Teaching magnetic properties of matter: Discovery laboratory approach

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The aim of this study was to construct a laboratory activity about magnetic properties of matter based on Discovery Laboratory Approach (DLA) and to investigate its effectiveness based on student opinions and observations. The study was conducted with sixteen freshman students in primary science education department. The study was utilized the case study approach and document analysis methods, in this process observation and interview forms were used in order to collect data. The DLA activities were performed with “Experiment worksheets” consecutively previously, during and after the laboratory discussions took place. Also, students’ behaviors were determined while conducting the worksheet. Finally interviews were conducted with the students about the effectiveness of the activity. It is concluded that the DLA approach is an effective way of teaching science concepts.

Key words: Discovery laboratory approach, magnetic properties, physics teaching.

INTRODUCTION

It is widely known that science education which starts from early childhood years and continues throughout the university period has a considerable importance. Whether it is called science or whether it is divided into sections like physics, biology and chemistry, experts claim that science education is a need for all the individuals of the society (Leach, 1996; Aydın and Uşak, 2003). It is known that a lot of daily experience could be explained with scientific terms like; laws, principles, theories, concepts and phenomena (Çepni, 1997).

Some studies (Nakhleh, 1992; Ayas and Demirbaş, 1997; Ispir et al, 2007) claim that especially physics and chemistry topics are much more difficult to understand. In order to provide more functional and effective science teaching, physics teaching also need to be considered seriously and extensively (Bozdoğan and Yalçın, 2004). Hence, physics concepts are more likely to include abstract concepts. How to teach physics effectively is a crucial question around academic society. In recent years, there have been a lot of studies on this hot issue since the learning is a dynamic process (Lawson and Lawson, 1993; Duphin and Jhousa, 1989; Greca and Moreira, 2000; Treagust et al., 2002; Dagher, 1995; Günbatar and Sari, 2005).

The purpose of the contemporary education is not to transfer existent knowledge rather the aim is to acquire the skills for to construct and reach new knowledge (Günbatar ve Sari, 2005). The general physics are consist of many fundamental topics, such as; motion, dynamics, atom, waves, electric and magnetism. Motion and electrical current concepts and shapes of magnetic area formation are difficult topics that students cannot visualize in their mind. It is important to perform activities about abstract concepts making them more concrete and daily life oriented manner (Gemici et al., 2002). However; there is no study dealing with magnetism and magnetic properties of matter teaching, although there is wide usage of magnetic waves in medical and health care field. An effort for such studies is necessary to develop students scientific and problem solving skills and to concretize such abstract concepts.

One of the fundamental aims of science teaching is to acquire scientific process skills and proper concept development (Gilbert et al., 1982). It is only possible with scientific and problem solving skills that an individual could easily overcome his/her daily problems (Colletta and Chiappetta, 1989; Ayas et al., 1997; Coştu, 2002; Coştu et al., 2003).

The need to teach difficult science topics and abstract concepts effectively and achieving scientific skills is increasing (Lazarowitz and Tamir, 1994). It is recently complained by students about the difficulties encountered when to learn abstract science concepts (Brown, 1989). Magnetism itself is a difficult abstract concept to teach...
and includes more abstract concepts. If the students are convinced that concepts which are related to magnetism are not abstract rather they are concrete concepts that are used in daily life, students will be more motivated and able to learn it more sincerely. It might even facilitate their learning (Çepni, 1997). However; traditional method is still being used frequently for teaching magnetism. Within this method teacher gives the distinctive properties and the verbal definition of the related concept and teachers enhance students to find examples which are related and not related to the concept. This method is also known as “deduction”. A lot of findings of the studies about concepts show that teachers prefer to use this method; but, they use ineffectively (Coştu, 2002; Coştu et al., 2003). Thus, a lot of misconceptions occur in students’ mind. In a study (Demirci and Çirkinoğlu, 2004) about electricity and magnetism in general physics II course, it was determined that most of the misconceptions exist in magnetism topic. It is emphasized in the study that most of the concepts teaching methods that science teachers developed are unique and their own creations according to their own experiences (Ayas, 1993; Keser and Akdeniz, 2001; Coştu et al., 2003). It is frequently mentioned by experts that students individual properties need to be taken into consideration and learning settings need to be designed according to these settings (Ulgen, 2001; Coştu et al., 2003). Until recent years traditional methods like direct exposition and problem solving are used to teach physics. Nowadays, it is aimed to use variety of methods to teach physics and it is thought that physics teaching would be more enjoyable with the help of new methods. In this context DLA is a frequently used method which gives special attention to cognitive activities, provides group and individual working opportunities. Also this approach provides first hand activities to activate students by experiencing on their own (Güven and Gürdal, 2002). Hence, laboratory activities are the fundamentals of science and physics courses and experiments are the most important elements of laboratory works. There are limitless experiment options for the physics course. Experiments let students’ all their senses to be involved to be able be more active and spend more enjoyable time. Also, the concepts which students learn would be more retention. Laboratory works develop students comparing and analyzing skills as well as critical and scientific thinking (Akdeniz et al., 1999; Güven and Gürdal, 2002). Otherwise, it is difficult to construct theoretical knowledge for a retentive learning.

It is believed that learning settings helping students to overcome their misconceptions and achieve the knowledge on their own need to be established. However; there are limited studies and material about magnetism topic. On the other hand, there have been more studies claiming that the traditional method is not effective enough and contemporary laboratory approaches need to be used (Yeşilyurt, 2003; Ayvacı and Devecioğlu, 2006). It is thought that the DLA is an effective approach that could be used for such purpose.

**DISCOVERY LABORATORY APPROACH (DLA)**

The approach is a student centered approach. According to Bruner (1961) a discovery oriented settings need to be formed that student could actively involves. The teachers’ roles in the DLA are not to inform students directly rather enhance them to solve problems by first hand activities (Çepni and Ayvacı, 2005). In order to conduct the DLA, students need to have some comprehensive and observation skills and could be able to decide at least some parts of experiment on their own and they need to be previously engaged with positive and negative results of experiments (Çepni and Ayvacı, 2005). The DLA has a lot of advantages since it uses deduction method. For instance, it motivates students and lasts until it is satisfied. Students could independently develop problem solving skills. Students could produce products which could be analyzed, conducted and are unique (Çepni and Ayvacı, 2005). Learning levels of students could be improved and they could be helped out to synthesize their knowledge with discussions guided by a teacher. Students can predict hypothesis regarding their pre-knowledge and pre-test and they establish a learning focusing on concepts in laboratory settings which the DLA is being used.

These steps should be considered while conducting an experiment according to the DLA:

1. In each discovery experiment only one concept or one problem should be issued.
2. The knowledge required in order to design and conduct an experiment should be previously given to students.
3. In order to reveal the knowledge that students have, questions should be asked and discussions should be made.
4. Along the process of the experiment small groups should cooperate in order to gather data.
5. Every group discussion conclusion should be discussed with other group mates with some intervals.
6. More time should be given to discussion rather than data gathering.
7. Student enrolment is necessary to decide the experiment steps in order to be successful (Bodner et al., 1998; Çepni and Ayvacı, 2005).

**APPLICATION PROCESS OF DISCOVERY LABORATORY APPROACH**

The DLA approach is executed in three stages. Such stages can be listed namely; pre experimental discussion, experiment-data gathering and post experimental discussion-student discovery.

**Pre- experimental discussion:** At this stage it is aimed to focus, attract students and to make students involve in the related topic by asking a well planned question that could boost their self esteem. Such a question should
establish a link between the previously known knowledge and future knowledge that is desired to be taught. It should be taken into consideration that students are not at the same level. Real life and natural daily life experience based questions need to be asked in order to reveal common knowledge. If the students cannot be focused on the related topic with such a question it is more likely that the students will not be able to learn desired knowledge (Çepni and Ayvacı, 2005).

With the help of group discussions students try to guess the unknown knowledge with their previous knowledge in order to make hypothesis. If more than one hypothesis comes out of such discussions, students are more likely to be excited and motivated to do the experiments. They try to prove their hypothesis by trying to find evidences through experimenting.

It should not be forgotten that within the time and the security aspects of the experiment each step should be planned by the teacher carefully. However; in some cases students could easily and reach the right conclusions, different types of questions should be asked in such situations.

**Experimenting - data gathering:** First of all evidences that could refute the hypothesis should be determined. Using the DLA it is aimed to enhance students to make a link between their hypotheses with the experiment. During this process students work in small groups and discuss their hypothesis frequently. Working in small groups would help students to be more successful. It is teachers’ responsibility to motivate students to make group discussions during the experimenting stage. It would enable students to focus on their experiment and the ones which lost the track of the experiment could easily keep up again with the help of their teachers and classmates. Thus teacher provides cooperative learning also among groups as well.

**Post experimental discussion – student discovery:** This stage is where students gather around to evaluate their data and to make discussions. The timing should be done properly so that the discussion would not take another lesson. The teacher could be sometimes active during this stage since the students are more likely to miss the important concepts of the experiment. Teacher emphasizes the most important answers and needs to provide an opportunity for the individuals to express themselves.

Students would understand and observe how to set up, execute and summarize an experiment by using the DLA. Students would experience the data gathering process. It is the student who is active all through the process. It facilitates learning since it involves sensory organs to be used during the experiment. Students discover by themselves which is the first stage of attaining scientific knowledge. Using such approach leads students to gain new problem solving skills. Learning becomes more efficient and progressive with the support of this approach. The practical benefits of this approach are also remarkable since what is being experienced is more likely to be used and better remembered. Improving hand skills, promoting research, activating students, boosting scientific knowledge, improving thinking skills, immediate feedback possibility could be mentioned as some benefits of the DLA approach (Ergün and Özdaş, 1997). The need for long hours and requirement of students with high cognitive levels could be mentioned as the limits of such approach (Ayvacı and Devecioglu, 2006). In recent years, more interest had risen towards the DLA. It is thought that activities need to be developed and reshaped according to this approach and could be used for meaningful concept teaching.

For this purpose an experiment was designed which aims to teach the magnetic properties of matter and the differences between ferromagnetic, diamagnetic and paramagnetic matter. The experiment is composed of stages like; pre experimental discussion, experimenting-data gathering and post discussion.

In pre experimenting discussion stage, it was aimed to focus students on magnetism by asking interesting questions. Then, students proceed to experimenting stage. This stage consists of 5 activities and each activity includes 3 steps. In the first step, students form their predictions about the problem, and in the second step, they execute the activity and test their hypothesis and discuss their conclusion with group members. In the third step, the groups share their conclusions with each other to make a class discussion.

After finalizing all the activities, they proceed to post experiment discussion stage. In this stage, it was expected from students to conclude the magnetic properties of matter. Also it is expected from students to explain the reasoning why copper is not magnetized although it is a conductor just like iron. They are also expected to distinguish paramagnetic, ferromagnetic and diamagnetic matter and their properties. As a result, they will be able to explain the stages of the experiment and which matter shows what kind of magnetic property.

**Aim**

The aim of this study was to construct a laboratory activity about magnetic properties of matter based on the Discovery Laboratory Approach and to investigate its effectiveness based on student opinions and observations.

**MATERIALS AND METHODS**

The sample of the case study comprised of sixteen freshman students in primary science education department of Education Faculty in Trabzon. The study took place during the spring term in academic years of 2008-2009. The collected data were gathered from document analysis, conducted interviews and course observations.
The study was conducted according to these steps:

1) Firstly, the physics II course was analyzed which is a part of the first grade science and technology teaching curriculum and it was decided to conduct a study on magnetic properties of matter regarding Barrow's (2000) study which emphasized the misconceptions of high school and college students misconceptions about magnetism (Barrow, 2000; Committee On Undergraduate Science Education, 1997; URL-1, 2004; URL-2, 2004; URL-3, 2003, Demirci ve Çirkinoğlu, 2004).

2) The fundamental properties of magnetic properties of matter were studied regarding the Discovery Laboratory approach and an experiment was designed according to such aspects. This experiment includes a five staged worksheet having 4 questions at every stage which needs to be followed according to the DLA. This worksheet was developed in order to present written knowledge since there could be lack of information during discussions. It is some kind of a guide that students can easily follow not to lose their path.

3) An activity guide booklet was developed for the teacher in order to facilitate the conduction of the activities for the teacher. The booklet contained the name of the experiment, aim, target behaviors, equipments, process, important points and evaluation questions.

4) Pre- and post- test were prepared in order to measure and evaluate the concept development, conceptual change and discrimination level of students about magnetic properties of matter.

5) In regarding the group collaboration property of the DLA, four heterogeneous groups were formed.

6) Students were informed about how to execute the activities and conduct discussions. Students were enhanced to make discussions before, during and after the activities. They were asked to fill the worksheets about their last decision on whether they have a common opinion or not.

7) An observation form was developed regarding the emotional and psychomotor areas of the Bloom Taxonomy in order to monitor student behaviors. The frequencies of target behaviors were checked on these forms regarding their existence during the activities. The behaviors were monitored according to three categories namely; never, sometimes, frequently. Student-teacher and student-student interaction, equipment usage, discussion participation aspects were taken into consideration.

8) Worksheets were analyzed at the end of the process in order to gather data about the cognitive development of students. Worksheets were classified according to the DLA steps, the answers which students claimed were given purely in order to present the data as it is to the reader (Merriam, 1988; Ayvacı and Devecioğlu, 2006). For some questions frequency of same answers were classified and given in tables.

9) Finally interviews were conducted with 16 students using four open ended questions. Their suggestions were determined about the execution.

RESULTS

The results from the worksheets, course observations and student interviews are given in this section.

Results from worksheets

In this part findings related to student answers are presented regarding their similar aspects.

Results from Pre-experimental discussion

In order draw students' attention and to determine their level of pre knowledge about the topic questions were asked like "What is a magnet or magnetizing", "How do we magnetize things", "Where do we use magnets in our life", "Does Earth shows a magnetic property" and then proceeded to activities. Every activity involves pre, and post discussions plus the execution of the experiment. Each activity's first question asks in order to make hypotheses and discuss it with group mates and to write down the overall decision on worksheets. It was observed that except the second group all students involved in discussions with interest. One of the students from each group was asked to share their opinions with the class.

Activity -1 Question 1

What do you expect to see if you were to sprinkle the iron dust on the magnet? Explain your predictions with drawings.

All the students drew their predictions as shown in Figure 1. Groups hypothesis were shown in Table 1 and the group numbers were indicated as 1, 2, 3 and 4. Table 1 shows hat the groups keep up eight hypo-theses and the second group formed more hypothesis compared to first group. None of the groups kept up the same hypo-thesis. Only one hypothesis was claimed from three groups. It was observed that students made their predictions without any anxiety and they mainly supported their group mates' opinions or claimed their own predictions.
Table 1. Hypothesis of groups related to question 1.

<table>
<thead>
<tr>
<th>Student hypothesis</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron particles would form circular lines.</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Iron particles would form lines which comes out of the poles</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron particles would concentrate on N-S poles and form magnetic field lines</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Iron particles would never stuck to each other</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Iron particles would move to end of magnetic fields by forming symmetric lines</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Iron particles would show up in the middle of magnet rarely</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Magnetic field lines would be more clear to see with the help of iron particles</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron particles would be pulled by the magnet and distributed among poles</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

Note: 1, 2, 3 and 4 refer to the group numbers in the study.

Figure 2. Students' prediction about question 1 for activity-2.

Activity-2 Question 1

What would happen to the iron dust if we were to sprinkle them after we switch off? Explain your predictions by drawing.

The students drew their predictions as shown in Figure 2. Groups hypothesis were shown in Table 2 and the group numbers were indicated as 1, 2, 3 and 4.

According to the Table 2 groups claimed five hypotheses and most of the hypotheses were done by the first group and two of the hypotheses were both suggested by all groups.

Activity-3 Question 1

What would happen when you spill iron particles on the mechanism after you switch off? Draw your predictions and explain.

All the students drew their sketches as shown in the Figure 3 except S6 who drew it as shown in Figure 4. Groups hypothesis were shown in Table 3 and the group numbers were indicated as 1, 2, 3, and 4.

According to the Table 3 all the groups keep up total of four predictions and they claimed the same number of predictions and one of the hypotheses was claimed by all the groups.

Activity-4 Question 1
### Table 2. Hypothesis of groups related to question 2.

<table>
<thead>
<tr>
<th>Student hypothesis</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron gains a magnetic property and would pull iron particles</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Iron particles would concentrate on the poles just as it happens in a magnet</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>A magnetic field would be formed around the string when electrical current is applied.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Iron particles would scatter around iron stick</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>When a current is given to iron stick, it gains a electromagnetic property and iron particles would form magnetic field lines.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

Note: 1, 2, 3 and 4 refer to the group numbers in the study.

Groups hypothesis were shown in Table 4 and the group numbers were indicated as 1, 2, 3 and 4. According to the Table 4 groups made three different hypotheses and in general they come up with same number of hypothesis. There is no common prediction that has been made by all the groups.

### Activity-5 Question 1

After you switch the mechanism on and sprinkle iron particles what would you observe? Support your explanations with your drawings.

Students mainly made such drawings as shown in Figure 6.

Groups hypothesis were shown in Table 5 and the group numbers were indicated as 1, 2, 3, and 4.

According to the Table 5 groups claimed four different hypotheses. First group came up with the most hypotheses and there was no common hypothesis which claimed by all of the groups.

### Results from experimenting and data gathering stage

At this stage it was expected that students corporate with each other in order to set up the experiment with the appropriate laboratory tools to prove their hypotheses. They conduct their experiments in order to reach a conclusion. It was desired that students fill up the worksheets and make in-group discussions to reach a common conclusion and present it to the rest of the class.
Table 3. Hypothesis of groups related to question.

<table>
<thead>
<tr>
<th>Student hypothesis</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Since the wooden stick is an insulator it would not act like a magnet and iron particles will remain the same</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Although it is wooden since there is a current there would be magnetic field since it is the current that produces magnetic fields.</td>
<td>X*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wooden stick would not form any magnetic field</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The wooden stick would not gain any magnetic property but the reason for this is not conductivity or insulating. If there is such situation then conductor strings would also show magnetic property.</td>
<td></td>
<td></td>
<td>X*</td>
<td></td>
</tr>
</tbody>
</table>

Note: 1, 2, 3 and 4 refer to the group numbers in the study.
* : Prediction was claimed by only one member of the group.

Table 4. Hypothesis of Groups related to Question

<table>
<thead>
<tr>
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<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Since the conductivity of iron is less than copper the magnetic field lines that iron particles form around copper stick would not be so clear.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Copper would form a magnetic field since it is a conductor.</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Since copper has a better conductivity than iron there would be more polarization and clear magnetic field formations.</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: 1, 2, 3 and 4 refer to the group numbers in the study.

Figure 5. Students’ predictions about question 1 for activity-4.

The answers were presented below for all second questions of the five activities.

Activity-1 Question 2

Sprinkle the iron particles and test your hypothesis.

Support your conclusion with drawings.

It was expected that students write should down; “Iron particles are situated on magnetic field lines” after they complete the experiment as shown in Figure 7. It was determined that they all came up with the right conclusion by using different ways of explanations and details.

Activity-2 Question 2

Adjust power supply to 9V and sprinkle iron particles and test your hypothesis. Support your conclusion with drawings.

As in the previous experiment, students were expected to write “Iron particles are situated on magnetic field lines” after they have finished the experiment as shown in Figure 8. In general they came up with the right conclusion with different explanation styles.
Figure 6. Samples of the students drawings about question 1 for activity-5.

Table 5. Hypothesis of groups related to question.

<table>
<thead>
<tr>
<th>Student hypothesis</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Since chrome does not show any magnetic property sprinkled iron particles will remain the same.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Although chrome is a conductor it would not show a magnetic property.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Chrome would form more magnetic field compared to iron.</td>
<td></td>
<td></td>
<td>X*</td>
<td></td>
</tr>
<tr>
<td>Magnetic field would form but the lines would not be so clear to notice.</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: 1, 2, 3 and 4 refer to the group numbers in the study
*: Prediction was claimed by only one member of the group.

Activity-3 Question 2

Adjust the power supply to 9V and sprinkle iron particles and test your hypothesis. Support your results with drawings.

Students were expected to write “Iron particles are situated on magnetic field lines” after they have finish the experiment as shown in Figure 9. In general they came up with the right conclusion with different explanation.

Figure 7. Results of the activity-1.

Figure 8. Results of the activity-2.
styles. It is observed that only S13 wrote his own thoughts rather than groups common conclusion.

Activity-4 Question 2

Adjust the power supply to 9V and sprinkle iron particles and test your hypothesis. Support your results with drawings.

Students were expected to write “Iron particles did not form magnetic field lines rather they stayed the same as they were sprinkled so forming magnetic field is not to do with conductivity” after they finish the experiment as shown in Figure 10. In general they came up with the right conclusion with different explanation styles. As a results groups did came up with right answers. S2 and S4 in the first group wrote their own individual opinions rather than groups’ common belief. They wrote that “Coppers magnetic property was declined since copper string was coiled around the Cooper stick” which was a wrong statement.

Activity-5 Question 2

Adjust the power supply to 9V and sprinkle iron particles and test your hypothesis. Support your results with drawings.

I was expected that students write “Iron particles managed to form a little bit of magnetic field” after they have completed the experiment as shown in Figure 11. It is observed that in general groups came up with the right the conclusion with different explanation styles.

Results from post experimental discussion

After every class discussion students were asked to write down their conclusions on worksheets. Teacher’s explanations and class discussion generally resulted with same opinion declarations on worksheets. When the answered questions of worksheets were analyzed it is found out that students preferred to answer them according to their individual opinions rather than group opinions.

Question –1: While iron is magnetized in activity 2 why copper did not magnetized in activity 4 although it is a conductor just like iron? Discuss.

In general students were able to make the right explanation by claiming that magnetizing is not a matter of conductivity rather than the lining up of the atoms.
Since iron spins direct the same direction it gains a magnetic characteristic while copper spins opposite and neutralizes its magnetism. Students were able to distinguish ferromagnetic and diamagnetic property at a sub atomic level. However most of the students did not mentioned all of the properties. And S12 were not able to clarify his thoughts. His definitions were like;

Although they were both conductors since the atomic line ups were different copper did not magnetized”.

**Question –2:** What are the properties that discriminates ferromagnetic, paramagnetic and diamagnetic matter from each other?

S1, S2, S3, S4 in the first group, S5, S8 in the second group, S9, S12 in third group and S13, S14, S15 in forth group said that “Iron, nickel and cobalt are ferromagnetic matters. Spins of such matters increase their magnetic force. Chrome could be given as an example for paramagnetic matter their spins have little influence on their magnetic force. Matter like copper decreases the magnetic force since its spins apply an opposite force towards magnetic field. Paramagnetism and diamagnetism are to do with atomic line ups”. The rest of the students did not come up with close true or full explanations. Here are some anecdotes of what group members had claimed.

It is observed that magnetic field formation of diamagnetic matters was less compared to iron’ (S16 in 4 groups).

They were classified according to whether they form an electric filed or not’ (S7 in 2 groups).

Ferromagnetic matters form really good magnetic fields because of their atomic structure’ (S6 in 2 groups).

Since there is a single electron in the outer shell of paramagnetic matters they would not be able to attain a magnetic property. Diamagnetic matters have double electrons in their outer shell which lets them to form a magnetic field (S10 in 3 groups).

Electron formation of ferromagnetic matters are complete and electron formation of diamagnetic matters are semi complete’ (S11 in 3groups).

**Question –3:** Explain the experiment by considering the magnetic properties of the matter.

Except S11 all the rest of the students claimed that “In the first activity sprinkled iron particles aligned on the magnetic field. In the second activity iron particles were aligned more clearly when the current is given to iron rod. We learned that iron is a ferromagnetic matter. In the third activity sprinkled iron particles stayed the same since wood rod is not a conductor no magnetic field lines were formed. In the third activity iron particles remained the same just like it has happened with the wooden rod when copper rod has been tried out. It has been acknowledged that magnetic field formation is not to do with conductivity rather it has to do with atomic order of the electrons in the outer shell. Copper was found to be a diamagnetic matter. In the fifth activity a little magnetic field was formed when chrome rod was used which indicated that chrome is a paramagnetic matter. S11 was unable to explain the reasoning of activities completely. He said that we provide current by using iron. There was no magnetic field formed when we used copper. And little magnetic filed was formed when we used chrome (S11 in 3 groups).

Most of the students answered this question like “Copper shows a diamagnetic property. Its’ spins effect the magnetic field in the opposite direction and since it has only one electron at its last orbit it does not form a magnetic field.

**Question –6:** What kind of magnetic property does chrome show? Explain.

Most of the students claimed that “Chrome shows a paramagnetic behavior and forms a little magnetic field”. It is observed that the rest of the students could explain this property of chrome with its reasons.

**Results from pre- and post-test**

**Question –1:** What are the properties used in order to discriminate ferromagnetic, paramagnetic and diamagnetic matter?

In the pre-test, half of the students answered this question as follow: “Ferromagnetic materials are matters that could gain magnetic property. Paramagnetic and diamagnetic materials are matters which either do not gain any or gain a little bit of magnetic property. The others answered the question as wrong or as they did not
Table 6. Observations of students’ behaviors related to emotional and psychomotor areas

<table>
<thead>
<tr>
<th>Behaviors related to emotional area</th>
<th>Yes</th>
<th>Sometimes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Listens to explanations that teacher make</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Follows the instructions according to its order</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asks questions about misunderstood points</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Answers questions</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Cooperates while doing the experiment</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Makes group discussions</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observes the experiment with caution</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Explains the magnetic properties of matter</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Listens to different point of views</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motivated towards the experiment</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speaks thinking hypothetically</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Relates situations among each other</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Can explain the causes of events</td>
<td></td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Behaviors related to psychomotor area</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Identifies the experiment equipment</td>
<td>X</td>
</tr>
<tr>
<td>Get ready for the experiment</td>
<td>X</td>
</tr>
<tr>
<td>Observes his/her friends</td>
<td>X</td>
</tr>
<tr>
<td>Does experiment properly</td>
<td>X</td>
</tr>
</tbody>
</table>

even answer it at all.

In the post-test, the students S1, S2, S3, S4 in first group, S5, S8 in second group, S9, S12 in third group and S13, S14, S15 in fourth group claimed that "Ferromagnetic matters are special matters like nickel, iron and cobalt. Their spins tend to strengthen the magnetic field. Chrome is a paramagnetic matter which has only one electron spin which causes a little magnetic field force. Copper is a diamagnetic matter which electron spins tend to move opposite direction of the magnetic field. Paramagnetism and diamagnetism are to do with electron line ups”. The rest of the students had difficulties with their explanations or they were wrong completely.

**Question –2:** What kind of magnetic property does iron shows? Explain.

In the pre-test, ten students were able to claim that iron shows a ferromagnetic property but they were not able to reason their answers while four students were totally wrong with their answers. In the post-test, most of the students were also able to clarify that iron shows a ferromagnetic property and they were able to exemplify nickel and chrome as ferromagnetic matters.

**Question –3:** What kind of magnetic property does copper show? Explain.

None of the students answered this question in the pre-test. In the post test, all the students were able to claim that “Copper shows a diamagnetic property since it has only one electron in its outer shell and its spins influence the magnetic field in the opposite direction, no magnetic field could be produced.

**Question –4:** What kind of magnetic property does chrome show? Explain.

None of the students answered this question in the pre test. Throughout the post-test students were able to explain “Chrome shows a paramagnetic property. It establishes a little bit of magnetic field” Rest of the students were able to explain the paramagnetic property of chrome with reasons.

**Results from observation form**

The results from the observation form are shown in Table 6.

The behaviors which were observed during monitoring were indicated as in Table 6. According to Table 6 students listened to what teacher have told carefully, followed the instructions, discussed and helped each other to conduct the experiment respectfully. However; students were insufficient to think hypothetically, to link the events, to explain the reasons of the events.

**Results from student interviews**

In this section questions and answers for sixteen students’ interviews findings are given below. The answers are given in general expressions.
What was the most attractive part of this experiment?

S1, S3, S4, S6, S8 claimed that copper not forming a magnetic field although it is a metal was interesting. S15, S12 claimed that comparing different materials was enjoyable. S11, S13 said that discovering that magnetism is depended on lining up of the atoms. S2, S9, S10, S16 claimed that the magnetic field formation of iron particles. S7 picturing the hypothesis. S5 said the surprise when the hypothesis and the results contradict. S14 said chrome forming a very little magnetic field.

What are the problems that you encountered during this execution?

S2, S5, S6, S7, S8, S9, S11, S14, S15 claimed that they had never encountered any problem, S1, S3, S4, S10, S12, S13, S16 said that they had some technical skill problems.

How would you change the experiment and how could it be improved according to your opinion?

S12 claimed that more time should be given for researching after the activity, S10 said that it would be better if names of the students are written on the laboratory equipment to increase the consciousness, S8 claimed that copper experiment should be done after the wooden experiment was done in order to increase the effectiveness, the rest of the students did not made any suggestions or change since they thought it is already good enough.

What would you like to say about this activity furthermore?

Students claimed that they all love to actively experience the execution. They said that they had lots of fun while doing it and discussing it. By this way they claimed that they have a more clear view in their mind for magnetism and related concepts. Although it is a complex topic which involves abstract concepts they said that they feel more comfortable about this topic. They emphasize the importance of discussions and their contribution to their learning achievement. They managed to refute their misconceptions and replaced them with the correct ones and their learning occurred both individually and as a group.

DISCUSSION and CONCLUSION

The results about necessity and effectiveness of the DLA which comes out of worksheets, observation forms and interviews shows similarity with the recent studies regarding the use of DLA while teaching science concepts (Ayvaç and Devecioğlu, 2006).

It was discovered from observation forms that students were more likely to pay attention, follow the instructions, help out each other, respect different thoughts, be motivated toward experiments and they were able to explain the magnetic properties of matter without any difficulties. Although some students had trouble in executing some cognitive thinking skills while conducting the experiments they were successful to answer the questions, thought hypothetically, link the events with each other, reason the facts, identified the experiment tools and made group discussions.

For this reason, it was suggested that experiments that include difficult concepts should be prepared which promote hypothetical thinking, not knowledge concentrated, explanatory, discursive, facilitate determining and identifying variables. Hence, students would be able to develop problem solving skills which they can use in their daily life (Tobin et al., 1994). They could also identify the variables and their impact value while testing their hypothesis from the beginning to the end of the problem. They could also think hypothetically and establish relation among variables. However; it is important to use discussions at every stage of the execution since it helps to develop cognitive skills of students. It was observed that they had some difficulties while explaining the results of their group discussion results. It is believed that the reason for encountering such problems is mainly because of the fact that it is students’ first time with such kind of execution. The interviews showed that students enjoyed and found the DLA attractive to use. They claimed that they were able to construct the abstract concepts more concrete and retentive. They expressed that they liked group discussions and cooperative work in order to clarify their results. It shows that they were able to correct their misconceptions while establishing individual and group learning. In a study (Demircioğlu et al., 2004), claimed that group discussion promote students meaningful learning, helps students to generalize their results, clarify the concepts more concrete and since students are active they had more fun and more participation was established. The DLA steps were tried to be conducted although there was not enough time for it with sixteen students. The executions started with the motivation questions which influenced students pre knowledge and made them focus on the desired topic. They were enhanced to make hypothesis and try them out. Worksheets were handed out in order to guide the experiments rather to let students to make their own settings. In a study (Atasoy and Akdeniz, 2006), it was concluded that using worksheets could be helpful in constructivist learning settings as a guide material and teachers need to act like a guide or an assistant rather than a information supplier during the activities. The reason for such execution is that worksheets require a lot of deep thinking effort while experiments require observation, hypothesis developing and try out in order to collect data. It is also believed that group discussion increase students
self esteem, trust, and motivation as they do not need a teacher to confirm their results. However; traditional methods may increase students failing anxiety and feeling insecure.

Although it was students first experience with DLA they were motivated and willing to test their hypothesis and they were able to execute and finish all the activities without encountering any problems. It was observed that they were also keen to discuss their results and personal opinions.

The findings showed that the DLA was successful to boost students leaning in cognitive, psychomotor and emotional areas. It is believed that discussions enhanced students’ social and communicative skills since they had opportunity to express themselves, listen to others’ opinion, respect different thoughts and reason their opinions. Especially traditional methods should be abandoned when difficult abstract science concepts are desired to be taught. Permanent learning, active participation, student centered teaching and active engagement aspects of the DLA makes this approach superior to other traditional methods.

Aycan and Yumuşak (2003) showed that high school students mostly complained about the difficult abstract concepts of physics and they were rather chosen to memorize the concepts. They suggested that more laboratory and experiment based teachings should be done, which are daily life oriented in order to conceptualize abstract concepts. Classroom settings could also be designed similar to laboratory settings in order to increase permanent learning and active enrollment. Another study (Bekar, 1996) showed that experiment based learning was found to be superior to traditional teaching methods. Moreover individually conducted experiments increased the success of the students more, compared to demonstrative experiments (Temiz and Kanli, 2005). Telli et al (2004) showed that an effective and permanent science teaching could be acquired by meaningful learning, student centered environments and active engagement of students with the activities. And learning environments need to be set up in order to provide active enrollment and enhance using high level thinking skills (Novak and Gowin, 1984), however; they also claimed that schools are insufficient to obtain such environments which promotes students to memorize concepts rather than learning. They pointed out that students had difficulties to concentrate on the topics although they found the subject interesting. They are more likely to have 70% of interested within the first ten minutes. However this interest rate decreases to 20% in last ten minutes. It was concluded that using traditional methods although the topic is interesting would still result in failure if students’ active engagement is not established. Students learning potential should be used and their skills should be enhanced for a better learning and improvement (McKeachie, 1996). Experimental teaching in science teaching enables student to use their potentials and natural instincts, thus, their active participation is required at every stage. Although this method does not use widely in schools it enables students to think more critically and hypothetically to solve problems (Ayas et al., 1997). Laboratory is a vital part of science teaching. It is also an important tool for a better and efficient meaningful learning. Without a laboratory it is difficult to teach abstract concepts for a retentive learning (Telli et al, 2004).

A widespread world view is that “Knowledge is not important alone rather it is more valuable when it is known how to be used” (pace number..). On basis of this view, the knowledge is needed to be the product of students which they could know how to use. Students should be actively enrolled during activities so that they could own the knowledge as a result of their effort (Ayas et al., 1997). This could be established with the help of DLA which is student centered and involves active participation. Hand skills of students could be well developed and they could think more productive. Students would have opportunity transfer their knowledge from theory to practice and relate it to daily life usage to make it more meaningful (Dekkers and Thijs, 1998). Permanent attention could be acquired since this approach stimulates multiple sensory organs. Students are able to discover knowledge by experimenting which is the first step of acquiring scientific knowledge and they gain new experiences. Students are active when they do experiments. Therefore the class becomes more active and alive which attains active enrollment and motivation. This is the most valid and contemporary method of learning (Iven, 1997; Telli et al, 2004). The results that pre and post test claim the effectiveness of this approach clearly. Students who were unable to explain or even answer the questions in pre test were able to answer and explain nearly all the questions in post test.

As a result the DLA appeared to be an approach which students have a better chance to involve actively, learn by doing, think critically, test their hypothesis and establish permanent learning by discussing. It is found to be more effective in teaching abstract science concepts compared to traditional methods.

SUGGESTIONS

Suggestions regarding this study given as follows;

i) The DLA is an approach which students could monitor how an experiment is settled up, what is to be done and how the experiment will finalize. Instructing at every step of the experiment will lead students to progress fluently and within a planned framework with concrete experiences. Hence, it is suggested that such approach should be used in order to teach and visualize subjects which are relatively more difficult to teach with traditional methods.

ii) In the DLA student lives within the knowledge acquiring
system. It is the student who is active all the way through the learning process. Students are able to acquire permanent learning by doing it by themselves. They get pleasure out of it which lets them to be motivated all through the process. The teacher has to be a guide rather than an active participant of the activities and let students to discover for themselves.

iii) Since the approach enables multiple uses of sensory organs it facilitates learning. Students discover knowledge which is the first step of acquiring scientific knowledge. Within this approach student; reaches a verdict by following problem solving steps, determines relations among situations, suggests hypothesis and tests such hypothesis by setting up an experiment, determine variables, criticizes conclusions and alternative results, discusses within a group and class, thinks hypothetically and reaches a reasonable conclusion. In order to acquire such meta cognitive skills the DLA should be used and such settings need to be established in classes.

iv) The DLA could also improve hand skills and investigation abilities, activate students, raise scientific interest, enhance creative thinking and enable immediate feedback and intervention. Thus this approach could be used in order to acquire cognitive, psychomotor and emotional skills.

v) Concept determining tests should be utilized before conducting activities on students in order to investigate their pre knowledge and comprehension levels. Pre tests could help us to discover the pre knowledge and comprehension levels of students and to prepare suitable activities for the students. Post test could reveal the change in learning levels and differentiation in concepts.

REFERENCES


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