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Evaluation through the use of drawings of the knowledge of science teacher candidates in Turkey regarding the recycling of waste batteries

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Abstract: The aim of this study was to determine through the use of drawings the knowledge of science teacher candidates regarding the recycling of waste batteries. The study was conducted with 47 third-year science teacher candidates attending the faculty of education of a public university in Turkey. In this study, the science teacher candidates were asked to demonstrate their knowledge regarding the recycling of waste batteries through the use of drawings and written descriptions. The drawings and written descriptions collected during the study were divided into different groups based on the 5 different levels previously used by Bartoszeck, et al. (1), Uzunkavak (2,3), and the answers provided by the students were evaluated using descriptive analysis. Based on the study results, the large majority of the teacher candidates' drawings and written descriptions were determined as being between level 2 and 4. The study results indicated that most of the science teacher candidates had either limited or erroneous information regarding the recycling on waste batteries.

Keywords: Recycling, Waste Batteries, Drawing, Science Teacher Candidates

1. Introduction

In the present-day world, the combined effects of industrialization, rising world population and the reckless use and destruction of natural environments have altered the ecological balance, leading to numerous environmental problems that threaten the lives of countless organisms on earth. One of the most important environmental issues in today's world is the disposal of solid wastes. The term "solid wastes" refer to materials generated by domestic, commercial and industrial activities which are disposed by consumers following use, but which, due to their adverse effects on human and environmental health and other public concerns, also need to be regularly removed urban settings (4, 5).

Batteries represent one of the different types of solid wastes. Once they become solid wastes after being used, batteries are considered and classified as "hazardous wastes", since they can lead to significant problems if disposed improperly. By definition, hazardous wastes include all types and forms of wastes (solid, liquid, gas, sludge, etc.) which pose a hazard for human health and the environment. Hazardous wastes can be either of domestic or industrial origin, and display a wide range of different properties. Thus, hazardous wastes are solid wastes which represent a potential threat for public health and the environment (6).

Recycling is a process that mainly involves the reduction of the amount of waste generated, and which can be summarized with the concept of "reduce, reuse, recycle." One definition of recycling is "the sorting, collection and grouping of recyclable wastes, followed by their conversion into other products or energy through physical and chemical methods" (7). As a concept, recycling also encompasses the "reuse and utilization" of wastes. The recycling and reuse of many materials we use in our daily lives is performed differently based on considerations such as the environmental problems they cause, the related economic factors, and the cautious use of existing natural resources. Some of these everyday materials consist a large variety of different substances, and may require complex processes for proper recycling. Batteries contain both recyclable metals such as nickel, and toxic metals such as cadmium; consequently, the recycling processes of batteries need to consider both of these types of metals (8).

The recycling process of waste batteries begins with the disposal of flat batteries by consumers into battery collection

containers located at battery collection points. The waste batteries are taken from the battery collection points by authorized persons, after which they are sorted and stored as necessary. Following this, the waste batteries undergo various process in order to extract the valuable and reusable substances within them, resulting in the formation of new products (9). The recycling process of waste batteries is illustrated in Figure 1.

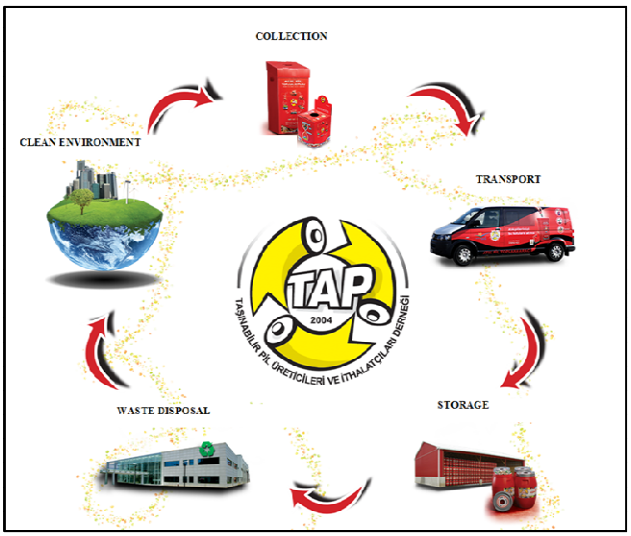


Figure 1. *The recycling process of waste batteries (9)*

Batteries contain numerous substances we commonly use in our daily lives for a variety of different purposes. The fact that batteries are widely used in everyday life further magnifies the problems associated with the hazardous waste they generate. For this reason, it is necessary to be cautious regarding the use of batteries, to avoid utilizing them when not necessary, and to dispose of them in a manner that results in the least harm for the environment or human health. Such measures regarding battery disposal are essential for a cleaner and healthier environment. It is important to bear in mind that, in addition to individual efforts, public regulations and responsibilities also play an important part in the proper disposal and recycling of batteries (10).

The drawing method is often used to illustrate the knowledge, misconceptions and conceptual changes of individuals regarding a particular subject (11) Compared to other methods used for illustrating changes in thought, the drawing method is more efficient in that it takes less time to complete, effectively reflects numerous different types of information, and is readily understood and performed by individuals (12). In addition, drawings allow students to reflect and express, independently of words, thoughts and beliefs which might otherwise remain concealed (13). It also enables students who otherwise do not like to answer questions to have a more enjoyable time, and to thus answer the relevant questions more willingly and rapidly (14). In this context, this study aimed to identify through the use of drawings the knowledge of science teacher candidates regarding battery recycling processes, and to thereby classify the level of knowledge of these teacher candidates.

2. Methodology

The study was performed at the faculty of education of a public university in Turkey, with the participation of 47 third-year science teacher candidates. During the study, the science teacher candidates were asked to describe the recycling process of batteries through drawings and written descriptions. The names of the science teacher candidates were kept confidential and coded using a "F_n" format. Several examples of the responses provided by the science teacher candidates are shown in this manuscript.

The drawings and written descriptions obtained during the study were separated into different groups based on the 5 different levels previously determined and used Bartoszeck et al. (1) and Uzunkavak (2,3). The answers to the questions were evaluated using descriptive analysis. The levels which were employed for evaluating the study data are shown in Table 1.

Table 1. *The levels and descriptions used for assessing the study participants' knowledge and drawings*

Levels	Statements
Level 1	No theoretical knowledge/drawing
Level 2	Wrong theoretical knowledge/drawing
Level 3	Partially correct theoretical knowledge/drawing
Level 4	Incomplete theoretical knowledge/drawing
Level 5	Entirely correct and complete theoretical knowledge/drawing

3. Results

The science teacher candidates were asked to make drawings regarding the recycling process of waste batteries, and to then describe these drawings in writing. The data obtained from the answers provided by the science teacher candidates are shown in Table 2.

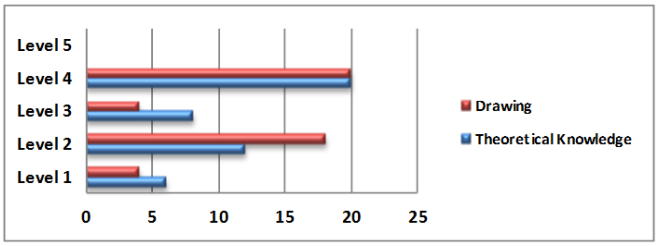
Table 2. *The theoretical knowledge and drawing levels of the science teacher candidates regarding the recycling of batteries, provided in percentage (%) and frequency (f)*

Levels	Theoretical Knowledge		Drawing	
	%	f	%	f
Level 1	12.8	6	8.5	4
Level 2	25.5	12	38.3	18
Level 3	17.0	8	8.5	4
Level 4	44.7	20	44.7	21
Level 5	0	0	0	0

According to the data on Table 2, 12.8% of the science teacher candidates provided no written theoretical information, while 25.5% provided incorrect theoretical information, 17.0% provided partially correct theoretical information, and 44.7% provided correct yet insufficient theoretical information. Evaluation of the teacher candidates' drawings revealed that 12.8% provided no drawings, while 8.3% provided incorrect drawings, 8.5% provided partially correct

drawings, 44.7% provided correct yet insufficient drawings. The study results thus showed that none of the science teacher candidates were able to provide fully accurate and complete theoretical knowledge and drawings regarding the recycling of waste batteries.

The frequency distribution of the levels of the science teacher candidates' drawings and knowledge regarding the recycling process of waste batteries is provided in Graph 1.



Graph 1. *The frequency distribution of the levels of the science teacher candidates' drawings and theoretical knowledge regarding the recycling process of waste batteries*

Evaluation of the teacher candidates' answers and drawings regarding the recycling process of waste batteries indicated that some of them provided incorrect (Level 2) answers and drawings concerning this process. Several examples of the Level 2 answers provided by the teacher candidates were as follows:

"Batteries can be recycled by recharging them." (F_{24})

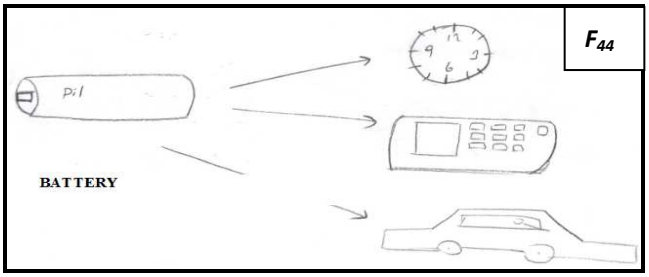
"During recycling, the chemicals inside batteries are removed and replaced." (F_4)

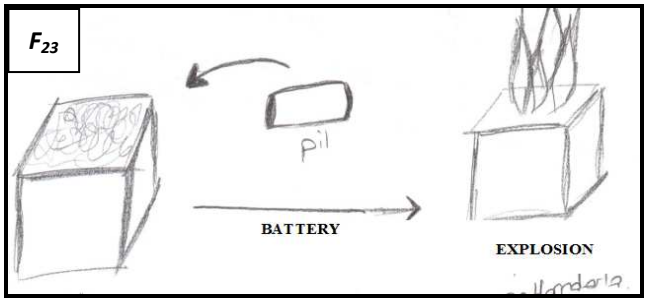
"When batteries are throw into trash cans, they will tend to expand and burst." (F_{23})

"It is wrong to burn batteries. This is because when burned, the smoke released by the battery due to its composition will pollute the air." (F_{36})

"Batteries can be recycled by restoring the activity of the substances between the (+) and (-) end." (F_{18})

Examples of Level 2 drawings performed by the teacher candidates are provided in Figure 2:





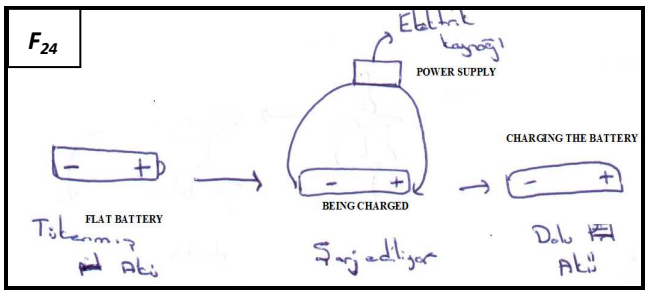


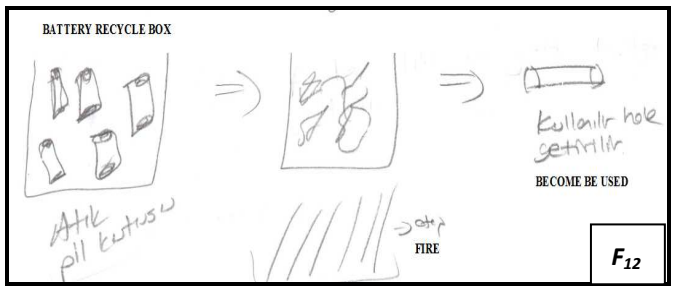
Figure 2. *Irrelevant wrong drawing which are example level 2*

Evaluation of the teacher candidates' answers and drawings regarding the recycling process of waste batteries indicated that some of these candidates provided partially correct (Level 3) answers and drawings concerning this process. Several examples of the Level 3 answers provided by the teacher candidates were as follows:

"There are waste battery containers. We are supposed to dispose used batteries into waste battery containers. Batteries can be recycled for reuse. During recycling, batteries will be recharged once again, thus making them ready for reuse." (F_{12})

"We should not throw the batteries we use into regular trash cans. Doing so may lead to pollution. Instead, we should recycle batteries in order to recharge them." (F_{22})

Examples of Level 3 drawings performed by the teacher candidates are provided in Figure 3:



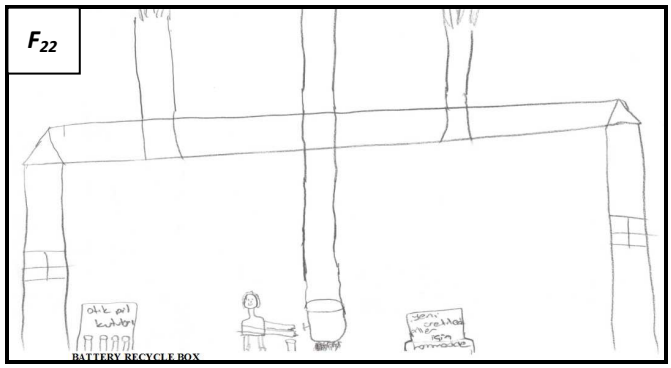


Figure 3. *Partly accurate drawing which are example level 3*

Evaluation of the teacher candidates' answers and drawings regarding the recycling process of waste batteries indicated that many of these candidates had correct yet insufficient (Level 4) knowledge concerning this process. Several examples of the Level 4 answers provided by the teacher candidates were as follows:

"We should dispose flat batteries in recycling containers. Batteries

collected in recycling containers will be processed in specialized facilities and converted into new batteries." (F_{35})

"We should dispose batteries in recycling containers. Organizations responsible for recycling will then collect these batteries, take them to factories, and perform the necessary recycling processes." (F_7)

"Batteries are first collected inside waste battery containers. Companies then collect these waste batteries and store them." (F_{19})

"Waste batteries are collected inside waste battery containers. These are then taken to recycling facilities to obtain new products." (F_{46})

Examples of Level 4 drawings performed by the teacher candidates are provided in Figure 4:

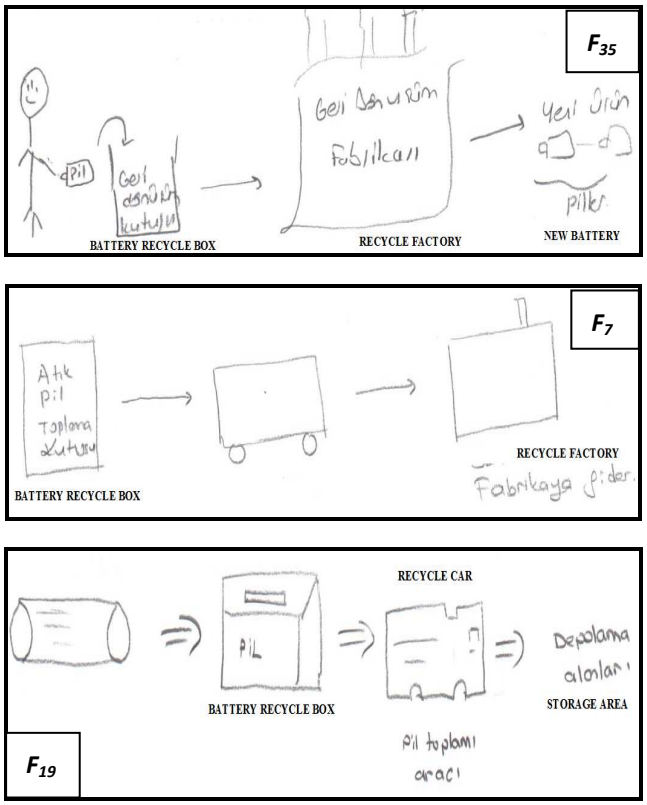


Figure 4. *Incomplete theoretical drawing which are example level 4*

4. Conclusions and Recommendations

Based on the study results, 25.5% of the science teacher candidates provided incorrect information regarding the recycling process of waste batteries, and were accordingly classified as Level 2; while 44.7% provided correct yet insufficient information, and were accordingly classified as Level 4. In addition, 12.8% of the science teacher candidates provided no drawings on the subject, while 44.7% provided Level 4 drawings – in other words, illustrations which were correct yet insufficient. During the study, none of the teacher candidates were able to provide theoretical information and drawings which were correct and fully complete. These results indicated that the teacher candidates generally have incorrect and incomplete information regarding the recycling process of waste batteries, and that their drawings were generally not sufficient.

The study results showed the effectiveness of the drawing method in reflecting knowledge on a particular subject without the limitations of words. Other studies which used the drawing method to evaluate students' knowledge on a given subject included Bartoszeck et al.'s study (1) regarding the human organs, Kara et al.'s study (15) on the concept of light, Kara's study (16) and Uzunkavak's study (2) on Newton's Laws, Köse's study (17) regarding photosynthesis and respiration in plants, Uzunkavak's study (3) on the concept of light, Çelikler and Topal's study (18) on the carbon dioxide and water cycles, Çelikler and Kara's study (19) on the period table, Çelikler and Aksan's study (20) regarding the greenhouse effect. All of these studies demonstrated that the students' knowledge on the subject could be identified more easily and effectively with the drawing method. In the current study, it was observed that although the teacher candidates had difficulties in expressing their knowledge regarding the recycling process of waste batteries, they were able to reflect their thoughts more easily through drawings.

Considering that batteries are commonly used in many of the objects and devices we routinely employ in our daily lives, and that waste batteries represent a hazardous form of waste; it is both necessary and important to raise the awareness of individuals regarding waste batteries and the recycling of batteries. For this reason, the recycling of batteries should be taught to students starting from elementary school and all the way up to higher education programs, though the use of student-centered methods and techniques. Education on this subject should be provided by organizing suitable educational activities, by creating suitable learning environment, and by ensuring a good and comprehensive classes regarding the environment. Such educational approaches would allow individuals to develop the necessary awareness towards the environment, thus enabling them to become individuals who display a healthy concern for the future, and who understand that the scope of environmental problems are not limited by time or space.

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