benefits". "Usefulness of Plastic" refers to student mentions of how plastic can be useful compared to other

materials, ease of disposal/recycling, and other mentions of how plastic can be broadly applied. "Environmental Benefits" refers to student mentions of how re-use or recycling of plastics, or otherwise removing them from places they can cause harm, can be helpful to the environment. It is interesting that the number of students mentioning the usefulness of plastics decreased here due to the significant increase in students who believed plastics were more useful in Question 1 of the quantitative attitudes survey. It is especially interesting considering the increase in student responses mentioning the environmental benefits of single-use plastics, a theme which does not appear at all in the pre-survey responses. This discrepancy may be due to a bias written into the questions, instruction in the program about about or experience with single-use plastics (which is crucial to long-term food transportation and storage), or it is possible students understood the three questions differently from each other in a way that was unexpected by the author.

Table 5 shows notable changes in the frequency of the themes "Awareness of Environmental Impact of Waste" and "Awareness of Health Impact of Waste on Humans". It also indicates the emergence of two themes in the post-survey which do not appear in the pre-survey: "Awareness of Possible Future Problems" and "Awareness of Alternatives to Recycling". To address the decreases first, it may be possible that these themes are things students simply did not see fit to mention in both surveys. To the author, it does not seem likely that this reflects a significant change in the students' attitudes, as the number of responses mentioning a concern about the amount of plastic waste, even after considering differences in sample size across pre- and post-data, only decreased by one. The appearance of the two new themes is interesting, as it suggests that a student is thinking not only about the current state of the problem but the potential long-term consequences of a plastic waste management problem. The student whose response expressed the theme "Awareness of Possible Future Problems" also

expressed that they did not think the current amount of plastic waste was a problem, but that there should be a plan in case it becomes one. The student whose response expressed the theme "Awareness of Alternatives to Recycling" also expressed "Concern about Waste", and indicated they knew about other methods of disposing of/recycling plastic waste rather than repurposing them into new products, which is what the program focused on.

Table 6 shows a decrease in the frequency of the theme "Awareness of Alternatives to Recycling" from four to two, as well as the appearance of a new theme in the post-survey, "Knowledge of Plastic Waste Types", which was meant to be specifically addressed by the instruction in the educational program. There is also a smaller decrease noted in the theme "Knowledge of Recycling", although this decrease is likely due to a smaller sample size in the post-survey. Not all students completed all questions in both the pre- and post-survey, so it is unlikely that this decreases represents any significant change in knowledge, attitudes, or behaviors. The decrease in "Awareness of Alternatives to Recycling" may be partially due to the same cause, but it may also be possible that fewer students believed alternative processes were equally or more viable than recycling plastic waste into new products after receiving instruction. The appearance of the new theme "Knowledge of Plastic Waste Types" is notable because it was one of the content goals of the curriculum. However, it only appears in one post-response. Given the number of students who changed their answer to "Sometimes" or more often in the quantitative portion of the survey (Behavior Q3), one might expect the number of post-responses mentioning plastic type in this qualitative response to be higher.

Other experience-based environmental education programs reviewed while designing this study (Zhan, He, & So, 2018 & Nicol, 2014) have produced more meaningful results than what was observed in this study. In their 2018 study focusing on elementary students' action

competence as it related to water conservation, it was found that the delivery of their seven-week educational program produced significant positive differences in all four components (knowledge, behavior, commitment, and self-efficacy) that were identified as critical to building action competence (Zhan, He, & So, 2018). Nicol's (2014) study was primarily of behavior and attitudes, and in its sample of 10 students it was concluded that three students experienced substantial transformation of mindset and behaviors. Nicol (2014) also concluded that four of the ten students showed evidence of questioning their pre-existing notions of the program's content, and five of the ten showed evidence of surface-level behavioral changes, such as carrying out a task because it is a rule/routine to do so. It is the author's belief that these differences are primarily due to a difference in the length of delivery of the program. Zhan, He, and So's program lasted for seven weeks, and Nicol's survey related to a semester-long course. Working within the time limits of one 90-minute instructional block, the behavioral outcomes were not expected to be on par with either of these publications. However, it is the author's belief that the data on the instruction that was provided shows the beginning of similar trends to these publications. It may be that with a longer program delivery time, similar results would be observed.

Implications for Future Programming

One of the major limitations on the applicability of the data in this study was the small sample size. It is difficult to say whether these changes were truly significant with a sample size of 12 responses, and often less than that. In repeats of this evaluation, it would be helpful to either collect responses from a larger class or over the course of a longer program. Significant changes, especially in behavior, are less likely to occur in this evaluation because the survey

evaluated the observed changes after only a single class meeting. A larger class or longer-term program may produce more meaningful conclusions.

A concerning outcome of this study was that students' responses concerning the downsides of plastic use or overuse experienced a decrease in both the qualitative and quantitative data. The students seemed to understand that recycling is environmentally helpful and that unnecessary waste is not desirable. However, in some places, their responses indicated a lack of deeper understanding of why overuse of plastic and growing numbers of unrecyclable plastic waste can become an issue for the health of people. Two out of the ten students who submitted written responses to the post-survey seemed to understand that it causes harm to animals which can, through the food chain, cause harm to us, but these students were not the majority and did not always see how improper waste management can cause direct harm to us. These numbers likely suffered from the small sample size and a lack of emphasis on that topic in the program. Rectifying this potential misunderstanding could be as simple as including an activity in the program about the cost-benefit analysis of using plastics. Giving students the choice of the type of plastic or plastic product to investigate may give them additional ways to engage personally with the content. Any way to incorporate the cons more clearly alongside the benefits of plastic usage would be beneficial to this program. That being said, it is important to make the downsides explicit while taking caution not to scare students away from the idea of using plastic entirely, as there are purposes plastic is uniquely situated to serve.

Concerning the data collection used in this paper, in addition to increasing the sample size it may be beneficial to increase the variety of tools being used. Other studies (Dalu et al., 2020, Zhan, He, & So, 2018, & Nicol, 2014) of efficacy employed instructor interviews and/or student interviews and activities. In a repeat of this study, the inclusion of one or both of those

methods of assessment may help to provide a clearer picture of patterns of thinking and learning in students, and the input of the regular classroom teacher could prove invaluable both in helping to modify instruction to fit the classroom and in providing a broader overview of the class to help contextualize the collected data. It may also be helpful to increase the number of qualitative survey items and to write them more clearly so as to avoid potential data "quirks" due to variable interpretations of the questions.

From a pedagogical standpoint, there are a few changes that may improve the efficacy of this program after observing its delivery. As already stated, a longer-term program may produce more significant results in student understanding and in positive changes in pro-environmental attitudes and behaviors. Increasing the length of the program would also give the instructor more opportunities to allow students to engage in open-ended investigation of the content being presented, helping them build stronger connections to the material. If understanding of the varied types of plastics continues to be a desired outcome, it may also be helpful to discuss more explicitly the different plastic resin identification codes and their properties. Similarly, going into more detail on varied types of recycling processes and why certain plastics must be recycled using specific processes would help build on the point that the types of plastic are distinct, have different properties, and not all of them are equally easy to recycle. These could all be implemented with a longer program timeline. The activities briefly described in the Methodology section build a strong foundation for learning about plastic and recycling, but the author believes that ongoing instruction and support beyond the initial class meeting is required to help build a stronger understanding of plastic recycling and start building the desired sense of capability and responsibility for reducing plastic waste.

Conclusion

Few significant changes were observed in student attitudes and behaviors. Those that were observed show that students participating in the program believed more strongly afterward that plastic is a highly useful and versatile material, and that students may be more likely to recycle in school or other public places. At least the first of these changes is further substantiated by themes appearing in the qualitative data and by changes in the median and mode values in the quantitative data. A larger sample size would be necessary to determine if these changes were truly significant or insignificant. Additionally, a larger suite of assessment tools would likely improve the usefulness of the qualitative data by a fair margin and allow for better assessment of whether the program met its desired educational outcomes. The program itself may benefit from some modifications to include a broader range of topics concerning plastic and plastic recycling, which could be implemented with a longer project timeline of multiple class meetings and more open-ended investigations of the concepts involved. Implementing these changes would have several benefits other than increasing student knowledge as well.

Helping students to build a stronger understanding of not only the knowledge of plastic, but also of its application to environmental policy and affecting local change, is critical to allowing students to become effective problem solvers and decision-makers. Existing environmental initiatives require support from both citizens and governments, and the people involved in that support must be well-informed on environmental science and issues as well as the particular details unique to plastic waste and recycling processes. Building this understanding through effective environmental education and opportunities to work with existing initiatives as students gives them the necessary tools to grow into well-informed and effective decision-makers when they eventually leave school to become professionals.

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NOTICE OF APPROVAL

Date: 2/22/2022

To: Collin Ryan

From: Kathryn Watkins Associate Director and IRB Administrator

IRB Number: 20221209

Title: Measuring Students' Pro-Environmental Behaviors and Attitudes Before and After Demonstration-Based Instruction

Approval Date: 2/16/2022

Thank you for submitting your Request for Exemption to the IRB for review. Your protocol represents minimal risk to subjects and qualifies for exemption from the federal regulations under the category below:

- ☐ **Exemption 1** – Research conducted in established or commonly accepted educational settings, involving normal educational practices.
- ☑ **Exemption 2** – Research involving the use of educational tests, survey procedures, interview procedures, or observation of public behavior.
- ☐ **Exemption 3** - Research involving the use of benign behavioral interventions in conjunction with the collection of information from adult subjects through verbal or written responses (including data entry) or audiovisual recordings, and subjects have prospectively agreed to the intervention.
- ☐ **Exemption 4** – Research involving the collection or study of existing data, documents, records, biospecimens specimens, pathological specimens, or diagnostic specimens.
- ☐ **Exemption 5** – Research and demonstration projects conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine public programs or benefits.
- ☐ **Exemption 6** – Taste and food quality evaluation and consumer acceptance studies.
- ☐ **Exemption 7** – Research involving the use of a broad consent for the storage or maintenance of identifiable information and/or biospecimens for future research.
- ☐ **Exemption 8** – Research involving the use of a broad consent for the use of identifiable information and/or biospecimens for future research.

Annual continuation applications are not required for exempt projects. **Any changes made to the study design or procedures require a change application be submitted to the IRB for acknowledgment and/or approval before the changes may be implemented**. If the IRB determines the change(s) pose an increased risk to subjects, and/or include activities that do not fall within the approved exemption category, a new application must be submitted.

Please retain this letter for your files. This office will hold your exemption application for a period of three years from the approval date. If you wish to continue this protocol beyond this period, you will need to submit another Exemption Request. If the research is being conducted for a master's thesis or doctoral dissertation, the student must file a copy of this letter with the thesis or dissertation.

☑ Approved consent form/s enclosed