Lessons In Waste:

Assessing High School Student Knowledge of Waste Sorting Literacy

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ABSTRACT

Municipal solid waste (MSW) generation is rapidly increasing within the United States, yet not much is known about the effectiveness of education in addressing this issue. This study aimed to understand Oakland high school students' and teachers' knowledge of waste sorting literacy and their waste sorting behaviors on campus. The study used waste sorting educational resources provided by Oakland Unified School District's Green Gloves Program as well as the EPA Guide to Facts and Figures Report About Materials, Waste, and Recycling to construct a survey to assess student and teacher knowledge of waste sorting. The results indicate that there is no significant difference in scores between Environmental Science Students and Non-Environmental Science Students. There was a significant difference in scores between teachers and students, with teachers scoring slightly higher on average, however the average score for both groups was below passing grade level. However, while students' knowledge of waste sorting was low, results from observations indicate that students are better at sorting their trash in practice than they are at identifying items for disposal. The implications for policy and further research are discussed as potential solutions.

KEYWORDS

Education, Environmental Knowledge, Teacher Knowledge, Environmental Science, Recycling

INTRODUCTION

Waste, its generation, and its management, are challenging topics faced by The United States of America. In 2018, the EPA estimated that the United States produced nearly 292.4 million tons of municipal solid waste (MSW) with only 23.6% and 8.6% million tons attributed to recyclables and compostables, respectively (EPA 2021). The total amount of waste generated is approximately an 8% increase from the previous year and 40.4% increase from 1990. Furthermore, there is a 2.9% decrease in the percentage of waste that was recycled and composted in 2018 compared to 2017 (EPA 2021). Poor waste management ultimately results in air, water, and soil pollution and has the potential to increase disease rates in human populations (Manfredi et. al 2010, DeWalle 1979). In the context of the United States, the excessive generation of waste contributes to landfills which produce harmful, highly-flammable gasses such as methane (New York State Department of Health 2019). Even more concerning is that the majority of modern day products contain larger quantities of toxic chemicals than ever before, which can permeate into water systems and pollute the air of nearby neighborhoods as they degrade over time (Rawlins 2009). But waste, and the environmental hazards it contributes to, does not magically manifest in landfills; It follows a very specific process prior to its arrival.

Waste is generally sorted into four different categories: landfill, recyclable, compost, or hazardous. Each category follows a different pathway, or waste stream, in the waste management system to arrive at a final destination (EPRS Briefing on Waste 2015). Perhaps the most relevant topic to United States citizens is the single stream recycling process that is used by 90% of household recycling companies (The Recycling Partnership 2020). Single-stream recycling allows consumers to place all of their recyclable items into a single bin rather than separate bins (National Waste and Recycling Association). The convenience of this system allows many Americans to quickly and easily sort their waste with little to no thought involved in the process and studies have shown that the introduction of single-stream recycling is synonymous with increased recycling rates nationwide (Goodman 2006). The problem with single-stream recycling arises when non-recyclable items, such as food or soft plastic bags, are assumed to be recyclable and are placed in the single-stream bin. These non-recyclable items contaminate the batch which detrimentally impacts efficiency at waste management facilities and reduces the overall recycling value if the percent contamination is too high (University of Michigan). At this point, it is more cost effective for waste management facilities to incinerate or divert the batch to landfill than to continue sorting efforts (Cho 2020). Given that an estimated 90% of single family residents in the United States are serviced by waste companies that utilize a single stream waste disposal method and that these companies report 16% of recycled material is contaminated, it is imperative that the United States abandon their Tragedy of the Commons mentality and be diligent in equipping the next generation with knowledge on proper waste identification and sorting methods (EPA 2021, Gendell 2016).

But where should increasing recycling compliance begin? One program sponsored by the city of Phoenix Arizona saw the number of contaminants in their recycling batches reduced by 50% after implementing a recycling education program in 2018 (EPA America Recycles). Another study found that education had a significant, positive impact on long-lasting waste management behavior changes (Saseanu 2019). The results of these studies seem to indicate education, specifically environmental and waste education, to be beneficial in improving waste management behaviors. But both of these programs rely on the voluntary participation of the adult population of the general public and struggle to reach the youth of the next generation. When accounting for these age ranges, especially those of students, various international studies have indicated that students possess positive perceptions of waste sorting and the environment but have a general lack of knowledge about either topic (Müderrisoglu & Altanlar 2011, Adeolu & Enesi 2014, Dung et. al 2017). But in all of these cases the responsibility to acquire and act on waste management knowledge is thrust entirely upon the individual. Indeed, the scale must be increased to witness marked improvement across the nation.

Compulsory education in California is designed to equip students with solid foundational skills for their survival and wellbeing in the modern world and inserting waste education in K - 12 subjects may increase overall rates (Oreopoulus 2006). However, the California state board of education (CBE) does not currently list waste management as a key component of K-12 curriculum requirements (California State Board of Education 2021). Despite this omission, the CBE has approved the California Education and Environment Initiative (EEI), an alternate curriculum designed to allow students to complete Science and History unit requirements through exploring the environment (EEI). Of the 85 history social sciences and natural sciences approved curriculum options across grades K-12 only 15 courses mention integrated waste management as a core unit component and none of them are based in natural sciences (EEI curriculum catalog). Additionally, the 15 curricula are primarily elementary and middle school programs with only 6 of the courses assigned to high school education. The impact of this poorly balanced curriculum leaves a significant gap in waste knowledge in compulsory education. Given that high school students, particularly juniors and seniors, are near the end of their compulsory education careers, it would be an incredible disservice to them and the planet they will inherit if they do not receive proper instruction on waste management procedures.

However, one school district in California, Oakland Unified (OUSD), has made an official statement to address the disparity in environmental knowledge within their schools. Board Policy 6142.5, enacted in 2004, officially recognized climate change as a pressing concern for human survival and established a set of district sustainability projects within the Environmental Science and Climate Change Literacy curriculum to better educate students on the relationship between humans and climate change (Oakland Unified School District 2004). One such project, the Green Gloves Program, was implemented to specifically target students' knowledge of waste sorting within school cafeterias and common areas, however there is no consensus on whether the program has had any lasting effects on the student population (OUSD 2022). In fact, the only statement that OUSD has made about the effectiveness of their Environmental Science and Green Gloves Program in combating the waste crisis can be found within their Wellness Program Evaluation Report from 2015, which claimed that 67% of OUSD schools had started or managed a waste-sorting program within their school (Bright Research Group 2015). As of April 2022, no research study has been performed to evaluate the effectiveness of these programs. As a result, it is currently unclear whether these programs have been able to improve students' knowledge of waste sorting or their waste sorting behaviors.

This paper describes the implementation of a small scale study within a participating OUSD high school that seeks to answer a central question: How effective are high school environmental science curricula at teaching waste sorting literacy to teenagers? To investigate this question, I explored the following three sub-questions: (i) Do Environmental Science students display a higher level of waste literacy on quizzes about waste? (ii) How does teachers' knowledge of waste literacy topics compare to the knowledge of their students? (iii) Are students applying their waste literacy outside of classroom settings by properly sorting their waste? I expect that the students of this study will exhibit low waste literacy scores and poor waste sorting behavior because they have had little to no exposure to waste management knowledge in their school curriculum. To answer this question, I collected data revealing the subjects' current knowledge of waste prior to their completion of an environmental science program and their knowledge after completing said program. Additionally, I collected observational data on these students' behaviors during lunchtime and break periods to determine whether students' knowledge of waste has any impact on their waste sorting behaviors.

EXTENDED INTRODUCTION

Waste Literacy

Waste generation and management are relatively clear in their meanings, but waste literacy is rather ambiguous. The term is all encompassing and has been loosely used in many studies to describe knowledge of waste issues ranging from zero waste concepts to the environmental hazards caused by waste build up (Siswantini et. al 2020). However, for the purposes of this study, most of these concepts are outside of scope as it is impossible to ascertain high schoolers' knowledge of all waste issues in a short survey design. Thus, the term waste literacy will be restricted to describe only the information related to residential waste sorting and management.

The Reality of Residential Waste Sorting Knowledge in the United States

Waste sorting is perhaps the most important factor in determining the success of waste management operations (Cudjoe et. al 2020). But the reality for most Americans is that waste sorting is a confusing and not easily understood process. In the United States, waste management falls under the jurisdiction of municipalities who outsource the work by contracting for-profit waste hauling and disposal companies (Hickman 1993). These companies possess differing views on what constitutes proper waste sorting behavior because properly processing most recyclables, such as thin plastic bags, is not a profitable action (Gaba 2008). What is profitable for these companies is simply moving large quantities of municipal solid waste to landfills which, unfortunately, results in many waste management companies tagging otherwise recyclable or compostable items as landfill.

But why is recycling not profitable? When an item arrives at a waste management facility, the facility must utilize one of two two waste management methods, a multi-stream or a single-stream system, in order to process their recyclables for disposal. Multi-stream recycling is a collection method that requires the person who generated the waste to assume responsibility for its disposal by properly identifying the waste item as a particular type of recyclable and placing it in the corresponding bin (Lakhan 2015). Conversely, single-stream recycling is a system that allows the person who generated the waste to place their recyclables into one bin to be sorted at a waste facility at a later time, thereby placing much of the responsibility for proper disposal on the recycling facility. The United States generally relies on single-stream recycling systems and many waste management companies do not have the budget to assign personnel to sort all the waste that they process nor the equipment to process every type of recyclable waste (Alter 1993). The combination of these two variables is what deters companies from pursuing recycling options and what influences their decisions to inform the public to place certain items in their landfill bin.

Laws and Regulations

Currently, the only national laws in the United States mandating that all citizens properly dispose of their residential waste are the Resource Conservation and Recovery Act of 1976 regarding hazardous waste disposal and the Ocean Dumping Ban Act of 1988 aimed at reducing the amount of municipal and industrial waste dumping in the ocean (EPA on RCRA) (EPA on Ocean Dumping 2016). The absence of federal legislation in this area allows state governments to determine their own waste management laws and procedures provided they do not violate the regulations set by the aforementioned national laws (de Kadt 1994). This gap is what allows states like West Virginia to not establish any mandates on recyclables outside of hazardous waste and states like California to implement waste management regulations aimed at reducing the overall waste that is diverted to landfills (State of California, The Ball Corporation 2021).

Environmental Motivations, Knowledge, and Education

The intention to perform a particular environmental action is often influenced by attitudes and perceptions of the issue, but more importantly, it is strongly influenced by knowledge (Barber 2009). The acquisition of environmental knowledge has the potential to change an individual's attitude toward environmental crises and develop their sense of concern for environmental issues

(Scott 2014). This concept also applies to the youth of the next generation as studies have found that students with greater levels of environmental knowledge tend to have more positive environmental intentions than their peers (Vicente-Molina 2013). Understandably the responsibility of imparting this knowledge falls upon parents and teachers within the youths' lives.

It has been said that the goal of environmental education should be to inform groups of students and instill positive environmental intentions within them (UNESCO 1978). To that end, studies have shown that instruction methods centered around attitude-shaping behavior have achieved far more success in this regard than other behavior achievement approaches (Pedro 2010). Additional studies have also corroborated the positive relationship between a teacher's own motivations and their students' academic achievement (Tastan 2018). Unfortunately, the learning outcomes of many high school programs are dictated by the district and place less focus on application and more on the memorization of concepts (Anugrah 2017). This ultimately leaves the responsibility of acting upon the newfound knowledge up to the students, rather than providing them with ample resources to shape their attitudes and guide their actions.

Unfortunately, the current state of environmental, and subsequently, waste sorting literacy of students is lacking, and research shows that Americans believe they know more facts about the environment than they actually do (Coyle 2005). But the United States is not alone in this regard. Studies conducted in Indonesia have confirmed this claim holds true in their student populations, revealing that 80% of students displayed inadequate environmental literacy (Gustria & Fauzi 2019). Another study conducted in Kerala determined that literacy rates for waste management practices among school children were generally low and stressed the need for immediate action in addressing the gap in waste management awareness (Licy et al. 2013). Young people are not naturally good students. They must be taught and continue to fill their minds with new information that builds on their pre-existing knowledge in order to effectively advance their level of literacy in a given topic (Myhill 2004). To that end, it is vital that student and teacher knowledge be assessed prior to developing a lesson plan so that the curricula can be adjusted to meet the diverse needs of the student population.

Methodology

This study utilizes a combination of quantitative survey results from a survey administered to students and teachers and observations on student behavior to determine overall differences in waste literacy knowledge. The decision to utilize a survey over a questionnaire was largely based on the level of comfort and familiarity the students' have with a quiz-based format over an interview. The sample of this study are high school freshman, sophomores, juniors, and seniors aged 14 to 18 at one randomly selected OUSD High School. , All genders and ages between these ranges will be considered to gain a clear understanding of the level of waste literacy this population possesses. The age range for this study was determined by the eligibility criteria for students to enroll in AP Environmental Science programs within their respective school. Because Board Policy 6142.5 established the Green Gloves Program within OUSD schools along with altering the course curriculum for science programs, all high school student grade levels and age ranges are eligible for study and analysis. Students who have not participated in or received any instruction from programs related to this Board Policy will be studied as well and assigned to the control group of the study so their results can be used to determine the overall effectiveness of environmental science programs at the school.

Since there is evidence supporting teacher content knowledge influences student academic achievement, the students' teachers will also be asked to complete the survey. How well the teacher performs, or how high their point score is, may be indicative of the students' scores and could identify a potential factor in perpetuating the waste crisis in America.

The third and final sub-question seeks to understand whether the knowledge students display in the waste literacy survey translates to the actions of the overall community. Realistically, the averages between the students' survey results and the observations of whether they have correctly sorted their trash outside of the classroom should roughly align as the survey includes some of the items they will be sorting.

METHODS

One school from within OUSD was randomly selected from OUSD's list of high schools and a convenience sample of 98 high school students and 15 teachers in science and english classes were selected to complete the survey. The individuals sampled were high school Freshman, Sophomores, Juniors, and Seniors aged 14 to 18 years old and their teachers. The age range for this study was determined by the eligibility criteria for students to enroll in AP Environmental

Science programs within their respective school. Thus, the subjects of this study include High School Freshman, Sophomores, Juniors and Seniors in Environmental Science classes and and other STEM classes.

I collected qualitative and quantitative data revealing each individual's demographic information and their knowledge of waste sorting as dictated by OUSD and the EPA's educational resources on waste sorting. Students and teachers accessed the survey by scanning an anonymous QR code on their personal electronic devices. The surveys were completed during morning classes, between the hours of 8:30am and 11:30am.

The Survey

The six-minute survey that I gave to students and teachers to assess their knowledge of waste sorting concepts was designed in a quiz format similar to quizzes students may take for any class. I divided the survey into three blocks with a total of 20 questions: A demographics block (4 questions), a true or false question block (5 questions), and a multiple choice question block (11 questions). I designed the demographics block to provide qualitative data about the subjects and that allowed me to compare the results by gender, grade level, and environmental science education level. The demographics block did not contribute towards the overall score on the survey and was strictly used for categorizing responses. I used this block to assign students to one of three class types, Current Environmental Science Student, Previous Environmental Science Student, or Non-Environmental Science Student, which effectively separated their survey scores into three distinct groups for comparison and analysis. I designed the latter two blocks with a binary response format in which students were assigned a point for a correct answer or a zero for an incorrect answer. The questions I chose to include in the survey were directly derived from educational resources provided by OUSD's Green Gloves Program and the EPA Guide to Facts and Figures Report About Materials, Waste, and Recycling. Examples of each type of question that the student was asked to perform can be found in Appendix A. I started by carrying out a pilot study in which 20 surveys were distributed to college students within the Environmental Sciences major and students of various other majors at the University of California at Berkeley. Participants completed the survey in an average of six minutes, and I used feedback from participants to modify wording but not question content. Responses from these categories contributed to the individual's overall waste sorting literacy score and I assigned 1 point for each correct answer for a total of 16 possible points.

I conducted a convenience survey between October 2021 and December 2021 with students and teachers from Environmental Science (2), Algebra (3), Biology (3), and Physiology (2) classrooms. I contacted the teachers for each of these classes and gave them access to an anonymous internet link to my survey as well as a QR code that students could scan to access the survey from their personal electronic devices. I then distributed the survey to the students and teachers which were completed during class time.

I analyzed the survey scores from the teacher and student responses using Qualtrics software, version May 2022 (Qualtrics, Provo, UT 2022) and R (R Core Team 2020). Qualtrics is an online survey tool that allows the user to build and analyze surveys while R is a programming language for statistical computing and analysis. I used both of these tools to construct histograms to compare distribution of score by count in order to provide a visualization of the distribution of scores for students and teachers.

I then conducted one-way ANOVA and Games-Howell Post-Hoc tests to compare the mean scores of student and teacher class types. I decided to use both of these tests because of the presence of three test groups (Current Environmental Science Student, Previous Environmental Science Student, and Non-Environmental Science Student) as well as both tests' ability to make definitive statements about the relationship between the mean scores of all three test groups. A Games-Howell Post-Hoc test was conducted to further explore the relationships between the groups that yielded a significant ANOVA result. Once these tests were completed, I then conducted a Welch's t-test to compare the mean scores of teachers and students. The decision to use Welch's t-test over the Student's t-test was determined by the unequal sample sizes and unequal variances of the teacher and student populations. Welch's t-test allows for accurate determinations to be made on two populations regardless of these two variables, making it the most appropriate tool for analysis of teacher and student results. To further increase the power of Welch's t-test, I took a simple random sample of 15 from the student scores and tested them against the available teacher scores.

Finally, after I received the results from my surveys, I randomly selected four waste items that were listed in the multiple choice block of my survey and made focused observations of high school students disposing of these items during school hours. All observations were made at the same set of three trash cans that were labeled and colored appropriately based on their categorization as either Landfill, Recyclable, or Compostable. I positioned myself at different locations roughly 10 feet away from the trash cans and observed students over the course of two months. Each time a student disposed of one of the four randomly selected items, I recorded the type of item, the trash can the student placed the item in, the correct trash can option, and whether the student had properly sorted the waste item. At the end of the two month period, I calculated the percentage of students who correctly sorted each waste item and compared the results to the percentage of students who were able to properly identify how to sort the waste item on my survey. I made this comparison by calculating the difference between the two percentages.

RESULTS

Survey Responses

A total of 10 classes were sampled which yielded 98 survey responses from the student sample population and 15 survey responses from the teacher sample population. Of the 98 student responses, 15 responses were incomplete and were not included in analysis, which left 83 usable responses for analysis. For teachers, all 15 surveys were distributed and all were completed. The final score for each individual participant is a sum of their scores on questions in Blocks 2 and 3.

A graphical representation of student score by count in the form of a histogram revealed that the results were approximately normal distributed about the mean of 6.9 with a median of 7. The maximum score achieved by students was 13 and the minimum score was zero (Figure 1).

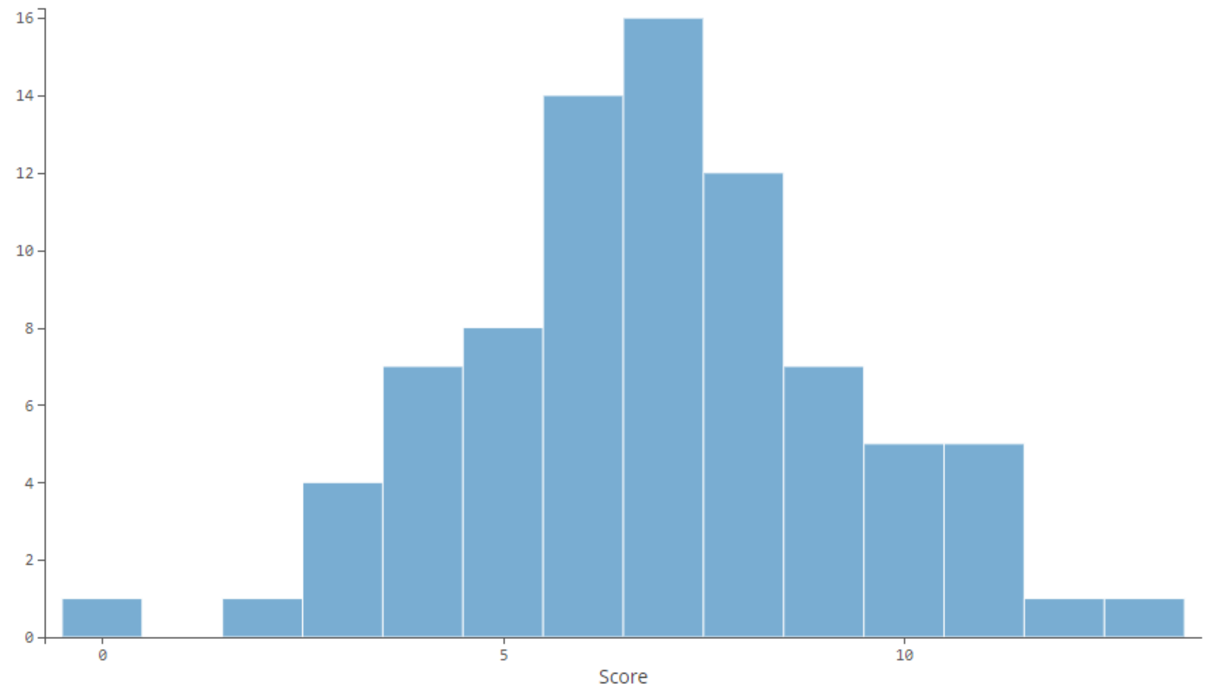

Figure 1. Student Scores by Count.

Of this population 10 students were enrolled in an Environmental Science class at the time they took the survey, 18 students had previously taken an Environmental Science class, and 53 students had never taken an Environmental Science class (Figure 2).

Q3: Have...survey.)	Count	Average	Median
Yes (Currently)	10	7.30	6.50
Yes (Previously)	18	6.83	7.00
No	53	6.77	7.00
Total (3)	81	6.85	7.00

Figure 2. Distribution of Environmental Science Students.

Teacher responses revealed a mean of 9.7, a median of 10, a maximum of 13, and a minimum of 6. The graphical representation of the responses is not normally distributed which is likely due to the low sample size (Figure 3).

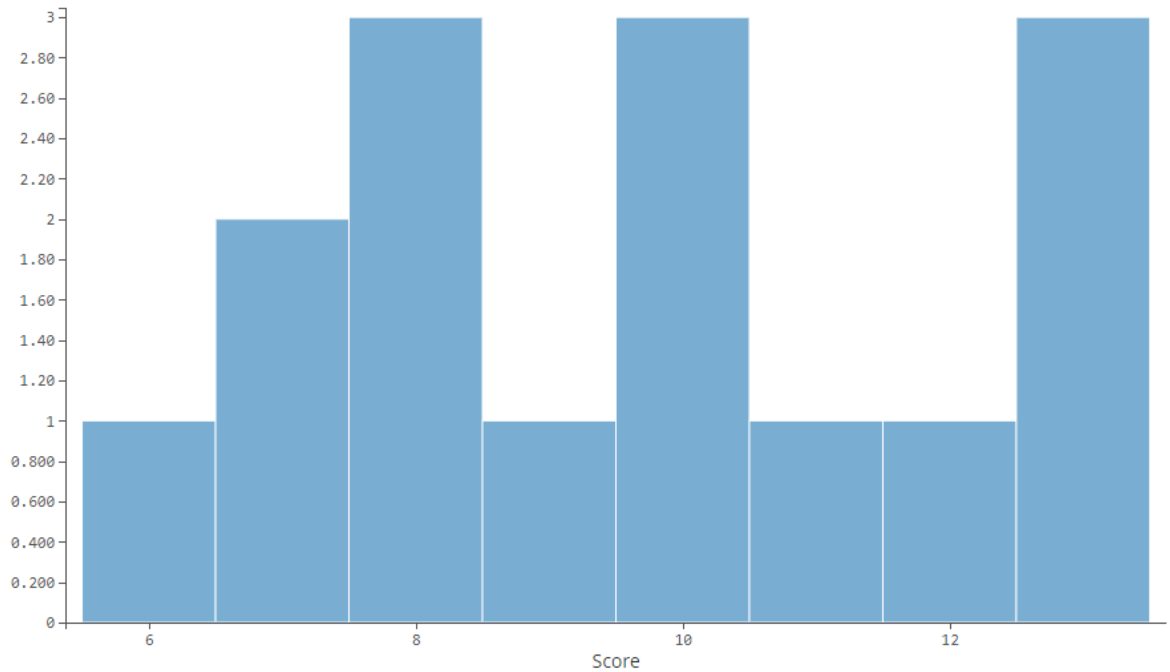

Figure 3. Teacher Scores by Count.

Hypothesis Testing - Student Data

A one-way ANOVA on whether or not a student's enrollment in an Environmental Science course had any effect on overall score on the waste sorting literacy survey yielded a calculated p-value of 0.88, and an F-value of 0.07. Compared against the alpha of 0.05, the results of the ANOVA revealed that there was not a statistically significant difference in means between the three groups (Table 1).

Table 1. Summary of Student Responses.

Enrollment Classifier	Count	Average	95% Confidence Interval	Median
Current ES Students	10	7.30	5.11 - 9.49	6.50

Previous ES Students	18	6.83	5.59 - 8.08	7.00
Non-ES Students	53	6.77	6.17 - 7.38	7.00

A one-way ANOVA on whether or not grade level had any effect on scores yielded a p-value of 0.01 and an f value of 0.44 (Table 3). Compared against the alpha of 0.05, the results of the ANOVA revealed that there is a strong statistically significant relationship between grade level and score on the waste literacy survey.

Table 2. Summary of Student Scores by Grade Level.

Grade Level	Count	Average	95% Confidence Interval	Median
Freshman	18	6.78	5.46 - 8.09	7.00
Sophomore	7	9.00	7.07 - 10.93	9.00
Junior	43	6.16	5.54 - 6.78	6.00
Senior	18	8.08	6.74 - 9.42	8.00

A Games-Howell post-hoc test on if one grade level tended to display higher scores than the others yielded a calculated p-value of 0.04 (Table 4). Compared against the alpha of 0.05, the Games-Howell post-hoc test revealed that the only significant relationship between student group scores was between the Sophomore and Junior students.

Table 4. Games-Howell Post-Hoc Test on Student Scores by Grade Level.

Group 1	Group 2	Difference in Averages (1-2)	P-Value	Effect Size	Sample Size 1	Sample Size 2
Junior	Senior	-1.91	0.05	-0.95	43	13
Junior	Sophomore	-2.84	**0.04**	-1.43	43	7
Freshman	Junior	0.61	0.79	0.28	18	43
Freshman	Senior	-1.30	0.46	-0.54	18	13
Freshman	Sophomore	-2.22	0.17	-0.92	18	7
Senior	Sophomore	-0.92	0.77	-0.45	13	7

Hypothesis Testing - Teacher Data

A one-way ANOVA on whether or not teachers' enrollment in environmental science had any effect on their overall score on the survey yielded a calculated p-value of 0.25, and an F-value of 0.56 (Table 5). Compared against the alpha of 0.05, the ANOVA revealed that there is no statistically significant relationship between whether a teacher had taken an Environmental Science class and their score on the waste literacy survey.

Table 5. Summary of Teacher Responses.

Enrollment Classifier	Count	Average	95% Confidence Interval	Median
Teachers Who Are Currently	1	13	13.00 - 13.00	13.00

Enrolled in an ES Class				
Teachers Who Have Previously Taken an ES Class	7	10.41	8.19 - 12.10	10.00
Teachers Who Have Never Been Enrolled in an ES Class	7	6.77	6.60 - 10.83	8.00

A Welch's t-test on whether there was a significant difference between Student and Teacher scores yielded a p-value of 0.003. Compared against the alpha of 0.05, the Welch's t-test revealed that there is a statistically significant difference in average scores between the teacher and student groups (Table 6).

Table 6. Welch's T-Test Summary.

Sample	**Count**	**Average**
Students	15	6.53
Teachers	15	9.67
P-Value	0.002	
95% Confidence Interval	-5.10 - -1.17	

Observations on Student Waste Sorting

Observations on the student population were performed in order to determine whether students' waste sorting knowledge was consistent with their practical behavior. Results from these focused observations revealed large disparities in students' knowledge of sorting properly Food Soiled Napkins and Pencils and their actual behavior. Food Soiled Napkins was the waste item that students struggled the most in sorting with the majority of students, approximately 95%, placing their food soiled napkins in the landfill bin and only 4.3% of students placing this item in the correct bin. Excluding Food Soiled Napkins, the percentage of students who were able to properly sort their waste was larger than the percentage of students who correctly identified the proper way to dispose of the waste item on the quiz for all waste items. Pencils were the waste item that students displayed the most positive difference in, with 56.4% of students properly sorting Pencils compared to the 38.6% of students who answered correctly on the survey (Table 7).

Table 7. Observation of Student.

Waste Item	Picture	Correct Answer	Percentage of Students who Answered Correctly on Survey	Percentage of Students who Correctly Sorted Their Waste	Difference
Empty Chip Bags		Landfill	**62.7%**	**68.3%**	**+5.6%**
Paper Cups With Plastic Coating		Landfill	**25.7%**	**37.7%**	**+12%**

Food Soiled Napkins		Compostable	**26.5%**	**4.3%**	**-22.2%**
Pencils		Landfill	**38.6%**	**56.4%**	**+17.8%**

DISCUSSION

This paper aimed at evaluating the current level of waste sorting literacy of high school students and the results from simply comparing the average scores of students and teachers reveal that neither group obtained an average passing score on the waste literacy survey. With teachers scoring approximately 9.67 (60.4%) and students scoring 6.85 (42.8%) on average, it is clear that both groups involved in the study have much to learn about waste sorting literacy. Additionally, ANOVA test results on whether a student's enrollment in an Environmental Science class improved survey score revealed that there was no statistically significant difference in the average scores of each group. ANOVA results comparing mean scores from student and teacher populations did yield a statistically significant relationship between the two, indicating that teachers' knowledge of waste sorting is greater than their students, however their knowledge is still insufficient to obtain a passing score. Finally, observations on student waste sorting behavior revealed that the percentage of students who correctly sort their waste outside of classroom settings is greater than the percentage who can correctly identify how to sort the waste item on the survey.

The Reality of High School Student Waste Sorting Literacy in the United States

Students surveyed displayed a general insufficiency in ability to identify the correct way to dispose of common waste items. The average score for the combined student population was 6.85 out of a total of 16 possible points. Moreover, with Current ES Students scoring 7.30, Previous ES Students scoring 6.83, and Non-ES Students Scoring 6.77, there was not a large disparity between the average score between all three groups. These results were confirmed to not be significant by the ANOVA test, indicating that a students' enrollment in an Environmental Science

Class at the sampled school and their knowledge of waste sorting literacy are not influenced by one another.

These findings are consistent with other studies that found that prior environmental classes had little to no impact on an individual's environmental awareness and that students generally have low levels of environmental knowledge (Pavliukh 2014; He et. al 2011). But why is student waste sorting knowledge so lacking in this particular OUSD school? The participating school's Environmental Science curriculum is dictated by the information outlined in Board Policy 6142.5, which specifies the need to address climate change through environmental science education. Within this context, OUSD highlighted a set of six goals for educational outcomes of their environmental science curriculum.

1. Understanding the essential principles of Earth's climate system
2. Knowing how to assess scientifically credible information about climate
3. Communicating about climate and climate change in a meaningful way, and
4. Understanding how humans have responded to environmental challenges in the past in order to make informed and responsible decisions about the present climate crisis
5. Integrating a project based approach that incorporates the scientific causes and effects of climate change and economic, political, social, and cultural factors
6. Social emotional learning components that provide positive, action-oriented projects to create schools that are sustainability hubs that can radiate out to our community

The goals are arranged in order of priority. Notably, waste sorting education falls under the fourth, fifth and sixth goals which are the least prioritized learning outcomes for the program. Additionally, the Board Policy also relegates waste sorting education to the Green Gloves Program, a sustainability project within OUSD schools that teaches waste sorting on campus during lunch and break times. However, since both of these time frames are essentially rest periods for students, it is likely that they are not interested in learning about waste sorting during these times, thus rendering the Green Gloves program ineffective. Due to the presence of the Green Gloves Program, it is possible that the Environmental Science classes at the sampled school are not prioritizing waste sorting in their lesson plans and instead relying on the Green Gloves program to teach students waste sorting literacy. As a result, neither program is effective at teaching waste sorting literacy to teenagers which could explain the students' poor performance on the survey.

The Reality of Teacher Waste Sorting Literacy in the United States

Analysis of teacher scores revealed a similarly low level of waste sorting knowledge. The results from the Welch's t-test revealed that there is a significant difference between teachers' and students' average scores on the survey, with teachers scoring higher on average than their students. These results are consistent with the results of another educational study that found that teachers generally possess greater knowledge than their students (Hill 2018). However, there was no statistically significant difference in whether an Environmental Science class influenced teacher knowledge of waste sorting.

Teacher content knowledge directly impacts the academic achievement of their students, which, given the low scores of the teachers in this study, may explain why students are not very literate in waste sorting knowledge. The most logical explanation for the low teacher scores, and lack of knowledge surrounding waste sorting, is likely a result of the STEM teacher shortage in California and the school's location in a high poverty area. A recent study on the STEM teacher shortage has indicated that high poverty districts are 2.7 times more likely to have a STEM teacher who is not fully credentialed (Wolf 2015). In California, a single-subject teaching credential signifies a teacher's mastery of content associated with the subject, thus it is possible that the teachers within this study were not credentialed for the subjects they are teaching (California State Government 2021).

The Reality of Student Waste Sorting Behavior

Interestingly, with the exception of Food Soiled Napkins, students were able to properly sort their waste more frequently than they were able to properly identify waste items for disposal on the survey. With the exception of The most notable results were those associated with Pencils and Food Soiled Napkins. 38.6% of students correctly answered "Landfill" when prompted on how to properly dispose of a pencil whereas 56.4% of students correctly disposed of their pencils in a Landfill bin outside of classroom settings. For Food Soiled Napkins, 26.5% of students correctly answered "Compostable" when prompted on how to properly dispose of the item as opposed to 4.3% of students properly disposing of their food soiled napkins during lunch and break periods.

Limitations and Future Directions

One of the main strengths of this study was its ability to be distributed to a medium sized population of students in a classroom setting. This allowed students to take the survey in a similar setting to how they would take a test associated with the Environmental Science curricula being evaluated. It also allowed for the collection of many responses from the target population. But this strength was also its greatest weakness. Because responses were collected via convenience sampling, the results could be biased and are difficult to extrapolate to explain the entire population. The same holds true for the teacher group, however there are significantly less teachers than students in a school at any given time which made it difficult to collect large amounts of data on teacher knowledge. This ultimately resulted in a low sample size for teacher responses that may have underrepresented the teacher population.

Another limitation of this study was observations were limited to one set of three trash cans in the most popular lunch and break area on campus. Understandably, this restricted the amount of information that could be obtained by only recording waste items that were visibly disposed of and disregarding students who preferred to eat in other areas on campus. Thus, depending on the contents of every waste bin on campus and the distribution of student demographics, it is possible that the observations were not representative of the entire student population's waste sorting practices. Given this information, further research should be conducted to determine the contents of all waste bins on campus and classify the actual percentage of trash properly sorted by students.

Additionally, intention towards waste sorting should be an area of study for future research as intention and knowledge are most often linked. These research efforts should ideally determine OUSD high school students' and teachers' intentions towards waste sorting and identify other factors that contribute to their waste sorting behavior. The results of this research could supplement the results of this study to better inform OUSD administration about how they can adapt their Environmental Science Programs to address the waste crisis and better prepare their students to serve effectively as United States citizens.

Broader Implications

The implications of these results suggest that there is a generational gap in waste sorting knowledge that is not limited to students. Further research should be conducted in order to obtain more results to make a definitive conclusion, however it appears that waste sorting is not a priority of OUSD's K-12 education. This is critically concerning as the waste crisis is continuing to grow in severity. The results of this study may indicate a need for policy changes within OUSD's education system, specifically in addressing waste sorting in high school STEM classes. An argument could be made that waste sorting education should be implemented in earlier education, particularly at the elementary and middle school levels, however building upon existing infrastructure, namely the Environmental Science curricula and Green Gloves Program, is more feasible than implementing new solutions in all of OUSD's elementary and middle schools.

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APPENDICES

Appendix A

Waste Literacy Survey

5/10/22, 4:54 PM Qualtrics Survey Software

Demographic Information

Waste Literacy Survey
The purpose of this survey is to obtain a better understanding of the overall waste literacy among high schoolers and their teachers. The survey is anonymous and the results will not be shared with anyone. Please be sure to answer all questions accurately and to the best of your ability to ensure that your results reflect your best efforts. Thank you for taking the time to complete this survey!

What gender do you identify with?

Male

Female

Non-binary / third gender

Prefer not to say

What grade are you in?

Freshman

Sophomore

Junior

Senior

What class are you taking this survey in (Ex: Algebra 2, Biology, Physiology, etc.)

Have you ever been enrolled in an Environmental Science or Waste-focused class? (These are classes that are specifically about the environment or about trash. Biology, Chemistry, and other science classes that do not only focus on environmental issues or trash are not considered Environmental Science for this survey.)

Yes (Currently)

Yes (Previously)

No

True or False Questions

Waste Literacy True or False Questions

This portion of the survey is designed to test your knowledge of waste literacy. Please read each question carefully and select the answer you believe to be true.

All items marked with the iconic recycling symbol can be placed in the blue recyling bin for processing at a waste facility (See picture for reference)

True

False

All items labeled with the recycling symbol are ready to be recycled, regardless of any food residue left on them

True

False

Food items that are moldy or stale are no longer compostable and should be placed in the landfill bin

True

False

It is more profitable for waste companies to send recyclable items to landfills than to recycle them

True

False

All waste companies sort garbage into compost, recycle, or landfill bins when it arrives at their facility

True

False

Multiple Choice Questions

Waste Literacy Multiple Choice Questions

For this section of the survey you will be presented with an image of an item and asked to categorize the item based on whether it is recylable, landfill (trash), compostable, or hazardous waste (ex: an aluminum can is recyclable so you would select the "Recyclable" answer). Please answer truthfully. Your answers will not be shared with anyone besides the person administering this survey.

Pencil

Recyclable

Compostable

Landfill (Trash)

Hazardous Waste

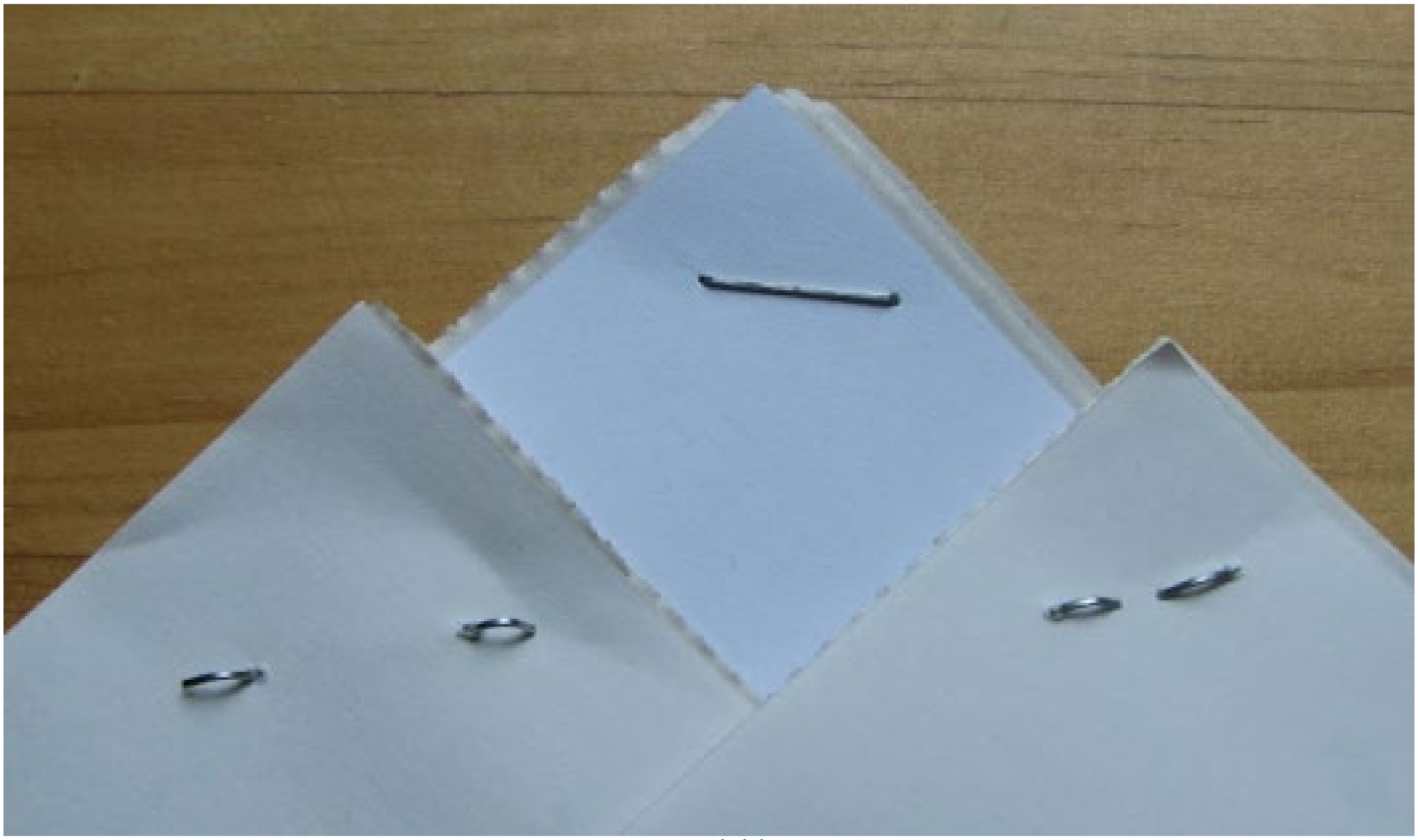
Spiral Notebook

Recyclable
Compostable

Landfill (Trash)

Hazardous Waste

Paper with staples in it



Recyclable
Compostable

Landfill (Trash)

Hazardous Waste

Old Phone Chargers

Recyclable
Compostable

Landfill (Trash)

Hazardous Waste

Potato Chip and Snack Bags

Recyclable

Compostable

Landfill (Trash)

Hazardous Waste

Candy Bar Wrappers

Recyclable
Compostable
Landfill (Trash)
Hazardous Waste

Greasy Pizza Box

Recyclable
Compostable

Landfill (Trash)

Hazardous Waste

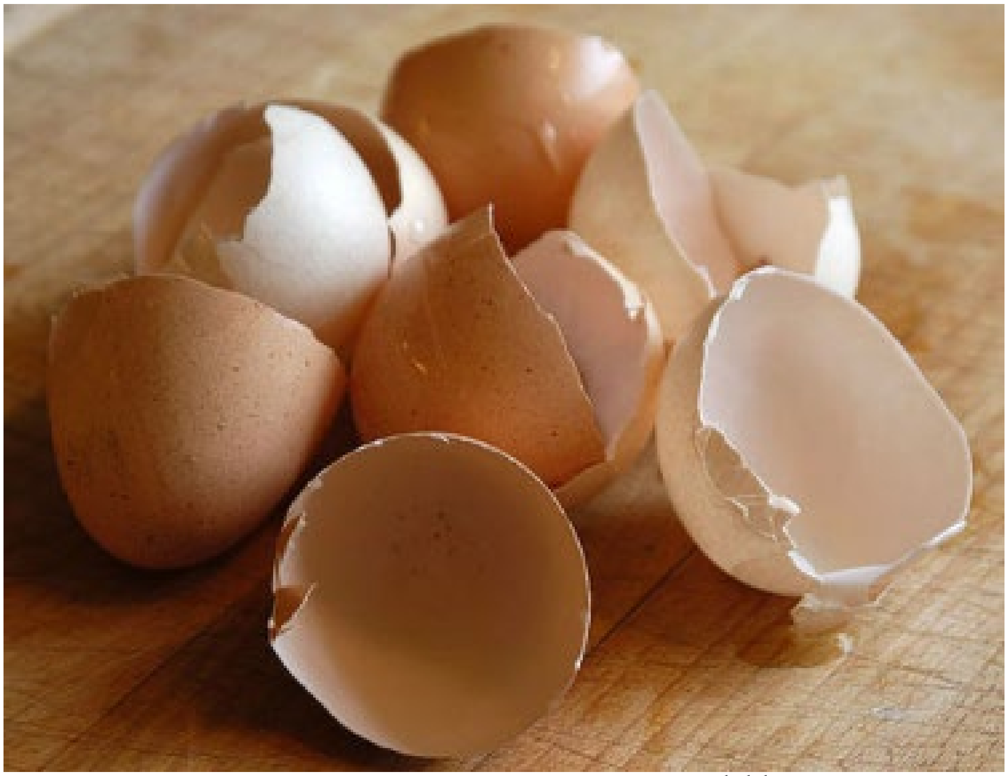
Half-Full Can of Spray Deodorant

Recyclable
Compostable

Landfill (Trash)

Hazardous Waste

Eggshells



Recyclable
Compostable

Landfill (Trash)

Hazardous Waste

Food Soiled Napkins

Recyclable
Compostable

Landfill (Trash)

Hazardous Waste

Paper Cups with Plastic or Wax Lining

Recyclable

Compostable

Landfill (Trash)

Hazardous Waste

Feedback

Please provide any feedback you have after taking this survey. If you have feedback about a specific question, please mention it in your response so I can review it. Any and all comments are appreciated!