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TEACHING THE CORROSION OF IRON PARTICLES IN SALINE WATER TO STUDENTS WITH SPECIAL NEEDS

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Abstract

The purpose of this research was to teach the corrosion process of 8-mm iron particles in saline water for students with special needs. We used an experimental demonstration method by varying salt (i.e., NaCl) concentration (i.e., 0, 2.5, and 5%) and the experiments were recorded as a learning video media. The subjects of this study were students with special needs at special schools in Kuningan Regency, Indonesia. We did the pretest and posttest to find out students' understanding levels. The test results showed that the NaCl solution had an effect on decreasing the mass of iron particles in the corrosion process. In addition, the level of students' knowledge has increased. The results of the posttest showed that students' understanding had increased. As many as 64.29% of students had learning outcomes above 70. This study shows that the iron particles in the 5% NaCl solution undergo a faster corrosion process when we analysed the faster colour change of buckshot. The experimental demonstration method equipped with interesting video learning media is an important factor in increasing student understanding.

Keywords: Corrosion, Iron particles, NaCl solution, Students with special needs, Teaching.

1. Introduction

Corrosion is the destruction of metal objects caused by environmental influences [1]. Corrosion usually occurs in metal objects. There are several factors that can accelerate the corrosion process, including water content, humidity, electrolytes, uneven metal surfaces, and the formation of electrochemical cells [2]. In Indonesia's education curriculum in Indonesia, it is essential to teach corrosion the phenomenon that occurs in daily life. As students understand corrosion, students gain knowledge about how to treat objects that are prone to corrosion and the objects which have corrosion will maintain their values.

Many studies discussed the corrosion process [3], the benefits of corrosion [4], the dangers of corrosion [5], the impact of corrosion [6], and the factors causing corrosion [7]. Some of these studies described the corrosion process in large industrial tools based on various factors. However, until now, there has been no research discussing the effect of NaCl solution on the corrosion process of iron particles and how the learning process is for students with special needs.

The novelty of this research is a trial using 8-mm iron particles and NaCl solution with various concentrations (i.e., 0, 2.5, and 5%). NaCl solution is an electrolyte solution that can corrode metal [8]. The reason we use iron particles in this study is that students can easily understand the corrosion material being taught. In the aspect of size selection, we choose 8-mm iron particles because they are easier for students to observe the corrosion process that occurs. Additionally, the choice of variations in the solution concentration is to enable students to see the speed difference in the corrosion process that occurs. In addition, the subjects of this research are students with special needs. Students with special needs are students who have obstacles both due to external and internal factors, so it impacts the learning process [9]. Thus, they need special education and services. Besides, teachers have difficulties in the process of teaching students with special needs. In fact, learning about corrosion is important, especially for students with special needs. Besides being found in the learning curriculum [10], corrosion material was chosen in this study because the corrosion process often occurs in the student environment. This is important for students with special needs, they learn something through the phenomenon in their environment [9].

Therefore, the aim of this research was to teach the corrosion process using NaCl solution and iron particles for students with special needs. Moreover, students with special needs may also need special media for improving their understanding. Considering the specialty of the students, utilization of iron particles and NaCl solution is therefore proposed by this study as an alternative learning media for improving their understanding of the corrosion process. We used an experimental demonstration method with several stages in the research process. First, we conducted experiments on 8-mm iron particles and NaCl solution with various concentrations of 0, 2.5, and 5%. After that, we carried out the learning process in the classroom using video and media that were concrete and interesting. We did the pretest and posttest to find out the level of understanding of the students. The test results showed that the NaCl solution with high concentrations had an influence on the corrosion process. We analysed that there was a change in colour in a faster time in the iron particles in the solution, as well as a decrease in mass. The results of learning in the class show that the level of students' understanding has increased.

2. Theoretical Framework

2.1. Corrosion

Corrosion in general is the destruction of metal objects caused by environmental influences [11]. In the process of rusting iron to form iron oxides, the corrosion process is described electrochemically. The process of rusting iron is the oxidation of ferrous metals by oxygen from the air [12]. Corrosion becomes one of the main considerations in industry [13], making it as the main subject learned in the school.

Figure 1 shows the process of corrosion in which objects will experience a change in surface colour and affect the colour of the solution. Figure 1(a) shows iron particles that have not undergone corrosion, while Fig. 1(b) shows iron particles in the water that have undergone a corrosion process. In Fig. 1(b), you can see that iron particles have rusted. Apart from that, corrosion also affects weight or mass reduction [14].

When the iron comes into contact with water, corrosion occurs, and the iron becomes an anode, and some become a cathode [15].

Anode	: $Fe(s) \rightarrow Fe^{2+}(aq) + 2e^-$	E^0=+0,44V
Cathode	: $O_2(g)+2H_2(I)+4e^- \rightarrow 4OH^-(aq)$	E^0=+0,40 +
Cell reactions	: $2Fe(s) + O_2(g) + 2H_2O(l) \rightarrow 2Fe^{2+}(aq) + 4OH^-(aq)$	E^0=+0,84V

Ion Fe^{2+} is then subjected to further oxidation by reaction:

$4Fe^{2+}(aq) + O_2(g) + (4+2n)\ H_2O(I) \rightarrow 2Fe_2O_3.nH2O+8H+(aq)$

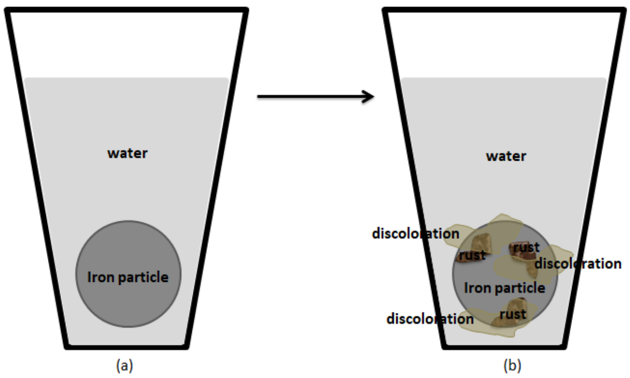

Fig. 1. Illustration the corrosion process.

Based on the value of its reaction potential, iron is a metal that is prone to corrosion. Other metals that have an electrode potential value greater than 0.4 V will have difficulty experiencing corrosion because with this potential it will produce E0 reaction <0 (negative) when in contact with oxygen in the air [16]. The metals silver, platinum, and gold have an electrode potential greater than 0.4 V so they are difficult to experience corrosion.

The factors that cause corrosion or accelerate corrosion are [17]: (a) Water content and humidity. Judging from the reactions that occur in the corrosion process, water is one of the important factors for corrosion. Humid air which contains a lot of moisture accelerates the corrosion process. (b) Electrolytes [18]. Electrolytes (acids or salts) are a good medium for charge transfer. This makes it easier for electrons to be bound by oxygen in the air. Rainwater contains a lot of acids, while seawater contains lots of salt. Therefore, rainwater and seawater are the main causes of corrosion. (c) Uneven metal surface. The uneven metal surface facilitates the occurrence of charge poles, which in turn act as anode and cathode. A slippery and clean metal surface will make corrosion difficult to occur because the poles that will act as anode and cathode are difficult to form. (d) The formation of electrochemical cells. If two metals with different potential values come into contact in an aqueous or humid environment, an electrochemical cell can be formed directly. Metals with lower potential will immediately release electrons when in contact with metals with higher potential and will be oxidized by oxygen from the air. This results in faster corrosion occurring in metals with low potential, while metals with high potential are actually more durable. For example, a rivet that is made of copper to attach the iron will cause the iron around the rivet to rust faster.

2.2. Students with special needs

Students with special needs are students who have obstacles either due to external or internal factors [9]. These obstacles cause problems in the learning process. They need concrete and attractive media because they have difficulty understanding abstract things [19]. In addition, they also have difficulties in understanding complex information [20]. Learning methods and simple explanations are needed by students with special needs.

There are several types of students with special needs, including students with visual impairments [21], students with hearing impairments [20], students with intellectual disabilities [18], students with physical disabilities [9], and students with emotional disabilities. Their characteristics make it difficult for them to follow learning as students in general. They need educational methods, media and services that meet their needs [9].

3. Method

3.1. Experiment the corrosion process

We used tools and materials, namely mineral water (Aqua, PT Tirta Investama, Indonesia), salt (Cap Kapal, PT Susanti Megah, Indonesia), iron particles (round shape (ball), size of 8 mm; purchased from Tokopedia), plastic cups, gloves, scales (Pocket scale, Indonesia), filter paper, plastic tea filter, tissue (Montiss, PT. Sun Paper Source, Indonesia), one large bottle (capacity more than 1 L), sandpaper (Taiyo, Indonesia), measuring cup/tube (Tyrex, Indonesia), sticker labels (Koala, Indonesia), pens/markers, and a ruler.

We conducted several stages in the experiment. The first was the preparation stage. At this stage, we made a NaCl solution with a concentration of 26.47%. Next, we diluted 0, 2.5, and 5% NaCl solutions. After that, we prepared the iron particles to be tested in steps, namely: prepared the scales, stored the filter paper on the scale, wore the gloves, calculated the weight of the iron particles. The second stage was the implementation stage. We prepared 15 iron particles which had been weighed (B). We put the iron particles into 15 plastic cups that have been labelled (1x, 1y, 1z, 2x, 2y, 2z, 3x, 3y, 3z, 4x, 4y, 4z, 5x, 5y, 5z). Then, we made three variations in the NaCl solution percentage (0, 2.5, and 5%) that would be used. After that, we put 30 mL of the NaCl solution into a plastic glass containing iron particles (0% of

NaCl solution in 5 cups, 2.5% of NaCl solution in 5 cups, and 5% of NaCl solution in 5 cups), removed the iron particles, and dried them. After a certain period of time, we let the iron particles stand for 1 day, weighed the weight of the iron particles before sanding (A0), sanded the iron particles in one direction, and weighed the irons particles after sanding. We documented all stages of this experiment for the video creation process. This 10-min video was used by the teacher in the learning process of corrosion.

3.2. Stages of the corrosion learning process

This study focused on limited research subjects (teaching the process of corrosion using iron particles to students with special needs). Research participants were 14 students with special needs (students with intellectual disabilities and students with hearing impairments) from the Special Schools in Kuningan Regency, Indonesia. This school is only for students with special needs.

We provided several questions to determine the level of students' understanding of corrosion materials on changes in shape and colour. We made 15 short answer questions, with a choice of answers and a score analysis of 1 (yes) and 0 (no) with a total score if answered yes of 100. The calculation method using Eq. (1), the answer score is yes multiplied by ten, then divided by thirty-five.

$$\frac{score\ obtained \times 10}{15} = student's\ final\ score \quad (1)$$

We empowered teachers to give tests using questions. Tests carried out before and after the learning process. The questions assessed to students were: (1) Do you know what solution is?, (2) Do you know NaCl is another name for salt?, (3) Do you know that the salt solution is an electrolyte?, (4) Do you know the salt solution has a salty taste?, (5) Do you know the difference between the taste of mineral water and salt solution?, (6) Do you know that corrosion is another name for rusting?, (7) Do you know that the corrosion process has discoloured?, (8) Do you know the corrosion process affects weight loss?, (9) Do you know the corrosion process affects the deformation of objects?, (10) Do you know objects that are prone to corrosion?, (11) Do you know that iron is an object that is prone to corrosion?, (12) Do you know the factors that cause corrosion?, (13) Do you know that saline solution speeds up the corrosion process?, (14) Do you know that the corrosion process of objects in mineral water is slower than in saline solutions?, (15) Do you know the corrosion process changes the colour of the solution?.

4. Results and Discussion

4.1. Experiment results

In this study, we conducted an experimental demonstration to determine the effect of NaCl solution on the corrosion process of iron particles. We used 8-mm iron particles weighing 2.1 g. In addition, we used NaCl solution with three variations in concentration, namely 0, 2.5, and 5%. The experimental results show that the iron particles that are put into the 5% NaCl solution will experience faster corrosion, it can be seen from the colour change that occurs. The reason is that NaCl is an electrolyte solution that accelerates the corrosion process [22].

Figure 2 shows the experimental results on 15 particles with the same weight (2.1 g). The results of the analysis showed that in the 0% NaCl solution the colour change occurred at 240 min or 3 h, but the weight reduction corrosion process occurred on iron particles that had been left idle for 24 h.

Figure 3 shows the experimental results on 15 iron particles with the same weight (2.1 g) in a 2.5% NaCl solution. The results of the analysis showed that the colour change occurred at 150 min or 2.5 h and the corrosion process decreased weight by 0.01 g. For iron particles that had been left for 3.3 h, the iron particles experienced a mass reduction of 0.02 g. Meanwhile, iron particles that have been left for 24 h, iron particles have decreased in mass by 0.02 g. This shows that NaCl is an electrolyte solution that can accelerate the corrosion process [22].

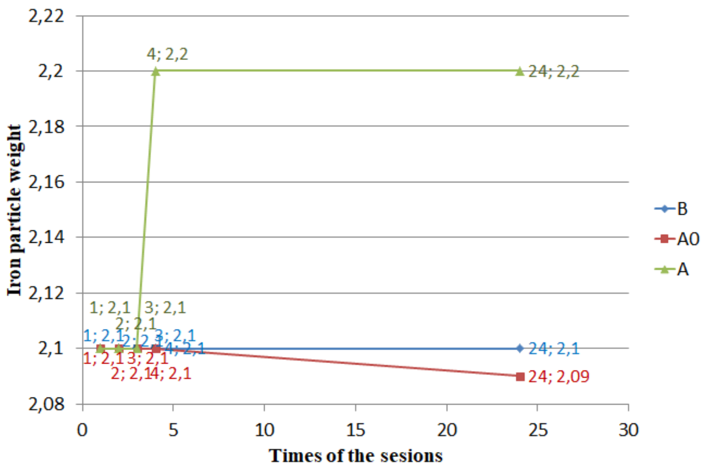

Fig. 2. Experimental results of iron particles in 0% NaCl solution.

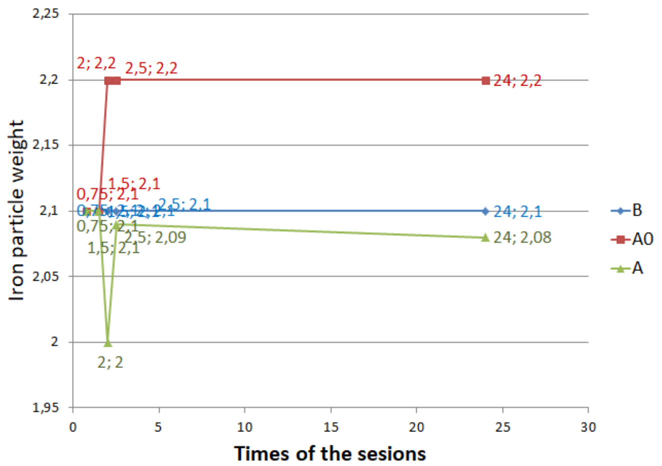

Fig. 3. The experimental results of iron particles in a 2.5% NaCl solution.

Figure 4 shows the experimental results on 15 iron particles with the same weight (2.1 g) in 5% NaCl solution. The results of the analysis showed that the colour change occurred at 120 min and the corrosion process decreased weight by 0.01 g. For iron particles that have been left for 2.5 h, the iron particles have decreased in mass by 0.02 g. Meanwhile, iron particles that have been left for 24 h, iron particles have decreased in mass by 0.03 g. This shows that NaCl is an electrolyte solution that can accelerate the corrosion process [23].

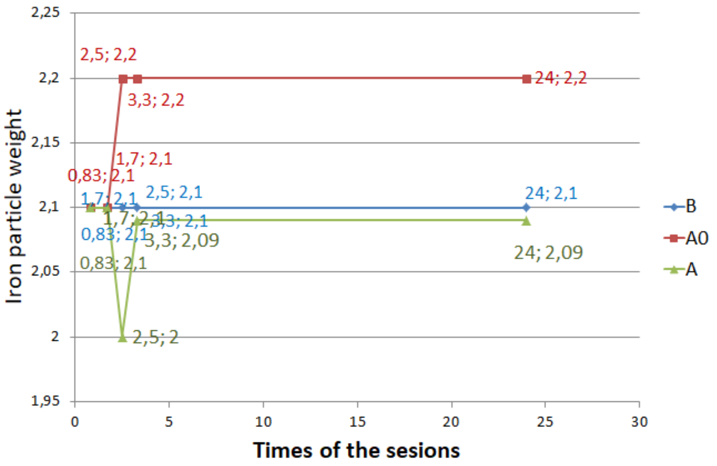

Fig. 4. The experimental results of iron particles in a 5% NaCl solution.

4.2. Student demography

Figure 5 shows the presentation of the number of children with special needs subjects based on their type of specialty. A total of 57.14% of the subjects of this study were students with intellectual disabilities. Students with intellectual disabilities are students who have intelligence characteristics below average, have adaptive behaviour problems, and problems that occur during development [19]. These student characteristics lead to various problems in the learning process, including difficulty concentrating, difficulty understanding complex and abstract learning. They need simple explanations, concrete, and interesting media in the learning process, and learning through habituation [9]. A total of 42, 68% of the subjects of this study were students with hearing impairments. In general, these students do not have problems in their intelligence or intelligence aspects as well as students in general. They have a characteristic difficulty communicating verbally because of problems in the hearing or speech organs [21]. They find it difficult to understand complex and abstract material because they learn by optimizing their visual senses. So that in the learning process, they need applicable methods and concrete media [20].

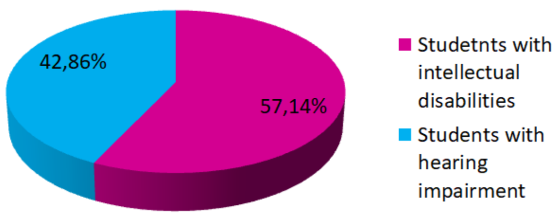

Fig. 5. Type of subject specificity.

4.3. Phenomena in learning and teaching process

Based on student demographic data, we found various problems faced by students with special needs in the learning process. Students have difficulties in understanding abstract concepts. Student learning must use methods appropriate to student needs, as well as concrete and interesting media [19]. Thus, we tried to use experimental demonstration methods and media that students often find in everyday life. The goal is to provide students with an understanding of the basic concepts of the effect of NaCl solution on the corrosion process.

The stages of the learning process were conducted as follows. In the first 20 min, the teacher explained about corrosion material through the lecture method and conducted a pretest. In this activity, students showed a lack of enthusiasm, and their concentration was easily distracted in following the lesson. In the next 50-min session, the teacher carried out the learning process using the experimental demonstration method, equipped with videos, and concrete learning media. Students showed an enthusiastic attitude, more focused, and actively participated in the learning process. Students with hearing impairments were more active in discussing the use of language cues, they looked pleased and responded quickly when asked questions. In the last 20 min of the learning process, the teacher gave 15 posttest questions which are the same as the pretest questions to determine the level of understanding of students [9].

4.4. Learning outcome data analysis

The learning process for students with special needs requires special techniques and services. In particular, teachers need to provide appropriate methods and media to attract student concentration and focus. Otherwise, students' level of understanding cannot be predicted. We ascertained the level of understanding of the students throughout the teaching process, by providing 15 questions ranging from elementary to intermediate level questions (Table 1). The results of the students' pretest and posttest are presented in Table 2.

Table 1 shows the posttest and pretest results of 14 students with special needs in special schools. A total of 6 students are students who experience hearing impairments (B1-6) and as many as 9 students who experience intellectual disabilities (C7-14). The pretest results show that 100% of students have a score below 70. After we conducted the learning process with the experimental demonstration method equipped with concrete and interesting videos and media, student learning outcomes increased. A total of 64.29% of students had a score above 70. Even five students or 35.71% of students had a score of 100.

Table 1 displays the analysis of students' understanding level when learning the effect of NaCl solution on the corrosion process. The level of student knowledge has increased, it can be seen from the posttest score that has increased. As many as 64.29% of students had scores above 70 and 35.71% of students had scores below 70. Students who had scores below 70 were students with intellectual disabilities because they have intelligence characteristics below average [9]. But even so, the learning process using demonstration methods, videos, iron particles, and NaCl solutions succeeded in increasing students' understanding of the intellectual disabilities in the learning process of corrosion material. Concrete and interesting media, as well as simple explanations, make it easier for students to understand various kinds of information [9]. This learning process makes it easier for students to understand material about corrosion, it is different when the teacher only uses modules or books, students are not motivated in the learning process [24]. Learning using book media alone is abstract learning for students with intellectual barriers, so they find it difficult to understand learning material. The analysis showed that their posttest scores increased by 40-50%. This shows that a difficult science learning process such as the effect of NaCl solution on the corrosion process can be taught to students with special needs. The experimental demonstration method using concrete and attractive media is one of the factors that can increase the level of understanding of students with special needs [20, 25].

Table 1. The results of the pretest and posttest learning of students with special needs.

No	Students	Pretest (X0)	Posttest (X)	Increasing value (%)	Percentage of students who have a score (X) above 70
1	B1	60	100	40	64.29
2	B2	20	100	80	
3	B3	20	100	80	
4	B4	20	100	80	
5	B5	20	100	80	
6	B6	20	93.33	73.33	
7	C7	20	73.33	53.33	
8	C8	20	73.33	53.33	
9	C9	20	73.33	53.33	
10	C10	20	66.66	46.66	35.71
11	C11	13.33	60	46.67	
12	C12	13.33	53.33	40	
13	C13	13.33	53.33	40	
14	C14	13.33	53.33	40	

• Note: B is a student with hearing impairment and C is a student with intellectual disability.

5. Conclusion

Research on the effect of NaCl solution on the corrosion process of iron particles shows that the data from the analysis shows that the iron particles in the NaCl solution which has a concentration of 5% experience faster corrosion. In addition, the learning outcomes of students show that students' knowledge has increased. As many as 64.29% of students had scores above 70. Factors that led to increased student understanding included the experimental demonstration method which was equipped with concrete and interesting videos and media.

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