Students in high school put the theory into practice by recycling materials and waste

Lazaris Dimitrios
Biology teacher, PhD, Dpt. of Medicine, University of Ioannina
dlazaris@yahoo.com.gr

Sismanidis Ioannis
Teacher of Greek language, Dpt. of Secondary Education, Ed. Directorate of Drama, Greece,
sisman21@gmail.com

Manousi Aikaterini
Teacher of Greek language
aikaterinimanousi27@gmail.com

Theoharidou Anna
Substitute Art Teacher for primary education
fratakatrana@hotmail.gr

Drosos K. Vasileios
Professor, Dpt. of Forestry and Management of the Environment and Natural Resources
vdrosos@fmenr.duth.gr

Abstract

Recycling is the process of reusing various materials that are no longer usable to humans in their current state. Waste is generally transformed into raw materials from which new goods are made in this process. The aim of the research was to investigate the relationship of the students with recycling in theory and in practice. Specifically, students were asked to collect recyclable items in bags for a two weeks period and to classify them according to the material they were made, after recording them in kind and number. Research shows that the largest share or part of recycled items are plastics, in a percentage 46%, the papers 37%, glasses 12%, electrical devices 4% and tinplate occupies a very small percentage of 1%. Also, the recorded recyclable products differed slightly based on the students' gender with a few exceptions. Through the implemented project for recyclable products, students learnt about the role and relevance of recycling in the natural world, and their research increased their understanding and respect for the environment.

Key words: environment, recyclable items, viability, protection, respect

Introduction

Recycling of materials and waste is the process of reusing, in part or in whole, anything that is the direct or indirect product of human activity and that is no longer suitable for man in its current state. The design and implementation of integrated systems is required by modern concepts and practices for municipal solid waste management, with the main aims being sustainability and ecologically effective management. Useful materials such as paper, glass, aluminum, plastic, metal, and wood must be used either by reusing them or by recycling and reusing them, saving a large amount of raw resources and energy. Modern living has "enriched" municipal solid garbage with new streams of unique waste that require separate (alternative) handling in order to conserve vital resources. Furthermore, the number of landfills containing hazardous compounds found in this garbage might be minimized (Waste

& Resources Action Programme, 2010; Shinkuma and Managi, 2011; United Nations Environmental Program, 2015).

Recycling dates to the Bronze Age (about 3300 BC to 1200 BC), when it was first used (Harding, 2000; Krause, 2014; Bronzization, 2016). Various metal artifacts had been melted during the period in order to create new products. The scenario altered due to the industry's rapid advancement, which made recycling more challenging. At a recycling conference in 1970, it was resolved to label all recyclable items with a logo, and November 15 (since 2009) was designated as “Recycling Day” (Labrecque, 2018).

The Greek Parliament approved Law 2939 in August 2001, which specifies the criteria and circumstances for the alternative or sustainable treatment of packaging materials waste. Furthermore, the legislation defines the primary axes that govern the management of other waste (waste electrical and electronic devices, batteries, accumulators, end-of-life vehicles, used tires, used lubricating oils, debris, etc.). Many years later, a law incorporated into Greek law establishes the non-profit nature of collective alternative management systems and the mode of operation of E.O.E.D.S.A.P. (National Organization for Alternative Management of Packaging and Other Products), while Greece is recognized as a pioneer in backward waste management methods (Sifakis and Haidarlis, 2004; Law 4042/2012; YPEKA, 2012).

Regarding the role of recycling in education, it is critical to emphasize that children as students must understand the value of recycling, its advantages, and how to do it from an early age. Primary and secondary school students, for example, learn about the natural world through scientific courses such as Biology and Chemistry. Also significant are school projects including recycling via an ecological framework and aimed at raising students’ environmental consciousness (Luan et al., 2020). According to research, attitude, subjective norm, and perceived behavioral control have a positive and substantial association with students' desire to recycle. Furthermore, students' intentions to recycle are favorably associated to their actual recycling practice (Thoo et al., 2021). In addition, numerous research have found that increasing parental environmental knowledge levels contributes to an increase in student awareness. Students' levels of knowledge regarding environmental education have already been proven to increase because of parent-child dialogues about environmental concerns (Ablak and Yeşiltaş, 2020).

This paper analyzes the interaction between students and recycling from both an educational and experiential standpoint.

Materials and Methods

Phases of project

The research action took place out by first-grade students from Vonitsa’s Vocational Lyceum (EPAL) in Greece and consisted of three separate phases over the course of a four-week program. During phase A, the project's teacher investigates and records the students' pre-existing knowledge and attitudes toward the environment, ecological concerns as well as recycling as an institution. This was achieved with a 30-item questionnaire distributed to students by the teacher. Based on the students' answers, the responsible teacher of the project adapted his introductory speech and information brochures on the ecology and recycling to the needs of the students involved. The presentation on the environment and recycling took place with PowerPoint and videos. The structural sections of the lecture included waste management issues in Greece and Europe (recyclable items, uncontrolled landfills, fires and pollution) and best practices/benefits for packaging recycling. At the end of the presentation the students showed significant interest in the ecological practice of recycling by asking questions to the teacher about the recycling process in their city and how it can be made more efficient. In phase B, the population of sixteen students in the class was separated into four groups of four. The responsible teacher informed the students about the process of the program by distributing questionnaires, to each group, for recyclable household items with details on their type and quantity (Table 1). For two weeks, the students gathered

various recyclable objects from their homes. The students completed the questionnaire using the objects they had collected at the end of the second week. Phase C included collecting the data from all of the students involved in a summary table, which was then evaluated further for analysis. The responsible teacher of the program with an informative seminar demonstrated the process of static data analysis. The students with the support of the teacher analyzed the data which they presented in the form of data tables and diagrams. The procedure took place in the school's lab at the end of the week (Figure 1). The results of the research were presented by the students in the school community in the school amphitheater. The presentation was opened with the introductory lecture from the responsible teacher while all the students involved presented the results through data tables and diagrams. The lecture was attended by the teaching staff of the school and the students of the other classes. The research activity was also posted on the school blog.

Table 1. The questionnaire of recyclable household items which was filled out by students.

RECYCLABLE MATERIAL	TYPE OF RECYCLING	NUMBER
Paper	Disposable paper	
	Shopping bags	
	Food packaging	
	Juice packaging	
	Food containers	
	Wraps	
	Books/magazines	
	Brochures	
	Device cartons	
	Various papers	
Glass	Soft drink bottles	
	Beer/alcohol bottles	
	Medicine bottles	
	Glass food jars	
	Bottles for Spring Water	
Aluminum	Soft drink cans	
	Beer cans	
	Canned food	
	Food pans	
	Aluminum food container	
Tinplate	Tins of oil/olives	
	Containers for paints, solvents	
	Aerosol cans	
	Bottle caps	
Plastic	Soft drink bottles	
	Beer/alcohol bottles	
	Medicine bottles	
	Food containers	
	Plastic wraps	
	Packaging material	
	Bottles for mineral water	
	Shopping bags	
	Garbage bags	
	Detergent bottles	

	Bottles for shampoo, shower Transparent membranes Packaging for hamburgers Food jars Straws Dairy cups, sweets Various caps
Electrical devices	Batteries Mobile phones Radios/cd player TV

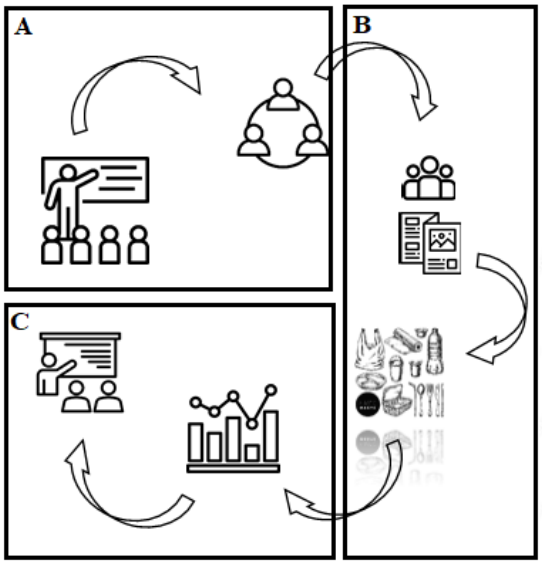

Figure 1. The phases of the student recycling project.

Statistical analysis of data

The data was statistically processed using the SPSS 21 (Statistical Package for Social Sciences) software. This program was chosen because it is a versatile package that supports a wide range of analyses and output formats, and it is widely used in academic and corporate settings. SPSS has numerous advantages, which is why it is selected by many students in bachelor, graduate, or undergraduate programs for the preparation of diplomas or projects. The most significant advantage is that the user can import from a variety of sources, including the 'Excel' spreadsheet. Furthermore, numerous statistical tests are built into 'SPSS,' and the results are simple to interpret. The data tables are shown fast and readily, and the application can be expanded further if the user so desires (Arkkelin, 2014).

In statistics, the Pearson correlation coefficient is a measure of linear correlation between two sets of data. It is the ratio between the covariance of two variables and the product of their standard deviations; thus it is essentially a normalized measurement of the covariance, such that the result always has a value between −1 and 1. As with covariance itself, the measure can only reflect a linear correlation of variables, and ignores many other types of relationship or correlation. Data from recycling items were employed as random variables and their association with the sex of students was investigated using the Pearson correlation coefficient (Dowdy & Wearden, 1983).

Clustering techniques play a very central role in various parts of data analysis. They can give important clues to the structure of data sets, and therefore suggest results and hypotheses in the underlying science. Many of the interesting methods of clustering available

have been applied to good effect in dealing with various data sets of interest (Facundo & Memoli, 2010). The Hierarchical Clustering Technique, also known as DIANA (DIvisive ANAlysis Clustering) is an algorithmic approach to find discrete groups with varying degrees of (dis)similarity in a data set represented by a (dis)similarity matrix. In an iterative process, the pairs of items with the highest similarity values are identified and merged into groups. Once an item enters a group, it cannot be considered as isolate anymore – what is considered for the next merger is then the newly formed group. This process is repeated until all items have been merged into one group. These groups are hierarchically organized as the algorithms proceed and may be presented as a dendrogram and has to decided how many clusters of the dendrogram reflects most revealingly. Many of these algorithms are greedy (i.e. the optimal local solution is always taken in the hope of finding an optimal global solution) and heuristic, requiring the results of cluster analysis to be evaluated for stability by, for example, bootstrapping (Efron, 1979) procedures (Fraley & Raftery, 2002, Naeni et al., 2016). For the project, this analysis was a useful tool in our analyses for categorizing recyclable things by both sexes of the students.

Results and discussion

Based on the materials were collected and recorded by the students, the type of material that predominates in the total of recyclable materials is plastic (46%) and paper (37%), with glass occupying the third place (12%). The electric appliances are followed at a rate of 4%, and a tinplate at a rate of 1% (Figure 2).

Disposable papers (e.g., paper towels, kitchen papers, paper towels, etc.) are the most common paper recyclable item (Figure 3a), accounting for 34%, followed by food packaging and paper shopping bags (14%-15%). The latter demonstrates an increasing inclination to eat fast-food restaurant meals, mostly among students, as well as the frequency of purchases. The papers from books or magazines, as well as brochures, were combined at a rate of 13% (= 12% + 1%, respectively), indicating readiness for instructional material. Juices and their derivatives also play an important role in the diets of students and their families, as seen by the proportion of their packaging (11%). The remaining 13% includes different papers, wraps, and other items. Glass, which occupies third place among recyclable items, reflexes more about students' and their families' purchasing habits. Soft drinks, which currently play a significant part in the Greek table and in the preferences of young students, rank top in terms of preferences with a percentage of 62%. Mineral water bottles account for 14% of the total, while beer/alcohol bottles account for 10%. Glass packaging for medications and food is in the last place accounting for 7% of all purchases (Figure 3b).

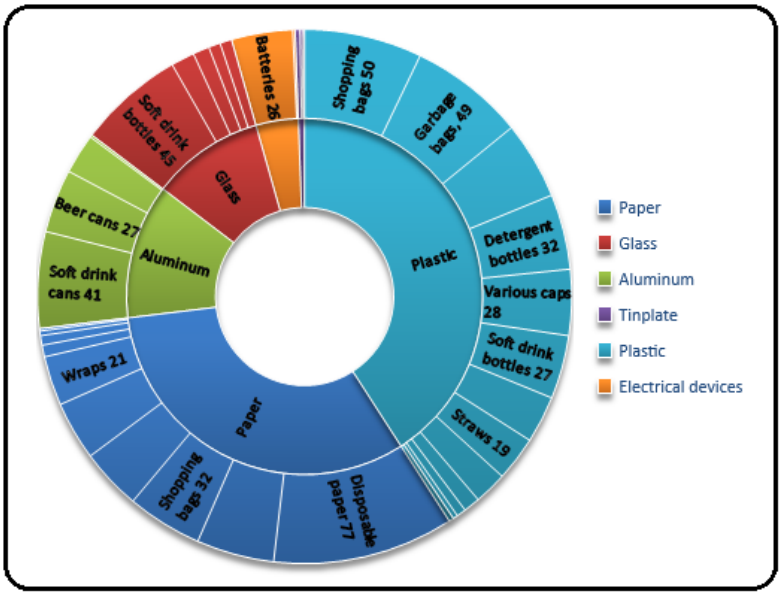

Figure 2. The recyclable household items were recorded by students.

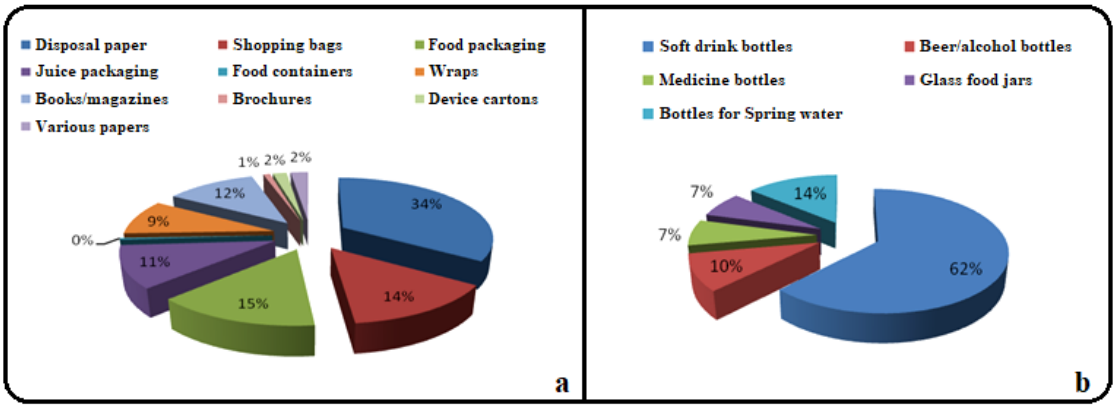

Figure 3. The most frequent types of paper (a) and glass (b) materials as recorded by the students.

Our results indicate a strong preference for soft drinks and beer in an aluminum can packaging, which accounts for 79% of preferences, while cans and food jars account for 21%. Our results clearly show that in the soft drink market, students' preferences converge (Figure 4a). Students and their families choose various tin-type aerosol cans at a rate of 50%, i.e. half of all recyclable products of particular chemical composition. The rest is occupied by oil/olive cans and various bottle caps (Figure 4b). Plastics are used by consumers for garbage storage and transportation of goods and products from department stores, accounting for about 34% of recyclable plastics. Bottles of soft drinks, water, beer, and other alcoholic beverages come in second with 21% of the consumer population's choices. Next are the plastic bottles for detergents at a rate of 11%. Plastic caps, medicine bottles, wrappers, straws, and dairy product cups account for the remaining 34% (Figure 4c).

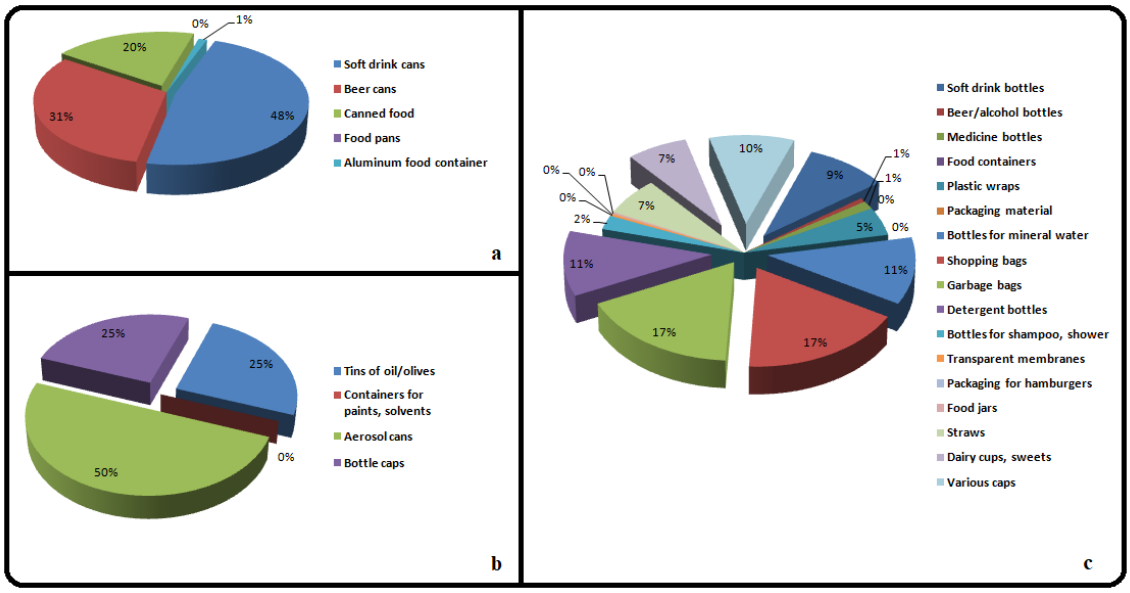

Figure 4. The most frequent types of aluminum (a), tinplate (b) and plastic (c) materials as recorded by the students.

The great majority of electrical appliance goods (96%) are batteries from various products, with the remaining 4% coming from TV appliances or their derivatives. Furthermore, because the data is limited and does not provide useful statistics, these results are obviously non-representative. Because recyclable electrical equipment has a wide range of functions and applications, the consumption picture in Greek households is quite different (Figure 5).

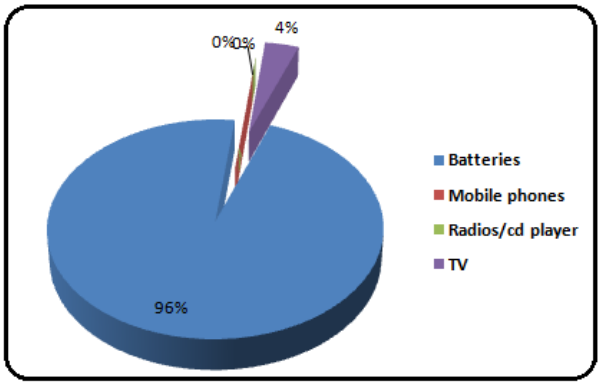

Figure 5. The most frequent types of electrical appliance goods as recorded by the students.

Plastic (41%) and paper items (32%) are the most commonly used materials in all-recyclable home products, according to data had provided by students. Aluminum items come in third place with a percentage of 12%, while the glass items (10%) and electrical devices (4%) come in second and third place, respectively. The data for tinplate items are strongly limited and do not provide helpful statistics results. It's conceivable that these numbers to be unrepresentative (Figure 6).

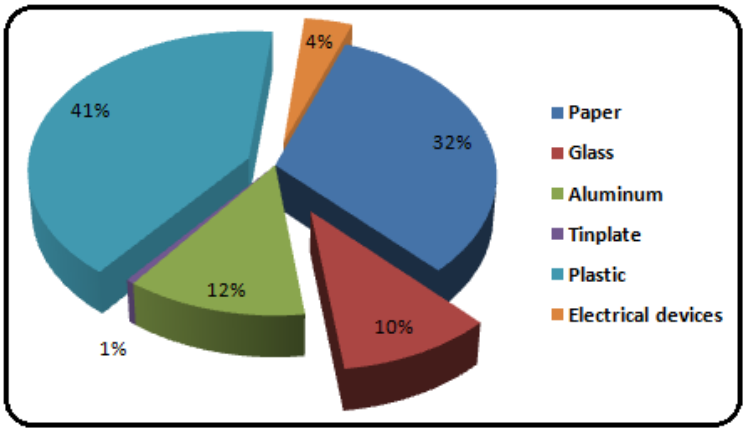

Figure 6. The most frequent types of recycling items as recorded by the students.

The processing of data indicates that the type and number of recyclable products were recorded from both sexes of students have an average correlation (0.530) which is statistically significant ($p<0.05$). This fact is reinforced by the control of the associated samples of recyclable materials by the students (schoolboys and schoolgirls) through the control of the Wilcoxon signed-rank test which do not differ statistically significantly, Asymp. Sig. (2-tailed)<0.904. This reflects the fact that recyclable products differed slightly based on the students' gender (Figure 7) with a few exceptions (various caps, soft drink bottles, garbage bags, beer cans).

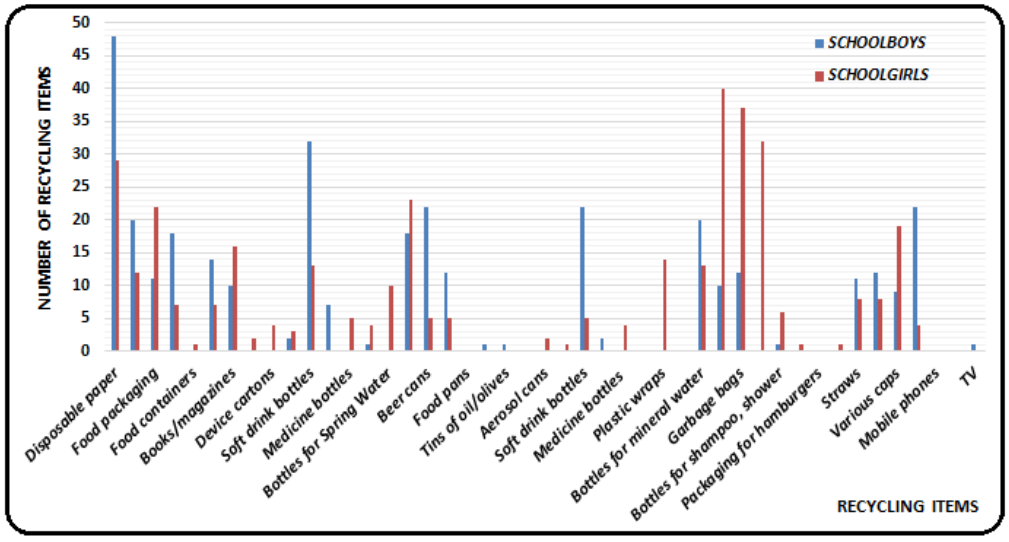

Figure 7. Type and number of recorded recycling items by students (Blue: schoolboys, Red: schoolgirls).

To estimate the frequency of usage in groups, the recyclable items collected by the students were grouped using the Hierarchical Cluster Analysis method (Figure 8). The results reveal that the materials were categorized into two basic groups. The first team includes recyclable objects made of paper, aluminum, plastic, and electrical equipment while the second group includes paper, glass and plastic.

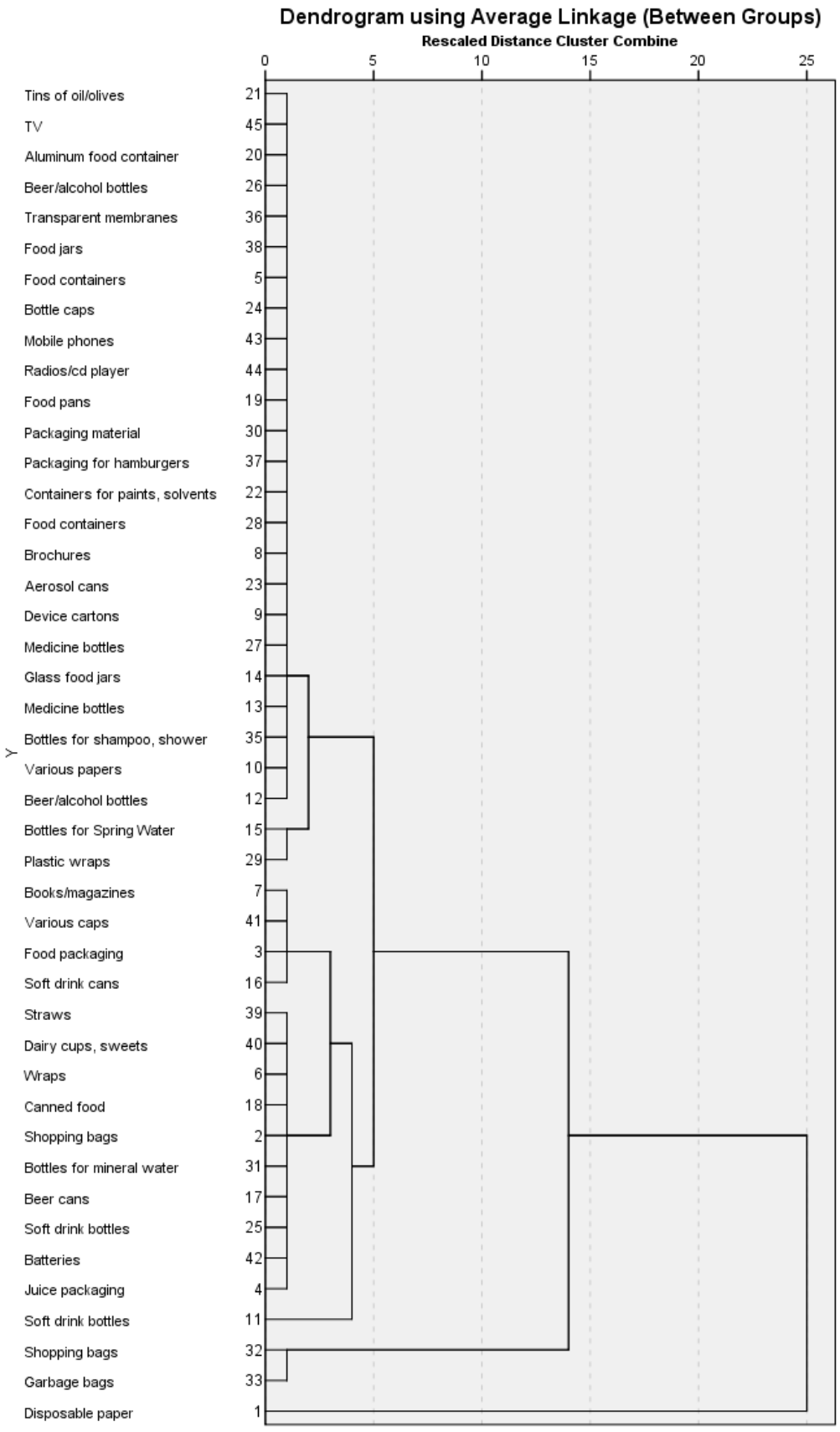

Figure 8. Dendrogram shows the relative similarities the type and number of recyclable products were recorded by students.

Conclusions

During the four months of school, students implemented a project for recyclable materials, allowing them the chance to learn about the function and importance of recycling in the natural environment. The students, as active members of the project team, were able to observe the "journey" of recycling packaging materials in a creative way. In the first phase, the collection and categorization of recyclable items have instilled in students a sense of responsibility as a future generation in terms of waste management. In the next part of the recycling project, the students, with great interest and enthusiasm, learned about the recycling process and separated recyclable materials so that they could recycle themselves in order to raise awareness and adopt this environmental behavior. By categorizing and statistically processing recycled materials, students realized that consumer goods preferences reflect the local population's consumer habits for basic goods. An obvious example is in the area where the students live, "spray" products are preferred, either for cosmetic reasons (deodorants) or for health and safety reasons (cleaning and disinfection products). The students demonstrated that plastic and paper are the most prevalent recyclable materials among all recyclable materials. The research also showed that gender does not have a significant effect on the consumption habits of students and their families. A limiting factor may be the low number of students and the recyclable materials or even the period at which the research was conducted.

The present project was based on the following learning theories: (a) sociocultural, because knowledge is built via interaction, (b) collaborative learning theory, since students learn to work collaboratively by being divided into groups and realizing their duties and tasks, (c) social building occurs as students gain information and actively participate in group activities, (d) critical reflection, as students think critically and build critical thinking through our activities, (e) open learning theory, since students choose the location, time, and rhythm in which they will study the subject.

Environmental awareness in general, and recycling in schools in particular, are critical issues in the educational community. The scholastic program Recycling in Primary and Secondary Schools is a movement whose fundamental objective is to sensitize the entire school community to the burning issue of recycling, which is not often highlighted. In each school unit, the program will be developed will have the objective of educating, raising awareness, and activating both students and their families on the issues of waste management and recycling in order to protect the environment.

References

Ablak, Selman, Yeşiltaş, Erkan (2020). Secondary School Students' Awareness of Environmental Education Concepts. Review of International Geographical Education (RIGEO), 10(3): 445-466. Retrieved from: http://www.rigeo.org/vol10no3/Number3Summer/RIGEO-V10-N3-9.pdf. doi: 10.33403/rigeo. 745951.

Arkkelin, Daniel (2014). Using SPSS to Understand Research and Data Analysis. Psychology Curricular Materials. 1. Valparaiso, Indiana, USA: Valparaiso University. Retrieved from: https://scholar.valpo.edu/psych_oer/1.

Bronzization, H. Vandkilde (2016). The Bronze Age as Pre-Modern Globalization, Prähistorische Zeitschrift, 91: 103–123.

Dowdy, Shirley and Wearden, Stanley (1983). Statistics for research. New York: Wiley. 537 pp. Retrieved from: https://doi.org/10.1002/pam.4050030448.

Efron, B. (1979). Bootstrap Methods: Another Look at the Jackknife. Ann Stat. 7: 1-26.

Fraley, C, Raftery, A.E. (2002). Model-based clustering, discriminant analysis, and density estimation. Journal of the American statistical Association, 97(458): 611–631.

Harding, A. F. (2000). European Societies in the Bronze Age. Cambridge: Cambridge University Press. Retrieved from: https://doi.org/10.1017/CBO9780511605901.

Krause, Rüdiger (2014). Metallurgie. In: Mölders D, Wolfram S, (editors). Schlüsselbegriffe der Prähistorischen Archäologie. Münster, North Rhine-Westphalia, Germany: Waxmann Verlag GmbH, pp. 185–189. ISBN 978-3-8309-3176-8.

Labrecque, Ellen (2018). Recycling and waste. Global citizens: Environmentalism. Ann Arbor, Michigan, USA: Cherry Lake Publishing. 32 pages.

Law 2939/2001. Packaging and alternative management of packaging and other products - Establishment of a National Organization for Alternative Management of Packaging and Other Products (EOEDSAP) and other provisions. [End of plastic bags] (in Greek). Government Gazette of the Hellenic Republic (Government Gazette 179/Aʹ/06-08-2001). Retrieved from: https://www.e-nomothesia.gr›, accessed 11 September 2021.

Law 4042/2012. Penal Protection of the environment - Compliance with Directive 2008/99/EU - Framework for waste generation and management - Regulating issues of the Ministry of Environment, Energy and Climate Change (in Greek). Government Gazette of the Hellenic Republic (Government Gazette 24/Aʹ/13-2-2012). Retrieved from: http://www.ypeka.gr/LinkClick.aspx?fileticket=7Z1up05Xrto%3d&tabid=777&language=elGR , accessed 11 September 2021.

Luan, Hui, Li, Tung-Lin and Lee, Min-Hsien (2020). High School Students' Environmental Education in Taiwan: Scientific Epistemic Views, Decision-Making Style, and Recycling Intention. International Journal of Science and Mathematics Education. Doi:10.1007/s10763-020-10136-z.

Memoli Facundo, Carlsson Gunnar (2010). Characterization, Stability and Convergence of Hierarchical Clustering Methods. Journal of Machine Learning Research, 11: 1425-1470.

Naeni, Leila Moslemi, Craig, Hugh, Berretta, Regina, Moscato, Pablo (2016). A Novel Clustering Methodology Based on Modularity Optimization for Detecting Authorship Affinities in Shakespearean Era Plays, PLoS ONE, 11(8): 1–27. Available at: http://hdl.handle.net/10453/52841.

Shinkuma, Takayoshi and Managi, Shunsuke (2011). Waste and Recycling: Theory and Empirics. New York, USA: Routledge. ISBN 9780415702911. 168 Pages.

Sifakis Antonios, Haidarlis, Marios (2004). Waste Management in Greece National Report. Retrieved from: http://www.lambadarioslaw.gr/publications/en/waste_management_greece.pdf, accessed 11 September 2021.

Thoo, Ai Chin, Tee, Shi Jie, Huam, Hon Tat, Mas'od, Adaviah (2021). Determinants of recycling behavior in higher education institution. Social Responsibility Journal. ISSN: 1747-1117, Vol. ahead-of-print No. ahead-of-print. Retrieved from: https://doi.org/10.1108/SRJ-05-2021-0209.

United Nations Environmental Program (2015). Global Waste Management Outlook 2015. Retrieved from: www.unep.org/waste.

Waste & Resources Action Programme (2010). Environmental benefits of recycling-2010 Update. Retrieved from: http://www.wrap.org.uk/content/environmental-benefits-recycling/.

YPEKA (2012). Waste Legislation (in Greek). Retrieved from: http://www.ypeka.gr/Default.aspx?tabid=437&language=el-GR, accessed 11 September 2021.