
Mental models which influence the attitudes of science students towards recycling

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Abstract: The aim of this study was to evaluate the mental models which influence the attitudes towards recycling of students attending the Department of Science Teaching. 31 first-year university students who are enrolling in the department of science education participated in the study. Based on the study results, it was determined that only a limited number of mental models influenced the students' attitudes towards recycling. It was also determined that the students' mental models focused on 8 categories, which were the "benefits of recycling," the "sorting of wastes at their source," the "promotion of recycling," the "use of different recycling containers for different types of wastes," "recyclable wastes," "recycling facilities," the "recycling process" and the "logo of recycling".

Keywords: Recycling, Mental Models, Drawing, Science Students

1. Introduction

The products we use in our daily lives for a variety of purposes are generally marketed and sold inside packages composed of paper, cardboard, glass, metal, plastic and composites. For this reason, the use of daily products is leading to a constant increase in the amount of waste generated. However, since materials used in package production are generally reusable, it is possible to convert package-related wastes once again into a usable form through collection, sorting and recycling [1].

Recycling is the process by which reusable waste materials such as glass, metals, paper, cardboard and composites are converted into raw materials or byproducts by undergoing various physical, chemical and biological treatments and processes, thus allowing them to be reused in production processes [2; 3]. Although they are extensively used and consumed, materials such as metals, glass, plastics and paper are among the easiest materials to recycle [4]. For instance, glass can be recycled many times, over and over again. As result, glass can be used repeatedly in the production of glass-based products. Similarly, new metal products can be obtained through the recycling of waste metals. Newspapers, packaging paper and cardboards can be recycled to produce second quality paper and packaging materials. Through recycling, objects and materials such as plastic bags, plastic

pipes and multiple purpose plastics can be recycled to produce plastic buckets, bowls, blinds, bottles, watertight objects/materials, automobile parts, construction materials, fibers, textile products composed of synthetic fibers, toys and office materials [5].

The recycling of waste materials is not only important in terms of contributing to the environment, public health and the economy; but it also represents an effective type of environmental protection activity for preventing pollution and the depletion of natural resources [6]. Recycling has a crucial role in in the protection of the environment and natural resources; in reducing the demand for raw materials; in preventing unnecessary energy consumption; and in reducing the amount of waste produced [7; 8; 4]. Recycling also represents a resource protection mechanism that is very beneficial for both the economy and the environment [9], as well as a prerequisite for a sustainable future. Recycling entails important tasks and responsibilities at the level of individuals. It is essential for individuals, and especially for the teachers who will raise these individuals, to embrace the principles relating to the reuse and recycling of waste materials; to be knowledgeable about these principles; and to be able to convey these principles to other individuals. The reduction of the generation of waste, the sorting of wastes at their source, and the systematic recycling of wastes can only be achieved through the efforts of environmentally conscious,

sensitive and aware individuals.

Schools play an important role in instilling behavior patterns that focus on the protection of the environment, such as the consistent use of recycled products. The importance of recycling, as well as environmental awareness, should be taught and conveyed in schools through classes on the environment [2]. In addition to this, it is both necessary and important to identify the mental models which shape individuals' behavior regarding recycling, and which effectively illustrate the internal and cognitive representations in the minds of individuals on this subject [10; 11]. As individuals are not able to comprehend and grasp nature directly, they tend to form mental models through internal representations [12]. Individuals expressed their mental models through speech and writing [13]. Using their preliminary knowledge and the scientific information they acquired during their education [14], individuals structure their mental models based on their own expressions and behaviors [15]. What is interesting about mental models is their ability to influence the activities of individuals [16]. Thus, the mental models students have regarding the concept of recycling will certainly influence their behaviors towards recycling. In addition to this influence, it was also noted that there are no studies in both the national and international literature which attempted to identify the mental models of science students regarding recycling. These considerations were instrumental in determining the subject of the current study.

In this study, the mental models of the students were illustrated with the aid of drawings. The drawing method is based on an open-ended questioning approach, which, when used in combination with other methods or processes, is effective in ensuring that the thoughts, learning and the level of understanding of individuals which might otherwise remain concealed can be revealed and identified without the limitation of words. Thus, this method which can be applied to any age group is useful in allowing students to reflect their learning and thoughts [17].

The aim of this study was to evaluate the mental models which influence the attitudes towards recycling of students attending the Department of Science Teaching in Turkey.

2. Methods

The study was conducted using the general screening model. The general screening model is a screening approach conducted on populations consisting of a large number of individuals in order to reach a general conclusion regarding the population [18]. It is performed by screening the population as a whole, or a certain group or sample within the population. A sample selection was performed based on the suitability sample, which is defined as the group of individuals who could be reached/contacted for the study [19]. Students' mental models about recycling were identified with drawing in the study.

The study participants included 31 first-year university students who are enrolling in the Faculty of Education,

Department of Science Teaching of a public university in Turkey.

The assessment tool used for identifying the mental models of the students regarding the concept of recycling consisted of a single open-ended question. The students were asked to answer the question "What does the word 'recycling' bring to your mind?" in both drawing and writing.

Science students' answers to the questions were analyzed by using the qualitative content analysis method. By doing content analysis, similar data collected by each researcher was gathered under the same categories, and then after combining these categories they were finalized. For the better understanding of the resulting data, the data was organized and interpreted. Content analysis of the data were achieved by following the steps: (1) data coding, (2) the creation of categories, (3) the regulation of the codes and categories, (4) the identification and interpretation of the findings [20]. The drawing-related and writing-related data obtained during the study were evaluated and analyzed separately as two different categories. The response categories and the frequencies placed in the categories were calculated. In addition, in order to identify common categories of science students' answers, they were constantly compared with each other. The reply codes belonging to the science students, common categories and frequencies of these categories have been created.

3. Results

The study data were structured and shown with tables based on 8 different categories, which were the "benefits of recycling," the "sorting of wastes at their source," the "promotion of recycling," the "use of different recycling containers for different types of wastes," "recyclable wastes," "recycling facilities," and the "recycling process."

Table 1. Students' mental models about recycling: First category: the benefits of recycling

Student's answers	Explain	Drawing
	f	f
to preserve trees	11	10
to use of recycled products	10	1
to prevent of environmental pollution	8	1
to leave a clean environment for future generations.	7	2
to reduce damage that was given nature	4	-
to preserve natural resources	2	-
to contribute to the economy	2	-
to provide the recycling of wastes	2	-
to prevent damage to living	2	-
to preserve the balance of nature	1	-
to prevent disposal of waste	1	-
to prevent air pollution	1	1
to reduce waste generation	1	-
to create new products with less cost	1	-
to live healthy	1	-

Table 1 shows the mental models of the science students regarding the benefits of recycling category. Regarding the benefits of recycling; the students provided drawings and written descriptions which mainly focused on the preservation

of trees, the use of recycled products, the prevention of environmental pollution, and the necessity to leave a clean environment for future generations.

Table 2. Students' mental models about recycling: Second category: the sorting of wastes at their source

Student's answers	Types of waste	Explain	Drawing
		f	f
Separate recycle	Paper	2	1
	Plastic	2	1
	Glass	2	1
	Battery	1	-
Same recycle	Paper, plastic, glass	-	2

Table 2 shows the mental models of the science students regarding the sorting of wastes at their source category. Concerning this category, it was observed that some of the students expressed the view that each type of waste should be disposed in separate recycling containers, while other students expressed the view that a common recycling container should be used for all wastes. In their drawings and written descriptions, the students mentioned wastes such as batteries, paper, plastic and glass, as well as other types of wastes.

Table 3. Students' mental models about recycling: Third category: the promotion of recycling

Student's Answers	Explain	Drawing
	f	f
to ensure that individuals fulfil their recycling-related responsibilities	1	-
to abide to the applicable rules imposed by the state	1	-
to ensure that individuals become knowledgeable	1	1
to use public announcements on TV in order to promote recycling	-	1

Table 3 shows the mental models of the science students regarding the promotion of recycling category. In their drawings and written descriptions, the students emphasized that in order to promote recycling, it is necessary to ensure that individuals fulfil their recycling-related responsibilities and abide to the applicable rules imposed by the state, and also to ensure that individuals become knowledgeable about recycling. However, one of the students emphasized in his drawings the strength of the media, and described the necessity of using public announcements on TV in order to promote recycling.

Table 4: Students' mental models about recycling: Fourth category: the "use of different recycling containers for different types of wastes

Student's Answers	Drawing
	f
Paper	8
Plastic	6
Glass	4
General	3
Battery	2
Metal	1

Table 4 shows the mental models of the science students

regarding the use of different recycling containers for different types of wastes category. Some of the students provided drawings which made generalizations regarding the types of wastes to be disposed in recycling containers. In other words, these students overlooked the different types of wastes that exist and which need to be disposed differently. Such an approach was, of course, not compatible with the requirements of recycling processes, since different types of package wastes require different recycling processes. In addition, two of the students erroneously described in their drawings that batteries can be thrown in recycling containers, whereas batteries are, in fact, disposed in special battery disposal containers. On the other hand, four of the students correctly described in their drawings that batteries should be thrown in battery disposal containers.

Table 5 shows the mental models the science students illustrated regarding the recyclable wastes category through their drawings and written descriptions. Both the drawings and descriptions of the students indicated that they mainly focused on paper, cardboard and plastic wastes. In addition, one of the students erroneously described flue gas as a recyclable waste, while flue gases are in fact pollutants for which recycling is not possible.

Table 5. Students' mental models about recycling: Fifth category: the recyclable wastes

Student's Answers	Explain	Drawing
	f	f
Paper-cardboard	3	12
Plastic	4	9
Glass	2	4
Battery	2	9
Oil	1	4
Phone battery	1	2
Plastic bag	-	2
Flue gases are in fact pollutants	-	1

Table 6. Students' mental models about recycling: Sixth category: the recycling facilities

Student's Answers	Drawing
	f
Paper	3
Glass	1
Plastic	1
Battery	1
General	1

Table 6 shows the mental models that the science students illustrated through drawings regarding the recycling facilities category. Some of the student made drawings showing specific recycling facilities for each type of waste, while one of the students erroneously made a drawing showing that all types of wastes can be processed by a single type of facility.

Table 7. Students' mental models about recycling: Seventh category: the recycling process

Student's Answers	Explain f	Drawing f
Paper	1	4
Plastic	-	1
Oil	-	1

Table 7 shows the mental models of the science students regarding the recycling process category. The drawings and written descriptions of the students regarding the recycling processes of paper, plastic and oil wastes indicated that their mental models about the types of recyclable wastes were fairly limited.

Table 8. Students' mental models about recycling: Eighth category: the logo of recycling

Student's Answers	Drawing
	f
logo of recycling	 10

It was noted that 10 of the students used the möbius strip, the logo of recycling, in their drawings.

4. Conclusions and Recommendations

Based on the study results, it was determined that the mental models which influenced the attitudes towards recycling of students receiving education at the department of science teaching were structured according to 8 categories. Evaluation of the drawings and written descriptions provided by the students showed that these categories were the “benefits of recycling,” the “sorting of wastes at their source,” the “promotion of recycling,” the “use of different recycling containers for different types of wastes,” “recyclable wastes,” “recycling facilities,” the “recycling process” and the “logo of recycling”.

With regards to the benefits of recycling category, most students mentioned the preservation of trees in both their drawings and written descriptions. This indicated that the students placed importance on the recycling paper and cardboard. The recycling of paper and cardboard is a very effective approach for preserving trees. The students also expressed in their descriptions a willingness/tendency to use recycled products, which indicated that they paid attention to the type of package used in the products they buy. This was an important finding which reflected that the students were conscious consumers. Another noteworthy point which the students expressed in their descriptions was the perceived necessity to prevent environmental pollution and to leave a clean future for future generations. This was significant in that indicated the students had an environmental model in their minds based on sustainability. As such, recycling was considered essential for a sustainable future. In the literature, students tend to rather describe the “formation of new products” and the “utilization of waste materials” as the main advantages of recycling. In parallel to the results of this study, one of the noteworthy and important results observed in the studies from the literature is the finding that students generally have a good grasp of the benefits of recycled products to the environment [2].

Recycling can be performed by sorting of wastes centrally or at their source. With regards to the sorting of wastes

category, the students provided drawings and written descriptions which especially placed emphasis on the sorting of wastes at their source. It was observed that some of the students expressed the view that each type of waste should be disposed in their separate and specific recycling containers, while other students expressed the view that wastes should be disposed in a common recycling container. It was noteworthy that the drawings and written descriptions provided by the students regarding the sorting of wastes at their sources especially made mention of battery, plastic and glass wastes, along with other types of wastes. However, recyclable wastes are not limited to paper, plastic and glass packages; in addition to these, it is also possible to recycle packages composed of cardboard, composite and metal.

All individuals have a centrally important role and responsibility in ensuring the proper recycling of wastes. Fulfilling this role and responsibility requires individuals who are environmentally conscious, sensitive and aware. While instilling such consciousness, sensitivity and awareness to individuals, it also important and necessary to encourage them to act in an environmentally responsible manner. In their drawings and written descriptions regarding the promotion of recycling category, the students described the need to implement measures that would encourage individuals to fulfill their responsibilities, and to abide to the existing rules concerning recycling. In addition, as the media is nowadays an effective tool for rapidly and easily reaching the masses, organizing public announcement on TV regarding recycling (as suggested by one of the students in his drawings) will be a useful approach for encouraging individuals to assume their share of responsibilities. In addition to these, it was noteworthy that only a limited of number of students had mental models about encouraging individuals to perform recycling.

It is possible to recycle glass, paper, cardboard, plastic, composite and metal packages. In their drawings showing different types of recycling containers depending on the types of wastes, most students did not include composite package materials, indicating that they lacked any mental models regarding this type of package. Although used batteries are normally collected in battery disposal containers, two of the students erroneously showed in their drawings that used batteries can be thrown in recycling containers. Four of the students, on the other hand, made drawings emphasizing the necessity to dispose batteries in battery disposal containers. Some of the students provided drawings which made generalizations regarding the types of wastes to be disposed in recycling containers. In other words, these students overlooked the different types of wastes that exist and which need to be disposed differently. Such an approach was, of course, not compatible with the requirements of recycling processes, since different types of package wastes require different recycling processes.

With regards to the recyclable wastes category, both the drawings and the written descriptions of the students mainly illustrated paper, cardboard and plastic wastes. This finding probably stemmed from the fact that, during their daily lives,

the students frequently encountered paper and cardboard collectors in their urban environment and/or the media, as well as various campaigns for the collection plastic bottles and caps. On the other hand, one of the students erroneously described flue gas as a recyclable waste, while flue gases are in fact pollutants for which recycling is not possible.

With regards to the recycling facilities category, some of the student made drawings showing specific recycling facilities for each type of waste, while one of the students erroneously made a drawing showing that all types of wastes can be processed by a single type of facility – an inaccurate generalization that runs contrary to the actual requirements of recycling processes. This indicated that the student in question lacked a mental model which considered the fact that each type of waste undergoes different processing, and that different recycling facilities consequently require different machinery and equipment. For this reason, in order to remedy this lack of knowledge, it would probably be beneficial to organize tours at recycling facilities and to have the students informed by specialists.

With regards to the recycling process category; it was observed that many of the students' drawings and written descriptions focused on the recycling of waste paper, plastic and oils, and that the knowledge of most students regarding recyclable wastes was limited to these materials. This observation indicated that these students' mental models on this subject were fairly limited in scope.

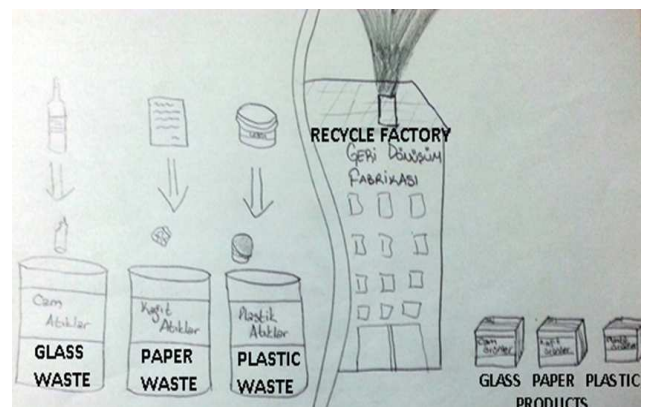
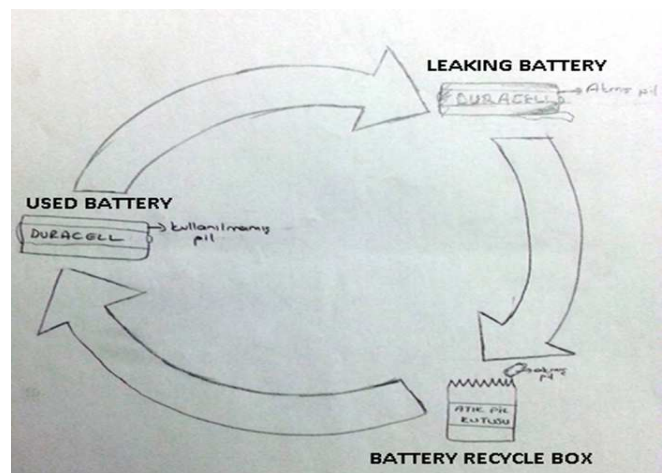
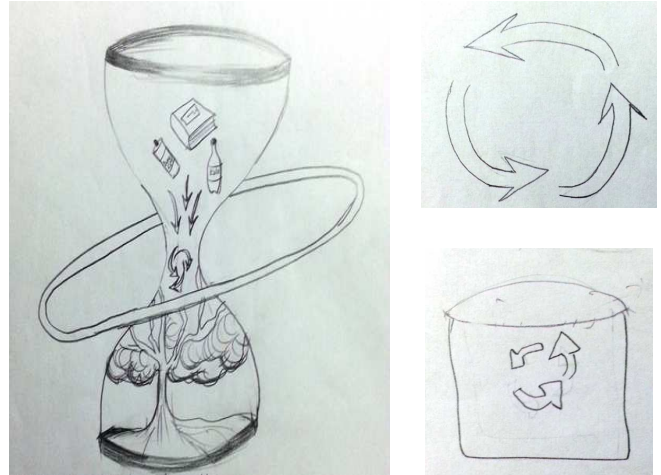
With regards to the recycling logo category, it was observed that 10 of the students drew the möbius strip in their drawings. This symbol is commercially used to indicate that a package is produced from recyclable or reusable materials. The students most likely encountered this symbol through the products they normally purchase. The fact that the students were knowledgeable of this symbol was significant, in that it indicated the students' knowledge and awareness of the recyclability of package wastes. Students who pay attention to this symbol are more likely contribute to recycling, by disposing packages with the logo into recycling containers specific for each type of waste.

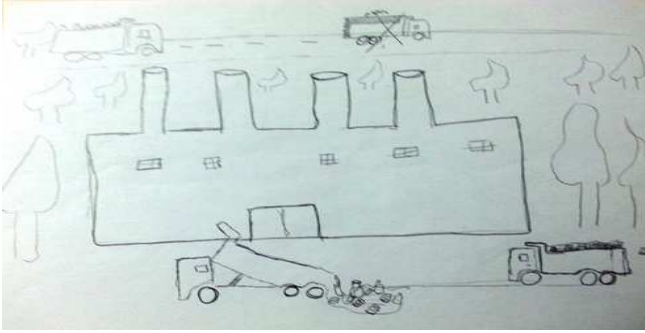
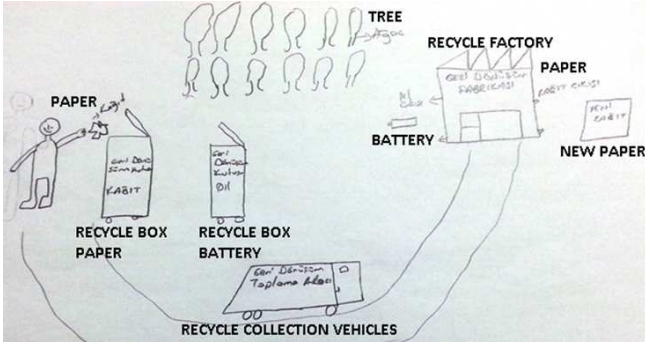
In a previous study conducted by [21], the level of awareness regarding solid wastes and recycling was identified as being very low among teacher candidates. In the current study, which was performed using similar methods to Karatekin's study, the students' mental models that influence their behaviors towards recycling were also fairly limited. Furthermore, the literature describes that the lack of knowledge regarding recycling processes, the benefits of recycling, and the types of products which can recycled is one of the most important obstacles for adequate recycling practices [22]. However, despite their relatively limited scope, it was nevertheless important that the students had developed various different mental models regarding the benefits of recycling, the sorting of wastes at their source, the promotion of recycling, the use of different recycling containers for different types of wastes, recyclable wastes, recycling facilities, the recycling process, and the recycling logo. These mental models are likely to significantly influence the

students' behaviors regarding recycling.

Appendix

Examples from Students' Drawings





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