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GenZs environmental attitudes and ecology behavior nexus: Urgent education message

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ABSTRACT

Environmental education in schools is critical to help decrease plastic litter pollution because plastic pollution could be the most significant health problem of the 21st century. Our research examined the environmental behaviors and attitudes of Generation Z (Gen Z) high school and undergraduate students in South Texas, USA. The research was important because we need to understand what young people believe and value if we are going to see any change in environmental behavior. Results supported research on how teachers can influence student environmental attitudes, behaviors, and knowledge with education. Feedback from students revealed significant attitude change and a rich narrative of pollution and watershed ecology knowledge and behavior themes. These themes disclosed that a holistic environmental science curriculum is necessary to connect Earth systems with the plastic litter pollution cycle.

Keywords: attitudes, behavior, beliefs, climate change, environmental education, Gen Z, plastic pollution cycle, plastic litter, science education, 2-MEV, values

INTRODUCTION

Plastic litter pollution is still a challenge to manage all over the world. Plastic litter pollution is worse than ever. During our project, we found plastic litter pollution profound, and it continues (Eriksen et al., 2023). Post-pandemic, litter is still everywhere, especially plastic (Ford, 2020; Kaufman, 2022; Peng et al., 2021; Roberts et al., 2022; Semuels, 2021). Our study sought to understand why people continue to litter and address littering at the source. We examined the environmental attitudes, watershed ecology knowledge, and behavior changes of Generation Z (Gen Z) high school and university undergraduate students between the ages of 16 and 24 in South Texas, USA. Gen Zs were born between 1997 to 2012 (12 to 26 years of age), and many are still students in the school systems. The first reason to particularly focus on Gen Z is that they are presumed to be the biggest litterer in Texas (Don't Mess With Texas, 2019). The second reason to focus on Gen Z is that this age group has a better chance to experience environmental attitudes and behavior changes with education (Wray-Lake et al., 2010). Erhabor and Dona (2016) have shown that environmentally aware and empowered youths are the best advocates of change for the sustainable protection of the environment. Gen Z and generations after will be the most affected by plastic pollution and will have to address the consequences now and in the future (Jones & Podpadec, 2023).

More effort is needed to understand people's attitudes, especially Gen Z's, because their attitudes reflect their beliefs and values in their decisions regarding how they validate resources (Lopez-Mosquera & Sánchez, 2012). They have or are entering leadership roles and can make a difference in managing litter and helping others understand why taking care of our environment is paramount.

Figure 1 shows the connections between Gen Z culture-beliefs and values overlapping with attitudes and education associations with the Gen Z environmental behavior nexus.

The study was conducted before the COVID-19 pandemic and was completed during the pandemic. The research was mixed methods including quantitative and qualitative research. Both dimensions are necessary to measure attitude and behavior change (Newman & Newman (2023). The study included a pre-survey of students' environmental attitudes at the beginning and a post-survey near the end of the semester. In addition, student feedback surveys were administered and collected a rich narrative on Gen Zs knowledge and behavior changes. This study was the first of its kind in the region. There are studies on adolescent environmental attitudes in different populations worldwide.

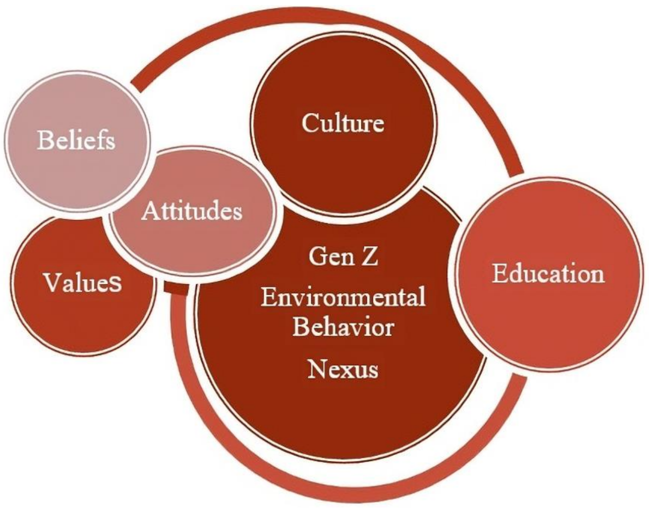

Figure 1. Gen Zs environmental behavior nexus connections (graphic portrays nexus connections of Gen Z culture, beliefs, values, environmental attitudes, education, & behavior © LeSage-Clements)

However, there are no studies of this magnitude, especially in Texas, USA. Previous environmental attitude studies (Hebel et al., 2014; Johnson & Manoli, 2008; Johnson & Manoli, 2011; Wray-Lake et al., 2010) with elementary and secondary students show that environmental attitudes can improve with environmental curriculum.

Two-major environmental value (2-MEV) model (Bogner et al., 2015) was administered to Gen Z students from Spring 2018 through Fall 2019, taking classes from steward science instructors participating in the program. 562 surveys were completed, with 272 pre-surveys and 290 post-surveys. McREL, an international external research evaluator, administered a student feedback survey to provide valuable, actionable insight and qualitative feedback data.

The research evaluator and the investigators developed a feedback survey for in-class administration to the students of steward teachers. The survey gathered information on the extent to which students' knowledge and behavior have been affected by their teachers' participation in professional development and stewardship days.

The research evaluator analyzed the survey question answers to discover the main themes. Two hundred and forty-seven students responded to the feedback survey. This study is notable because it documents the environmental attitudes, behavior, and ecology knowledge of Gen Zs and adds to the body of the environmental education narrative. New knowledge was uncovered in Gen Zs environmental attitudes and reflection feedback.

LITERATURE REVIEW

Idea of Environment & Global Threat

Roughly 10,000 years ago, essentially all humans existed as small hunting groups, and by 2,000 years ago, most people lived by farming along river valleys (Berry, 2018). Population growth and migration were the most influential engines in the progression of environmental change in the 20th century and into the 21st century. Individual and political choices affected reproductive behavior and the geographic movement of billions of people, and almost none of the choices took the environment consciously into account (McNeill, 2020). In many countries (Erhabor & Dona, 2016), ignorance, poverty, greed, and overpopulation are responsible for human anti-environmental behavior and actions.

Only 200 years ago, it was estimated that 1 billion people lived on the planet (Tarbuck & Lutgens, 2015), and today there are over eight billion people (US Census Bureau, 2023). Complicating the situation are people's historical, cultural, and psychological factors, such as attitudes, beliefs, and socially shared values, contributing to environmental deterioration (López-Mosquera & Sánchez, 2012). The unprecedented growth of the human population was accompanied by equally unprecedented growth in resource use and waste production, including plastic litter.

The idea of 'environment' began to take shape after World War II. There was a great fear that humans could destroy the world with atomic bombs (Warde & Sorlin, 2018). At this time, people worldwide were beginning to understand how human behavior impacted the planet. Today, people still fear humans can destroy the planet, but now includes pollution and accelerated climate change due to humans. Littering is a major human behavioral problem (Texas Disposal Systems, 2020). While studies such as keep America beautiful (KAB, 2009, 2021) suggest there was less littering ten years ago, others have found roads and waterways have more plastic trash than ever, especially since the COVID-19 pandemic (Ford, 2020; Kaufman, 2022; Peng et al., 2021; & Roberts et al., 2022; Semuels, 2021).

Plastic Pollution Environmental Threat

Plastic litter pollution may become the most critical problem in the 21st century (Koh et al., 2023; Landrigan et al., 2020). Plastic litter fragmentation and per- and polyfluoroalkyl substances (PFAS) in our ecosystems may add to global health disasters (Jones, 2015). Pollution, especially plastic litter discarded into the environment, contributes to health threats never experienced (Eriksen et al., 2023; Xu et al., 2023).

The primary source of plastic pollution is secondary (processed, post-use) plastics. The different types of plastic's physical and chemical characteristics and the different sizes result in unique forms and hazards (Julienne et al., 2019; Lim, 2021; Mitrano et al., 2021; National Academies of Sciences, 2023). There is clear physical evidence of impacts on wildlife, especially marine life, and increased concern about the potential for toxicological effects on human beings since plastic forever chemicals entering the environment (PFAS) are transferred from organism to organism when ingested (Reddy, 2018; Renfrew & Pearson, 2021; Steer &Thompson, 2020). Exposure to PFAS has been associated with decreased fertility, developmental effects in children, increased cancer risks, decreased immunity to fight infections, and increased cholesterol levels (Ginty & Windwall, 2022). PFAS are from chemicals used in industry, such as plastic pipes, and consumer products, such as food packaging. There is hope that PFAS can be broken down into benign products, although only

10 out of approximately 11,990 PFAS have been thus far (Morris, 2022).

The microscopic plastic fragments and molecules produced by the breakdown of plastic litter are now included in the hydrologic cycle (Allen et al., 2019; Jones, 2023; Simon, 2023). In the plastisphere (biologists recently identified the new sphere), there are thriving ecosystems living within the plastic trash in the garbage patch-ocean gyres, coastal waters, urban rivers, and other water bodies (Dussad et al., 2023; Eriksen et al., 2023; Koh et al., 2023; Xu et al., 2023). Plastic waste is so abundant that some scientists call this geological epoch the Plasticene (Campanale et al., 2020).

Fragmented plastic in our environment travels along with the hydrologic cycle and the rock cycle. On the ocean floor, Simon (2023) discovered gas bubbles from decaying organic matter and hydrothermal gas attaching to plastic particles and effervescing their way back to the surface. When the bubbles reach the surface, they burst and add more plastic into the atmosphere. The wind and currents stir up seafoam bubbles and entrap plastic particles, as well. The bubbles burst at the ocean surface through wave action, releasing more plastic into the atmosphere. Once in the atmosphere, the particles can serve as condensation nuclei, enhancing cloud formation and altering the Earth's climate (Jones, 2023).

On land, plastic is fragmented primarily by water and wind. The plastic particles end up in the watershed and become part of the rock cycle, specifically in sedimentary rocks. Degraded plastic litter particles and molecules can be found virtually everywhere: in the Arctic and the Antarctic, in the atmosphere, floating in giant island gyres in the ocean, on the ocean floor, in the sedimentary rocks, in our food, and even in our blood (Chrobak, 2021; Cózar et al., 2017; Lim, 2021; Parker, 2020; Renfrew & Pearson, 2021).

Why People Pollute

Wray-Lake et al. (2010) found a decline in high school seniors' conservation behaviors across several decades: the 70s, the 80s, and the early 2000s. Most people agree that litter negatively affects our environment, including waterways, the quality of life, health and safety, home values, tourism, and businesses (KAB, 2021). Still, it has not been enough of a threat or personal value to change a person's mind. One cannot assume people will stop polluting without changing their minds, Otherwise, pollution would not be a problem. Therefore, environmental education is crucial, especially for impressionable Gen Zs forming their values, attitudes, and behaviors (Wray-Lake et al., 2010).

Why have people not stopped polluting, and how do we change people's environmental behavior? The primary way to change people's behavior is through education and relating it to their values. Environmental education should be related to all education, or people will not understand how pollution impacts their lives. Pollution must be perceived as a human threat, or people may not be motivated to change (Abun & Racoma, 2017). People do not realize everything, especially plastic debris (cigarette butt filters, bags, bottles, caps, straws, cups, lids, wrappers, & packaging) discarded into the environment, stays (Bristol, 2022; Jones, 2015; KAB, 2020; Texas Disposal Systems, 2020).

All the states in the USA and Puerto Rico have laws and penalties for polluting, yet we still have litter everywhere. The justification behind littering is one of five reasons: laziness or carelessness, lack of access to trash receptacles, no personal responsibility, lenient law enforcement, and the presence of litter already in the area (KAB, 2021; Texas Disposal Systems, 2020; Victorian Litter Action Alliance, 2022). There are reasons why we do something that makes sense to ourselves and others. Making sense of what we do is often understood as placing a value on it and relating it to what we do. It is an excuse for our actions in the broader context. We may not even be aware of our reasons for doing something (Holland, 2017).

There is a social stigma attached to polluting as well. Nevertheless, even with laws and social shame, people are intentionally polluting and littering. The average person holds a piece of litter for 12 steps before dropping it. So, if people do not find a litter bin within about thirty feet, chances are it lands on the street. People are more likely to drop litter if there is already litter there (Bristol, 2022; Schultz, 2022; Schultz et al., 2011). Littering continues to be a deliberate act (Texas Disposal Systems, 2020). It can be conjectured that when people see pollution, where they live and work, they are more inclined to add more.

Humans are social and conscious creatures who can make choices about what matters to them (Gruen, 2017; Usó-Doménech & Nescolarde-Selva, 2016). Their basic requirements, such as physiological, health, safety, and social belonging, come before a behavior change. Environmental litter pollution has its origins in human behavior, and any solution requires changes in behavior (Schultz, 2014). Therefore, environmental education should include understanding what people believe, what they value, and their attitudes toward the environment. Cultures, affluence, technology, living environments, education, business, religion, political organization, etc., influence behaviors (Gardner & Stern, 1996; Stern, 2002; Vlek & Steg, 2007). These life experiences shape people's beliefs, values, and attitudes about their polluting behavior.

Thus, what people believe, and value affects their behavior. Beliefs are associated with cognitive relationships, values are more culturally bound, and attitudes are mentally attached to a concrete or abstract object (Gifford & Sussman, 2012). Values can combine cognitive, affective, and conative elements, and environmental attitudes can be described as having preservation and utilization dimensions (Gifford & Sussman, 2012). Environmental beliefs, values, and attitudes are related and are reflected in people's environmental response behavior (Abun & Racoma, 2017; Johnson & Manolli, 2011; Stern et al.,1999).

To change a culture, the system that generated it with its beliefs and values has to change, or we will continue to observe litter pollution in our environment (Coelberg & Kurtz, 2020). Understanding belief and value systems requires learning about a group's culture. Belief systems define what is valuable or not valuable: these include social events and statements, such as "Don't mess with Texas," and take many forms; there is orientation and assumption (may be an illusory assumption) with shared politics, religions, sociologic beliefs; and a language of rules (Usó-Doménech & Nescolarde-Selva, 2016). We cannot convince people with rational arguments or economic inducements to be environmental stewards (Stern, 2002).

There are vital principles required to help change belief systems. These principles include social norms, communication, motivation, empowerment, productivity, perspectives, interpersonal relationships, social networks, flexibility, solutions to constant change, delivering on commitments, and leveraging power (Stern, 2002). Examples of power are persuasive abilities, knowledge, and relationships. Recognizing and respecting people's choices helps us identify how we can help understand their values (Gruen, 2017). People's beliefs differ, and knowing these differences is important in changing a behavior.

Reversing pollution means changing human behavior. It means not being content with awareness or merely tugging on heartstrings without following up with action (Spodek, 2017). If people believe their valued objects are threatened, there should be changes in their behavior to ensure their value (Stern et al., 1999). People need reasons for taking environmental action. People must relate the reasons to their lives, which appeals to their self-interest and human interest (Holland, 2017). All the above must be considered in an education program to promote change.

Gen Zs Mentality & Values

Understanding Gen Zs behavior and their surrounding world will help educators design and implement an environmental curriculum to maximize learning, attitude, and behavior changes. The mentality of Gen Z is different, "mobile and computer are their communication tools, so they feel 'blind' without online connection" (Niemczynowicz et al., 2023, p. 12). Gen Zs are "location-aware" and speak a "technological-language," and their brains are wired differently (Cilliers, 2017, p. 1). Since Gen Zs are digital natives, they seem to have greater visual ability and are better at making visual forms of learning more effective (Cilliers, 2017). Their life paradigm is to make a difference, work with authority, have collaborative relationships, value open-mindedness, and solve problems of the future (Mohr & Mohr, 2017). Gen Z demands instant information, visual forms of learning, and replacing communication with interaction wanting to collaborate (Cillars, 2017).

An important motivator for Gen Z is a work environment balanced with life. Niemczynowicz et al. (2023) research found that members of Gen Z prefer their work to be exciting with advanced technology, incorporate a hygge ambiance, and have a global focus. These individuals value security, healthy lifestyle, and well-being benefits and expect their employers to be socially responsible. We should remember what motivates Gen Z when we design and implement curriculum if we want to see a behavior change. Younger generations need to experience environmental education with the above stimuli because they will become our environmental stewardship leaders responsible for making informed and responsible decisions in the future (Environmental Protection Agency [EPA], 2022; Wray-Lake et al., 2010).

RESEARCH PERSPECTIVES/THEORETICAL FRAMEWORK

Research Purpose

This research investigated if Gen Z students' environmental attitudes could change during a semester and to what extent Gen Z students' knowledge and behavior have been affected by science teachers participating in environmental education professional development.

Null Hypotheses

H1. There are no student environmental attitude pre- and post-survey preservation and utilization factor differences as measured with 2-MEV model after students have experienced a science instructor participating in environmental education professional development.

H2. There will be no difference in students' environmental knowledge and behavior after students have experienced education from a science instructor participating in the environmental education professional development.

Research Question

What do the GEN Zs know about the connection between the hydrologic cycle, watershed, plastic pollution, and climate change?

Subjects

The students completing the surveys were Gen Zs between the ages of 16 to 22 years of age. 2-MEV model was administered to high school and university undergraduate students taking science classes with steward teachers. Five hundred and sixty-two environmental attitude surveys were completed, with 272 pre-surveys and 290 post-surveys. Two hundred and forty-seven students responded to the ecology watershed feedback survey.

The stewardship litter clean-up site was in front of a mall adjacent to a stormwater channel and creek near a river watershed. The view is a non-obstructed and plain view for the community to observe. About once a month, teachers and their students met at the stormwater channel on a rotating basis. The teachers and students GPS the litter, classified it, cleaned the stormwater channel, and weighed the trash. All the teachers completed water quality laboratory professional development connected to the region's watershed.

Instruments

2-MEV model used in this study has been extensively tested. It is a reliable and valid instrument used in several global populations, including the USA (Bogner et al., 2015; Bogner, 2018). 2-MEV model survey has 16 questions and is a Likert scale with five levels: strongly Agree (5); agree (4); not sure/neutral (3); disagree (2), and strongly disagree (1) located in **Appendix A**.

2-MEV model measures two higher-order factors: preservation of nature, the intent to preserve the environment, and utilization of nature, the usage of the

Table 1. Education level

		Pre-environmental survey	Post-environmental survey	Total
Education level	High school	164	173	337
	Some college	27	42	69
	Associate degree	81	75	156
Total		272	290	562

Table 2. Ethnicity

		Pre-environmental survey	Post-environmental survey	Total
Ethnicity	Hispanic or Latino	105	112	217
	Asian/Native American/Alaskan Native/other	17	15	32
	Black or African American	36	28	64
	White	114	135	249
Total		272	290	562

environment (**Appendix B**). Preservation is "a biocentric dimension that reflects conservation and protection of the environment," while utilization is "an anthropocentric dimension that reflects the utilization of natural resources" (Hebel et al., 2014; Johnson & Manoli, 2011). These two higher-order factors consist of primary factors: intent of support, care with resources, and enjoyment of nature are preservation factors, whereas altering nature and human dominance are both factors of utilization (Hebel et al., 2014; Johnson & Manoli, 2008, 2011).

The ecology watershed student feedback survey (**Appendix C**) was administered by McREL International, serving as the external research evaluator. McREL is a leader in research evaluation and provided insight throughout the project to guide the curriculum. McREL and the project investigators developed the survey. The survey aimed to gather information on the extent to which students' ecology watershed knowledge and behavior have been affected by their teacher's participation in professional development.

Limitations of the Study

The following limitations were postulated:

1. The research was conducted in Texas, USA, and may not be extrapolated to other regions.
2. Teachers and students self-selected to participate.

Treatment of Data

The study was a mixed method, including a quasi-experimental pre- and post-survey design and student feedback surveys. 2-MEV data were compiled into IBM SPSS 26 (2019) for statistical treatment and descriptive comparisons. Frequencies were computed to check general trends and overall means.

Next, pre- and post-surveys were compared with cross tabulation, Pearson Chi-square, likelihood ratio, and linear-by-linear associations to help understand relationships and test whether the variables were independent. If there were significant Pearson Chi-square, additional descriptives, Phi & Cramer's V, mean comparisons, and ANOVAs were generated to compare differences between the groups and determine the strength of associations. Also, the means were arranged by factors.

Student feedback was analyzed and evaluated to identify watershed ecology knowledge and behavior themes to guide environmental education stewardship curricula. The themes are summarized under the student feedback survey, 'Findings: Watershed ecology student feedback survey.'

RESULTS: 2-MEV

The following data compares the pre- and post-survey education level, ethnicity, and gender and the significant results. All frequencies, if warranted, have been rounded in the narrative.

Table 1 shows the education levels and the number of surveys completed for each level, high school, some college, and associate degrees for the pre- and post-surveys.

There was no significant difference for education level with Pearson Chi-square value of 3.159, two degrees of freedom, and p=.206. Likelihood ratio was also insignificant, with a valve of 3.181, two degrees of freedom, and p=.204. Linear-by linear association was not significant. The cell counts were satisfactory, with zero cells not meeting the expected counts.

Table 2 portrays the student ethnicity. Most students completing the survey were Whites (44.0%) and Hispanic/Latino (39.0%). Black or African American comprised 11.0% of the respondents, and Asian/Native American/Alaskan Native/other comprised about 6.0%.

There was no significant difference for ethnicity level with Pearson Chi-square value of 2.548, three degrees of freedom, and p=.467. Likelihood ratio was also insignificant, with a valve of 2.550, three degrees of freedom, and p=.466. Linear-by linear association was not significant. The cell counts were satisfactory, with zero cells not meeting the expected counts.

Table 3 shows the gender of the students completing the survey. The majority of students completing the pre-survey were female (77.0%/210 students), and post-survey were (76.0%/284 students) female. Males' pre-survey comprised (22.0%/58 students) and in the post-survey was (22.0%/63 students), and about 1.5% (4 students) were in other, while in the post-survey, 3.0% (10 students) selected other.

There was no significant difference for gender with the Pearson Chi-square value of .311 with two degrees of freedom, and p=.856. Likelihood ratio was also insignificant, with a valve of .314, two degrees of freedom, and p=.855. Linear-by linear association was not significant. Cell counts were satisfactory, with only one cell with less than expected count.

Table 3. Gender

		Pre-environmental survey	Post-environmental survey	Total
Gender	Female	210	221	431
	Male	58	63	121
	Other	4	6	10
Total		272	290	562

Table 4. Questions 1-8 means pre-survey compared to post-survey: Factor utilization of nature-significant

Survey questions	Mean	Pre-n	SD	Mean	Post-n	SD	TM	SD
1. If I ever have extra money, I will give some to protect nature.	2.5551	272	.98919	2.4759	290	1.05281	2.5142	1.02238
2. To save energy in winter, I make sure heat is not too high.	2.1801	272	1.05245	2.2103	290	1.07852	2.1957	1.06514
3. I would like to sit by a pond and watch dragonflies.	2.3824	272	1.14653	2.3759	290	1.10681	2.3790	1.12520
4. People have right to change the environment (nature).	**2.8676**	**272**	**1.12869**	**3.0621**	**290**	**1.26283**	**2.9680**	**1.20266**
5. Building new roads is important that trees should be cut down.	3.7243	272	.83803	3.8069	290	.90210	3.7669	.87189
6. I would help raise money to protect nature.	2.1838	272	.82132	2.0759	290	.86118	2.1281	.84311
7. I always turn off the light when I do not need it anymore.	1.6985	272	.84887	1.7483	290	.90103	1.7242	.87575
8. I like to go on trips to places like forests away from cities.	2.0037	272	.93516	1.9000	290	.95232	1.9502	.94464

Note. SD: Standard deviation & TM: Total mean

Table 5. Questions 9-16 means pre-survey compared to post-survey: Factor utilization of nature-significant

Survey questions	Mean	Pre-n	SD	Mean	Post-n	SD	TM	SD
9. I like a grass lawn more than a place, where flowers grow on their own.	**3.3971**	**272**	**.93934**	**3.1966**	**290**	**1.05849**	**3.2936**	**1.00671**
10. Because mosquitoes live in swamps, we should drain the swamps and use the land for farming.	3.6765	272	1.04074	3.6586	290	1.05752	3.6673	1.04853
11. I try to tell others that nature is important.	2.1985	272	.89542	2.2379	290	.88935	2.2189	.89171
12. I try to save water by taking shorter showers or by turning off the water when I brush my teeth.	2.3713	272	1.16451	2.2793	290	1.10422	2.3238	1.13372
13. I like the quiet of nature.	1.6103	272	.68911	1.6655	290	.83304	1.6388	.76659
14. To feed people, nature must be cleared to grow food.	**3.2537**	**272**	**1.00460**	**3.2448**	**290**	**1.08723**	**3.2491**	**1.04713**
15. People are supposed to rule over the rest of nature.	3.7022	272	1.01806	3.6138	290	1.06330	3.6566	1.04166
16. Weeds should be killed because they take up space from plants we need.	**2.8272**	**272**	**.98864**	**3.1966**	**290**	**1.06176**	**3.0178**	**1.04261**

Note. SD: Standard deviation & TM: Total mean

Table 6. Crosstabs people have right to change environment (nature) (survey question 4: 2-MEV model factor utilization-alternating nature)

		Pre-environmental survey	Post-environmental survey	Total
People have right to change environment (nature)	Strongly agree	38	48	86
	Agree	63	44	107
	Not sure/neutral	84	74	158
	Disagree	71	90	161
	Strongly disagree	16	34	50
Total		272	290	562

Table 4 and **Table 5** portray the means for the pre- and post-survey for each question on the survey. Attitudes 4, 9, and 16 were significant. Attitude 14 was highlighted because the student's attitude was part of the higher-order factor, the utilization of nature. Many students were neutral to "feed people nature must be cleared to grow food."

Significant Results

For brevity, only the utilization factor-alternating nature with significant results is portrayed. There were no significant differences between gender, education level, or ethnicity with 2-MEV model factors.

Table 6 shows the results of "people have the right to change the environment (nature)." 32.0% (87 students) of the pre-surveys were disagreeable, 38.0% (101 students) were agreeable, and 30.0% were not sure/neutral. The post-survey showed 43.0% (124 students) unfavorable and favorable at 32.0% (92 students), with 26.0% (74 students) not sure/neutral.

There was a significant difference between the pre- and post-survey on "people having the right to change the environment (nature)" with Pearson Chi-square value of 13.329, four degrees of freedom, and p=.010, as shown in **Table 7**.

Likelihood ratio was also insignificant, with a valve of 14.489, four degrees of freedom, and p=.009. Linear-by linear association was significant. The cell counts were satisfactory.

Crosstab residuals show where the differences are. The main differences between the pre- and post-survey were on the models agree (-2.4 on pre- and 2.4 on post-survey), disagree (-1.3 on pre- and 1.3 on post-survey), and strongly disagree (-2.4 on pre- and 2.4 on post-survey). More students strongly disagreed with "people have the right to change the

Table 7. Chi-square tests people have right to change environment (nature)

	Value	df	Asymptotic significance (2-sided)
Pearson Chi-square	13.329[a]	4	**.010**
Likelihood ratio	13.489	4	**.009**
Linear-by-linear association	3.668	1	.055
Number of cases	562		

Note. [a]Zero cells (0%) have expected count less than five & minimum expected count is 24.20

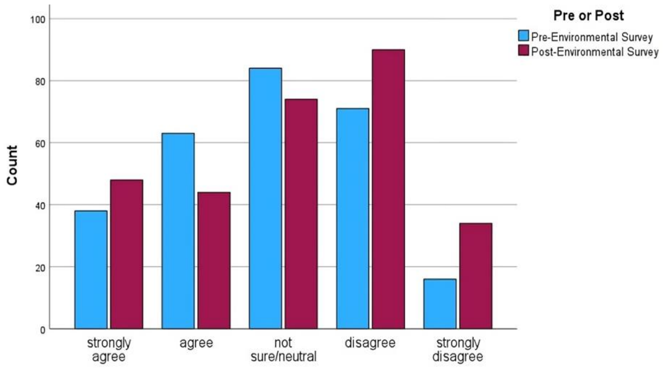

Figure 2. Bar chart 1: People have right to change environment (nature) (Source: IBM SPSS Project Data)

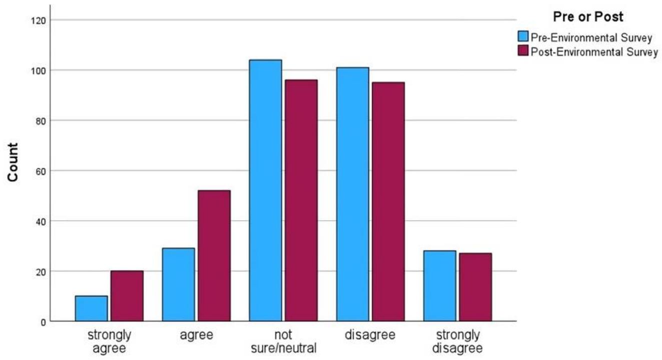

Figure 3. Bar chart 2: I like a green lawn more than a place, where flowers grow on their own (Source: IBM SPSS Project Data)

environment (nature),” and some agreed more firmly with the post-survey. Phi & Cramer’s V were significant, with values of .541 and p’s of .010.

Most students disagree with the post-survey that “people have the right to change the environment (nature),” as shown in **Figure 2**. A few students were more agreeable “people should have the right to change the environment.”

Table 8 reveals more students, 47.0% (129 students) on the pre-survey were disagreeable than agreeable, and 14.0% (39 students) to “I like a green lawn more than a place, where flowers grow on their own.” Students in the post-survey were more agreeable than the pre-survey, with 20.0% agreeable (72 students) and 45.0% disagreeable (124 students).

There was a significant difference for “I like a green lawn more than a place, where flowers grow on their own” with Pearson Chi-square value of 9.820, four degrees of freedom, and p=.044, as shown in **Table 9**. Likelihood ratio was also significant, with a valve of 9.965, four degrees of freedom, and p=.041. Linear-by linear association was significant. The cell counts were satisfactory, with zero cells with less than expected counts. Crosstab residuals showed where the differences were. The main difference between the pre- and post-survey was on the scale of agree (-2.5 on pre- and 2.5 on post-survey). More students agreed on the post-survey, “I like a grass lawn more than a place, where flowers grow on their own.” Phi & Cramer’s V were significant, with values of .132 and p’s of .044.

Figure 3, “I like a green lawn more than a place, where flowers grow on their own” shows almost a normal distribution of the student responses for both pre- and post-surveys. Students are trending toward being neutral and agreeable with “liking a grass lawn over natural flowers growing.”

Table 10 shows more students (110 pre- & 127 post-survey) were disagreeable (41.0% pre- and 44.0% post-survey) or not sure/neutral (38.0% pre-/104 students and 31.0% post-survey/90 students) “to feed people, nature must be cleared to grow food” than agreeable for both the pre- and post-surveys.

There was no significant difference in “to feed people, nature must be cleared to grow food” with a Pearson Chi-

Table 8. Crosstabs I like a green lawn more than a place, where flowers grow on their own (survey question 9: 2-MEV model factor utilization-alternating nature)

		Pre-environmental survey	Post-environmental survey	Total
I like a green lawn more than a place, where flowers grow on their own	Strongly agree	10	20	30
	Agree	29	52	81
	Not sure/neutral	104	96	200
	Disagree	101	95	196
	Strongly disagree	28	27	55
Total		272	290	562

Table 9. Chi-square tests I like a green lawn more than a place, where flowers grow on their own

	Value	df	Asymptotic significance (2-sided)
Pearson Chi-square	9.820[a]	4	**.044**
Likelihood ratio	9.965	4	**.041**
Linear-by-linear association	5.568	1	.018
Number of cases	562		

Note. [a]Zero cells (0%) have expected count less than five & minimum expected count is 14.52

Table 10. Crosstabs to feed people, nature must be cleared to grow food (survey question 14: 2-MEV model factor utilization-alternating nature)

		Pre-environmental survey	Post-environmental survey	Total
To feed people, nature must be cleared to grow food	Strongly agree	12	18	30
	Agree	46	55	101
	Not sure/neutral	104	90	194
	Disagree	81	92	173
	Strongly disagree	29	35	64
Total		272	290	562

Table 11. Chi-square tests to feed people, nature must be cleared to grow food

	Value	df	Asymptotic significance (2-sided)
Pearson Chi-square	3.701[a]	4	.448
Likelihood ratio	3.709	4	.447
Linear-by-linear association	.010	1	.920
Number of cases	562		

Note. [a]Zero cells (0%) have expected count less than five & minimum expected count is 14.52

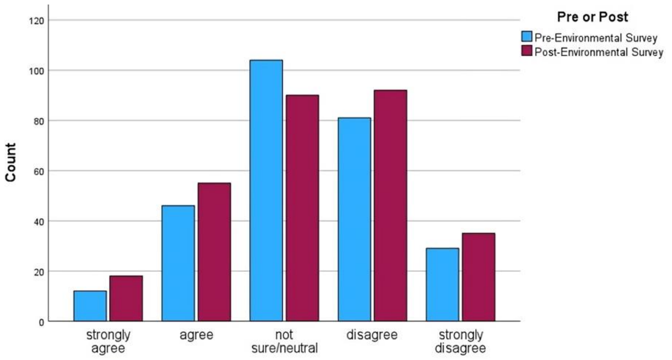

Figure 4. Bar chart 3: To feed people, nature must be cleared to grow food (Source: IBM SPSS Project Data)

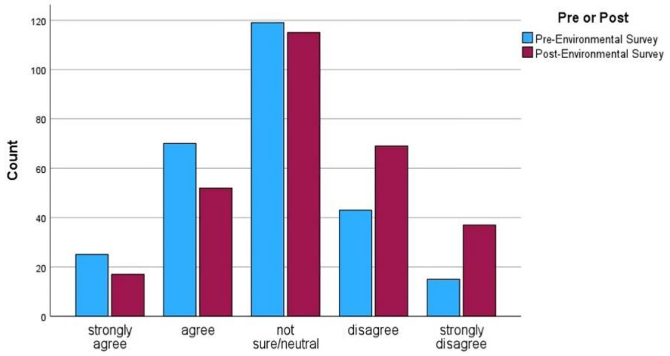

Figure 5. Bar chart 4: Weeds should be killed because they take up space from plants we need (Source: IBM SPSS Project Data)

square value of 3.701, four degrees of freedom, and p=.448, as shown in **Table 11**.

Likelihood ratio was also insignificant with a valve of 3.709, four degrees of freedom, and p=.447. Linear-by linear association was not significant. The cell counts were satisfactory, with zero cells with less than expected counts. Crosstab residuals showed where differences were. No further tests were conducted due to non-significant Chi-square.

Figure 4 reveals more students are neutral to disagreeable, "to feed people, nature must be cleared to grow food."

Table 12 portrays the crosstab results for "weeds should be killed because they take up space from plants we need." The majority of students were agreeable (35.0%/95 students) or not sure/neutral (44.0%/119 students) on the pre-survey and more disagreeable (27.0%/184 students) and not sure/neutral (40.0%/115 students) on the post-survey.

There was a significant difference for Pearson Chi-square value of 19.034, four degrees of freedom, and p=.001, as shown in **Table 13**. Likelihood ratio was also significant with a valve of 19.389, 4 degrees of freedom, and p=.001. Linear-by linear association was significant. The cell counts were satisfactory, with zero cells with less than expected counts. Crosstab residuals showed where the differences were. The main differences between the pre- and post-survey were on the models agree (-2.2 on pre- and 2.2 on post-survey), disagree (-2.4 on pre- and 2.4 on post-survey), and strongly disagree (-3.0 on pre- and 3.0 on post-survey).

More students strongly disagreed that "weeds should be killed because they take up space from plants we need," and a few students agreed strongly on the post-survey. Phi & Cramer's V were significant, with values of .184 and p's of .001.

Figure 5 portrays a somewhat normal distribution, where most students are not sure/neutral about "weeds should be killed because they take up space from plants we need."

Table 12. Crosstabs weeds should be killed because they take up space from plants we need (survey question 16: 2-MEV model factor utilization-alternating nature)

		Pre-environmental survey	Post-environmental survey	Total
Weeds should be killed because they take up space from plants we need	Strongly agree	25	17	42
	Agree	70	52	122
	Not sure/neutral	119	115	234
	Disagree	43	69	112
	Strongly disagree	15	37	52
Total		272	290	562

Table 13. Chi-square tests for weeds should be killed because they take up space from plants we need

	Value	df	Asymptotic significance (2-sided)
Pearson Chi-square	19.034[a]	4	**.001**
Likelihood ratio	19.389	4	.001
Linear-by-linear association	17.614	1	.000
Number of cases	562		

Note. [a]Zero cells (0%) have expected count less than five & minimum expected count is 20.33

Table 14. Utilization factor-altering nature

Surveys		Q.4 People have right to change environment (nature)	Q.9 I like a grass lawn more than a place, where flowers grow on their own	Q.14 To feed people, nature must be cleared to grow food	Q.16 Weeds should be killed because they take up space from plants we need
Pre-environment survey	M	**2.8676**	**3.3971**	**3.2537**	**2.8272**
	n	272	272	272	272
	SD	1.12869	.93934	1.00460	.98864
Post-environment Survey	M	**3.0621**	**3.1966**	**3.2448**	**3.1966**
	n	290	290	290	290
	SD	1.26283	1.05849	1.08723	1.06176
Total	M	**2.9680**	**3.2936**	**3.2491**	**3.0178**
	n	562	562	562	562
	SD	1.20266	1.00671	1.04713	1.04261

Note. M: Mean & SD: Standard deviation

Table 15. ANOVA

Factor utilization-altering nature			Sum of squares	df	Mean square	F	Sig.
People have right to change environment (nature)	Between groups	(Combined)	5.305	1	5.305	3.686	.055
	Within groups		806.118	560	1.439		
	Total		811.423	561			
I like a grass lawn more than a place where flowers grow on their own	Between groups	(Combined)	5.643	1	5.643	5.614	.018
	Within groups		562.914	560	1.005		
	Total		568.557	561			
To feed people, nature must be cleared to grow food	Between groups	(Combined)	.011	1	.011	.010	.920
	Within groups		615.114	560	1.098		
	Total		615.125	561			
Weeds should be killed because they take up space from plants we need	Between groups	(Combined)	19.147	1	19.147	18.152	.000
	Within groups		590.675	560	1.055		
	Total		609.822	561			

Significant Result Investigation

Since questions 4, 9, and 16 had significant Pearson Chi-squares, further investigation was conducted to determine the differences. The means were compared, and ANOVAs were generated. An interesting result after the initial investigation was that the factor-utilization (see **Appendix B**) had three significant Pearson Chi-squares.

4. *People have the right to change the environment (nature).

9. *I like a grass lawn more than a place, where flowers grow on their own.

14. To feed people, nature must be cleared to grow food.

16. *Weeds should be killed because they take up space from plants we need.

There were significant differences between the pre- and post-survey for the factor utilization-altering nature noted with the Chi-squares and residuals for questions 4, 9, and 16.

As shown in **Table 14**, reviewing the means for questions 4, 9, 14, and 16, there was more disagreement that "people have the right to change the environment (nature);" more agreement that students "liked a green lawn more than, where flowers grow on their own;" and more disagreeable "weeds should be killed because they take of space we need." Student attitudes remained neutral, "to feed people nature must be cleared to grow food."

Table 15 shows the ANOVAs for the utilization factor-altering nature had three significant differences between the pre- and post-survey groups.

Question 4, "people have the right to change the environment (nature)," was approaching significance at .055; question 9, "I like a green grass more than a place, where flowers grow on their own," was significant at .018, and question 16, "weeds should be killed because they take up space from plants we need" was significant at .000.

Findings: Watershed Ecology Student Feedback Surveys

To aid in answering the research question, what do the Gen Zs know about the connection between the hydrologic cycle, watershed, plastic pollution, and climate change? The findings below were gleaned from the McREL project summary reports. The survey questions and summaries of key themes from student responses are listed below.

1. What is the most important thing you've learned about water pollution in your science class this year? Students

most frequently described the following as valuable takeaways regarding water pollution:

a. Water pollution is much more widespread and critical than many people realize.
b. Water contamination devastates marine life but can also cause disease and long-term health complications for humans living nearby (or consuming affected marine animals.
c. Pollution has wide-ranging consequences and negative effects on ecosystems beyond the water and our climate.
d. Air pollution & carbon emissions
e. Cows and farming
f. The Pacific Garbage Patch
g. Stoichiometry
h. Many household chemicals–like fertilizers–are significant contributors to water pollution.
i. Carbon dioxide emissions and fracking are sources of pollution. Microplastics are a challenge, too.

2. What steps can people in your community take to help improve the Texas Gulf water quality by decreasing water pollution? Students provided the following suggestions for ways in which individuals in their community can help improve water quality in the Texas Gulf region:

a. Increase awareness and education on the issue of pollution and its negative effects on plants, animals, and human life.
b. Stop littering (rivers, lakes, beaches, and the ocean, in particular).
c. Improve recycling efforts and properly dispose of all materials/substances.
d. Advocate for stricter laws and regulations around environmental issues (e.g., littering, fracking, and waste disposal.
e. Reduced use of plastics.
f. Reduce fossil fuel consumption.
g. Increase carpooling and ride-sharing efforts to reduce carbon dioxide.
h. Recycle and use more biodegradable products.
i. Use fewer straws (and less plastic in general).
j. Increase awareness of and decrease the use of–chemicals and substances that contribute to water pollution (specifically, fertilizers).

3. What changes have you made to your own behavior or lifestyle to help improve water quality in your community based on what you've learned in your science class this year? Students indicated the following changes to their behavior based on what they've learned in their science class this year:

a. Reduced littering, reuse of materials, and intentional recycling.
b. Picking up litter when they see it.
c. Reduced use of plastic (straws, in particular).
d. Reduced time spent in shower to conserve water.
e. Increased carpooling and ride-sharing.
f. Reduced use of common chemicals at home (e.g., fertilizers, weed killers, detergents).
g. Many students indicated that they had not changed their behavior based on what they've learned in their science class.

4. What is one question you have about watershed ecology or water pollution (or something you'd like to learn more about)? Common questions around watershed ecology included the following:

a. What is the largest contributor to water pollution in our local area?
b. What are effective ways to clean water (specifically, get plastic out of the ocean)?
c. Why does not our community do something about pollution?
d. How can we increase awareness of pollution issues and make people more willing to make positive changes to their behavior?
e. How do we get communities more invested in preventing or alleviating water pollution?
f. What steps are being taken by political leaders and businesses to prevent wasteful practices and alleviate water pollution?
g. How can I help prevent water pollution and climate change?
h. What types of pollution issues are happening in other parts of the country?
i. What will happen to the earth and human life if pollution is not addressed?

Summary of Knowledge & Behavior Themes

Students were interested in learning the next steps to decrease pollution and climate change with community members. Many students were motivated to engage with local policymakers and businesses to encourage the responsible use and disposal of pollutants. Overall, student responses indicated an improved understanding of water pollution and watershed ecology, the importance of addressing water pollution, and how to improve water quality in the Texas Gulf region. Many students expressed interest in learning more about watershed ecology and provided examples of advancements in their behavior. The behavior changes supported the significant 2-MEV results in the dimension utilization of nature, which showed progress in better use of resources. These changes in behavior included reduced littering, decreased use of plastics, and use of fewer household chemicals, as well as increased carpooling and recycling efforts (McREL Report, 2019).

DISCUSSION

Gen Z students' environmental attitudes significantly differed between the pre- and post-survey as measured with 2-MEV model for the utilization of nature-altering nature. Student environmental attitudes 'using nature and altering nature' were improved. The null hypothesis Ho1 was rejected for survey question 4, "people have the right to change the environment (nature);" question 9, "I like a grass lawn more than a place, where flowers grow on their own;" and question 16, "weeds should be killed because they take up space from plants we need." Question 14 was insignificant, "to feed people, nature must be cleared to grow food," although more students were unsure when answering the question. Students may have thought, should people go without food or grow food to survive? This attitude may be a quandary for many people.

The null hypothesis **H1** was not rejected for the utilization of nature-dominance and the preservation factors-intent of support, care of resources, and enjoyment of nature (see **Appendix B** for the factors and questions). Although the factor of utilization of nature-dominance and the factor of preservation did not have significant results, the students generally had good environmental attitudes, which is encouraging. For example, the majority of students were agreeable to "taking a trip to a forest away from the city;" students were more disagreeable to "building new roads is important trees must be cut down;" most students were neutral or not sure to disagreeable to "because mosquitoes live in swamps, we should drain the swamps and use the land for farming;" students were very agreeable to "I like the quiet of nature;" and more students were agreeable to "help raise money to protect nature." The results show that students are thinking or wondering about the impact of humans on the environment.

The null hypothesis **H2**, 'there will be no difference in students' watershed and ecology knowledge and behavior' affected by their teachers during the project, was rejected. The feedback surveys showed that students were learning and concerned about the polluted environment and climate change. The survey provided insight into how students have benefitted from environmental education. Overall, student responses indicated an improved understanding of water pollution and ecology, the importance of addressing water pollution, and community involvement to improve water quality. Many students expressed interest in learning more about ecology and provided examples of changes to their behavior. Student behavior changes included reduced littering, reduced use of plastics, better recycling efforts, reduced use of household chemicals, use of more bio-degradable chemicals, and increased carpooling to reduce carbon dioxide emissions. It was noted that some students indicated no change in their behavior.

The research question "What does GEN Z know about the connection between the hydrologic cycle, watershed, plastic pollution, and climate change?" What was missing in the student feedback? The connection between the plastic pollution cycle has a need for attention. In addition, the feedback did not reveal problem-solving solutions to help eliminate or decrease plastic pollution. These criteria have been revised in our curriculum to encourage more brainstorming and problem-solving reflection time for students.

Gen Z Learning Environment

A key factor in designing a Gen Z learning environment is to consider the hygge concept. Gen Z appreciates the presence of greenery and coziness around them (Niemczynowicz et al., 2023). Another critical learning attribute of Gen Zs is that they are digital natives and may have better visual ability and make sense of visual forms (Cilliers, 2017), which can be used to expand their capacity to understand spatial/global relationship learning. Gen Z and younger youth are not just current stakeholders but change agents with stakes in the climate change agenda. They must be listened to and involved in environmental stewardship planning (Jones & Podpadec, 2023).

Elevating environmental education is essential in improving pollution literacy and communication. Teaching just the facts will not modify what students believe and value. The mentality and values of Gen Zs are important to include in curriculum design to help ensure the success of effective environmental pedagogy.

Shifting human behavior can take a long time. Culture and education are the keys to changing people's behavior. **Figure 6** portrays three lenses: the environmental education lens, the nexus lens, and the cultural lens. All the lenses must work together to advance new environmental thinking and knowledge, attitudes, and good works.

Recommendations

The research resulted in the following recommendations:

1. Environmental education must be elevated in the curriculum. Environmental science (earth and space science included) must be required for students to take, especially in secondary school science. "Scientists, educators, politicians, and parents need to push for the schools in their regions to incorporate rigorous Earth

Figure 6. Gen Z environmental behavior lenses (it portrays three lenses: environmental education lens, nexus lens, & cultural lens & nexus lens overlaps culture & education lenses © LeSage-Clements)

and space science." and help prevent future bad decisions (Wysession, 2023, p. 1).

2. For an optimum learning environment, Gen Zs need a learning environment with state-of-the-art constructive learning tools connected to fieldwork and their lives. They require a learning environment with the presence of hygge.
3. Older generations need to provide eco-leadership. Although this might not be possible (remains to be seen). Gen Z and younger generations are whom we need to focus on.
4. Environmental educators must be eco-leaders and help provide a community bridge for Gen Zs to communicate locally, regionally, and globally. They need space to exchange knowledge and develop viable solutions supporting sustainability (Barrón et al.,2022).

CONCLUSIONS

Our research showed that Gen Z's environmental attitudes and behavior changed in the dimension utilization as measured by 2-MEV model during their environmental education. The students overall had good environmental attitudes and behaviors. The student feedback revealed several salient pollution and watershed ecology knowledge themes, disclosing that a holistic environmental science curriculum is needed to connect the plastic pollution cycle with petroleum production and products. Gen Zs need help from our community stakeholders and leaders to make behavior changes and make a difference in cleaning up our planet.

Reversing plastic litter pollution and how we use fossil fuels means changing human behavior, and it is not an easy task. It will take much challenging work to continue impacting our region and influencing others to protect the environment. Most people agree that plastic pollution is a problem, but plastic litter is everywhere. Furthermore, most people agree that we need alternative energy resources to decrease carbon dioxide emissions and slow down climate change. Despite this, fossil fuels are used for many products and energy needs.

It is essential to include environmental education in the curriculum taught in all grade levels and related in most subjects because students will not figure it out on their own. How could they? You cannot assume people are going to get it. Students/people may not have prior knowledge of why they should not be polluting the environment. We need to require environmental science in all education programs for people to understand earth systems, or we can expect nothing to get better environmentally. Environmental education is more urgent now than ever because plastic pollution may be the most compelling environmental health problem of the 21st century.

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Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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APPENDIX A: 2-MEV MODEL QUESTIONS

1. If I ever have extra money, I will give some to help protect nature.
2. To save energy in the winter, I make sure the heat in my room is not on too high.
3. I would like to sit by a pond and watch dragonflies.
4. People have the right to change the environment (nature).
5. Building new roads is so important that trees should be cut down.
6. I would help raise money to protect nature.
7. I always turn off the light when I do not need it anymore.
8. I like to go on trips to places like forests away from cities.
9. I like a grass lawn more than a place where flowers grow on their own.
10. Because mosquitoes live in swamps, we should drain the swamps and use the land for farming.
11. I try to tell others that nature is important.
12. I try to save water by taking shorter showers or by turning off the water when I brush my teeth.
13. I like the quiet of nature.
14. To feed people, nature must be cleared to grow food.
15. People are supposed to rule over the rest of nature.
16. Weeds should be killed because they take up space from plants we need.

APPENDIX B: PRESERVATION & UTILIZATION FACTORS

Preservation is a biocentric dimension that reflects the conservation and protection of the environment. Individuals with this environmental attitude prioritize preserving nature in its initial state. These individuals are often keen on protecting nature from any human use or alteration.

Utilization is an anthropocentric dimension that reflects the Utilization of natural resources. Individuals with this environmental attitude believe it is appropriate for natural resources to be tapped into for human use and alteration.

Preservation

Intent of support

1. If I ever have extra money, I will give some to help protect nature.
6. I would help raise money to protect nature.
11. I try to tell others that nature is important.

Care with resources

2. To save energy in the winter, I make sure the heat in my room is not on too high.
7. I always turn off the light when I do not need it anymore.
12. I try to save water by taking shorter showers or by turning off the water when I brush my teeth.

Enjoyment of nature

3. I would like to sit by a pond and watch dragonflies.
8. I like to go on trips to places like forests away from cities.
13. I like the quiet of nature.

Utilization-alternating nature

4. People have the right to change the environment (nature).
9. I like a grass lawn more than a place where flowers grow on their own.
14. To feed people, nature must be cleared to grow food.
16. Weeds should be killed because they take up space from plants we need.

Dominance

5. Building new roads is so important that trees should be cut down.
10. Because mosquitoes live in swamps, we should drain the swamps and use the land for farming.
15. People are supposed to rule over the rest of nature.

APPENDIX C: STUDENT REFLECTION SURVEY

McREL and the investigators developed a survey for in-class administration for students of steward teachers. The survey gathered information on the extent to which students' knowledge and behavior have been affected by their teachers' participation in professional development and stewardship days. McREL analyzed the survey question answers to discover the main themes.

1. What is the most important thing you've learned about water pollution in your science class this year?
2. What steps can people in your community take to help improve the Texas Gulf water quality by decreasing water pollution?
3. What changes have you made to your own behavior or lifestyle to help improve water quality in your community based on what you've learned in your science class this year?
4. What is one question you have about watershed ecology or water pollution (or something you'd like to learn more about)?